

**POLICY
PAPER**

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Strategies for Agricultural Research in the North-East



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Introduction

The North-Eastern Region of India, comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, lies between 21.5° N to 29.5° N latitude and 85.5° E to 97.5° E longitude. It has a total cropped area of 5.3 million hectares and a population of around 39 million. The region falls under high rainfall zone and the climate ranges from subtropical to alpine. The region is characterised by difficult terrain, wide variations in slopes, altitude, land tenure systems and diverse cultivation practices. The transport and communication system is poorly developed and as a result majority of the areas in the region remain still inaccessible. The infrastructure facilities like supply of input, marketing, institutional credit and extension services are inadequate. Majority of the population, predominantly tribal, is dependent on agriculture and land-based activities. The agricultural production system in the region is predominantly rainfed, mono-cropped at subsistence level. Slash and burn agriculture is still practised in almost all the states except Sikkim on steep slopes with reduced cycle of 2-3 years as against 10-15 years in the past. The region, once richly endowed with rich genetic diversity of plants, has been denuded due to human interference by adoption of unscientific land use system. With rapid increase in human and livestock population and the rising demand of food, feed, fuel, fodder, fibre, timber and the other developmental activities, the farmers have been forced to exploit forestland and water resources at sub-optimal level in complete defiance of the inherent potential. This has resulted in progressive decrease in forest cover, loss of biodiversity, serious soil erosion leading to depletion of plant nutrients, gradual degradation and decline in land productivity and its carrying capacity, silting of major river basin causing recurrent floods in the plains, and drying up of perennial streams as well as ecological imbalances. Gradual degradation of these resources is of prime concern and calls for location-specific measure to conserve, utilise and manage these resources for optimising production on sustained basis without adversely affecting its quality.

Agriculture is the main economic activity in the region and despite major impact of green revolution in the irrigated areas of the country, modernisation of agriculture has escaped this region as evidenced by poor adoption of modern technologies, low consumption of fertilisers and other indicators of growth. One of the most important reasons for this slow growth is the lack of location-specific and system-based technologies. Apart from this, the dwindling resources of soil, water, flora, fauna and increasing concern for environmental safety has drawn the attention of the planners and policy makers at regional as well national level. In view of these concerns and enormous opportunities, the National Academy of Agricultural Sciences in collaboration with Indian Society of Hills Farming deliberated on the theme "Strategies for Agricultural Research in the North-East."

The following records salient features of the issues discussed and the recommendations made at the seminar.

* *The seminar was hosted by ICAR Research Complex for North-Eastern Hill region, Umiam, November 1999.*

Resources-Advantage North-East

North-East India is endowed with rich natural resources in the form of soil, water, plants and animal diversity and this provides the basic ingredients for development.

Land

About 53 per cent of the reporting area is classified as forestland though there are large variations from minimum of 8 per cent in Meghalaya to a 91 per cent in Arunachal Pradesh. The land under the forest apart, about 60 per cent of the land is classified as not available for cultivation. The net area sown is hardly 7 per cent of the total reported area in the region. The hill areas present some very special ecological and geophysical features. The terrain is mostly rugged and steep. The unit cost of infrastructure development in the region is high and the returns are relatively low. The cost of infrastructure is high largely because of rugged nature of terrain with widely dispersed population. It would, therefore, take considerable time for this region to build up an adequate resource base.

Water

The region has large surface and groundwater resources mainly because of its location in high rainfall area and the extensive river system. But all the water resources cannot be utilised because these are inaccessible or non-reversible. The availability of these resources has not been adequately documented and as such full information is not available. The total surface water potential of the region is 928873 mm³. The region, excluding Sikkim, has a total groundwater potential of 855 mm³. As usual all the hilly regions have low groundwater potential, the lowest being in Sikkim. The exploitable water balance is mostly concentrated in Tripura. Water application on slopes for irrigating plantation crops poses serious problem of soil erosion.

Plants

The region is a treasure house of genetic diversity and 6-7 thousand plant species constituting approximately 40 per cent of the total flora of the country are represented here. A large number of economically important plants such as food, fodder, spices, oilseeds, fruits, vegetables, medicinal and aromatic, orchids and other flowering plants grow wild in nature. The region is either primary or secondary centre of origin for many crop plants.

