Vision 2030

ICAR Research Complex for N. E. H. Region
(Indian Council of Agricultural Research)
Umiam-793 103, Meghalaya

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डा. एस. अय्यपन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
Secretary & Director General

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN,
NEW DELHI 110 114
Tel: 23382629,23386711 Fax: 91-11-23384773
E-mail : dg.icar@nic.in

Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR , have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

The ICAR Research Complex for NEH Region (ICAR-RC-NEH), Umiam, (Meghalaya), established in 1975, with one station in each of the six NE Hill States of the region, was initially mandated to develop alternatives to shifting cultivation –based farming systems. Over the years, the institute has provided solutions to the agriculture and allied sectors related problems of the resource poor tribal farmers. It has been undertaking a leading role in the agricultural research and development in the North Eastern Hill Region.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*, document will prove useful for the researchers, policymakers and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

Dated the 22nd June, 2011
New Delhi

(S. Ayyappan)

PREFACE

Agriculture in the north east is facing multifarious challenges in checking degradation of natural resources especially land degradation, developing adaptation and mitigation strategies in the changing climatic scenario and in meeting the changing food requirement for the incresaing population. The constraints of contraction of the land holding size, local land tenure systems, undulating hilly topography further complicates the challenges making them more difficult to address. On the other hand, the North Eastern Hill region including Sikkim is endowed with rich repository of biological diversity, valuable genetic resources of agricultural crops and plethora of natural resources. There is also vast scope for entrepreneurship development and agri-marketing system which are highly unorganized. To ensure food and nutritional security, sustainable development of hill agriculture through conservation and judicious utilization of natural resources, regional planning and demand driven technology led agriculture is essentially needed.

The ICAR Research Complex for NEH Region has been endeavoring to develop skills and technologies to meet these challenges and fulfill the needs and aspirations of tribal people of the region. The institute has developed and demonstrated many farming systems models as alternatives to *jhuming*; released location specific crop, animal and fish varieties; designed and developed farm tools and implements suitable for hill farmers. Acid soil tolerant crops, packages of pests and diseases management in high rainfall and humid conditions, conservation agriculture technologies, agroforestry practices, integrated farming systems, organic food production packages etc have been adopted in the region. The molecular techniques for animal diseases diagnosis and pathogen characterization, establishment of grant parent stock based poultry, parasitic diagnosis,

development of transgenic crop, and gender friendly agri-entrepreneurship have found a stay in the economic development and prosperity of farmers of the region.

Keeping in view of the strength and weaknesses, strategies for achieving food sufficiency have been worked out through agroforestry interventions, horticulture and livestock based farming systems. Research in frontier areas such as bio-prospecting, allele mining, bio-technology, agricultural diversification, water productivity, conservation agriculture, soil health management, crop weather monitoring, market intelligence, nano technology have been in envisioned.

Institute has been disseminating the available technologies through ATIC and the 13 KVKs attached to the institute. The technology dissemination activities through on farm demonstrations, FLDs, training programmes, kisan mela, institute-village linkage programme, watershed development programmes etc have been able to improve the local competence and skill development for various client groups. The institute also contributes to the human resource development by working hand in hand to impart post graduate teaching at Central Agricultural University, Imphal and its colleges in the various NEH states. It has launched several other sponsored programmes such as NAIP, NICRA, and Knowledge Innovation Repository in Agriculture for North-east (KIRAN).

To overcome the challenges for increasing demand for agricultural commodities, the Vision document 2030 is prepared addressing innovation driven agricultural research in the region.

I wish to acknowledge and thank Dr. S. Ayyappan, Secretary DARE and DG, ICAR for the valuable inputs and leadership, he has shown in preparing this vision document.

(S.V. Ngachan)
Director

Date: 30th June, 2011

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EXECUTIVE SUMMARY

The Institute covering seven North Eastern States including Sikkim has contributed significant scientific and technological support in agriculture and allied sectors for the agricultural development of the region. During the last five years, the institute focused on strategic programmes on Farming Systems Research for rural empowerment and livelihood improvement under NAIP Component - III, National Horticulture Mission (MM- I) and provided quality planting materials in fruits, vegetables, spices, etc. Five Rice varieties namely Bhalum -3 & 4 (Upland), Megha Rice 3 & 4 (quality rice for low land) and RC Maniphou -11 (resistant to blast and stem borer) for Meghalaya and Manipur has been released / notified. Hence a total of 21 rice varieties for different locations in the region have helped in increasing rice productivity and production in the region. Among the pulses TRCP-8 has been released / notified for Tripura and Meghalaya. Seven composite Maize varieties resistant / tolerant to cob borer in the region are in pipeline . In addition to Megha tomato – 3 released variety, Singnath and Bholanath (brinjal varieties) from Tripura and selection -5 and RCM – BL-1 are in pipeline for release. In fruit crops Guava cv. RCGH – 1, RCGH- 4, RCGH – 7 and RCG -11 are in pipeline for release which are sent under ACRIP. From Tripura, Papaya variety RCTP -1, (tolerant to ring spot virus) is also in the process for release. Technologies on post harvest, value addition, storage etc., have been sent for patent registration. Similarly, strategic focus in natural resource conservation positive development in field operations have given success. Rain water harvesting, conservation agriculture (zero tillage, agro-forestry interventions, raised and sunken beds, identification of acid tolerant varieties), bio-dynamics and integrated nutrient management etc., are operational in the farmers' field after technological assessment. Crop losses (rice, maize, oilseeds, spices, vegetables) due to high humidity and high rainfall have been reduced and increased the economy of marginal and resource poor farmers. In fruits citrus decline has been a major problem throughout the country where effective management packages for the region has been evolved.

Livestock and fisheries are recognized as major components of hill agro ecosystems. Integrated Farming Systems models have been developed to meet the challenges of natural resource conservation as well as finding alternative to shifting cultivation. Organic based agriculture and their packages are in practice in the farmer's field. Softwares and molecular-

based diagnosis of parasites, bacterial and viral diseases of animals have been developed. Development of upgraded pig variety up 87.5% and artificial insemination in pig are getting popular among the regional farmers.

In delivering a transforming vision for improved food security a number of prototype farm tools, implements and machineries has helped to reduce the drudgery of women farmers and better mechanization in production systems. Low cost polyhouse for protected cultivation of high value and low volume crops have been introduced. Hills in general offer a large scope for cultivation of diverse mixed crops. Despite the growth of food production in the region, increased human population growth rate could not bridge the gap of demand and supply of food. Hence, conservation of the natural resource based agricultural production system and diversification will ensure optimum utilization for attaining sustainability.

A new strategic initiative (NICRA – National Initiative on Climate Resilient Agriculture) for food security in climate change to build a comprehensive programme of strategic research, resource information, extension and capacity building is underway. Forecasting advisories of weather, pest and diseases, development of bio- pesticides and botanicals, potent traps pasted with chemicals that mimics scents secreted by female insects, are few examples empowering rural farming communities and stake holders. Information flow through Knowledge Innovation Repository in Agriculture for North East (KIRAN) which is recently launched by the institute envisioned to apply knowledge in service to individuals and communities. The institute not only encourages mandated research and their intellectual property rights, but interacts with private sectors and facilitates entrepreneurship development. The location specific technologies are disseminated through a sound extension mechanism (13 KVKs under the institute) to the client / user groups after technology assessment and refinement. The institute organizes regularly Kisan Melas, on-farm demonstrations, publications, summer and winter schools etc.

The institute has close linkages with the regional universities to accommodate post graduate level students to conduct their research at the institute farm and laboratories. Teaching and training are extended to the post graduate students of CAU and Ph.D students from other universities working in disciplines of agriculture and allied fields.

Many collaborative projects with national and international agencies are also underway in the institute. Interface meeting with the line departments, NGOs, students, universities, research institutes, self help groups etc., are regularly organized.

PREAMBLE

The North Eastern hill region is endowed with diverse edaphoclimatic situation inhabited by equally diverse ethnic communities. The region is one of the mega diversity centres and very rich in diversity in flora and fauna. The region being a repository of rich biodiversity is also recognized as climate marker. Different cultural back grounds 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. Agro-forestry, animal husbandry and fisheries are the integral part of the prevalent farming systems. *Jhuming* widely practiced in the region has shown a declining trend in recent past. The total area under shifting cultivation has reduced from 1.77 to 0.88 million hectares within a period of three years (Wasteland Atlas of India, 2010). There has been increase in production of food grains, fruits and vegetable over the last few years. However, hill agriculture is still showing a very slow growth due to some complex inherent constraints like undulating topography, difficult terrain, poor market accessibility etc. Degradation of the natural resources has been rapid. The crop husbandry is characterized by low cropping intensity, mono cropping and subsistence farming. This indicates greater challenges in food and nutritional security especially in the current changing climate scenario. The livelihood of the local inhabitants is heavily dependent on the availability and utilization of the natural resources of region. Hence conservation of natural resources, its optimum and effective utilization is addressed for feasible and sustainable agricultural production systems. In other agroforestry, horticulture, livestock, fisheries and soil and water conservation are the major focus for development of hill agriculture.

The ICAR Research Complex was established on 9th January 1975 with research priorities and strategy that were guided by three major recommendations:

1. Development of alternative farming systems to replace the practice of *jhuming*.
2. Making up the gap in the food needs of different States/U.T.s by introducing improved and adaptable varieties of crops; efficient management of soil, water and pests and increasing the animal production by adopting scientific system.
3. Increasing the rural income and employment through developing high-value low-volume produce/products that can be sold at a competitive advantage outside the region.

The Region and its Agriculture

The northeastern region comprising eight states *viz*., Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim has a total geographical area of 262180 km^2 which is nearly 8% of the total area of the country with more than forty five million populations. About 35% area in the region is plain excepting Assam where plains account for 84.44% of its total geographical area. Net sown area is highest in Assam (35.09%) followed by Tripura (24.30%) and Nagaland (19.06%). Arunachal Pradesh has lowest net sown area in the region. Cropping intensity is highest in Tripura (176.4 %) followed by Manipur (160.1%), Mizoram (146.50%) and Assam (140.50%). Nearly 0.88 million hectare area is under shifting cultivation in NE region. Out of 4.13 million hectare net sown area of the region, roughly 1.3 million hectare suffers from serious soil erosion problem.

The region receives an average annual rainfall of 2000 mm accounting for around 10% (42.50 mhm) of the country's total precipitation of 420.00 mhm. The soils are rich in organic matter, but the soil of the region is acidic to strongly acidic in reaction. The depth of the soil varies from shallow in *inceptisols* and *antisols* to very deep in *alluvial* soils. Total forest cover in the region is 13.02 million ha, which is about 49.65% of its geographical area as against the national average of 19.39%.

The region, by and large, is characterized by fragility, marginality, inaccessibility, cultural heterogeneity, diverse ethnicity and rich biodiversity. Rural population is around 82%. In the absence of major industries except in the state of Assam, the society is agrarian and depends on agriculture and allied sector for its livelihood.

Around 56% of the area is under low altitude, 33% mid altitude and the rest (11%) under high altitude. Agricultural production system is, by and large, of CDR type. The system is characterized by low cropping intensity (131.4%), monocropping and subsistence farming. Average landholding is 2.5 ha. Although the landholding appears to be higher, the entire holding cannot be used for agricultural purposes due to topographical disadvantages. Land use pattern is relatively faulty for which annual loss of top soil is much higher (46 tonnes/ha) than all India average of 11 tonnes/ha. Similarly, due to lack of proper water harvesting and utilization measures, only 0.88 mhm out of 42.5 mhm water is used. There is no reliable assessment of total irrigated area. Record gathered from different sources indicates that around 20.74% area is irrigated out of which 18.78% is irrigated through surface flow, 1.82% through surface lift and 0.14% through groundwater lift irrigation. Farmers also use an indigenous technique called bamboo drip irrigation particularly for less water demanding crops. Fertilizer consumption in the region is also very low and stands at around 6.47 kg/ha ranging from

as low as 3.8 kg/ha in Arunachal Pradesh to a high of around 73.54 kg/ha in Manipur.

Farming is predominantly rice-based with exception in the state of Sikkim where maize is the predominant cereal crop. Mixed farming system is the order as most of the farmers want to produce their household food and nutritional needs from their own farm. The system, therefore, supports a large horticulture and animal husbandry base in addition to the main cereal and pulse crops. Livestock is an indispensible and integral part of every farm as it fulfills the animal protein requirement of the population, majority of which have non vegetarian food habit. The livestock also complements synergistically other components such as fishery, horticulture and field crops. With this production practices, the region produces a total of 6.17 million ton of food grain against a requirement of around 7.99 million tons. The deficiency is, therefore, around 1.72 million tons (26.16%) of food grain. Similarly, in spite of a strong adoption of animal husbandry practices, annual milk, meat, egg and fish production are only 12.44 million litres, 0.21 million tonnes, 989.4 million numbers and 0.27 million tonnes, respectively.

