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Sustainable Management of Land, Water and Crop in Hills of North East India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Hill agriculture in Northeast India has tremendous potential to grow and contribute towards improving productivity, enhancing food and nutrition security, reducing rural poverty and accelerating the overall economic condition of the region due to its rich land, abundant water resources and favorable climate. The North-eastern region lying between 21.5^{o}N - 29.5^{o}N latitudes and 85.5^{o}E - 97.3^{o}E longitudes comprises eight states - Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim. The growth potential of hill farming has remained under-exploited due to various reasons like lack of system-specific production technologies, poor infrastructure (transport, markets, processing) and underdeveloped institutions (credit, extension, information, insurance), inaccessible habitations, diverse socio-cultural and fragmented land holdings. In hilly areas, *jhum* cultivation provides a basis for subsistence farming, maintenance of cultural values and social stability at low population density. But in the present context, this system cannot sustain increased demographic pressure. Moreover, shifting cultivation also causes

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problems of land degradation, accelerated deforestation, out of control forest fires ultimately affecting climate change. Therefore, adoption of various agro techniques as an alternative to *jhuming* may prove to be a boon for the overall growth of the region. Cultivation of plantation crops and orchards established on hill slopes will prevent soil erosion. Watershed development also plays an important role in sustaining the natural resource base and improving the productive potential of hill states. The hill states have the potential for production of vegetables in off-season that has greater demand in neighboring plains when there is scarcity of supply as this region is bestowed with the most congenial climatic conditions for the production of under-exploited agricultural and horticultural crops that provides many fold employment opportunities in agro-based industries, packaging, storage, preservation, canning and transportation.

Keywords: Sustainable farming; climate change; cropping system; hill agriculture; NEH region.

1. INTRODUCTION

"Hills offer a vast scope for the cultivation of a diverse mix of crops – cereals, pulses, oilseeds, vegetables, flowers & fruits. Animal husbandry is an integral part of the hill farming system. The hilly mountainous areas differ from the plains in topography, elevation, physiographic features, diversity of habitats for flora and fauna, ethnic diversity, land use systems and socioeconomic conditions. The development of hilly and mountainous areas and the protection of their ecology have become matters of national concern as these are recognized as climate makers and repositories of rich biodiversity" [1].

"The hill region of North East India mainly comprises eight states viz. Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim, inhabiting more than 124 tribal communities that have distinct agricultural practices differing from one another. The North east hill region occupies about 5.6% geographical area of India with net sown area of 1.76 m ha" [2]. Almost 73.87% of the geographical area of the region is covered with forest cover as against the national average of 21.55% [3]. "The region receives an average annual rainfall of about 2000 mm accounting for around 10% (42.5 m ha m) of the country's total precipitation of 420.0 m ha m" [1]. "The soils are rich in organic matter; acidic to strongly acidic in reaction. The different cultural backgrounds of the inhabitants coupled with variable food habits and climatic situations resulted in cultivation of diverse and mixed crops of cereals, pulses, oilseeds, vegetables, fruits, spices and flowers. Agroforestry, animal husbandry and fisheries are the integral parts of their farming systems. Around 56% of the area is under low altitude, 33% mid altitude and the rest under high altitude. The system is characterized by large variation in cropping intensity (range 100-189% with an average of 135%), monocropping and subsistence farming" [1].

The Karbi Anglong and Dima Hasao districts are the hill and mountainous agro eco-zones of Assam. The total gross cropped area of Karbi Anglong district is about 2,27,598 ha and the net area is about 1,62,410 ha with a cropping intensity of about 140% (Krishi Vigyan Kendra Karbi Anglong official website). It receives maximum rainfall from the Southwest summer Monsoon from June through September with an average rainfall of 1147 mm. The average maximum temperature varies from 32.9^{0}C to 23.0^{0}C and the minimum temperature ranges from 24.2^{0}C to 7.9^{0}C. The irrigation potential area of Karbi Anglong district is 6275 Ha and the net irrigated area is 38397 Ha in the year 2020-21 (Statistical Handbook of Assam, 2021). Dima Hasao district also known as North Cachar Hills district, is predominantly hilly with a lot of variation in climate ranging from sub-tropical monsoon type to temperate alpine type with temperatures ranging from 20 to 30^{0}C in summers and 8 to 25^{0}C in winters. In the year 2020-21, the net irrigated area was7473 ha in Dima Hasao in the year 2020-21 [4].