Livestock

Livestock in this region comprises cattle, buffalo, sheep, goat and pigs. In the hills, draught power is rarely used for tilling the soils and most of the tribal populations do not fear cattle in the usual sense. They depend on semi-wild animals like mithun and yak for meat. Cattle is generally let loose to graze and stray in the open. Basic problem of livestock rearing is shortage of feed and fodder and absence of commercialised dairy and piggery.

Agricultural Farming Systems

The agricultural practices in the region are broadly of two distinct types, viz., (i) settled farming practised in the plains, valleys, foothills and terraced slopes and (ii) shifting cultivation practised on the hill slopes. In the hills, agricultural operations are carried out at a maximum elevation of 5000 m with 'slash and burn' method.

Shifting (Jhum) Cultivation

It is a primitive mode of agriculture evolved as a reflex action under the stress of the peculiar geophysical and ecological situations prevailing in the hills of the NE region. The system reflects a sort of community farming without heritable rights over the land. The practice starts with selection of forested land, clearing and burning of the forest before the onset of monsoon, planting of various crops in an intimate mixture by dibbling and harvesting. The land is abandoned after cultivation for a period of 2-3 years and cultivation is shifted to another site. The method of allotment of land varies from tribe to tribe. In most cases it is decided upon by the village councils or by village elders, and size of the plots depends on the number of working hands in respective farm families. Out of the total area of 2.2 million ha of *jhum* lands, 17.5 per cent is cultivated at anyone point of time; the rest is left for natural regeneration over a period of several years. Consequent upon population pressure, the *jhum* cycle has, however, shrunk to 3-6 years or even less against, earlier practice of a cycle of 10-15 years resulting in soil degradation and ecological imbalance. Indiscriminate destruction of forests in the *jhum* land, coupled with high rainfall, has resulted in heavy soil erosion and consequent silting of rivers causing floods in the lower reaches.

Settled Cultivation

Settled cultivation is practised in plains and valleys. Adequate precipitation ensures availability of water for the crops grown in *kharif*. However, *rabi* crop faces water deficit, which is met by irrigation. With increasing awareness of the disadvantages of shifting cultivation, the farmers have started adopting settled cultivation. This is likely to result in reduction of area under shifting cultivation.

Present Status of Agriculture

Cropping Pattern

The cropping pattern in the region, with the exception of Sikkim, is characterised by predominance of rice as the lead crop. In Sikkim, maize is the dominant crop. Food crops account for more than 80 per cent of the gross cropped area, which is suggestive of prevalence of subsistence agriculture and lack of crop diversification. About 70 per cent of the gross cropped area is accounted for by cereals alone. Within the region, however, there are exceptions. Sikkim records 9.3 per cent, and Tripura 6.2 per cent of the gross cropped area under oilseeds. These state level variations are a manifestation of the differences in the status of agricultural development prevailing in the constituent units of the region. A remarkable feature of shifting cultivation is that a wide variety of crops is grown in the *jhum* fields. *Jhum* paddy is the dominant crop and is mixed with maize, millets, beans, tapioca, sweet potato, ginger, cotton, tobacco, chillies, sesamum and

vegetables. The production units are more or less self-contained, each family growing crops according to its needs. Major food crops of the region are cereals and pulses which are cultivated in 78.03 per cent of the cropped area.

Crop Intensity

The region's agriculture is characterised by low crop intensity (117 per cent). Physical constraints like weak and underdeveloped irrigation network, extremely cold weather in the higher elevations limit the crop season to summer months only. Low density of population in the hills and sociological constraints like values and attitudes, which are not wholly conducive to market oriented agriculture, have resulted in near stagnation in agricultural production in the region.

Irrigation

The available data on irrigation shows that about 24.42 per cent of the net sown area is irrigated. Of the total 302.96 thousand ha of the irrigated area, 56.89 thousand ha (18.78 per cent) is irrigated through surface flow, 5.51 thousand ha (1.82 per cent) through surface lift, 0.41 thousand ha (0.14 per cent) through groundwater lift and 240.15 thousand ha (79.29 per cent) through other irrigation methods. The normal way of irrigation in the hills is by diverting small streams. In other areas, the irrigation is provided from natural sources only during rainy months. The hydro-geomorphology of the hilly region is such that groundwater resource cannot be easily utilised for irrigation purpose. In such areas techniques for harvesting rainwater appears to be essential.