Agriculture and allied activities are the main source of livelihood for the people of NE region and any attempt to reduce poverty as well as to place the region in developmental paradigm shall have to have a system based eco-regional planning for agricultural development. While planning this, the strength of farming system approach to judicious utilization and conservation of natural resources of the region with concurrent policy and research back up to increase production, add value to the produce and their disposal /sale management shall be of paramount importance.

In light of the above scenario, present vision document has been prepared keeping in view the strength, weaknesses, opportunities and threats to support the sustainable agricultural development vis-à-vis poverty alleviation in the region.

An Analysis of the Strength and Weaknesses of the Region

Strength

- **One of the 12 mega bio-diversity hot spot areas.**
- **Abundant natural resources (in Lakh ha.)**
  - o Geographical area : 262.18
  - o Forest : 132.20
  - o Agricultural land : 40.50
  - o Total water resources : 42.50 million ha meter
  - o Indigenous crop germplasm : 6000 (Approx.)
  - o Orchids : 600 (175 rare species)

- o Medicinal and aromatic plants including flowering species : 5000
- o Bamboo resources : 50% of the country
- o Total livestock : 20.98 million
- o Total poultry : 36.46 million
- o Fish germplasm including ornamental fish : 274 species
- o Agro -climatic zones : 06
  - ■ Alpine zone : More than 3500 m asl
  - ■ Temperate and sub-alpine zone : 1500 – 3500 m asl
  - ■ Sub-tropical hill zone : 1000 -1500 m asl
  - ■ Sub-tropical plain zone : 400 – 1000 m asl
  - ■ Mild-tropical hill zone : 200 – 800 m asl
  - ■ Mild-tropical plain zone : 0 – 200 m asl

Weaknesses of the Region

Inaccessibility, marginality and fragility.

- ■ Over exploitation of forest for fuel, timber and fodder.
- ■ Improper land use practices.
- ■ Shifting cultivation on hill slopes.
- ■ Poor infrastructure related to agricultural development.
- ■ Inadequate agricultural mechanization.
- ■ Absence of storage and agro processing mechanism and infrastructure.
- ■ Limited availability of quality seeds.
- ■ Lack of policy frame work for harmonization of production-processing-marketing components.
- ■ Lack of entrepreneurship in agricultural production system both at local and regional level.

Opportunities

Development of agro - ecological zone specific farming and production system.

- ■ Opportunities to increase agricultural production by 3-4 folds through input maximization.
- ■ Opportunity for extensive organic farming under upland ecosystem.
- ■ Mechanization of hill agriculture for increasing production and reducing drudgery.
- ■ Rain water conservation and management.
- ■ Agro forestry intervention particularly in classified waste lands/ marshy lands and permanent fallow.

- Conservation and utilization of bio resources through conventional and biotechnological interventions.
- Tremendous opportunities for horticulture sector development including and floriculture.
- Post harvest processing, value addition and export/domestic market tapping.
- ITKs for validation and utilization.
- Opportunity for giving a meat revolution to the country.
- Ornamental fish farming.
- Opportunities to attract the youths through industrial approach to agri-horti-animal-fish sector.
- Scope to encash the potential of apiculture and its integration on the existing farming systems.
- Opportunity to benefit the farmers of the rich biological diversity through the provisions of PPVFRA.

Threats

- Danger of extinction of valuable bio-resources.
- Larger areas became barren /degraded due to shifting cultivation.
- Gradual replacement of ecosystem people by ecological refugees.
- Danger of losing biodiversity due to bio piracy on account of international boundaries.
- People losing interest in agriculture sector due to poor productivity and economic returns.

Physiography of the Region

Physiography of north east India can be divided into three regions *viz.* Meghalaya plateau, the north eastern hill and basin of the Brahmaputra valley. The first two accounts for 78% of the region. Based on the topography, rainfall and temperature, the region has been divided into following three categories:

- Himalayan hills comprising of Sikkim and Darjeeling district of West Bengal.
- NE hills and plains comprising of Arunachal Pradesh, hill districts of Assam, Meghalaya and Nagaland.
- Southern hills and valleys comprising of Manipur, Mizoram and Tripura.

Climate and Rainfall

The region comprises of extensive network of rivers, valleys and hills. The weather in the region does not follow the pattern as observed in

other places of the country and show large spatial and temporal variability due to the presence of hill and mountain ranges on the synoptic system. The region is climatically classified as sub-tropical humid in general. The south west monsoon is the dominating factor for rains due to which the region receives most of its rainfall during the monsoon period. Average annual rainfall is 2400 mm. The region receives considerable amount of rainfall during pre-monsoon (March –May) and post monsoon (October-November) periods due to localized low pressure belts and north east monsoon. The annual maximum temperature ranges from 10-20^{o}C during winter and 25 – 35^{o}C during summer season over different places. The annual minimum temperature ranges from 5 – 8^{o}C during winter and 15 – 25^{o}C during the summer months. The average bright sunshine hours received in the region is lowest in the country (2- 5 hours during monsoon and 7 -8 hours during winter). The range of average wind speed is 2 – 10 km/h only. The average relative humidity of the region remains in the range of 60 - 80% for most part of the year. The average annual potential evaporation is 1400 – 1600 mm over most part of the NE region.

Soil status

Soils of north-eastern hill states have developed *in situ* on various types of rocks. They are broadly represented by four groups, *viz*. *Inceptosols, Ultisols, Entisols* and *Alfisols*. Soils are usually rich in organic matter and are acidic to strongly acidic in reaction. It is indicated that 95% of soils of NE states except Nagaland (77%) are acidic in reaction. Majority of the acid soils in the region have pH below 5.6. North east India has, in diversified climatic environs, the largest stretches of acid soils with a variation in pH from 4.0 – 6.8.

The soils of this region are rich in total N due to presence of high amount of organic matter. The content of organic matter and all forms of N and C: N ratio tends to increase with elevation. The soils are deficient in available phosphorous. The reason of low availability of phosphorus in the soils of NEH Region is high content of exchangeable aluminum.

Land Use Classification

State-wise land use classification is given in Table 1. It is observed from the table that out of a total reporting area of 232.01 lakh hectare net sown areas is 41.13 lakh hectares with a total of 35.44 lakh hectare area not available for cultivation.

Table 1 Land Use Classification in N.E.R. 2007-08 ('000 ha)

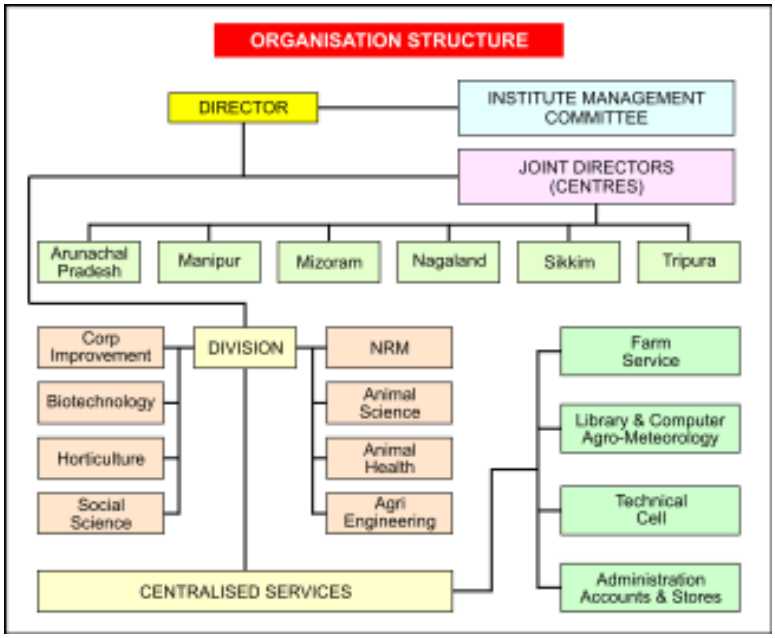
State	Geographical area	Reporting area for land utilisation	Forest area	Area put to non agricultural use	Barren and unculti-vable land	Total of col. (5+6)	Permanent pastures and other grazing land	Cultivable waste land	Others	Current fallows	Fallow land other than current fallows	Net area sown
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Arunachal Pradesh	8374	5660	5154	25	39	68	(n)	(n)	170	61	-	211
Assam	7844	7850	1853	1218	1408	2626	160	77	196	126	59	2753
Manipur	2233	1964	1693	26	1	27	10	13	13	21	12	175
Meghalaya	2243	2227	944	91	136	227	-	451	156	63	167	219
Mizoram	2108	2109	1594	125	9	134	5	5	67	45	166	93
Nagaland	1658	1618	863	74	4	78	-	64	111	99	87	316
Sikkim	710	724	319	143	107	250	4.1	-	16.4	-	64.0	70
Tripura	1049	1049	606	131	3	134	4	4	21	3	1	276
	23201										4113	

Note : (n) included under the head " Land under miscellaneous trees crops and groves etc. Source: NEDFI data bank

ICAR RESEARCH COMPLEX FOR NEH REGION

The institute is the first of its kind set up by ICAR, which encompasses all the disciplines of agriculture, horticulture, animal sciences, agricultural engineering, agroforestry, fishery and social sciences to cater to the research needs of the tribal areas of NEH Region including Sikkim. The headquarters of the institute is located in Meghalaya (Barapani), while its regional centres are located at Basar (Arunachal Pradesh), Imphal (Manipur), Kolasib (Mizoram), Jharnapani (Nagaland), Lembucherra (Tripura) and Gangtok (Sikkim). The institute has thirteen Krishi Vigyan Kendras (KVKs) attached to different centres for providing on/off campus training to the practising farmers, school dropouts and farm women in the field of agriculture and allied sectors. Considering the entire NEH Region as one unit, the research centres have been so located as to represent the varying altitudes (60-1800 m above msl) and agro-climates of the region. The research findings of the institute at different centres can thus be utilized for specific altitudinal range and agroclimatic conditions in component states. The headquarters at Barapani has now been housed in spacious new building with well-equipped laboratories and administrative wing.

As per the QRT, 16 disciplines have been re-categorized into eight divisions including biotechnology. The organizational setup of the Institute is given below:



Mandate of the institute at the time of its inception

- To provide alternative farming system to replace *jhumming* (shifting cultivation) and to improve its productivity.
- To develop each area according to its potentialities through research on food crops, fruits, vegetables and other economic crops and animals.
- To collect indigenous, cultivated and wild germplasm in crops and animals – their evaluation and utilization for improvement and preservation.
- To raise the level of local competence to scientific manpower.

The mandate of the institute as approved by ICAR in the VIII Plan

- To improve and develop sustainable farming systems for different agro-climatic and socio- economic condition of the region.
- To improve crops, livestock, fishery and to impart training for development of local competence for management of resources to enhance agricultural productivity.
- To maintain, analyze and project data base resources for perspective planning.
- To collaborate with the state departments of the region for testing and promotion of improved farming technologies.
- To act as a repository of information on different farming systems of the region.
- To collaborate with national and international agencies in achieving the above objectives.
- To provide consultancy

QRT for the period between 1995 and 2000 suggested addition of the following two mandates which were also approved by the council.

- Research on organic agriculture
- To develop local human resources through post graduate teaching and research

INFRASTRCTURE

HEAD QUARTER

Laboratories: At the initial stages of its establishment, there were makeshift laboratories in rented buildings at all the centers and headquarter of the institute. With the completion of institute's own buildings, laboratories of all discipline were established. Biotechnology laboratories have also been established for research on genetics, pathology and disease diagnosis. The institute has the following divisions/disciplines:

Crop Improvement

- Genetics and Plant Breeding
- Plant Pathology
- Entomology
- Nematology

NRM

- Agronomy
- Agroforestry
- Soil Science
- Water Management
- Soil and Water Conservation Engineering
- Agricultural Meteorology

Horticulture

- Pomology
- Olericulture
- Floriculture
- Medicinal and romatic Plants

Biotechnology

- Plant Biotechnology
- Animal Biotechnology

Animal Sciences

- Animal Production
- Poultry Science
- Animal nutrition
- LPM
- Fisheries

Animal Health

- Veterinary Parasitology
- Vet public health

Agricultural Engineering

- Farm machinery
- Post harvest technology

Social Sciences

- Agricultural Economics
- Agricultural Extension
- Agricultural Statistics

Library: The library made a very modest beginning during its first year in 1975 with only 8 books and 24 Indian Journals. Today the library has a total of 25,301 books and it subscribes 160 Indian and 15 foreign journals. It also has 205 news letters and 11,052 back volumes of journals. To promote the Hindi language, the library procured 2100 Hindi books, 45 popular journals and 16 newspapers. The growth of the library budget rises to 40.0 lakhs in 2011 from Rs. 1,200 in 1975. Recently the library has acquired data bases like Soil CD, Crop CD, Hort CD and Vet CD. Reprints and reports published by the institute are supplied by the library on demand in addition to a regular clientele on the mailing list which is constantly upgraded. The library has been connected with NKN network recently. Besides providing SDI services to the scientists of the institute by accessing various national data bases, the institute is also linked to the CERA project of NAIP.