"Agriculture is the main source of income for the people of these regions along with Horticulture, Livestock, Plantation, Sericulture, Weaving, etc where more than 85% of the population in these districts is mainly dependent on agriculture. The wide range of climatic conditions and rich soil of the district are suitable for growing almost all types of field crops like rice, maize, wheat, toria, sesamum, sugarcane and horticultural crops like banana, pineapple, orange, papaya, ginger, turmeric etc. In Karbi Anglong, rice is the main food crop covering about 60% of the total gross cropped area and maize covers an area of 9174 ha which is the highest in the state of Assam. Pulse crops like arahar, blackgram, greengram

and pea are also grown. Sugarcane and oilseed crops like sesamum, rape and mustard, castor *etc* are grown extensively. The tribal population mostly relies on wild vegetables found in hills for domestic consumption and commercial purposes, *eg*,roselle is a common plant grown in almost every tribal household for consumption of both its leaf & seed bud. Colocasia along with its roots are also consumed. The GI Registry of India situated at Chennai has granted geographical indication rights to the Assam Karbi Anglong ginger which is grown by about 10,000 farmers with an average annual production of 30,000 tonnes. As per the Statistical Hand Book Assam, 2021, the district has 2672 tea growers registered with the Tea Board of India with a total area of 3741 hectares**.** The region also produces a significant amount of Arecanut, Beans, Jackfruit, Maize, Pineapple, Ginger, Potato and Sweet
potato, Sugarcane, Tapioca, Turmeric, etc" [4].

2. PREDOMINANT PRODUCTION SYSTEMS IN HILL REGION OF NORTHEAST INDIA

The concept of production system takes into account the components of farming, *i.e*, livestock, horticulture, agroforestry, pastoral, silviculture systems, and other resources with the farm family at the center managing them independently or in complex diverse mixed form giving rise to multiple-sustainable approaches. In these regions, cereals, plantation crops, horticulture, agro-forestry, livestock, and bamboo-based production systems dominate. Livestock also contributes significantly to the farm income. The farmers of the region are innovative and they have developed various farming systems.

2.1 Shifting/Slash and Burn/*Jhum* Cultivation

Shifting cultivation, regarded as the first step in transition from food gathering and hunting to food production is a widely practiced system on steep slopes which mainly involves cultivation of crops where the land is cleared by cutting of the forests, bushes, etc. The cut materials are left for drying and finally burned to make the land ready for dibbling of seeds before the onset of rains. After 2-3 years the cultivated area is abandoned and a new site is selected to repeat the process.

This method of cultivation was considered sustainable until the *jhum* cycle was 10-15 years, however, in recent years, it has been drastically reduced to 1-3 years due to increased demographic pressure on land which hardly provides time for natural regeneration of soil fertility. On an average, about 3.85 lakh families are engaged in slash and burn agriculture [5].

Soil erosion is one of the major challenges under slash and burn agriculture [6] where annual loss of topsoil is much higher (46 t/ha) during the first year of *jhum* which further increased to 136 t/ha during second and 174 t/ha during third year of *jhum*, respectively [1]. The region was challenged with a very high degree (up to 46% in Sikkim) of land degradation with an average of 24.59% of the total geographical area of the region, which is almost double than the national average of 14.75% [7] Similarly, due to lack of proper water conservation and utilization measures, only 0.88 m ha m out of 42.5 m ha m water is effectively used for farming. Around 20.74% area is irrigated of which surface flow accounts 18.78% and rest is through surface lift and groundwater lift irrigation system in the NE Region. Farmers also use an indigenous technique called '*Bamboo Drip Irrigation*', particularly for less water-requiring and high value crops. Such local innovations and traditional ecological knowledge (TEK) on agriculture-based natural resource management is praiseworthy in the region owing to a close socio-cultural bondage to the natural resources.