Fertiliser

Fertiliser consumption in the region works out to be as low as 23 kg/ha as against the national average of 95.6 kg/ha (1999-2000). The low level of fertiliser consumptions is attributable to heavy loss through run off of rainwater during the *kharif season* and due to slow and limited spread of fertiliser-based technology in the region.

Seed

Seed is the most important component of agricultural production system. Information available from different sources indicates that there are large gaps in the supply of this vital input. The time lag in the supply of seeds frustrates the production programmes of the region. The spread of HYV has been poor as evidenced from the fact that only 56 per cent of the rice area has been brought under HYVs in NE hill states against 74 per cent in the country. Of the total quantity of improved seeds required by the farmers, roughly 40 per cent is met from within the region leaving a gap of 60 per cent in its present requirement. This gap is very likely to widen over time, as the percentage of adoption is sure to increase in near future. Except Assam, organised seed production programme does not exist in any of the NEH states.

Agro-based Industries

The status of agro-based industries in the region is not very satisfactory because of lack of development in this area. However, there has been some growth in traditional agro-

based industries like rice mills, oils mills, etc. Hindustan Paper Corporation has started a paper pulp unit in Nagaland. This paper mill uses bamboo, which is widely cultivated in the region, as the raw material. The scope of growing soybean and groundnut in large scale as agro-industrial crops has been strengthened with the establishment of *vanaspati* plant in neighbouring Assam. Research results indicate that there exists very good potential for these two crops in the region. Despite considerable potential for development of fruit processing industries in the region, there has not been much progress in this area. The North-Eastern Regional Agricultural Marketing Corporation (NERAMAC) was set up in the region for marketing and processing of fruits.

Foodgrains and Oilseeds

An analysis of area, production and productivity trends in North-Eastern region shows that the region produced a total of 5.2 million tonnes of foodgrains from an area of 3.78 million hectares during 1998-99. Thus, the average productivity of the region during the above period has been around 1377 kg/ha, which is much below the national average of 1620 kg/ha. The population growth is higher than the growth in foodgrain production in the region. The region faces a deficit of 2 million tonnes of foodgrains, which is met by imports from other parts of the country. It drains the capital out of the region. This can, however, be curbed by making the region self-sufficient in foodgrains. The grain harvest of NE region in the post-Green Revolution era has continued to rise; yet per capita production flattened because of population growth.

Crop improvement research in the country in general and NE region in particular has so far been commodity-oriented. Moreover, improvement programmes pursued elsewhere in the country do not take into account the ground realities prevailing in different farming systems of the region. Further, the unique soil and agro-climatic conditions justify breeding programmes targeted specifically for the region. A case study of rice shows that most of the varieties introduced from other states had limited success whereas the varieties developed in the region by involving indigenous land race/variety, have been highly successful. Work done in varietal development in rice and wheat through enhancement of harvest index has increased the grain yields.

Within the region, there are marked variations in the performance of the states. The per cent area under HYV is highest in Tripura and Manipur being 46 per cent and 42 per cent respectively. The use of fertiliser per unit cropped area has decreased in Arunachal Pradesh, Meghalaya, Nagaland, Sikkim and Tripura whereas it has increased in Assam, Manipur and Mizoram. Overall, productivity of foodgrains has increased substantially in Manipur from 1763 kg/ha to 2411 kg/ha (37 per cent), Mizoram from 1317 kg/ha to 1600 kg/ha (26 per cent) and Meghalaya from 1161 kg/ha to 1349 kg/ha (16 per cent) during last couple of years.

The growth scenario of pulse and oilseed production is a mixed one. The region produces 111.7 thousand tonnes of pulses and 239.1 thousand tonnes of oilseeds from 176.1 thousand ha and 424 thousand ha with an average yield of 634 kg/ha and 563 kg/ha respectively during 1998-99. Non-availability of adequate quantity of quality seeds of improved varieties and lack of use of inputs like fertiliser, weed control and disease and pests protection are major constraints in pulses and oilseeds production in the region. The total area under pulses in seven hill states is only 46,300 ha and that of oilseeds is only

93,800 ha. However, the area under pulses and oilseeds showed a substantial increase from 11,000 ha in 1993-94 to 16,400 ha in 1997-98 and 21,000 ha in 1993-94 to 28,500 ha in 1997-1998 respectively.