Farms: When the Research Complex came into existence in 1975, all the field experiments were conducted in State Govt. and private farms, till land at Barapani was acquired from the Govt. of Meghalaya in 1980. The 110 ha area of the farm (mostly hilly terrain) is about 22 km away from Shillong city. The land has mild to steep hill slopes and flat valleys which provides almost all kinds of hill topography. After a topographical survey, development plans for areas for each discipline was prepared so that the entire farm could come up on the scientific principle of watershed management. Bench terracing on mild slopes, contour trenches and half moon terraces on steep hills were developed for conservation of soil and water. Trenches and earthen dams were made to harvest the run-off water. All these development were completed by the end of 1981 and thereafter, all experiments and trials were shifted to the Barapani farm.

IT facilities

The institute has developed strong IT infrastructure along with a rich computer database of library resources. An AC lab with computers (installed with SAS) along with projector and UPS backup of 2.30 hrs with internet facility has been created. A general purpose Statistical Software Package SAS (Standalone as well as internet based) consisting of all modules for perpetual use by different NARS organizations is also available. An online system for NET/ARS Prelim Examination for ASRB, ICAR was established and scheduled to be commissioned soon.

Buildings: The Complex Headquarters made a humble beginning at the rented buildings, and buildings provided by the State Governments. Private buildings had to be hired to accommodate the fast expanding laboratories and offices. In Shillong, as many as ten buildings had to be hired to meet the requirement. With the completion of the office-cum- laboratory buildings of the institute at Barapani, the entire activities of the Complex started functioning at its own buildings from 1992. Besides the office-cum-laboratory buildings, staff quarters have also been constructed to accommodate around 35% of the staff. The Complex also has two spacious and well furnished conference hall for holding meetings, seminars etc. besides an engineering workshop, video conferencing room, committee room, staff canteen, farmers hostel, scientist's home and one ATIC building.

REGIONAL RESEARCH STATIONS

Basar, Arunachal Pradesh

Regional research station, Basar, is spread over 40.5 ha land at Gori research farm. It has moderately furnished laboratories and staff quarters with a small library. The center has minimum transport and farm machinery facility. One KVK is attached to the centre to disseminate evolved and tested technologies to the user group.

Imphal, Manipur

The Regional Research Station, Imphal has its own campus at Lamphelpat comprising of residential quarters, laboratory buildings, KVK buildings and farms. The farm area is spread over 108 ha of land. The library of the center has reference books, Indian and foreign journals. It has 1 bus, 2 jeeps, 2 tractors and 1 power tiller. The centre has almost all the equipments in commensurate with the strength of the scientists. It has

common instrumentation centre where equipments like PCR, AAS etc. are used by the scientists. It also has a plant health clinic besides fish and poultry hatcheries.

Kolasib, Mizoram

The area of the farm at Mizoram centre is 32 ha that is located at altitudes varying between 750-800 m. The whole set up with 16 quarters and an office-cum-laboratory building was handed over to the ICAR by Govt. of Mizoram in 1977. One KVK is now attached to the centre. It has 2 jeeps and a power tiller for agricultural operations.

Jharnapani, Nagaland

Nagaland state has an altitudinal range of 194-3840 m above msl and therefore, when the center was envisaged for the state, two different stations were planned; one at Yiesumyong for taking up the problems of high altitude areas and the other at Jharnapani. However, due to lack of even the basic minimum facilities, the Yiesumyong station could not come up and, therefore, ultimately shifted to Jharnapani. The farm has an area of 84 ha. The station has now its own campus with office-cum-laboratory buildings, staff quarters and a trainee's hostel. The library has 2000 books and more than 250 journals. The center has 2 jeeps, 1 bus, 2 tractors and 3 power tillers. The centre also has conference hall, guest house and the required equipments for the scientists.

Tadong, Sikkim

After the merger of Sikkim as a State of India, the center was established in 1976. The center has a farm area 21.2 ha in an altitude of 1200-1400 m. The station has well furnished office-cum-laboratory buildings, residential quarters and a scientists' dormitory. Other facilities included are a small library, one bus, two jeeps, audiovisual aids and a staff welfare club.

Lembucherra, Tripura

The center has a farm area of 48 ha comprising mostly of tilla land with only about 2 ha of low land. It has a good office-cum-laboratory building, some staff quarters, library, one bus, two jeeps, one tractor and two power tillers.

KVKS

Thirteen KVKs are now attached with the Institute

LOCATION	STATE	LOCATION	STATE
Basar	Arunachal	Barapani	Meghalaya
Imphal West	Manipur	Jharanapani	Nagaland
Churachandpur	Manipur	Okha	Nagaland
Chandel	Manipur	Ranipool	Sikkim
Tamenlong	Manipur	Birchandramanu	Tripura
Ukhrul	Manipur	Hailakandi	Assam
Tura	Meghalaya		

ANY OTHER

The institute has a Scientific Co-ordination and Publication Unit for coordinating scientific and publication activities, a Medical Unit, Estate Unit, Instrumentation Unit, Engineering Workshop, Vehicle Cell and Construction Cell for self reliance as far as possible.

BUDGET (IN LAKHS RUPEES)

Plan	Period	Plan	Non-plan	Others	Total
1.	V	78.18	-	-	78.18
2.	VI	1001.27	516.71	-	1517.98
3.	VII	861.00	1338.77	106.71	2306.48
4.	Annual [1990-91& 1991-92]	526.00	882.00	68.00	1476.00
5.	VIII	1300.00	3839.00	556.55	5695.55
6.	IX	1869.00	5466.58	-	7335.58
7.	X	3270.50	6942.43	1888.63	12101.56
8.	XI	5049.00	18512.00	5500.00	29061.00

MANPOWER

The present approved discipline-wise scientific strength is given below

Discipline	Head quarters				Regional Stations				Grand Total
	PS	S S	S	Total	PS	S S	S	Total	
Agricultural Entomology	1	1	2	4	0	2	7	9	13
Plant Breeding	1	1	5	7	0	2	7	9	16
Plant Pathology	1	1	3	5	0	2	6	8	13
Soil Science	1	0	4	5	0	4	6	10	15
Horticulture	1	1	6	8	0	3	10	13	21
Agronomy	1	3	3	7	0	2	6	8	15
Soil physics/ Soil Water Conservation	0	1	2	3	0	0	0	0	3
Plant physiology	0	1	1	2	0	0	0	0	2
Soil Water Conservation Engineering	1	2	2	5	0	0	0	0	5
FMP	0	1	4	5	0	0	0	0	5
PHT/FST	0	1	1	2	0	0	0	0	2
Agricultural Economics	1	1	1	3	0	0	1	1	4
Agricultural Statistics	0	0	1	1	0	0	0	0	1
Agricultural Extension	1	1	2	4	0	0	3	3	7
Forestry	1	1	1	3	0	0	3	3	6
Food & Nutrition	0	0	1	1	0	0	0	0	1
Biotechnology (Plant Science)	0	0	1	1	0	0	0	0	1
Biochemistry (Plant Science)	0	0	1	1	0	0	0	0	1
Cytogenetics	0	0	1	1	0	0	0	0	1
Agricultural Meteorology	0	0	1	1	0	0	0	0	1
Animal Reproduction	1	2	2	5	0	2	4	6	11
Veterinary Public Health	1	2	2	5	0	1	2	3	8
Animal Nutrition	1	1	2	4	0	0	3	3	7
Veterinary Parasitology	0	1	2	3	0	0	0	0	3
Fishery	1	1	1	3	0	0	4	4	7
Veterinary Microbiology	0	0	1	1	0	0	1	1	2
LPM	0	1	0	1	0	0	2	2	3
Animal Breeding and Genetics	0	0	1	1	0	0	0	0	1
Poultry science	0	1	2	3	0	1	2	3	6
Seed technology	0	0	0	0	0	0	1	1	1
Genetics	0	0	0	0	0	0	1	1	1
Total	14	25	56	95	0	19	70	88	183
RMP (Director & JDs)	0	0	0	0	0	0	0	0	7
Prog coordinators of KVKs	0	0	0	0	0	0	0	0	13

Sanctioned staff strength over different plan period is furnished below:

Plan period	Scientific	Technical	Administrative	A & S
1. V	186 (123)	179(89)	77(63)	67(64)
2. VI	244 (112)	349(89)	156(97)	229(127)
3. VII	251(113)	327(253)	167(118)	237(196)
4. VIII	192(92)	326(254)	167(120)	239(207)
5. IX	198 (141)	326(289)	150(126)	134(127)
6. X	202 (118) + 4(0) KVK	353(289)	143(132)	129(128)
7. XI	183 (inst.) + 13 (KVK)	253 (inst.) + 152 (KVK)	130 (inst.) + 26 (KVK)	114 (inst.) + 28 supporting

SCENARIO

Regional Scenario

Decadal Growth in Area, Production and Productivity of Major Food Grains

It would be seen from Table 2 that production and productivity of major food grains in the region recorded a growth of 3.28 and 9.89% between 2000-01 and 2009 - 10. Considering the fact that only 17.73% of the reported area is sown in the region, there is scope to increase the area under cultivation and thereby the food production.

Table 2 Area, production and yield of major food grains and decadal growth

State	1990 – 91			2000 - 01			2009-10				
	Area (Lakh ha)	Pro-duc-tion Lakh MT	Yield (kg/ ha)	Area (Lakh ha)	Pro-duc-tion (Lakh MT)	Yield (kg/ ha)	Area (Lakh ha)	Pro-duc-tion (Lakh MT)	Yield (kg/ ha)	% incre-ase/ decre-ase of produc-tion in 2000-01 over 1990-91	% incre-ase/decre ase of produc-tion in 2009-10 over 2000-01
Arunachal Pradesh	1.83	2.14	1173	1.84	2.03	1103	2.02	2.50	1235	-5.14	22.96
Assam	27.19	34.42	1226	28.88	41.67	1443	25.23	39.40	1561	21.06	-5.46
Manipur	1.62	2.85	1763	1.64	3.78	2305	1.82	3.90	2141	32.63	3.3
Meghalaya	1.33	1.53	1147	1.31	2.03	1550	1.31	2.33	1785	32.68	14.88
Mizoram	0.59	0.77	1296	0.61	1.24	2033	0.67	0.80	1196	61.04	-35.28
Nagaland	1.70	1.97	1161	2.11	2.77	1313	2.93	5.24	1785	40.61	89.17
Sikkim				0.76	1.03	1355	0.78	1.09	1394		5.93
Tripura	2.89	5.15	1783	2.54	5.23	2059	2.54	6.48	2554	1.55	23.9
NE Total	37.14	48.83	1315	39.69	59.78	1506	37.30	61.74	1655	22.42	3.28
All India 11.36	1275.18	1762.30	1392	1197.83	1959.20	1636	1211.20	2181.86	1801		11.17
%share of NE	2.91	2.77		3.31	3.05		1.70	2.82			

Projection study on production and requirement of food grains in the coming decades in north eastern states was carried out to estimate the demand-supply gap of food grains. State-wise compound growth rates (CGR) of food grains production (includes rice, wheat, maize and pulses) were estimated by using time series data for a period of 2000 to 2010. Requirement of food grains was estimated by multiplying the recommended amount of per capita food grains with the population base at that point of time (say,

2010, 2015 etc.). The population base was estimated through CGR for which the same time series data was used (Table 3)

Table 3 Population (2011) in lakhs

Population	States							
	AP	AS	MN	MEG	MIZ	NGL	SIK	TRP
Male	7.20	159.55	13.70	14.92	5.52	10.26	3.22	18.71
Female	6.61	152.14	13.52	14.72	5.39	9.55	2.86	18.00
TOTAL	13.81	311.69	27.22	29.64	10.91	19.81	6.08	36.71

Total Population of North Eastern Region : 45.59 million
Total Population of India : 1210.19 million
% NE : 3.76%

Based on the present population and projected cumulative growth rate (CGR), food grain production and requirement by 2030 is presented in Table 4.

Table 4 Projected food grains production and requirement ('000 tonnes) in North Eastern states (with livestock)

States	Production			Requirement	
	CGR (Prod.)	2010	2030	2010	2030
Arunachal	0.006	249.6	249.99	268.06	367.93
Assam	-0.003	3939.6	3937.6	6043.10	7312.38
Manipur	0.003	390.47	390.7	527.70	721.32
Meghalaya	0.002	233.20	233.30	574.67	808.50
Mizoram	-0.06	80.25	79.25	211.53	278.32
Nagaland	0.02	524.00	526.12	384.00	343.81
Sikkim	0.007	109.11	109.25	117.82	132.82
Tripura	0.007	648.00	648.86	711.74	833.11
All	0.002	6174.23	6174.48	8838.6	10756.80

Where the region stands?