The main crop grown under shifting cultivation is upland rice along with a mixture of crops like maize, millets, beans, tapioca, yam, banana, sweet potato, ginger, cotton, tobacco, chillies, sesame and vegetables. All these crops are sown by dibbling, are rainfed and harvesting starts from August onwards. A single crop of rice is usually grown in the second year. Mostly, the economy of the shifting cultivators is limited and usually there is little marketable surplus which is exchanged with traditional goods. In the present situation, this practice has become unproductive due to soil erosion, loss of plant nutrients, loss of forestry resources, loss of flora & fauna and moreover it is also hazardous to the environment. However, the advantage due to jhum cultivation is that the use of inorganic fertilizers and pesticides has been kept very low in these regions which provides ample opportunity to develop these 'Organic *by De-fault'* areas as "Organic food hubs". Arunachal Pradesh, followed by Nagaland and Mizoram has the lowest consumption of inorganic fertilizers compared to other states [8].

Table 1. Geographical area, net sown area and cropping intensity of NEH states

	Geographical area (m ha)	Net sown area (m ha)	Cropping intensity (%)
Arunachal Pradesh	8.37	0.225	133
Manipur	2.23	0.383	100
Meghalaya	2.24	0.286	120
Mizoram	2.11	0.145	100
Nagaland	1.66	0.384	130
Sikkim	0.71	0.077	176
Tripura	1.05	0.255	189
NEH Region	18.37	1.755	135
All India	328.73	140.13	142

Source: Land use Statistics at a Glance, 2015

Table 2. State-wise soil degradation status in north-eastern states

States	Water erosion	Waterlogging/ flooding	Soil acidity	Complex problems	Total deg. area	TGA of state	Deg. area%
Assam	688	37	612	876	2213	7814	28.2
Arunachal Pradesh	2372	176	1955	-	4503	8374	53.8
Manipur	133	111	481	227	952	2233	42.6
Meghalaya	137	07	1030	34	1208	2243	53.9
Mizoram	137	-	1050	694	1881	2108	89.2
Nagaland	390	-	127	478	995	1658	60.0
Tripura	121	191	203	113	628	1049	59.9

Source: Gajbhiye, [15]

Table 3. Extent of acid soil in the northeast region (m ha)

States	pH <5.5	pH 5.5-6.5	Total acid soil	Geographical area	Geographical area acid soil (%)
Arunachal Pradesh	6.52	0.27	6.79	7.786	81.08
Assam	2.33	2.33	4.66	7.844	59.41
Manipur	1.87	0.32	2.19	2.233	98.07
Meghalaya	1.19	1.05	2.24	2.243	99.87
Mizoram	1.27	0.78	2.05	2.208	97.20
Nagaland	1.60	0.05	1.64	1.658	99.50
Sikkim	0.60	-	0.60	0.710	84.51
Tripura	0.81	0.24	1.05	1.049	100.00
Total NE India	16.19	5.04	21.23	26.219	80.97
India	30.00	58.94	89.95	328.726	27.36

Source: Sharma et al. [16].

2.2 Raised Beds Cultivation & Construction of Terraces

Tuber crops like potato, sweet potato and rhizomatous crops like ginger, turmeric are commonly cultivated in the central plateau of Meghalaya on raised beds along the slope and covering the beds with soils in the month of February. Later the beds are put up to fire and the tubers are sown in March that results in large-scale soil degradation. With every tonne of potato cultivation, 2 tonnes of soil is lost which is a matter of great concern.

The terraces are constructed by the farmers in a scientific manner. The width of the terrace depends on the slope, keeping the maximum height of the riser up to 1 m in general. Contour lines are drawn by scraping the top soil upwards so that the sub-soil is exposed for firm foundation. Leaves and branches of Alder, *Albizia* sp. and other thrash material are added and covered with the soil for decomposition.

Table 4. State-wise Consumption of Fertilizers (N, P & K) in the year 2017-18 (Kgs/Hectare)

State	N	P	K	Total
Assam	50.34	16.08	14.45	80.87
Tripura	16.48	5.80	5.95	28.23
Manipur	31.69	13.54	12.81	58.04
Meghalaya	0	0	0	0
Nagaland	16.42	10.94	7.30	34.66
Arunachal Pradesh	0	0	0	0
Mizoram	36.83	0	0	36.83
Sikkim	0	0	0	o
Total NE India	38.28	12.33	11.16	61.77
All India	81.65	33.00	13.38	128.02

