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Resource conservation through indigenous farming system in hills of West Bengal

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Available natural resources such as land, forests and water have continuously been degrading globally. There picture at regional level too is dim. Yet indigenous farming practices including, crop, seed production and management had always motivated the agriculturists to develop an improved agriculturally fit technology. This becomes needier in hilly areas. Therefore, the resource conservation is of major importance for hilly and a rainfed areas as it restores 'farm moisture' after recycling weed as green manure. Soil, water and vegetation are three basic natural resources. In order to manage land, water and vegetation, technical knowledge suitable to the specific conditions of a region was required. Darjeeling – Sikkim himalaya farmers gained this knowledge and developed skill through experience and learning by doing. The Eastern Himalaya region is characterized by a diversity of farming practices that have been developed and nurtured through many generations.

The role of conservation agriculture in improving efficiency, equity and environment is well recognized and concerns have been raised at the global level to conserve natural resources for a better quality of life. This can be efficiently practice by use of local indigenous and traditional knowledge. The idea behind conservation agriculture is the integration of ecological management with modern, scientific agriculture practice along with indigenous traditional knowledge (ITKs) practices (Mukherjee and Chakraborty, 2010). The design of farming system is the need of an hour that would permit continuous sustainable production and the same time well adapted to the requirements of farming community. Keeping the above aspect in mind present investigation was conducted to know various indigenous methodology use under various farming system. Because the economy base of the himalaya comprises of the sustainable integration of land, water and farming systems.

In Darjeeling hills people have lot of knowledge which is helpful to farming community based on their experience with natural farming. Work on various indigenous technique of farming system used by local people and tribe was surveyed and documented out during the 2007-10 at Regional Research Station (Hill Zone) under the aegis of Uttar Banga Krishi Viswavidyalay. Darjeeling –Sikkim hills is a home of tribal groups (lepcha, bhutia, sikkimist and nepali) speaking a variety of languages with a strong tradition of social and cultural identity marked by diversity in customs, cultures and traditions. The average annual rainfall of the region varies from 1500 to 2200 mm. The climatic conditions range from sub-tropical to sub-temperate types of climate. The data on traditional practices of the indigenous agriculture primary data collected through semi-structured interview schedules and discussions with farmers and key informants who are located at different places. In Darjeeling, we held dialogue with villagers living along the corridor between Singalila National Park and Senchel Wildlife Sanctuary. These villages practice typical hill agriculture and fields are rain fed. A variety of crops are planted ranging from maize, vegetables like cabbages, potatoes, squash, coriander and chillies. This information along with those obtained through interviewing personnel from the agriculture departments and researchers were analysed to present the result.

Farming systems in the Hills go hand in hand with elevation for differences of resource availability and resource use. Mainly, two types of farming systems, first one is the Mid Hills - one at the lower elevation (below 1500 m), and the other at the higher elevation (located in – between 1500 m. and 2750 m.).

Villages on the bottom of the Hills and near the bank of the river have relatively more irrigated flat as well as level terraced lands usually cut into the valley side slopes. The land which is more flat and large in size rice is grown (this includes doors part of hills to mid altitude range). They are located below 1500 m. In such surroundings fewer livestock are seen which tend to be tethered and grazed within the vicinity of the households and farmers make compost with animal bedding and forest litter. One can see the fodder trees on the edges of the terraces, in a few cultivated holdings and also on the edges of the

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terraces in their courtyard. Overgrazed pastures and shrub/ands can be seen. Rotations in the cropping pattern which have two to three crops per year are found and there is little access to forest (intact). One of the remarkable features that one finds here is "Goth" (huts for livestock keeping). The area near the ponds, rivers and streams are allocated for "Goth". Some rich farmers having more than 2 ha, take their livestock to low elevation for winter grazing. During this period herders live there. Because of the concentrated agricultural holdings, settlement patterns are also dispersed accordingly.