Agricultural production (major crops as in 2010)

Area (m ha)	Production (million ton, projected)	Yield (kg/ha)	Requirement (million ton, projected)	Deficit (%)
3.73	6.17	1655	7.99	26.1

Horticultural crops

Sectors	Area (lakh ha)	Production (lakh ton)	Yield (ton/ha)	Deficit (D)/ surplus (S) (%)
Fruits	3.68	34.0	9.24	80 (S)
Vegetables	4.06	61.0	15.02	25 (S)
Spices	1.22	3.15	2.58	
Plantation crops	1.19	2.07	1.74	

Animal Husbandry and Fishery

Sectors	Production (Million ton)	Requirement (Million ton)	Deficit (%)
Meat	0.21	0.50	58.92
Milk	1.25	3.33	62.5
Egg (million nos.)	989.4	6838.00	85.53
Fish	0.27	0.59	54.00

Why such a situation?

The above scenario is primarily due to the following constraints:

Environmental Constraint

- **Acidic soil-** low availability of P, high concentration of Fe and Al and low Zn.
- **High rainfall and humidity-** Harbors pests, diseases and weeds.

- **Shifting cultivation-** Both strength as well as weakness.
- **Land tenure system-** Lack of sense of belongingness to the land due to absentee land ownership as well as allotment of land for cultivation on time scale basis.

Technical Constraint

- Seed and planting material.
- Disease and pest management.
- Farm mechanization.
- CDR type of agriculture.
- Constraints of various kinds in transfer of technology.

Physical Constraints

- **Infrastructural-**Road and communication, procurement and distribution, processing and storage, value addition and marketing.
- **Undulating Topography-** Leads to inaccessibility with resultant constraints in service delivery.
- Lack of water for irrigation in lean period.

Economic Constraints

- **Lack of commercialization-** Leading to small-scale household production system.
- **Limited credit flow** - The farmers do not have easy access to credit flow as yet for which they are, many a times, compelled to continue small scale cultivation practices.
- **Market constraints -** Most of the places in the region do not have proper market to dispose off the produce. As a result the farmers often resort to distress sale of their produce.

Likely scenario if the situation is allowed to be continued as above

Current loss of top soil @ 46.0 t/ha and water drainage to the tune of 41.5 mhm, if not checked, shall limit the capacity of land to retain the current productivity pattern and may fail to bridge the demand – availability gap shown above.

- This will lead to loss of interest in agriculture especially among the youth and farmers with resultant increase in rural-urban migration as well as preference for non-farm sector.
- The region shall also remain dependent on other states of the country for food which may lead to social entropy.
- Unless the agriculture in the region is made remunerative, agrarian economy shall be shattered thereby increasing rural poverty.

National scenario

- Overall agricultural growth in the country has been showing a steady decline since 1980s and the growth in XI five year plan has been below 4 %.
- The decline in growth is basically due to the fatigue in green revolution belt which has reached production plateau.
- In order to achieve 10% growth in economy, agriculture sector during XII and subsequent plan periods needs to grow at a minimum rate of 4% per annum.
- In order to achieve this, productivity in 63% rainfed areas of the country has to be doubled with concurrent steps to increase area horizontally, if possible.
- Regions like North-East, therefore, have to play vital role to contribute its share to national food basket to ensure food security to the country.

International scenario

- North-East India is going to be influenced by the agri-sector development in five of its neighbouring countries namely Bhutan, China, Bangladesh, Myanmar and Nepal.
- Opening up of East – West road link connecting these countries as well as opening up of trans-boarder trade with China through Sikkim has come as a challenge to the farming community and the people of North-East India to prepare themselves for quality food production keeping WTO aggrements in view to benefit mutually for which technological support has become even more relevant.
- India could be a beneficiary through its North-East territory if adequate measures are taken to augment the productivity, particularly the horticultural and animal based enterprises including mass production of organic products for export purposes to the countries bordering North-East.

Steps to put NE region in agricultural development paradigm

Capacity building of the existing institutions, while identifying some progressive NGOs for the same, in the following areas:

- Molecular genetics and crop / animal health protection measures.
- Post harvest handling, processing, value addition and packaging.
- Regional gene bank for conservation of available bio-diversity as well as to protect them from bio-piracy on account of international border.

- Increased capacity to develop human resources locally so as to prepare them to handle region specific issues for production optimization.
- Continuous gathering of reports on market intelligence including the shift in WTO world for production planning and information dissemination.
- IT lead extension mechanism system.

Economic revolution through agriculture and allied sector in the following ways :

- Diversification into non-traditional sector like wheat, pulses and oilseeds for more income generation as well as for preparing the region as effective market partner.
- Popularising the concept of protected cultivation of high value low volume crops for off season sale to ensure increased income.
- Preparing artisans to manufacture farm implements.
- Preparing youth group for mass production of quality planting material / seed.
- Involvement of NGOs / SHGs in ornamental fish trade.
- Facilitating outlets at regional level for livestock vaccine production.
- Overall development of agri-business sector based on the strength of the region.

HARNESSING SCIENCE

A. Salient Research Achievements

Development of package of production practices

- Package of practices for organic production of groundnut, French bean, tomato, rice and maize has been developed.
- Package of practices for system of rice intensification (SRI) and integrated crop management (ICM) for rice has been developed and demonstrated in farmers' field.
- Technology for double cropping of rice in mid altitude involving pre-*kharif* rice and its ratoon has been standardized.
- Bio-organics from different plant species for production and protection of various crops *viz*. rice, maize, turmeric, zinger etc. have been developed that resulted in 10-30 % increase in productivity.

New programmes

- Conservation agriculture approaches for rice and maize based cropping system involving minimum tillage, zero tillage and residue management has been developed.

New introduction

- SRI and ICM method of rice cultivation have been introduced in Dhalai (Tripura) and South Garo Hills (Meghalaya).
- Year round vegetable production in low cost polyhouse introduced in North Sikkim (Sikkim) and Upper Subansiri (Arunachal Pradesh).

Natural Resource Management

- Farming system technology developed could check soil erosion from 46 t/ha earlier to the level of 8 – 10 t/ha and water retention in situ upto 93%.
- *Jalkund*- micro rain water harvesting structure for hill-top at a cost of Rs 0.07 per litre of harvested water have been popularized among farmers.
- Farming system models involving farm pond (aquaculture)-crop-livestock have been demonstrated in more than one hundred farmers field for effective utilization of natural resources.

- More than 8000 ha of lowland rice fallow areas have been brought under zero tillage toria in Manipur.
- More than 200 hectares of rice area have been brought under SRI and ICM in Dhalai (Tripura) and South Garo Hills (Meghalaya).

Development of rapid soil health testing kit (RSHTK)

A Rapid Soil Health Testing Kit (RSHTK) has been developed, particularly for farming community and other user groups. It assesses rapidly soil health status at the farmer's field following simplified standard procedures. The kit can effectively analyse 40 soil samples for pH and major nutrient elements (e.g. available N, P and K) in one go (without refilling). Soil Health Card (SHC) has also been prepared and attached to the kit. So far, more than 200 RSHTK along with soil health cards and an operating manual depicting all the steps in simplified manner have been distributed to various user groups including farmers. Seeing the encouraging response/feedback regarding the demand and utility of the kit from different user groups, ICAR Research Complex has taken up initiatives to mass produce the kits and make the kits available to the farmers at nominal price.

Amelioration of soil acidity and sustaining the crop productivity

Soil acidity poses greater challenge to the sustainability of agricultural crop production, particularly in high rainfall, hilly and mountainous regions of northeastern states of India. ICAR Research Complex for NEH Region developed some of the cost effective ameliorative approaches for acid soil reclamation. Among them, the notable ones are

(a)Liming for amelioration of soil acidity induced fertility stresses-

- Lime rate equivalent to 25% lime requirement (LR) is sufficient to raise the soil pH around 5.5 to eliminate the Al toxicity to get optimum productivity of crops in acid soils for the next two years.
- Liming at the rate of 2-4 q/ha in furrows at the time of sowing can increase the crop (maize) yield by around 50% over farmers' practice.
- Lime sludge, a waste product of paper mill industry, was proved to be excellent, low cost, ameliorative agents, substitute to agricultural lime for acid soil reclamation.

(b) Integrated nutrient management (INM) package featuring liming materials for acid soil amelioration and crop productivity

- The Integrated Nutrient Management (INM) approach (Agricultural lime @ 10% LR + Recommended doses of NPK and organic manure @ 5t/ha) resulted a 2-3.8 fold increase in

productivity of upland crops viz., maize, groundnut and soybean over farmer's practices.

- Benefits of INM approach comprising combined applications of FYM @ 5 t/ha, half of the recommended doses of fertilizer (N, P and K) and bio-fertilizers (phosphate solubulizers and Azotobacter @ 250 g/ha seedling root dip treatment) produced more than 7 t/ha rice yield (var. Shah Sarang) in the acid soils of Meghalaya.

Horticulture

Variety development and release

- One variety of turmeric named as Megha Turmeric-1 with yield potential of 30.0 t/ha and with curcumin content of 6.8% was released. The variety, due to its higher yield (30 t/ha against 15.5 t/ha from the existing ones), has become very popular.
- One variety of tomato named as Megha Tomato-3 has been developed and released. The variety is tolerant to bacterial wilt and low temperature with an average yield of 400-450 q/ha. The Breeder's seed of the same has been given to the Director, Deptt. of Horticulture, Govt. of Meghalaya

Varieties in the pipeline for release

- Two genotypes of tomato (Megha Tomato 1 & 2) have been proposed for release.
- Two genotypes of brinjal developed by the institute (RCMB-1 & Sel-5) are in the last year of AICVIP trial.
- Four genotypes of guava (RCG-11, RCGH-1, RCGH-4 and RCGH-7)
- One genotype of French bean (RCFB-1)
- Two genotype of ashgourd (RCAG-15 and RCAG-28)
- One genotype of dolichos bean (RCDL-10)

Development of package of production

- Citrus rejuvenation package was also developed to address the issue of citrus decline.
- Package for high density pineapple planting with 55,000 suckers/ha against the practice of 25,000 suckers/ha was developed.
- Pruning time and method for early fruiting of peach has been standardized.
- Propagation of *Khasi* mandarin through soft wood grafting has been standardized.

- Protocol for raising the *Sohiong* seedling has been developed
- Vegetative propagation through grafting of *Sohiong* has been standardized.
- Protocols for preparation of tuity fruity from chow-chow has been developed and a patent has been filled.
- Protocols for preparation of instant ginger candy has been standardized.

New introduction

- Strawberry was introduced in mid-hill situations in Meghalaya and Sikkim. In Meghalaya, it is currently being grown by farmers leading to the opening up new vistas for crop diversification.
- Passion fruit was introduced in Manipur, Mizoram and Nagaland.
- Kiwi fruit was introduced and popularized in Sikkim.
- Cole crops like broccoli was introduced and popularized.

Agricultural Engineering

- Low cost polyhouse made of 250 µ polythene and bamboo for terraced land conditions was developed and replicated in the farmers' field. The cost of the polyhouse was worked out as Rs 150/- per m^2 of covered land area.
- Technology for plastic lining of water harvesting structure was developed. Plastic lining controlled the seepage loss by 95%. The cost of lining of the structure was worked out as Rs. 50/ m^3 of water stored.
- Technology for slow conversion of bench terrace by contour bunding and hedgerow was developed and demonstrated in farmers' field under watershed programmes. Vertical spacing of 1.0 – 1.5 m of bund/hedgerow was found suitable and it took 4-5 years for formation of bench terrace.
- Simulation studies indicated that the Water Erosion Prediction Project (WEPP) model was found quite satisfactory for conservation planning of hilly watersheds in the region.
- Groundnut and maize intercropped with soybean were found to have potential to reduce sediment yield by 27%.
- Adoption of drill-no-tillage system and field cultivator in place of existing tillage system of spading in upland may reduce sediment yield by 21 and 13%, respectively.
- Simulation of combinations of crop, tillage and structural control scenarios revealed soybean–drill-no-tillage–with structural controls combination has potential to reduce sediment yield by 78.40% i.e.

from 23 t ha^{-1} in case of unmanaged watershed to 4.9 t ha^{-1}.

- Design of rainshelter for strawberry cultivation was developed and demonstrated in the farmer' field. The cost of construction of rainshelter was found as Rs. 146/- per m^2 of covered area.
- Cono weeder, 4-row pre-germinated paddy seeder, adjustable row marker, plastic body maize sheller were developed/modified according to the requirement of regional agricultural practices.
- Long handle weeders, fruit harvester were developed for drudgery reduction and enhancing production of horticultural crops of the region.
- Large cardamom dryer of 400 kg per batch capacity was developed and installed at ICAR, Sikkim Centre with collaboration of CIAE, Bhopal.

B. Impact Assessment

Overall impact of the programme of activities of the institute on the production/productivity/profitability/sustainability of the relevant agricultural systems in operation in its area of responsibility are summarized below:

Impact of farming system research

Ø SRI and ICM method of rice cultivation have been introduced in Dhalai (Tripura) and South Garo Hills (Meghalaya). Cost of Cultivation was on an average Rs. 21656/ ha with gross income of Rs. 35500/ha and net Income 14,000/ ha. A total of 1200 farmers were benefited.