Source: *Indian Fertilizer Scenario 2018, Department of Fertilizers*

2.3 Silvi-Agri-Livestock-Fisheries Production System (Zabo Production System)

Zabo system of farming is practiced in Phek district of Nagaland which is a combination of forest, agriculture, livestock and fisheries with a well-organized soil and water conservation base. The forest lands are present on top of the hill, water-harvesting tank in the middle and livestock yard and rice fields at the foothills. In case where a proper site is not available for water storage, the runoff water from the upper catchment area is taken directly to the rice field. The water loss is controlled through puddling and use of rice husk on shoulder bounds ensuring proper utilization of rainwater and maintenance of soil health through organic sources of crop nutrition. soil loss by erosion is reduced to the minimum. A study reported considerable improvement in available nutrients and organic matter as well as in-situ soil moisture conservation under this system in hilly eco-system [9].

2.4 Rice-Based Production System

The region produces 4.04 million tonnes of rice annually. In Arunachal Pradesh, the Apatani plateau occupying a stretch of about 26 km is the 'rice bowl' of the ‘Apatani' tribe. Terraces are developed on alluvial materials washed down from the hills that are perfectly leveled and provided with strong bunds where wet rice cultivation is practiced. The bunds are made of soil and supported by bamboo or wooden chips at base, if the height of the riser is more. The Apatanis have developed a remarkable system of water management and irrigation where every stream rising from the surrounding hills is tapped, channelized at the rim of the valley and diverted by a network of channels. The agricultural wastes are recycled and used to add nutrition to the soil. Apart from conserving the soil, farmers have taken up the plantations of *Terminalis myrinalia, Ailanthus excelsa, Michelia sp., Magnolia sp.*, pines and bamboo. Thus, the entire hills surrounding the valley, and uplands surrounding the villages are fully kept conserved as forest. Along with rice, pisciculture is also practiced. Intercropping and mixed cropping can provide a solution to the ever growing food requirements. Area under the high yielding variety of rice in Karbi Anglong district is 73389 Ha and Dima Hasao is 12472 Ha in the year 2020-21 [4].

2.5 Agroforestry-Based Production System

Northeast hills except Arunachal Pradesh have experienced heavy biotic pressure due to shifting cultivation and massive clearance of forests for tea cultivation in Darjeeling and foothills of other eastern states and commercial exploitation in these areas. A need was felt to introduce agroforestry to meet the wood and fodder requirement considering the agricultural productivity, conservation, agro-ecosystem, tree farming and rehabilitation as major issues of sustainability through agroforestry. Large cardamom plantations in Nagaland and Manipur is an example of commercial agro-forestry. Alder tree based farming system is mostly done in Nagaland for maintaining soil fertility and getting sustainable crop yields. It also helps in providing shade for coffee at lower altitudes and for cardamom at higher altitudes. Extraction of bamboo from natural forests is also in practice for the paper industry. These are high-value potential crops with short gestation and recurring returns for the farmers. Litter fall also enriches the soil. Sericulture also holds a great promise for which mulberry plantations play an important role.

2.6 Horticulture and Plantation Crops-Based Production System

Several fruit crops like pineapple, banana, mango, papaya, litchi, guava, pomegranate, jamun, amara are commonly grown in NEH region. This region has nearly 24,000 ha of land under pineapple, producing about 0.282 million tonnes and more than 30,000 ha under citrus fruits with an average production of over 0.138 million tonnes. In Assam, coffee plantations in hilly zones occupy 1,045 ha area producing 50 tonne coffee beans which contributes 50% of tea production in India alone. In Arunachal Pradesh also, several tea units have come up with the Tea Board's assistance. Rubber plantation in this region covers 19,000 ha area with a total production of 400 tons rubber. Low temperatures in winter and high altitude situations of the north-east region are the major constraints, contributing towards the low productivity of rubber.

2.7 Vegetable-Based Production System

Vegetables are grown mostly in the backyards and also for commercial purposes covering a large variety of beans, cucurbits, cabbage, radish, tomato and brinjal. Potato is the most important cash crop, particularly in Meghalaya, Arunachal Pradesh, Manipur and Assam. Khasi hills and Jaintia hills of Meghalaya, Kameng and Subansiri districts of Arunachal Pradesh, north and east districts of Manipur are the major potato-growing belts of the region.