In the high elevations villages have few irrigated lands, but more widely rainfed terraces. The rainfed terraces, in most of the instances, are outward sloping not properly levelled and relatively more slopy rainfed terraces suitable only for maize and millet. Every year farmers grow two crops of maize, millet, barley, wheat, and a variety of other crops on rainfed land below 2300 m. In a very small scale wheat can be seen in a few pockets. However, wheat even in the irrigated field is found only in a few instances, because wheat farming in the Hills is relatively a recent phenomenon. There is a fourth type of agricultural slopy land (30' to 35' slopes) known as "Pakho" sometimes which is suitable only for maize. Farmers usually plant one crop of potatoes or barley buckwheat in the fields above 2300 m. because of the cooler climate- steeper slope and stonier soils. Here, as compared to lower elevation agriculture is more marginal. Here terraces are often scattered, fragmented, having more parcels and are located at a distance of three or more hours of walking from the farmer's house. Area (surroundings) located above 2500 m. is covered by monsoon cloud and has broad leaf evergreen forest. Higher villages have a larger number of livestock which they keep away from the village for significant period of the year and are more mobile with household members. Farming is accomplished by keeping livestock on harvested fields for several weeks prior to planting the new crops. Thus, they can deposit dropping to be used as manure and urine in their crop land. Most of the households keep their herds of cattle, buffalo, sheep and goats in the forests during the time when the fields have crop. Fodder lopping (illicit cutting) gradually kills forest trees and grazing browsing prevents regeneration of the forest trees. Villages on the upper elevation control large areas of forest (1000 - 2500 m). Here, most of the areas have been converted into agricultural and grazing lands. However, some slopes and steep lands have still preserved forest. Most of the temperate and sub-alpine forest above 2700 m is being used and gradually converted into shrub lands. Herders take livestock to the forest or alpine pastures. Farmers from the lower elevation also collect firewood, fodder forest materials for cottage and small scale industries, wood for shingles and roofing together with other roofing material, and timber from higher elevation forest. As we proceed to higher elevation representing the ridges descending from the high Himalayas, agriculture is supplemented by pastoralism and trade. The size of land holding decides their degrees of agricultural intensification, are the determining factors of the farming system.

In addition to above said farming practices farmer of Darjeeling –sikkim Himalaya practice indigenous farming which are very location specific. These are as :

Indigenous farming systems (IFS)

IFS includes the rice-based farming system consists of wet rice terrace cultivation integrated with fish culture, finger millets and conservation of forest areas around them. The farmers rely on biodegradable waste and inputs. So without the aid of modern farm inputs such as chemical fertilizers and plant protection chemicals the farmers have been able to produce food crops on a sustained basis year after year keeping the ecological around them intact. Land quality is maintained very well through environmentally sound and sustainable farm practices such as bio-waste recycling. Most of the Himalayan range soil erosion and land degradation is big problem. To overcome this people practice few indigenous practices. Before restoration of degraded lands, the stabilization of landscape against erosion or slope failure is essential. It can be done through the grading of slopes before surface treatment and revegetation or cut-off-ditches with a variety of terraces. With an effective vegetation cover, the establishment of plants may control gradients without supplemental mechanical measures in protecting the landscape against water erosion.

The people of the region following some indigenous farming system from time immemorial which are " Pani Kheti" system of rice cultivation at low altitude (Doors of Darjeeling hills), Rice + pig + fish + poultry farming in platu region of Mirik (Khurseong block), Zabo farming and Alder based farming system (Lava range at high altitude).

In pani-kheti system of cultivation, water is diverted from hilltops and allowed to stand in the terrace, by making small bunds or grow water erosion control shrubs such as lemon grass and citronella. The weed and other plant biomass available were incorporated into the soil for nutrient management.

Rice + pig + fish + poultry farming is multi-purpose water management system was practiced in lower region that integrates land, water and farming system by protecting soil erosion, conserving water for irrigation and paddy-cum fish culture. Every stream rising from the hill is trapped soon after it emerges from forest, channelized at the rim of valley and diverted by network of primary, secondary and tertiary channels. This system is eco-friendly and the

rice productivity in this system is very high approx. three ton/ha compared to the average yield.

The farmers grow wet rice on terraces, integrated with fish culture in the terraces and finger millets on the risers/ terrace bunds. Sound soil conservation and soil management practices should be an integral part of such farming system, to suit the specific location conditions of the varying elevations of hills. The four years results revealed cropping system/livestock was economically viable and integration of livestock in the farming systems enhanced the income, provided manure for soil health and family labour utilization. Since kitchen waste, ashes, pig and poultry droppings from the village are emptied in the nearby terraces, the plots closer to the village are relatively nutrient and humus rich. Risers or terrace bunds are used for growing finger millets (*Eleusine coracana*). Although the yield of finger millet was low, it strengthens the bunds by binding the soil and it also suppresses growth of weeds on the bunds. Millets were used for local breweries. Usually common carps (*Cyprinus carpo*) are reared in the terraces after the transplanting of paddy. There is no cost of maintenance as the fishes feed on naturally available organisms such as phytoplankton and other microorganisms. No additional feeding is done. Resource conservation through IFS by traditional knowledge includes:

1. Sustainable land use planning

Sustainable land use planning is one of the most important aspects in hill agriculture. In the initial stage severely eroded lands, require complete forest cover of local origin coupled with protection from grazing. The local perennial tall tufted grass species amliso (*Thysanolaena agrostis*) can reclaim and protect the degraded land, terrace risers, water ways, land between trees, and vulnerable points, provides fodder to animals in winter and spikes for brooms. Farmers take care to grow the crop on steeper marginal and fragile lands so as to minimize the soil erosion and landslides. Alnus also grows naturally on landslide affected sites and being an actinorhizal (nitrogen fixer) plant (Sharma *et al*, 1997), it is a good associate for the large cardamom crop. The practice of using nitrogen fixing Alnus as shade trees has been adopted by the indigenous communities to maintain the soil fertility and increasing the productivity. This system shows that how an ecological and economical traditional farming practice has evolved indigenously as the main agroforestry practice in the region.