Horticulture

Endowed with diverse climate, the NE region offers ideal agroclimatic conditions for cultivation of a wide variety of tropical and temperate fruits in its hills and valleys. The dominant horticultural crops of the region include pineapple, citrus, banana and areca nut. The region has a total area of 35.7 thousand ha. under pineapple and 35.6 thousand ha under citrus. Banana is grown in 54.9 thousand ha with a production of 707.6 thousand tonnes. The area under papaya, coconut, areca nut, temperate fruits, apple and miscellaneous crops are 9.14, 21.06, 81.32, 2.31 and 9.50 thousand ha with a production of 129.48, 128.61, 63.17, 58.08, 6.73 and 51.64 thousand tonnes respectively.

Orange is a unique crop of this region, however, average productivity is poor except in Assam and Meghalaya. High productivity from well-maintained orchards and trees bearing 2500-3000 fruits have been reported. Orange is a highly remunerative crop in Jampui hills of Tripura where organised efforts made by the state department has paid rich dividends. Productivity of pineapple in Assam compares well with that of all India average but it is much lower than the neighbouring West Bengal where production technologies viz. flower inducements, balanced nutrition and high density plantations have been adopted in North Bengal situations. These technologies need to be tried at large scale in NEH region to improve the productivity. Productivity of banana in Assam and Meghalaya (12-13 t/ha) is, however, at par with that of the neighbouring states like, West Bengal and Bihar.

Ginger and turmeric are well-established cash crops of Meghalaya. Ginger is grown in Mizoram too with high productivity. Large-scale production of planting material and marketing support has encouraged ginger cultivation. Large cardamom is a major plantation crop in Sikkim.

Potato is the most important vegetable which gives quite high average yield (17.1 t/ha) in Tripura. This state has achieved the distinction of producing true potato seed at commercial scale. Meghalaya and some other states also produce potato but productivities are low. Among vegetables, beans, radish and cauliflower are grown extensively in all the states.

Livestock and Poultry

Livestock in this region comprises cattle, buffalo, sheep, goat and pig. Poultry is yet to develop on commercial lines. Many tribal populations have no habit of rearing cattle for milk production. Therefore, animals are reared largely for meat. Feed and fodder both in quantity and quality are major constraints for any improvement in livestock and poultry production.

Fishery

Fish resources of the region reside in the tributaries of the Brahmaputra and Barak, the rivulets and streams and reservoirs, lakes, ponds and paddy fields. Opportunities for

both warm and cold water fisheries are available in the region. These resources can be broadly classified into two categories namely riverine comprising rivers and streams and inland comprising reservoirs, lakes, tanks and ponds.

The region has total riverine fisheries resources of 14,648 km and inland fisheries resources of 82962 ha. The bulk of the fishery resources, however, consists of tanks ponds and lakes. The region produces annually 48227 metric tonnes of fish. The extent of exploitation of aquatic resources of the region remains quite low. Of the over 14,000 km of the riverine aquatic source very little is presently harnessed. One of the reasons for this is the sizeable length of the rivers and streams lying nearly fallow. Lack of regulatory measures for conservation of fish stock and industrial pollution are an added constraint in fisheries development.

Farm Power

Availability of farm power is a pre-requisite for timely field operations that are essential for optimum productivity in agriculture. In farming systems dependent upon animate power sources (men and animals) about 1 kW/ha is considered sufficient. However, our farms are semi-mechanised where a farm power of about 2 kW/ha is considered essential. In NE region, the farm power availability is estimated at 0.67 kW/ha with a maximum of 1.44 kW/ha in Meghalaya and a minimum of 0.17 kW/ha in Arunachal Pradesh against the average farm power availability of 1.15 kW/ha in the country.

Studies have revealed that under rainfed farming, seed-bed preparation and sowing, harvesting and threshing, inter-culture, and weeding, and transport are the most energy intensive operations. Means will have to be found to bridge the gap between availability and requirement of power for farming operations in the NE. NE region experiences hot and humid weather, which poses serious problems for post harvest handling. In humid weather, it becomes difficult to dry the agricultural produce to safe moisture levels and this results in huge post-harvest losses.