2.8 Livestock-Based Production System

The diet for the bulk of the population being animal protein; there is a vast internal market for meat, eggs and fish. These are in short supply as the animals from this region are less productive, slow growing and late maturing. The local animals, however, have developed over generations an adaptation value and thus, thrive better than the exotic and crossbred animals introduced for enhancing productivity under similar conditions of management. There is a great scope for rearing rabbits for meat and fur skin in these regions.

2.9 Broom Grass-a High Value Cash Crop

Broom grass (*Thysanolaena maxima*), a grass with soil conservation value and established market as cash crop can be grown in the wastelands. The fine root system of this grass protects from soil erosion and prevents landslides and has wide scope for multiplication without any care and protection. It is being used for terrace riser stabilization and as fodder during lean periods.

3. TECHNOLOGIES FOR ENHANCING SUSTAINABILITY OF PRODUCTION SYSTEMS IN HILL REGIONS

The production and productivity enhancement of basic food crops can be achieved through intensive agriculture based on the development and spread of high-yielding varieties of food crops coupled with good water and soil fertility management. Assam Agricultural University has recently developed three rice varieties viz. Dehangi, Rongkhang and Inglonkiri which have been notified in Indian Gazette and recommended for growing in hill regions of Assam under direct seeding stress condition. The advancement in the pattern of production should be land saving crop husbandry and grain saving animal husbandry. The ecological sustainability and equity in the use of natural resources should constitute the basic norms of all agricultural and rural development programmes, so that the livelihood of the poor is protected. Agricultural technology should be intellectually satisfying and economically rewarding to attract and retain youth in farming. Proper crop planning and post-harvest technologies need to be given attention, so that the comparative strengths in agriculture with regard to exports are carefully identified and nurtured. The average land holding varies from 0.12 ha/cultivator in Manipur to 0.49 ha/cultivator in Tripura. Keeping in view a large number of small and marginal holdings in hills the economic stability can be achieved and sustained through diversification of the production systems by incorporating components of off-season vegetables, sericulture, medicinal plants, mushroom cultivation, fisheries, livestock, value-addition to the produce etc. The following technological interventions need attention in hill and mountainous areas for achieving the aim of sustainable livelihood security through sustainable agricultural development, which alone can provide the foundation for enduring ecological security.

3.1 Soil and Water Conservation

Soil conservation includes conservation farming, bunding, terracing and safe disposal of water, whereas water conservation reflects in mostly

storage of rainwater in the soil profile. Land leveling helps to protect the sloppy land and reduces runoff upto 5-6% when 1% slope is reduced in comparison to the natural slope of 5% yielding a run-off of 50%. Construction of stabilized drains also helps in proper disposal of excess rainwater thus maintaining cultivable lands and reducing soil as well as water losses. "Cultivation of alternate strips of erosion-permitting and erosion-resisting crops, fast-growing and early-maturing crops, mixed cropping also conserves soil and water. To conserve water, in certain areas lands are kept fallow during *Kharif* or monsoon season and cultivation of *Rabi* is carried on residual conserved moisture. Soil and water conservation is also managed by providing mulches through crop residue mulch, soil mulch and polythene covers. Agroforestry interventions reduce erosivity of rainfall or runoff and erodibility of soil. Up to 30% slope in humid, sub-humid and sub-tropical climate, alley cropping with *Leucaena*, *Glyricidia* hedges and grass barriers are effective for mulching and erosion control" [10].

3.2 Vegetative Barriers

Conservation through vegetative measures is cost-effective and productive. Performance of vegetative barriers is situation specific. Citronella has been effective for checking soil erosion in some parts of Assam. Therefore, barriers of native grass species should be emphasized. Agroforestry barriers are quite effective in controlling runoff and soil loss on 4% slope.

3.3 Watershed Management

The productive and protective benefits from watershed management are considerably higher than the investment benefit: cost ratio ranging from 1.92: 1 to 7.1: 1 with 48 to 99% reduction in runoff and 81 to 98% soil loss. The impact of these changes led to the sustainable development of natural resources. Besides conserving soil and water, it generates employment which prevents out migration of population which was 26.6% before watershed management programme & later reduced to 9.3% during the project period. A study revealed that due to these structures, "farmers were able to cultivate more gaining crops as irrigation water availability was increased, moreover, benefit cost analysis showed that all the construction cost of structures was recovered in 3 to 4 years" [11].