Before restoration of degraded lands, the stabilization of landscape against erosion or slope failure is essential. It can be done through the grading of slopes before surface treatment and revegetation or cut-off-ditches with a variety of terraces. With an effective vegetation cover, the establishment of plants may control gradients without supplemental mechanical measures in protecting the landscape against water erosion. Catastrophic events (such as land slides) cannot be altogether prevented, but management action can be implemented to reduce the frequency of events by preventing human occupation, economic development therein and planting of deep-rooted trees and/or shrubs on steep slopes.

2. Agroforestry practices

In Darjeeling, agro-forestry is an integral part of the farming system, where trees are integrated extensively with crop and livestock production. Traditional agroforestry systems in the Eastern Himalaya show the way to reconciling short-term food and livelihood needs with long term environmental conservation and enhancement. The combination of trees, grasses, herbs and shrubs along with large cardamom plantation arrest the flow of water, reduce the risk of soil erosion and water pollution hazards. Besides this, fodder trees are extensively grown around the settlement, roadsides, on field bunds and small patches of land among the terraces serve as a lean fodder to animals. The multistory homestead gardening and mandarin (*Citrus reticulate* Blanco) based agroforestry possess the inherent capacity to arrest land denudation. All the existing systems optimize the positive interaction among components (trees/shrubs and crops/animals) to obtain a more diversified and/or more sustainable production from the available resources and physical environments that is possible under socio-economic conditions. Farmers have taken up plantation of *Terminalis myrinalia*, *Ailanthes excelsa*, *Michelia* sp., *Mangolia* sp., pines (*Pinus* sp.) and bamboos (*Bambusa* sp.).

(a) Cardemom based agroforestry system

The large cardamom based agroforestry system is observed to accelerate the nutrient cycling, increases the soil fertility and productivity, reduces soil erosion, conserves biodiversity, conserves water and soil, serves as carbon sink, improves the living standards of the communities by increasing the farm incomes and also provides aesthetic values for the mountain societies (Buckingham, 2004). Large cardamom with shade trees on hill slopes unsuitable for crop production is ecologically sustainable. Some common shade trees for the agroforestry are *Schima wallichii*, *Engelhardtia acerifolia*, *Eurya acuminata*, *Maesa chisia*, *Symplocos theifolia*, *Ficus nemoralis, Nyssa sessiliflora, Osbeckia paniculata, Viburnum cordifolium, Litsaea polyantha, Macaranga pustulata and Alnus nepalensis.* Hence, large cardamom agroforestry practice also supports conservation of tree biodiversity in the region (Mukherjee, 2008). Majority of cardamom plantations have Himalayan alder (*Alnus nepalensis*) as shade trees since the combination of Alnus and cardamom is sympatric and has proved to be ecologically and economically

viable. The crop is predominantly cultivated between 600 and 2000 m that covers the subtropical to the cool temperate zones. The cardamom agroforestry stored 3.5 times more carbon than the rainfed agriculture showing potential mitigation possibilities of the agroforestry by sequestration of the atmospheric carbon. The agroforestry is an efficient management system where ratio of output to input is more than 13 compared to rainfed agriculture.

(b) Jhum system of cultivation

The alder-based *jhum* system, a unique and highly productive form of *jhuming* (shifting cultivation or slash and burn agriculture) has been developed. This system is usually practice at high altitude of Rimbhik and Lava region only by lepchas. Normally a *jhum* farmer cultivates the *jhum* fields for two years within a nine-year cycle (1:4 ratio of cropping to fallow). But the alder system allows two harvests in two out of every four to five years (1:1 ratio of cropping to fallow). The farmers are able to improve the already declining jhuming system through the incorporation of a component, alder tree which is native and indigenous to the community (Ramakrishnan, 1992). This intervention results in minimized soil erosion, availability of more productive land, increased soil fertility and sustainable food production. The introduction of alder into the *jhuming* system under a five-year agricultural cycle could stabilize the system, with adequate nutrient recovery and make the system sustainable. Apart from nitrogen fixation, the production of nitrogen-rich litter and mineralization too contribute to biological build-up of soil fertility.