Agricultural Research

The research needs of the agricultural sector of the region are largely met by the ICAR Research Complex for NEH region, Barapani and its centres in Arunachal Pradesh (Basar), Manipur (Imphal), Mizoram (Kolasib), Nagaland (Jharnapani), Sikkim (Gangtok) and Tripura (Lembucherra). Two agricultural universities viz., (i) Assam Agricultural University at Jorhat and (ii) Central Agricultural University at Imphal also contribute to this requirement. The former has eight regional agricultural research stations located in eight agroclimatic parts of Assam whereas the CAU has six colleges spread over all the six states and headquarters in Manipur.

The other ICAR establishments that cater to the research needs of the region are: NBPGR regional station, Shillong; CPRI Substation, Shillong; NBSS&LUP regional station at Jorhat; Ramie research station, Sarbhog; CPCRI substation, Kahikuchi and CICFRI, Guwahati. In addition, National Research Centre on mithun, yak and orchid are located at Medziphema in Nagaland, Dirang in Arunachal Pradesh and Pakyang in Sikkim respectively.

Agricultural Education

The literacy rate of the region varies between 49.1 per cent in Meghalaya to 82.27 per cent in Mizoram. The region is ahead of many other states of the country in literacy. However, it has lagged behind for of agricultural education mainly due to lack of infrastructure. The agricultural education of the NEH region is the responsibility of the Central Agricultural University, Imphal and Assam Agricultural University, Jorhat. Assam Agricultural University, Jorhat has six colleges: two for agriculture, two for veterinary science, one each for fishery and forestry. These colleges have played important role in imparting education in the field of agriculture and animal husbandry.

The Central Agricultural University, Imphal is the first such university of the country which was established by the ICAR at (CAU) Imphal, Manipur in 1993. The CAU envisaged establishment of seven major campuses in six states of NEH region namely Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura with provisions for establishment of other smaller institutions, especially krishi vigyan kendras and regional research units, at different places in these states. Agricultural education in the region is imparted through College of Agriculture at Imphal, Manipur; Colleges of Agriculture, Medziphema, Nagaland; College of Veterinary Science at Aizawl, Mizoram. The other colleges under the Central Agriculture University are yet to become functional.

Agricultural Extension

Agricultural extension is primarily the responsibility of the departments of the state governments of the region. The ICAR research complex conducts some extension activities through the extension division, krishi vigyan kendras and trainers' training centre located at Umiam. The extension directorates of two agricultural universities in conjunction with 12 krishi vigyan kendras existing in the region help in transfer of technology.

Policy Recommendations

Major theme-wise policy recommendations are as follows:

1. Resource-base, Potential, Problems and Strategies for the Future

a. Soil and Water Resources

- Soil and water resources of the region need to be properly inventorised, characterised and evaluated for appropriate uses.
- Implementation of appropriate soil conservation practices should be mandatory for any cultivation programme in the hills, where soil and water losses are beyond the permissible limits.
- Watershed approach of soil and water conservation and development of land-based production programmes in participatory mode need to be propagated.
- The surface run off should be captured and used by following appropriate irrigation methods.

b. Plant Resources

- For plant genetic resources, a collaborative approach should be followed under the Indian National Plant Genetic Resources System (IN-PGRS). Policy planning for research and development of agriculture in NEER should include horticulture and forestry to simultaneously cover agrobiodiversity.
- Diversity mapping should be done along with inventorisation at micro-level for effective management, conservation and use of crop species and their relatives.
- Agroecological niches should be clearly identified and records should be maintained on prevalent crops and cropping system, the ethnic group and economic background of indigenous communities. The information collected should form the basis for designing 'on-farm' conservation.
- Regional networking should be planned/developed to enable safeguarding regional interests for genetic diversity.
- Specially designed genetic reserves, gene sanctuaries and/or genetic garden should be earmarked for wild species of food value and other economic importance. Strategies, approaches and technologies including biotechnology should be developed/standardised for gradually bringing these wild economic species under cultivation. Linkages should be strengthened with NBPGR, other government departments, universities, NGOs and communities to get desired results.
- Greater emphasis needs to be given on (a) *in situ* conservation of endangered species, *ex situ* conservation of base collections in field gene banks and *in vitro* storage and cryopreservation of important germplasm, where tissue culture protocols are available. Germplasm screening for processing and diversified use should be encouraged.