Districts	Avg. yield of rice in SRI (t/ha)	Avg yield of rice in local method (t/ha)	% increased of yield	Area covered (ha)
Dhalai	3.7	2.1 t/ha	76.2	235
S.G. Hills	4.8	1.5	218.0	88

➤ More than 8000 hectares of lowland rice fallow areas have been brought under zero tillage toria (Var. M 27) in Manipur. The practice conserved soil moisture and required less irrigation water, saves tillage cost and the soil is protected from erosion due to the retention of surface residues.

➤ Introduction of *Jalkund* led to integration of different component in IFS in which water productivity has increased by three times. Around 200 number of *Jalkund* have been constructed in different parts of NEH region.

➤ Several household in 11 villages of Sibbari cluster, South Garo Hills were identified for Fish + duck (Sonali) + pig (Hampshire)

based farming system. Due to this intervention farmers' fish productivity has increased by about 1.5 t/ha and individual farmers are earning about Rs.10,000 from their pond (25 m x 25 m). Duck gave about 150 eggs/ annum as compared to 110-120 from local one and villagers are selling egg @ Rs. 6-7/egg. The improved Hampshire pig breed is giving two furrowing in a year with 7-8 piglets/ furrowing.

- Year round cultivation of high value vegetables; tomato (Megha Tomato-3, Avinash 2, Anup, Romeo and All Rounder), capsicum (Indra and Orebelle), cauliflower (Suwashini and Girija), broccoli (Everest and Aishwarya) etc under polyhouse has increased the income of the farming in North Sikkim (Sikkim) and Upper Subansiri (Arunachal Pradesh).

- The farming system models developed have been able to bring down the soil erosion to 8 tonnes/ha against the average soil loss report of 46 tonnes/ha in the region besides being able to conserve water *in situ* up to 93%. The conserved water could also be utilized for life saving irrigation and maintenance of animal farm unit in the system. Observing these positive attributes of the system, farmers have started adopting the models to derive the benefit from these systems.
- The gradual process of conversion of the contour bunds into terraces over a period of 3-4 years achieved under the systems

has also a positive impact on the farmers who have now resorted to this method because of the system being cost effective, labour saving and paying.

Improved crop varieties

Improved varieties of rice (RCPL 1-87-8) yielded 2.5 to 3.0 t/ha as compared to the yield of local variety of rice, which was 1.0 to 1.5 t/ha. Introduction of improved varieties of rice and maize along with new crops such as French bean, Groundnut, cabbage, cauliflower and brocolli led to increase in cropping intensity from 100 to 165 % in two years in the watershed.

Impact of horticultural based farming system

The horticultural based farming system model developed has been able to provide the various fruits like Assam lemon, guava, sweet orange, peaches etc, vegetables like cow-pea, chow-chow, French bean, cabbage, broccoli, capsicum, tomato, pea etc, spices like ginger and turmeric and flowers like gerbera and marigold round the year. The conserved water is utilized for life saving irrigation for crops during lean period and residue of vegetable crops is used for production of vermicompost and vermiwash. Observing these positive attributes of the system, farmers have started adopting the model to derive the benefit from the systems.

A number of horticultural crops were found suitable for vertical expansion under agroforestry such as Chow-chow, Dolicos bean, Dioscoria, Mucuna, Winged bean etc.

Impact of screening and development of varieties

Turmeric variety developed by the institute had a positive impact on increasing the production and productivity across the region particularly in Meghalaya and Nagaland states. During 2010-11, about 150 tonnes of Megha Turmeric-1 seeds were produced through different SHGs of Ri-Bhoi district


of Meghalaya and all the seeds were further distributed in 14 districts of NE India for cultivation.

The guava varieties developed (RCG-11, RCGH-1, RCGH-4, RCGH-7) and peach varieties identified (Shan-e-Punjab, TA-170, Florodasun) by the institute had a positive impact on increasing the production and productivity of the fruits in a few locations of Meghalaya. During last 2-3 years lot of demands for planting materials have been received from various Governmental agencies, NGO's and farmers.

Impact of protected cultivation

After observing the benefit of protected cultivation of low volume high value horticultural crops viz. gerbera, capsicum, tomato etc. farmers of the region have started the cultivation under low/medium cost polyhouse for off season and round the year production of above crops.

Impact of fishery sector

Due to the successful breeding and production of fish fingerlings and also the demonstration of economic benefit from fish culture, both under integrated and pond culture system, the farmers of the region have been attracted towards aquaculture particularly because of an access to fish


seed as well as their production technology in the Institute. Fish production as a result, has gone up from around 1.9 lakh ton to 2.23 lakh ton.

Among the different component species used in composite fish culture, silver carp attained the maximum growth (700g to1.2 kg), followed by grass carp (600g to 900g), catla (500g to750g), common carp (350g to 600g), rohu (400g to550g). The lowest growth was obtained in case of mrigal (250g to 350g). An average fish production of 2250 kg/ha/yr was obtained through composite fish culture with a net profit of Rs.43,000/- per ha culture area per year. A genetically improved variety of Common carp –Amur (Hungarian strain) was introduced in the ICAR NEH Region fish farm, Barapani, Meghalaya in early 2010. The breeder's seeds of this variety were procured from the Fisheries Research and Information centre of Karnataka Veterinary, Animal and Fisheries Sciences University, Bangalore. Initial trial on this variety had shown encouraging results.


Impact of engineering

For round-the-year utilization of polyhouse, capsicum-tomato-carrot-lettuce fetched highest return of Rs. 97.89 /m^2 of land with B: C ratio of 2.6 considering the life of structure as 5-6 years.

Rain shelter for strawberry increased the yield by 47% as compared to open area. The cost of construction of the rain shelter was Rs. 146 per m^2 which increased the yield by 1.10 kg per m^2


Plastic lined ponds constructed in upper reaches of hill slopes reduced seepage losses by 94.7%, i.e., from 55 (unlined) to 2.9 L/m^2/day. The system (Rainwater harvesting, storing and recycling) was found to be economically viable with B-C ratio 2.7 over a period of 15 years.

A total 1894.07 ha area was treated with soil conservation measures (contour bunding, bench terracing, contour hedgerow, silt retention tank/ water harvesting pond and drainage line treatments etc.) and improved hill farming technologies.

The benefit cost ratios observed in multi location trials of the watershed based farming systems, such as dairy farming, agro pastoral farming and agri-horti-silvi pastoral systems were 2.08:1, 1.83:1 and 1.4:1 respectively.

Mixed land use systems with appropriate soil conservation measures like bench terraces at lower reaches, contour bunding in middle portion and contour trenches at upper reaches reduced the soil loss to 3.5 - 5.0 t/ha/yr and retained upto 90% rainfall in-situ. Surface runoff from watershed to the extent of 38.44% can be harvested through the construction of water harvesting structure.

The slow conversion of bench terrace by contour bunding and hedgerow helped in progressive development of terraces through accumulation of up slope hedgerow and stabilization of risers against rain storms by stems and roots. Regular pruning of nitrogen fixing hedgerow species added 20–80, 3–14 and 8–38 kg ha^{-1} yr^{-1} of nitrogen, phosphorous and potassium, respectively.

Adoption of Agro-forestry System resulted in 2.4 to 2.8 fold increases in Rice Equivalent Yield (REY) and an average annual net profit of Rs.20, 000 to Rs.50, 000/- per ha, was realized from the different AFS.

Total 5349 number of prototypes of farm tools and implements which includes mainly long handle weeders, manual sowing equipments, maize shellers, paddy threshers, hand operated winnowers, row markers and fruit harvesters were fabricated and supplied to different Government, Non-Government Organizations and individual farmers of the region during the year 2004 – 2011.

Training on mechanization and manufacturing of agricultural implements for local village artisans were conducted to increase farm mechanization level and implement manufacturing in the region.

The level of participation in training programmes and demand for the tools and implements indicate the impact of mechanization.

Genetic improvement of indigenous pigs and Artificial Insemination

ICAR Research Complex for NEH Region developed and popularized upgraded pig variety (87.5%) by crossing indigenous pigs of Meghalaya with exotic Hampshire boar in order to achieve better growth rate, feed conversion efficiency, body weight gain and better adoptability to the local conditions and overall improvements of socioeconomic status of the poor farmers of the region. As a result of crossbreeding together with improved feeding and health care nmanagement, the body weight gain was increased from 50 kg to 150 kg in 12 months.

A total of 220 pig breeding farmers were selected from 26 villages and 180 farmers were trained on scientific breeding, reproductive management and artificial insemination in pig. The key persons were selected from each villages and formed facilitator group for information sharing. More than 200 female pigs were inseminated with the semen of superior boar and obtained the pregnancy rate of 79.4% and farrowing rate of 77.8% with average litter size of 8.2. The obtained piglets were OF superior germplasm, which has higher body weight gain and high feed conversion efficiency and higher litter size. Further, the each farmer earned additional direct income of Rs 4000 by saving mating cost and higher litter size (2-3 piglets extra). Therefore, 80% of tribal farmers adopted the artificial insemination technology

in pigs in the selected villages and the farmers were highly satisfied with this technology.

Incidence of reproductive disorders of dairy cattle in Meghalaya

To assess the incidence of reproductive disorders in dairy cattle, survey has been conducted in RiBhoi, East Khasi Hill, East Garo Hill, West Garo Hill and South Garo Hill District of Meghalaya. Based on gynaecological examination of cows and reproductive history, animals were classified into normal cyclic/ pregnant, repeat breeder, anoestrous and infertile. Out of 492 animals screened, 136 (27.64%) showed reproductive disorders. These cases were further divided into different categories (table 6). Maximum incidence was found to be of repeat breeding, which comprised of 43.28% of the total reproductive disorders. Incidence of anestous was next to the repeat breeding i.e. 33.90 %. Other reproductive disorders recorded were retention of fetal membrane (15.44%), abortion (2.20 %), pyomettra (2.94 %), vaginal prolapse (1.47 %), dystocia (2.20 %) and mummified fetus (0.07 %) respectively.

Impact of animal health research

The Division of Animal Health has been carrying out work pertaining to three major areas of the institute mandate. They are serosurveillance, clinical surveillance and diagnostic assay development. The services of this Division are being regularly utilized by the state governments, farmers and other related laboratories for identification and characterization of animal disease/fish pathogens. This is apart from the research work being done under the broad thematic areas of public health, zoonotic pathogen emergence, drug resistance profiling of pathogens, characterization of novel antimicrobials and innate immune response studies in poultry. A brief impact of the services rendered by the division are being showcased for the period from 2001-2009.

Serosurveillance of animal diseases

Detailed studies on serosurveillance of animal diseases were carried out. A total of 1538 serum samples were analysed during 2001-2009. Out of these 1538 serum samples tested, 115/588 (19.56%) samples for Infectious Bovine Rhinotracheitis (IBR), 123/971 (12.67%) for Brucellosis, 12/18 (66.6%) for Leptospirosis, 30/258 (11.62%) for *Hemonchus* spp., 39/258 (15.11%) for *Oesophagostomum* spp. and 58/258 (22.48%) for *Trichuris* spp. were found to be positive by ELISA. Additionally, 621 serum samples were also collected from cattle from different parts of the NEH region (Assam-92, Manipur-140, Mizoram-359, Arunachal Pradesh-4 and Sikkim-

26) which were tested for IBR and Brucellosis. Overall, 152/528 (28.79%) and 100/485 (20.62%) serum samples of cattle were positive for IBR and brucellosis, respectively. Serum samples (200) from mithun were also collected during the period 2001-09 from NRC, Mithun farm, Nagaland for sero-prevalence for IBR and brucellosis. All the 200 serum samples were tested for IBR and brucellosis where, 18 (9.0%), and 26 (13.0%) samples were found to be positive for the respective diseases. One hundred and sixty seven serum samples were collected from Swine of Meghalaya for detection of sero-prevalence rate of Classical Swine Fever (CSF) and brucellosis. Total of 14/119 (11.76%) samples for CSF and none for brucellosis were found to be positive.

Clinical surveillance for animal diseases

Cattle: There were two outbreaks of FMD at Umiam and Nongshillong, Meghalaya were recorded in 2001-02. However, no mortality was recorded. Serotype "O" has been found to be the causative agent of the outbreaks. In another outbreak, in 2002-03, a total of 150 cattle were affected with mortality of 2 animals. FMD type A virus was found to be the causative agent of the outbreak.

Pigs: Outbreak of swine fever in pigs of Meghalaya was recorded in 2002-03 and 2005-06. Mortality of 5/14 (35.71%) and 10/100 (10.0%) was recorded in the respective outbreaks. Another outbreak was also recorded in 2006-07.

Goats: An outbreak of contagious ecthyma was recorded in September, 2003 in organized goat farm where 16 animals (13 female and 3 male) were affected with no death. Taeniasis in goat was recorded in 2005-06.