3.4 Sloping Agricultural Land Technology (SALT)

This is a method of controlling erosion by farming natural terraces without much expenditure. These options are Tropical grasses like *Pennisetum*, vetiver, lemon grass, citronella, napier grasses, rhodes grass, tropical panic grass and *Calamagrostis sp*.; Temperate grasses like Switch grass, wheat grass, pampas grass (Cortaderia), feather grass (*Stipa sp.*), bamboos, and giant reed and ribbon grass; Shrubs and trees like Sea buckthorn, alder, *Leucaena*, asparagus and Siberian pea shrub (*Caragana sp*.); Contour grass strip as an erosion or soil conservation measure. It is cheaper than terrace making and other biological options, labour saving (300% less labour compared to terracing) and better crop yields because of effective soil conservation. Seven years average showed that soil loss from traditional farming methods was 113 tonnes/ha, from strip cropping 16 tonnes/ha, from Leucaena strips 16 tonnes/ha, from terraces 1.9 tonnes/ha and from grass strips the least 1.6 tonnes/ha, and these do not involve any infrastructural investment [12].

3.5 Organic Cultivation

The consumption of chemical fertilizers is quite low in the hills which can be exploited for the large-scale production of organic food for the export market. Fertilizer consumption rate in Karbi Anglong district is 21.42 kg/ha whereas Assam's fertilizer consumption rate is 72.80 kg/ha in the year 2020-21 [4]. Adequate market support systems as well as certification mechanisms are required to improve the economic viability of the product. Organic farming in hills offers the most sustainable solution for developing the agricultural sector and provides food security with least negative impacts on the environment and also offers solutions for sound rural development, provides healthy food and creates jobs [13].

3.6 Agricultural Implements

The lowland areas need special machinery to cultivate rice which should be light in weight and proportionately small in dimensions, permitting them to remain workable in small farm fields. Upland agriculture demands machinery to save time and remove drudgery mainly in land preparation, sowing, weeding and harvesting. In the hilly areas, mechanization is also required in handling horticultural produce (fruits and

vegetables), i.e. picking, packing and marketing [14].

3.7 Niche for Comparative Advantage

High altitudes are very suitable for the seed production of vegetables, off-season vegetable production of cole crops, wood or bamboo-based cottage industries, generation of hydro-electricity, cultivation of medicinal plants, flowers, organic farming, fishery, bee-keeping, mushroom cultivation etc. These practices need to be taken up judiciously in these areas. In the valley region, rice is the major crop during *Kharif*. Therefore, it offers immense potential for growing crops like beans, tomato, chillies etc. on raised beds before taking the main crop.

3.8 Aromatic and Medicinal Plants

The majority of the medicinal plant species (70%) occur in the forest areas. The tribal people and the forest-dwellers collect a variety of leaves, fruits, seeds, nuts, roots, bark, tubers and rhizomes which have great medicinal value. But only a fraction (about 5%) of the vast resource is gathered for marketing due to absence of direct market linkage, sporadic distribution of the plants, inadequate knowledge about medicinal values and shrinkage of areas under forests. Banning the extraction of raw materials from habitat and simultaneously encouraging the cultivation of medicinal plants are essential.

3.9 Proper Input Delivery and Output Marketing

Proper input availability at proper time and at proper place along with output sale at proper price at proper time with least cost is important for improving the agricultural development in hill regions of India. The sustainability in hills can only be achieved if the technologies are modified in consultation with the local people through participatory approaches, is the only solution for the optimal use of natural resources in the hilly zones of Assam. This would ensure the conservation of biological diversity of plant and animal resources in these regions.

4. CONCLUSION

Farming in the hills of north-east India has considerable potential to grow and contribute to the overall economic growth and livelihood of the rural population. The climate is favorable to grow a wide variety of crops, particularly fruits, vegetables and spices that can capture the off season market in the neighboring plains. System-specific technologies, improved infrastructure and marketing linkages must be strengthened for realization of the true potential of agriculture. With the objective to enhance productivity with full ecological balance and security, it is essential that the resources should be effectively managed through improved agricultural practices for sustainable agricultural development and harnessing the growth potential of hill agriculture in the north-eastern region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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