c. Livestock Resources

- Characterisation of indigenous livestock and poultry resources and their conservation need to be emphasised as there are many valuable genes for adaptability and disease resistance available in these animals.
- The swamp buffaloes of the region and goats need to be improved either through selection or crossbreeding. Pigs of the region are required to be improved by using exotic breeds. Similarly, poultry, including ducks and other animals like rabbit, mithun and yak need to be exploited to boost farm income.
- Research on standardising improved technologies of artificial insemination, intra-uterine insemination, embryo transfer for improved reproduction of livestock is also the need of the hour.
- For animal health improvement, research on disease control/health care, vaccine production, diagnostics, disease surveillance and monitoring are extremely important.

- Feed and fodder resource enhancement should receive urgent attention.
- Research is called for: (i) on cultivation of indigenous grasses, fodder trees for feed and fodder (ii) nutritional requirements of various categories of animals, including cross-breds and (iii) conservation of fodder for the lean period. These steps are needed for improvement in animal nutrition.
- Management system research and animal product processing and marketing research are other areas, which need attention.

d. Fisheries Resources

- Areas requiring emphasis are: standardisation of technologies suitable to varied agrarian practices and investment potentials of the region. This requires establishment of an elaborate research network across the North-Eastern states. This is also true of the species-based systems, with a high biodiversity of fish species present in this part of the country.
- Development of suitable and specific aquaculture packages for acidic soil condition, upland waters and lowland waters.
- Research programmes aiming at intensification and diversification of freshwater aquaculture in tune with the geomorphological feature of the region *viz.*, upland aquaculture and lowland aquaculture.
- Training to farmers and entrepreneurs at different levels along with better coordination between extension functionaries.
- Extension activities in terms of demonstrations, publications, farmers' meet, village adoption, production of audio and video materials for promoting scientific aquaculture.
- Extensive bio-monitoring of all rivers in time and space to assess threat perspectives in relation to biodiversity conservation.
- Regular monitoring of reproductive biology of economically important fish species so as to suggest remedial measures for depleting population.
- Conservation and rational exploitation of *beel* resources which are the back-bone of fish and fisheries in the region.
- Introduction of fish husbandry in *beel* ecosystem. It would be prudent to exploit the nutrient enriched marginal areas of the *beels* profitability with new technologies like pen culture/cage culture successfully demonstrated by CICFRI, Barrackpore. The pen-culture technology developed by CICFRI for 'fin' fish can open new vistas in the fishery activities of the region as it is less capital and labour intensive and has the added advantage of producing reasonably high fish/prawn biomass without disturbing the main fishery of the lake proper.

2. *Traditional System, Their Problems, Potentials and Strategies for Improvement*

a. **Shifting Cultivation**

Following course is recommended:

- Detailed survey to identify specific problems of various agroclimatic situations and ethnic groups.
- Selection of crops and varieties to suit different farming systems based on the needs of farmers. Identified crops should have assured market and should fulfil specific needs such as fodder, etc.
- Development of different types of farming systems suited to irrigated and rainfed situation coupled with efficient management of soil and water.
- Proper use of the biomass and recycling of wastes in the various farming systems.
- Studies on development of suitable irrigation system for hillslopes with scientific water management.
- Participatory research and extension involving farmers to bring about community empowerment by considering a number of socioeconomic issues in order to achieve success.

b. **Agroforestry and Horticulture**

- A greater intervention through agroforestry and horticulture is necessary to remove the unbalanced and unsustainable short cycle of *jhuming* and limited opportunity to expand arable lands and their mechanisation on the slopes.
- Traditional agroforestry practices existing in NE region need in-depth understanding for agronomic improvement.
- There is need to encourage product diversification in a unit of land through agroforestry to increase land's capacity to produce and bring the land to its full potential by linking to assured marketing channels by identifying demands and outlets or outputs.
- Collaboration on rubber-based farming system will help identification of the most suitable and economically viable farming system models by taking care of adapting low input agricultural practices, which can be followed by a smallholder. Rubber cultivation will help in soil conservation, enrich organic matters, improve soil properties and microclimate, besides being eco-friendly.
- Vast expansion of area under rubber is possible where land is denuded and is not suitable for cultivation of other crops. From the ecological restoration, socioeconomical development and rehabilitation of shifting cultivators' point of view,

rubber can play a crucial role to alleviate the problems in the North-East to a large extent.