Poultry: Disease outbreaks like aflatoxicosis, salmonellosis and IBD were also recorded with an average mortality of 38.63%, 70.0% and 50.50%, respectively in 2002-03 in poultry. In 2005-06, the outbreaks of Marek's disease, New Castle disease and colibacillosis was reported in poultry with an overall mortality of 320/8000 (4.00%), 95/800 (11.87%) and 42/200 (21.0%), respectively. Outbreaks of fowl pox, aspergillosis, mycotoxicosis, salmonellosis, colibacillosis and necrotic enteritis in poultry were also recorded in 2006-07.

Diagnostic assay standardization for animal pathogens

PCR assay was standardized for detection of virulent genes such as *stx1, stx2, hly, est, elt* genes etc. Plasmid profiling study of *E. coli* isolates was also carried out. PCR based assay for detection of virulent genes such as *stn, fimA, invA, sopB, sopE, pefA* and *sefC* was standardized for

Salmonella. PCR based diagnostic protocol was standardized for identification of *Cl. perfringenes* based on detection of toxin genes such as *cpa.* PCR based method for detection of *Pasteurella multocida* serotype B:2, the causal agent of hemorrhagic septicemia in cattle was standardized. PCR assay was standardized for detection of Glycoprotein C gene of Bovine herpes virus 1, the causal agent of IBR in cattle. *A. hydrophila* was isolated from pork, beef, mutton, chicken and fish samples. For rapid detection and characterization, PCR based assay was standardized by targeting 16S RNA and toxin genes such as *ahh1, asa1, aerA. L. monocytogenes* were recovered from clinical as well as food samples including beef, pork, chicken and mutton. Virulent genes such as *plcA, plcB, hly, iap* were targeted using various specific primers for detection of pathogenic *Listeria* spp. PCR was also standardized for detection of *B. abortus, B. melitensis* and *B. suis* based on the detection of repetitive genetic element IS*711*. PCR protocol was standardized for detection of *Campylobacter* spp. based on the detection of 16S RNA, *cdt*A, *cdt*B, *cdt*C, *fla*A , *cad*F (*Campylobacter* Adhesion to Fibronectin F), *rac*R (Reduce Ability to Colonize R), *vir*B11 and *pld*A (Phospholipase A) genes.

Impact of treatment against *Babesia bigemina* in cow

Cross-bred cow suffering from Babesiosis caused by *Babesia bigemina* was treated with a single dose of 4,4' Diamidine diazoamine benzene diaceturate by deep intra muscular injection in recommended dose with supportive treatment. Average daily decrease milk production as observed was 1.72 litre . After treatment the milk production gradually increased and reached to normal production after 17 days PT.

Effect of strategic treatment of gastrointestinal parasitic infection on milk production in lactating cows

Productivity of cattle in terms of milk yield was estimated to be considerably higher (3,715, 3,590, and 3,154 L) due to strategic anthelmintic treatment as compare to control group (2,928 L). Based on the probability of occurrence of parasitic infection as well as increase in value of milk production, the possible economic gain at state level has been estimated to be Rs. 46 million, Rs. 35 million, and Rs. 14 million, depending upon the different strategic treatment.

The Vision

Food grain production and requirement scenario indicates a deficit existing in all the NE states varying from 10% for Tripura/Sikkim to 69% for Mizoram, except Nagaland having some surplus food grains. In cereals alone there is about 19 % deficiency in the region. The region as a whole is deficit of 33 % in food grains. The projected food grain demand for NE is 10 mt in 2030. In order to make the region self sufficient in food grain production, the productivity of all the food crops has to be increased from the present low level with effective utilization of natural resources and wide variabilities in climatic conditions. Drought, floods, cold, pest and disease problems are the major concern for food security. The vision and strategy to achieve this objective is described below:

Amelioration on environmental constraints

Major environmental constraints limiting agricultural productivity are the acid soils, low phosphorous availability, low zinc and high concentration of iron and aluminium. Any attempt to increase production and productivity shall have to be adequately supported through appropriate amelioration of these constraints. One of the viable options to counter soil acidity is the application of lime. Another important environmental constraint is the high incidence of pest and diseases due to heavy rain fall and high humidity. Shifting cultivation, though considered as a constraint, has also the positive features to place the region in organic agriculture movement. Land tenure system which results into poor management of the soil health is another issue that needs to be addressed through the involvement of state governments.

Climate resilient agriculture

The region has a favourable balance between the total rainfall and evaporation loss in a year. But, the undulating topography, dry spells in the winter, lack of irrigation facility, acidic soils, severe insect pest pressure etc makes the region more vulnerable to the climatic fluctuations. Therefore, development of production strategies have to be made that are resilient to the climatic aberrations. The strategies would be to develop stress resistant varieties/breeds coupled with adaptation and mitigation technologies suitable to specific agro-climatic situations.

Natural resource conservation

The abundant natural resources available in the region in the form of water, soil, forest and bio-diversity shall be conserved both for short and long term use through both conventional and molecular means.

Food and Environmental Security- Research Aspect

Agriculture Sector

Making the region self sufficient in food

The region suffers from an overall food grain deficiency of 1.82 million tones. The deficiency of meat, milk, egg and fish are to the tune of 58.9, 62.5, 85.5 and 54%, respectively for a population of 45.6 million as in 2011. The immediate efforts should be to bridge this deficiency gap.

Bioresource inventorization and utilization

The region is rich both in floral and faunal diversity. They have gone through the process of intense natural selection and have developed unique traits of economic importance. Such resources shall be inventoried and used through conventional and molecular breeding techniques for production of improved varieties.

Placing the region in the organic food production map of the world

The uncommon opportunity of the region in organic food production shall be converted into strength through development of organic food production process initially in select crops/animals with a view to enlisting the region in the organic food production map of the world. The vision is to bring the shifting cultivation areas (0.88 m ha) into organic map of the country through technological and policy interventions. Technology for production and export of organic glutinous/per boiled rice, baby corn and vegetable crops, fruit crops and spices like passion fruit, kiwi fruit, orange, pineapple, turmeric, ginger and large cardamom shall be generated and tested.

Addressing the constraints of deliverables

To address the constraints like cold/heat tolerance, drought, flood tolerance, disease and pest resistant varieties with higher production potential, adequate support through research backup shall be provided in the form of developing resistant/tolerant varieties, weather-based disease and pest forecasting models and molecular disease diagnostic systems for

both crop and animals. The constraints of animal feed availability shall be attempted to address through the development of suitable feed formula based on locally available feed ingredients. Production constraint due to lack of improved farm tools and machineries shall be addressed through the development of improved tools and machineries by blending traditional and modern knowledge. The constraint of seed storage, post harvest handling and processing of the produce shall be addressed through development of appropriate technologies in a collaborative mode by partnering with the ongoing national /ICAR schemes.

Managing the effect of global warming

Effect of increase in global temperature which is predicted to rise by 3°C by the end of this century needs to be addressed through research on carbon sequestration, emission of greenhouse gases reduction from the agriculture and allied sectors

Harnessing the benefit of plant, animal and fish biotechnology

Application of biotechnology in the development of high yielding varieties of crops and animals with assured quality parameters, enhanced tolerance to biotic and abiotic stresses with increased nutritional parameters (like enrichment of varieties with vitamins, minerals and other essential nutrients) is envisioned. Also research on the production of biotechnologically effective vaccines (or vaccine candidates) for animals against some of the specific diseases of concern to the livestock growers is proposed.

Validating ITKs in agriculture and allied sector

Because of difficult terrain and inaccessible localities, people of the region have less access to technology. They have developed their own system of remedy against diseases/ pests/ parasites control, crop rotation, natural resource conservation and utilization, seed storage etc. Validation and scientific intervention in this system are planned for developing eco-friendly and sustainable production systems particularly in the fragile ecosystem of the region.

Horticulture sector

The total area under horticultural crops (fruits & vegetables) during 2009-10 in the region is around 773.5 thousand hectare, which is around 5.40% of the total area under fruits and vegetables in the country. From this area the region produces about 9908.2 thousand tones of fruits and vegetables with a productivity of 12.81 t/ ha against the national productivity of 14.34 t/ha. The area under fruits has been increased from 270.40 thousand

hectares in 1999-00 to 367.7 thousand hectares during 2009-10 with a production of 2337.7 and 3404.4 thousand tones, respectively. Likewise, the area under vegetables has been increased from 359.80 to 405.8 thousand hectares during the same period with a production of 3270.6 to 6503.8 thousand tones, respectively (Table 5 & 6).

Table 5 Area and production of fruits during 1999-2010

States	Area (000' ha)				Production (000't)			
	1999 -00	2006 -07	2008 -09	2009 -10	1999 -00	2006 -07	2008 -09	2009 -10
Arunachal Pradesh	44.10	57.50	57.60	72.0	93.10	107.9	108.00	107.9
Assam	106.10	137.00	105.20	117.3	1249.50	1572.4	1574.77	1575.5
Manipur	25.60	34.00	42.40	38.4	118.10	229.10	341.91	281.9
Meghalaya	26.90	26.00	32.95	32.9	223.30	216.70	294.81	294.8
Mizoram	13.00	22.30	34.10	27.1	40.70	219.60	123.1	328.3
Nagaland	19.40	21.00	18.16	30.8	232.30	147.30	151.27	223.7
Sikkim	5.90	09.00	10.5	12.2	8.60	13.40	15.7	18.5
Tripura	30.40	33.60	36.5	36.9	372.10	525.60	477.18	573.8
North east	270.40	340.40	337.41	367.7	2337.70	3032.0	3086.74	3404.4
India	3796.80	5806.5	6100.9	6329.2	45496.0	62858	68465.5	71515.5

Source: NHB Database, 2010

Table 6 Area and production of vegetables during 1999-2010

States	Area (000' ha)				Production (000't)			
	1999 -00	2006 -07	2008 -09	2009 -10	1999 -00	2006 -07	2008 -09	2009 -10
Arunachal Pradesh	16.70	23.70	23.80	4.20	80.50	110.00	110.00	38.50
Assam	223.20	354.00	240.05	255.2	2074.1	4800.8	2916.69	4569.9
Manipur	8.00	10.30	16.62	19.9	53.20	91.80	174.26	221.8
Meghalaya	41.80	39.40	44.27	44.3	412.20	380.70	415.79	415.8
Mizoram	6.80	1.20	14.4	10.6	49.60	37.30	114.4	179.1
Nagaland	19.30	15.20	10.38	10.4	188.40	96.80	78.33	78.3
Sikkim	12.00	17.80	21.5	28.7	54.0	80.80	98.0	147.7
Tripura	32.00	33.60	25.59	32.5	358.50	423.50	294.71	446.9
North east	359.80	495.20	396.61	405.8	3270.5	6021.7	4202.18	6098.00
India	5515.2	7727.8	7980.7	7984.8	75074.6	122255.9	129076.8	133737.6

Source: NHB Database, 2010

Research infrastructure in horticulture

The ICAR is carrying out horticulture research in the region through NEH Research Complex, Barapani (Meghalaya); National Research Centre for Orchids, Gangtok (Sikkim); Central Potato Research Station, Upper Shillong (Meghalaya); Central Plantation Crops Research Institute Regional Station, Kahikuchi (Assam), Central Agricultural University, Imphal (Manipur). In addition Assam Agricultural University, Jorhat and its regional stations are contributing to horticulture research and development in Assam. Further, 11 research centers of All India Coordinated Research Projects on Vegetables, potato, Tuber Crops, Palms and Betelvine located at AAU, Jorhat, Tinsukia and Kahikuchi are conducting multi-locational trials for identifying promising cultivars for the region. Thirteen Krishi Vigyan Kendras (KVKs) in the region are providing research back-up support towards popularization of improved technology and development of skilled manpower for various horticultural programmes.

Progress of research

Concerted research efforts have been made to identify a large number of improved varieties and production technologies of fruits, vegetables and tuber crops including potato and plantation crops suitable for the region.

Fruits crops: Based on survey conducted in Meghalaya, Arunachal Pradesh, Mizoram, Sikkim and Assam to ascertain the status of orange orchards, a large number of economic citrus species were collected and analyzed for physio-chemical characteristics. Manurial schedule for Khasi mandarin was standardized. RCG-11, RCGH-1, RCGH-4 and RCGH-7 were the suitable varieties of guava for mid hill situation besides L-49 and Allahabad Safeda. Agro-techniques for high density planting and fertilizer schedule for guava were also standardized. Flordasun, Partap (TA-170) and Shan-e-Punjab were most suitable peach varieties for mid hills of Meghalaya. Festival, Ofra and Sweet Charlie were identified as suitable variety for strawberry in Meghalaya. Tongue grafting in December was the best propagation methods of peach. Wedge grafting during February-March was the suitable propagation method for guava. Pruning in last week of October or first week of November enhanced early fruiting in peach and harvesting of peach by pruning during this period could be completed (by April) before onset of monsoon. Tongue and wedge methods of grafting in 2nd week of October have been found suitable for *Sohiong* (*Prunus nepalensis*). Propagation of Khasi mandarin through soft wood grafting has been standardized.