Seeds of all the crops which require planting are mixed at the seed stage and broadcast in the field during the first rainy days of the season on the land prepared after burning the forest land. Maize and rice seeds are dribbled in furrows at regular intervals. Tuber crops like aroids, ginger and tapioca, banana are planted or sown throughout the growing season. The castor plant (*Ricinus communis* L.*)* is planted on borders for rearing silkworms. The crops are routinely harvested are replaced by other seasonal crops (*Ipomoea batatas* (L.) Poir., *Eleusine coracana* Gaertn., *Dioscorea alata* L., *Coix lacryma-jobi* L.) at regular intervals. This traditional '*Jhum*' cultivation is followed by most subsistence farmers.

(2) Zabo Farming System (under rain shadow zone)

The " Zabo" is an indigenous farming system in high altitude. *Zabo* means impounding of water. It has a combination of forest, agriculture and animal husbandry with well founded soil and water conservation base. It has protected forest land towards the top of hill, water harvesting tank in the middle and cattle –pig yard and paddy for storage for the crops as well as for irrigation during the crop period. Seepage water accumulates by internal drainage system which will enhance crop yield.

(3) Management of water

Water application on hills slopes for irrigation of plantation crops such as ginger, turmeric, large cardamom and tea etc. poses a serious problem of soil erosion. The hill farmers have developed the indigenous techniques of bamboo drip irrigation for irrigating crops in hill slopes (Mukherjee, 2010). Long peeper planted with the supporting tree in Gourebathan (Dooars) was irrigated with this system, in which water trickles or drips at the base of the crop. In this system, water from the natural streams located at higher elevation is conveyed with the use of bamboo channels, supports to the site of plantation through gravity flow. Discharge of water up to 20 L /min can be easily managed by manipulating the distribution system.

Bamboo and wood log pipes (*huburs*) of various sizes are made and used as prefabricated water management structures. Pegs of different sizes are used as energy dissipaters in earthen channels or at the outlets. The feeder channel branches off at angles, leading water through the series of terraces, so that by blocking or reopening the connecting ducts any field can be flooded or drained as required. The *huburs* are installed above 15-25 cm above the bed level of these fields in order to maintain proper water level (Mishra and Sharma, 1999). For fish culture, a vertical pit is dug in the middle of the plot, so that the water remains in these pits even when it drains away from the surrounding fields. This system of tapping natural streams, making water courses, application and harvesting of water behind the bunds on wet terraces, and safe disposal is a good example of the indigenous understanding of natural resource conservation and management.

Bamboo pipe irrigation

- It involves, tapping of stream and spring-water, using bamboo pipes to irrigate plantations. About 18-20 litres of water enter bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20-80 drops per minute per plant.
- Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity.
- The channel made of bamboo, divert & carry water to the plot, where it is distributed into branches, again made and laid out with different forms of bamboo pipes.
- Reduced channel sections and diversion units are used at the last stage of water application. The last channel section enables the water to be dropped near the roots of the plant.

- Bamboos of varying diameters are used for laying the channels.
- Other components of system are small pipes and channels of varying sizes used for diversion and distribution of water from the main channel to about four to five stages of distribution
- System has helped in conserving forests and natural resources.

(4) Livestock-based farming

Livestock forms an integral part of village life of Darjeeling hills. The rearing of different species of animals (cattle, sheep and goat, yaks, pigs, poultry, etc.) is done for draught, milk and meat purposes and these animals also provide manure to meet the crops requirement of nutrients. The government is also providing the necessary inputs through its various departmental schemes for the development of livestock. The production of dairy cattle on small land holdings in the rural area in conjunction with primary agriculture production creates employment and contributes substantially to domestic income and obtaining better utilization of farm resources. In Darjeeling plenty of grasses are available during the monsoon periods and scarcity only occurs in winter (November to March). Cultivation of fodder crops on agricultural lands is impractical due to constraints of land availability and other inputs. Here number of natural feed resources (tree leaves, grasses, shrubs and vines) is available. The only practical alternative is available to encourage the propagation and planting of fodder tree species and grasses on village waste and marginal lands, community grazing lands, out scrub between and around the farm boundary etc. under different afforestation programme for their lopping of leaves to meet the feed requirement during lean period. The leaf of some fodder trees is almost as nutritious as that of leguminous fodder crops and offers an added advantage of producing fuel wood as a by-product. Leguminous fodder trees (*Albizia* sp; *Alnus nepalensis*, and others) enrich the site through nitrogen fixation, which helps in effective soil and water conservation.

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