- Research on mushroom cultivation and processing of the produce need to be encouraged.

c. Agricultural Research and Education

- To raise productivity of existing crops, intensive research efforts are required to (i) breed/identify suitable varieties of existing crops, (ii) employ newer technologies to speed up crop improvement, (iii) evolve suitable agro-techniques (iv) develop an integrated pest and nutrient management system and (v) develop appropriate soil and water management techniques. Similarly, for improving productivity of animals besides breed upgradation, research efforts should be directed towards animal nutrition and health care. Since, agriculture is rarely practised in isolation, development of appropriate mixed farming models, based on landholding size, will be helpful in improving the productivity in the livestock as well as agriculture sector.
- Grassland improvement scheme must be introduced and cost of meat and milk production should be reduced for the enterprise to become economical.
- To bring cash in the hands of the farmers and to raise their economic status three pronged approach is required which includes: (a) identification of suitable production technology, (b) development of technologies suitable for adoption at farm level to reduce the post-harvest losses and to increase the shelf life of produce to enable transport of perishable commodities to distant consuming centres and (c) marketing support.
- There is an urgent need to document the traditional knowledge, collect different plant materials and ascertain their medicinal properties. Useful plants can be popularised for large-scale cultivation, which will help in providing employment and improving income of large number of tribal and other rural families.
- Short or medium range programme on horticulture-based cropping system; water management including micro-irrigation and fertigation, greenhouse cultivation of vegetables and flowers have already received research attention. Further refinement of the technologies and their transfer will bring perceptible change/improvement in production of different crop commodities.
- Commercialisation of micropropagation protocols for banana, orchid, cardamom, and ginger. Refinement of TPS and microtuber production technology in potato. Improvement in STG techniques and cross-protection in citrus for virus elimination and control; hybrid seed production of temperate vegetables in high altitude areas.
- In order to reduce post-harvest losses at production centres low cost eco-friendly on-farm storage structures can play a crucial role. Significant advancement has been made in this direction and some small and medium sized cool chambers on the principles of evaporative cooling have been devised. Further refinement of the

technology will go a long way. Also, standardisation of packing line operations and proper packaging of different commodities are of urgent need.

- Pesticide residue management and newer product development will add values to the produce.
- In crop improvement programmes, new genes need to be introduced for increasing total biomass, which should then be followed by more efficient partitioning. This will require crossing the cultivated races with wild types, many of which are not sexually crossable. This can, however, be accomplished through embryo rescue/protoplast fusion and other biotechnological approaches.
- Among abiotic stresses, cold is a limiting factor in realising full potential in most of the crops. Biotechnology can be employed for incorporating cold-tolerance through introduction of genes for relevant enzymes such as *glycerol-3 phosphate acetyltransferase* in to high yielding varieties. Research on insect-pest management need to deploy resistant genes rather than depending on chemical control in this high rainfall region. Overall, a new regional initiative is needed that focuses on the varietal improvement of cereals (rice and maize), pulses and oilseeds.
- Establishment of a College of Agricultural Engineering & Technology at Sikkim under Central Agricultural University, through teaching, research and extension function can become hub of technology upgradation in the region for both agricultural production as well as post production management. Post-harvest engineering and technology can help farmers earn more and increase employment through value addition to their produce and by-products.
- Improvement of tea, ornamental plants, medicinal plants, forest trees through application of biotechnology should receive immediate attention.
- Judicious use of biotechnology tool in crop and livestock improvement programme/research is important as the conventional breeding methodology sometimes provides quicker results at less cost in many cases.
- Human resource to serve immediate requirement of academic and developmental activities in the region is an urgent need. It is also necessary to produce middle level technicians/professionals to assist developmental activities.
- In the context of growing public concern for environment, globalisation, household food security and eco-regional imbalances, new directions are required in planning and transfer of technology by designing more effective linkage between scientists and farmers for technology information to meet future challenges of growing demand of food.