Vegetable, tuber and rhizomatous crops: Three tomato varieties namely Manileima, Manikhamnu and Manithoibi were released by State

Variety Release Committee, Manipur and found suitable for rice-based cropping system. Another tomato variety named as Megha Tomato-3 has released by the Meghalaya State Variety Release Committee as a bacterial wilt and low temperature tolerant variety. Tomato varieties namely BT-2, Arka Alok, Arka Abha and LE-79 were identified as bacterial wilt resistant varieties. Among the hybrids, the promising ones are Arka Vardhan, HOE 303, Swaraksha, S-7610, Avinash-2 and Rocky. Three pure line selections of French bean from the local germplasm were identified for multiplication. In brinjal, Pant Samrat and Arka Shirish and hybrid HOE 414 were the promising cultivars. Among the tuber crops, C-7 and TVM-293 in colocasia and S-162, Sonipat-2, X-69 and S-30 in sweet potato have been identified high yielding and most suitable varieties for the region. Turmeric and ginger are high remunerative crops for the farmers. Turmeric variety Megha turmeric-1 (earlier known as RCT-1) and ginger variety Nadia were found suitable for the region. Two varieties of brinjal, two varieties of tomato, two varieties of ash gourd, one variety each of French bean and dolichos bean are in the advance stage of release.

Potato: Potato is an important vegetable crop of the region. The CPRI Station in Meghalaya has developed a number of improved varieties and appropriate management practices. The productivity is fairly high particularly in Tripura (17.1 t/ha) and the state has achieved distinction in producing TPS on commercial scale. Kufri Khasi Garo and Kufri Jyoti have been recommended for main and autumn season crops for the region. Among the recently developed cultivars, Kufri Megha and Kufri Giriraj resistant to late blight, are widely under cultivation. A number of improved cultural practices have also been developed for the region.

Plantation crops: Coconut, arecanut, black pepper, large cardamom and cinnamon have great potential in the region. Research work has been undertaken by CPCRI Regional Station, Kahikuchi for development of improved cultivars of different plantation crops. A profitable coconut/arecanut based cropping system involving spices and fruit crops has been developed for the region.

Biotechnology: Protocols have been developed for micro propagation of different citrus species used as rootstock for *C. reticulata* as well as Khasi mandarin. Successful and cheap acclimatization methods have been developed for acclimatizing micro propagated citrus plantlets. DNA finger printing of 43 germplasm of ginger have been completed. The same working is in progress in turmeric.

Apart from above there are other promising varieties of fruits, vegetables, spices, tuber and rhizomatous crops, plantation crops and ornamental crops which were tested in the region, found suitable and recommended for commercial cultivation.

Vision for Horticulture Sector

Fruit sector development

The region produces a total of 3.40 million tones of fruits from a total area of 3.68 lakh ha with a productivity of 9.26 t/ha. The vision is to raise per hectare productivity to the all India average of 11.3 t/ ha through the development of suitable agro-techniques so as to achieve a total production of 4.16 million tones i.e. a gain of around 7.6 lakh tones.

Vegetable sector development

Present productivity of vegetable crops in the region is 16.03 t/ha against all India average of 16.75 t/ha, i.e. a difference of 0.72 t/ha only. First vision would be to increase the productivity in the states like Sikkim, Nagaland, Meghalaya and Arunachal Pradesh where the productivity is below 10t/ha.

Spices sector development

The region is known for high quality ginger, turmeric (curcumin content >7 %), chillies (e.g king chilli), large cardamom and black pepper. Average productivity of ginger (6.4 t) is much higher than all India average of 3.5 t, while the average productivity of chilies is almost on par with all India average. However, the productivity of turmeric in the region is only 1.5 t against 3.9 t/ ha in the country. Vision therefore would be to increase the productivity of turmeric to at least 4 t/ha with simultaneous attempt to increase the areas to raise the production at least up to 0.8 lakh t from the present level of 0.21 lakh t (excepting Manipur and Nagaland).

Floriculture

Due to favourable agro-climatic conditions, the region has been identified as a potential area for promoting floriculture. Flowers from the state like Meghalaya, Mizoram, Sikkim and Nagaland are now being marketed to other parts of the country. The floriculturists are approaching the institute for technological backup to address the issue of quality growing techniques, pest and disease control, better varieties with planting material, measures to increase shelf-life, packaging and transportation technique, maintenance of green/poly houses etc. In view of providing the needed support to this sector where the region has competitive advantage, it is planned to initiate research in these areas besides screening and developing varieties in demand both under protected and natural environment. Tie up with NRC on Orchids and other institutes are planned to develop suitable package from cultivation to market.

Animal science sector

The NER possesses 11.9 million bovines, 4.5 million ovines, 3.81 million pigs and 36.1 million poultry birds (2003). These accounted for about five per cent of the total bovines, three per cent of ovines and seven per cent of poultry birds in India. Livestock supplements the livelihood of all categories of households in this region. At the aggregate level, 57 per cent of households possess livestock in the NER, the corresponding figure for India being 56 per cent. However, there exists a wide inter-state variation. About 30 per cent of landless and 48 per cent of marginal households keep livestock in this region. Small landholders (< 2ha) in the NER constitute 76 per cent of rural households. However, it is worth mentioning that 82 per cent of the smallholders in the NER rear livestock to supplement their livelihood. It implies that there are more income and employment opportunities for smallholders in the livestock production. This also indicates that the development strategy for livestock must be focused on the small farm sector. The extent of technological intervention in breed improvement can be assessed through the compositional changes in livestock population over time.

The percentage share of crossbred cattle population was found significantly lower in the NER than at national level. The milk production had increased at a slower rate in the region (1.62%) than at the national level (4.27%). The per capita milk availability had declined at the aggregate level in NER and it was well below the recommended level of per capita milk consumption of 220 g/day. Therefore, massive R&D back up shall be required for production of improved cross breed cattle, health care facilities, and modern disease diagnosis system.

Growth in egg production had also been much slower in northeast region than at all-India level. Egg production had increased at an annual growth rate of 2.1 per cent in the NER and at 5.7 per cent at all-India level.

Therefore, responding to the burgeoning demand for livestock products in a sustainable manner is a big challenge. The widening gap between the demand and supply of livestock products can be bridged by introducing changes in production structure or opening up the international trade, rapid diagnosis of animal diseases using molecular techniques, forecasting of livestock diseases, increase the participation of smallholders in the livestock sector, and identifying the factors influencing the farmers to participate in livestock rearing. It is very important to develop a strategic approach and implement the same for improving this sector which, if achieved, shall help alleviating rural poverty as livestock has been found to provide insurance coverage to the socially weaker section during the distress period.

Pig is most preferred livestock among the tribal population of the north eastern hill region. Therefore, a pork revolution is necessary to fulfill

the pork requirement of the region. To achieve this objective, breed improvement, delivery mechanism of high quality boar semen, development of cluster concept for establishment of semen bank and health care facilities, value addition of the meat products for getting better economic returns is envisioned.

The support services like providing health back up, input delivery like semen and A I, feed blocks etc are planned to be arranged through public-private partnership. The area of promoting agri-business and veterinary clinics in the remote villages are also envisioned through such partnership.

Agricultural Engineering

- Promotion of watershed based farming systems integrating crop, animal, fish, poultry, and honey and mushroom farming for conservation of natural resources and income enhancement.
- Research and demonstration of protected cultivation, precision farming and off-season cultivation techniques for high valued crops of the region for enhancing productivity, production and quality of produce.
- Water harvesting and judicious utilization of harvested rain water including multiple use of water should be promoted to mitigate water scarcity in winter and increasing the water productivity.
- There is lack of organized manufacturing units of farm tools and machinery in the region, due to which the farmers of the region are not getting good quality implements and spare parts in time. Hence, the commercialization of farm tools and machinery suitable for the region need to be addressed.
- Promotion of suitable zero tillage machinery for energy conservation, increasing cropping intensity and production.
- Research and popularization of post harvest technology for value addition of economically important local crops such as ginger, turmeric, pineapple, chilly and large cardamom.
- Promotion of charcoal briquettes as an alternative fuel source for domestic use such as cooking and space heating which also mitigate the challenges of climate change to some extent needs to be popularized.

Fishery sector

India is home to more than 10% of global fish diversity with 2200 species living in varied water bodies, out of that NEH region itself harbors about 274 fish species belonging to 114 genera under 38 families and 10 orders. Therefore, the region is considered as hot spot of fish biodiversity.

Many of the indigenous fish species of the region are also considered as ornamental fish in the global ornamental fish markets. In this prospective, fisheries form important economic activities in Northeastern states with direct or indirect involvement of more than 5% of total population. The total fish production in the region has increased more than twofold from 112 thousands tonnes in the year 1990-91 to 271 thousands tonnes in 2008-09. Nevertheless, the region has immense potential to increase further the fish production through utilization of various untapped and/or marginally utilized water resources and introducing location specific new candidate fish species having impressive growth rates. Further, the region also has enormous potential in generating self-employment amongst the resource poor farmers or unemployed youths through promotion of ornamental fish sector. The vast fisheries resources of the northeastern region and their optimization for augmentation of fish production and strategies for amelioration in socio-economic conditions are outlined bellow;

Riverine fishery

The regions' major and minor rivers along with their tributaries, minor streams and other microlotic systems have an estimated combined length of 19, 150 km. The rivers are generally characterized by complicated flood regimes, a heavy silt load, marked seasonal variability in volume, course shifting and heavy bank erosion. The catch from these rivers does not contribute significantly to the total fish production in terms of volume, although a large number of traditional, artisanal fishers make a living on it. Commercial fishery in the upper reaches of Brahmaputra and Borak cross through inaccessible terrain, so fishing activity is limited to the middle and lower stretches. For centuries, all of the river systems of the region have provided a means of livelihood to thousands of fishers. It is estimated that 20000 fishers are presently engaged in riverine fisheries and the average catch per fisher amounts to a meagre 25-30 kg/year. This calls for an urgent attention so as to increase the average fish production from these vast resources, while protecting the natural habitat.

Reservoir fisheries

In Northeast India, reservoirs covers an estimated area of 23, 792 ha, Loktak being the single largest covering an area of 14, 600 ha. The reservoirs in the region are mainly considered the prime resource as regards to capture fisheries and are a growing resource with enormous potential for yield augmentation. The fish yield from these reservoir is poor, varying from 4-5 kg/ha against the nation average of 20 kg/ha. It is possible to achieve higher fish production through adopting improved package of

practices like cage and pen culture and sound management practices (like allowing natural self-recruitment process and growth of target species, enforcing seasonal closure and banning of species that causes concern for ecosystem destruction) coupled with conducive socio-economin environment. In this context, the reservoirs should receive adequate attention in future plan owing to the fact that the region has limited resources of ponds, tanks and mini barrages and, that the region needs to boost up the fish production to meet its consumer demands.

Beel fisheries

The beels in Northeastern region of India occupies around 143, 790 ha area, out of that Assam only has 100, 000 ha. area. The evolution of river beds and the effects of extensive flood control and irrigation works have reduced the fish production levels of many of these beels through siltation, habitat destruction and heavy weed infestation. Eutrophication and accumulation of bottom mud are the greatest problems, further aggravated by the indiscriminate killing of brood fish during recruitment phase/breeding season. The current yield of such floodplain wetlands is not precisely known. Nonetheless, some basic studies were conducted on the limnology and productivity of these ecosystems and a production potential ranging from 1000 to 2000 kg/ha/yr has been estimated. The beels also provide the ideal location for pen and cage culture operations. Pen culture of major carp has indicated a production potential of up to 4 t/ha in six months culture period. The rearing of catfishes like *Clarias batrachus* and *Heteropneustes fossilis* would be most ideal in a weed-choked beel.

Species diversification in pond aquaculture

Aquaculture in the Northeastern region was restricted only to a homestead backyard pond activity until late 1980s, with seed from riverine sources as the only input, resulting very low levels of production. Though importance of fish culture as an economically promising enterprise was gradually realized, non- availability of quality fish seed and lack of scientific culture know-how hindered development of aquaculture. Currently fish production from aquaculture is below 600 kg/ha/yr in most of the northeastern hill states, which is far below the national average of 2000 kg/ha/yr. However, average fish production from states like Assam, Tripura and Manipur have improved considerably and reported to within the range of 1000- 1500 kg/ha/yr. The major species contributing to the total fish production in the region are those from Indian Major Carp and Exotic carp varieties. Another approach to increase productivity may be through species diversification. Encouraging farmers to culture other fish species that are

geographically compatible, grows faster in short time, resistant to disease and other environmental disorders etc.

Rice-fish culture

Most of the area of 2780 ha under paddy-cum-fish culture is confined to the state of Arunachal Pradesh followed by Manipur (970 ha) where rice-fish farming is popular. Though, other states of the region also have the potential, the available resources are not fully utilized for organized paddy-cum-fish culture.

Common Approaches/Issues to Promote Agricultural Growth

Intensive integrated farming system

To develop self sustainable systems and harness the benefit from crop-animal-fish complementarities the vision is to promote the concept of intensive integrated farming system in massive scale.

Precision farming

It is imperative to develop site specific technology for precision agriculture so as to utilize the scarce resources judiciously and effectively. It would be desirable for the research agencies to provide exact quantity of water and other input requirements to the farmers for each crop on per unit area basis.

Post harvest handling of the produce

Post harvest losses of almost all the farm produce in the region is very high due to unfavorable climatic conditions, absence of facility for their handling, processing, value addition, packaging and organized marketing. Although the region produces best quality of turmeric, ginger, pineapple, orange etc., there is no processing unit for any of these crops. Due to inaccessibility and transportation bottleneck restricting timely linkage between production site and the market, post harvest losses particularly for fruits and vegetable crops becomes very high ranging between 30 and 60%. Technology should be developed to enhance shelf life of perishable products, proper packing material for transportation in difficult and rugged terrain.

Research on sanitary and phyto-sanitary measures

North eastern region is relatively more vulnerable to introduction of new and alien trans-boarder insects, pests, diseases and weeds because of its sharing of boarder with five other surrounding countries. The humid

climatic conditions also favour the growth and spread of such organism very fast. Therefore, strong phyto-sanitary measures and state of the art tracking mechanism needs to be established.

Innovative extension procedures for technology dissemination

For assessment, refinement and dissemination of evolved technologies in a focused manner, one model village for each of the important crop and animal is planned to be established to spread the message for deriving benefits from the improved technologies. Information technology can be used extensively to reach far flung areas with minimum cost. Innovative concepts like KIRAN (Knowledge Innovation Repository in Agriculture for north east), e-choupal, weather and market forecasting through SMS services and toll free kisan help line services for effective dissemination of technologies.

Studies on market dynamics and intelligence through IT-based technologies are planned to be carried out together with developing E-villages both for feeding market information, agricultural input services and weather-based information and produce delivery systems. Collaboration with Space Research Organization, Community Information Centres, marketing wings of State Govt.s and other financing bodies, NGOs and self help groups is planned to achieve this.

National and International collaboration

In post WTO era, it has become absolutely necessary for every organization / country not only to assess its own strength and weaknesses but also the strength and weaknesses of the competitors and stake holders alike. National collaboration is required both for avoiding duplication as well as for benefiting from the complementarities of approaches so as to deliver the output in such a way that visible outcome of the technologies at operational level is achieved. In order to achieve the same, it is proposed to develop effective collaboration of the institute with other national and international agencies working in mutually beneficial areas. Another objective for developing such collaboration is to place the institute in the information repository / information exchange list of the reputed R&D Institutions across the globe. Yet another vision is to facilitate development of externally funded R&D projects for the benefit of the farming and other communities that the institute represents.

STRATEGIES AND FRAMEWORK

Bridging food grain deficiency	Following strategies can be followed to bridge food grain deficiency in NEH Region: **Rice** • Improved rice varieties can be used to enhance crop productivity. Five rice varieties namely Bhalum -3 & 4 (Upland), Megha Rice 3 & 4 (quality rice for low land) and RC Maniphou -11 (resistant to blast and stem borer) for Meghalaya and Manipur was released/notified. A total of 21 rice varieties released for different locations in the region have can be popularized to augment rice productivity and production in the region. • Developing rice variety with abiotic stress tolerant with average yields of 2.5 t/ha from the present yields of 1.7 t/ha i.e. a gain of 2.7 million tons from 3.4 million ha of rice area. The total rice production would be about 8.5 million tons with the optimization of production technology. • Improving rice productivity in *jhum* fields by about 1.5 t/ha from the present level of 0.7 t/ha would add another 0.70 million tons (a total of 1.32 million tons of rice) from 0.88 mha to the regional food basket. • Introducing double cropping in 25 – 30% valley land area of 1.5 million ha to gain 1.12 million tons. **Maize** • Introduction of quality protein maize (QPM) at state government farms and major maize growing areas. • Replacement of low yielding traditional maize cultivars with high yielding varieties. • Introduction of *rabi* maize in potential areas in the state of Manipur, Sikkim, Tripura and Mizoram. • Development of maize variety for increasing productivity from 1.5 t/ha to 2.2 t/ha from 0.17 mha of maize area. The total maize production would be about 0.36 mt in the region.

	Pulses • Improved varieties of pulses such as TRCP-8 can play a major role in increasing pulse production in the region. • The strength of rice bean in terms of regional adaptability and social acceptability should be fully exploited. Massive genetic improvement programme coupled with cultural practices should be taken up. • Promotion of crop diversification by including legumes in rice fallow in about 10 % rice area to gain about 0.20 million tons of pulses. Crops like pea, lentil, French bean etc would be encouraged in rice fallow to get additional food grain.
Fruit sector development	• Gradual replacement of low producing varieties with high yielding varieties screened for different fruit crops for different areas. • Production of required number of planting material using techniques like tissue culture and other propagation methods both under field and protected conditions. • Dissemination of appropriate orchard management practices to enhance the production and productivity. • Technology development of local and indigenous fruits for yield and quality improvement • Arranging stake holder workshops/trainings to propagate orchard management packages to support production and maximize yield. **Strategies to achieve the above** • Seed/planting material production of screened/ recommended varieties through public-private partnership and skill upgradation of the producers on improved agro-techniques through training and demonstration, preparing master trainers from among the producers, awareness building through press and media, roping in insurance agency and financing houses. • Different State Governments of the region are presently engaged in the implementation of

	Technology Mission Project under Horticulture. Each State is also engaged in expansion of area under MM-II. A strategic planning in addition to the technical programme of MM-II shall be required to identify the cultivable waste land in each State and also the fruit crop based on the topography and other parameters for the proposed expansion of area under fruit crops. • In order to cover the additional areas, desired initiative shall be taken to make available the planting material for which following steps would be needed. ➤ Establishment of nurseries in each districts/blocks preferably under State Horticulture Deptt. and/ or certified growers/progressive farmers. ➤ Establishment of production sites for organic compost in each identified pocket to support organic nutrient management. ➤ Training and introduction of integrated nutrient management, integrated pest and disease management concepts in the identified pockets. ➤ Training and introduction of the concept of *Jalkund* (water storage structure), drip irrigation and other water harvesting devices for life saving irrigation. • Facilitating procurement, processing and value addition to the produce at block/district level. • Facilitating marketing of the enhanced produce and developing database through IT.
Vegetable sector development	• A similar approach outlined under fruit sector shall be followed to achieve the above. • A similar perspective as outlined in the fruit sector is envisioned
Spices sector development	• Ginger, turmeric, king chilli varieties/ types having processing qualities shall be evaluated by research agencies for propagation and production maximization. • Facilitating private-public partnership for processing, value addition and marketing.

	• Facilitating local production of inputs for large scale production. • Considering the potentiality, quality and market demand for the above 3 spices products, a mission oriented programme needs to be launched separately for spices sector development in North Eastern Region. Such mission need also to cover large cardamom and black pepper under the Agro-forestry programmes in high and low altitudinal conditions, respectively. Cultivation of black pepper need to be made mandatory in the tea garden areas of Assam as well as in the foot hills areas of adjoining states.
Post harvest management	• Strict adherence to the appropriate post harvest management practices like harvesting (following maturity indices), sorting, grading, waxing, packaging and storage. • Technology development for post harvest management and value addition of local and indigenous fruits and vegetables having commercial importance. **Strategies to achieve these** • Capacity building of stakeholders to promote PHM and value addition of horticultural crops. • Installation of pack house facilities (at least one in each district) in production catchments for sorting, grading, packaging etc to reduce post harvest loss. • Short and long term research projects for technology development of local and indigenous fruits and vegetables
Managing shifting cultivation	• Improved *jhum* packages including improved seeds and appropriate soil conservation measures should be disseminated through the Department of Agriculture well in time to the *jhumias.* • Demonstration of site-specific improved agroforestry / horticulture/ livestock based integrated farming system models for *jhum* improvement. • Forest, water and land tenure policy should be relooedin light of bringing down the ill effects of shifting cultivation.

	• Intensification of improved *jhum* cultivation and improved fallow management involving physical and biological practices/biodynamics should be promoted for higher production and soil fertility build-up. • Setting up of an independent Regional Resource Centre on Shifting Cultivation involving various stakeholders to share the knowledge, information and dissemination of technology.
Amelioration of soil acidity and soil health related constraints	Soil acidity induces deficiency of nutrients (phosphorous, nitrogen, calcium, magnesium, molybdenum and boron) while induces toxicity of others (Al, Fe, Mn). Therefore, it is of the essence to carry on the research activities on amelioration of soil acidity and improvement on soil health in tandem. • Soil health attributes from three dimensional views i.e. physical, chemical and biological properties with special emphasis on soil acidity parameters shall be assessed, categorized and mapped at spatial scale for the entire region. • Neutralize the acid soil at the rate of 33% of the upland cultivated area per year at a total lime requirement 0.67 million tones. This strategy shall contribute towards double productivity / hectare at the rate of 1.33 million hectare area / year and by third year of the operation, the capacity of the entire area of 4.0 million hectare hall be enhanced. • Physiological lime requirement for major crops should also be worked out in order to reduce substantially the existing rate of lime doses based on buffer solution approach and thus reducing the burden of input costs as well. · In so far as addressing the issue of high concentration of iron and aluminium, plant biotechnology units are proposed to be strengthened to produce varieties tolerant to such soil conditions.
Development of soil quality indices for different land	Soil quality assessment through indices provide the most appropriate way to quantify the changes in soil health attributes under any set of management practices including adoption of traditional/improved landuse

use/farming system	practices. For development of soil quality indices as a tool for quantification the following steps need to be taken up • Identification of key soil quality indicators for different land use and management practices under varied agro-ecological condition. • Interpretation and setting up of critical limits (scoring values) for those indicators. • Finally, development of soil quality indices.
Conservation of soil and water resources, rehabilitation of degraded areas	• Derivation of crop-coefficient values (Kc) and consumptive crop water requirements through water balance approach (Lysimeter/field) for major crops (e.g. cereals, pulses, oilseeds, vegetables etc.) under varied agro-climatic/ecological conditions across NEH region. This will ensure efficient utilization and management of water resources, including in devising strategies for future expansion of irrigated area, irrigation scheduling etc. • Delineation of watersheds (micro, mini & macro), catchment, command areas etc. (along with gradation w.r.t to susceptibility/prioritization) at spatial scale should be done for NEH Region. • Soil erosion prone/tolerance limit, artificial recharge zone for rain water harvesting etc. zonation at detailed scale including elevation factor (through DEM approach) generation for NEH region is very much needed for effective implementation of soil and water conservation measures.
Climate change –soil health – crop productivity continuum	Concern about the possible impacts of climate change on crop productivity and food security has recently led to a series of impact assessment studies. However, most of these studies tend to focus primarily on the climate change-induced alteration in above-ground responses of plants, ignoring the potential impacts of climate change on soil health and productivity potential in long term. Clearly, soil health assessment has been a missing component of the "climate change-soil health-crop productivity continuum". Thus, a more realistic and

	precise assessment of climate change impacts on crop productivity and food security in northeast India warrants elaborate experimentations for exploring the potential impacts of climatic changes on soil health and production sustaining capacity on long run. The required approaches include the assessment of climate change impacts on- and evolving management strategies for- • Nutrient dynamics and bio-chemical activities in rhizosphere of crops grown in acid soils of northeast India • Nutrient and water use efficiency by major crops grown in the region • Studies on carbon dynamics under different cropping systems and land use practices in relation to nutrient dynamics and crop productivity along with soil and environmental quality. • Soil organic matter content and carbon sequestration strategies need to be developed and tested for NE region. • Possible alteration in interactions among various major- and micro-nutrients in soil and plants • Potential effects on soil erosion, acidification, nutrient loss by denitrification, volatilization and leaching, and their management. Long-term changes in soil health and productivity-determining soil processes, and strategies for developing soil resilience against the climate change-induced stresses
Remediation of polluted soils resulting from coal mining and industrial activities	Soil contamination with organic and inorganic pollutants is a widespread ecological problem resulting from anthropogenic activities like fossil fuel burning, mining and smelting, industrial and municipal waste disposal, and agricultural activities. Accumulation of toxic heavy metals in agricultural soils not only has detrimental effects on the ecosystem functioning but also poses potential health risks due to transfer of these contaminants into the food. The high cost of remediation by conventional techniques has incited research on the development of innovative technologies, of which

	phytoremediation has been offered as an environmental friendly and cost effective alternative to the conventional remediation approaches. Phytoremediation is the use of green plants for removing pollutants from the contaminated environment. Development of location specific phytoremediation technologies for reclamation of contaminated soils involving selection of metal hyper accumulators from the region and standardization of phytoremediation technologies hold promise. Vision is to build the capacity of the existing research institutions so that appropriate phytoremediation technologies can be developed to reclaim contaminated soils of the region. Therefore, focusing research in this direction is urgently required.
Fishery sector	• Promotion of scientific aquaculture in newer areas, utilization of untapped water resources for fish culture practices. • Introduction of location specific fish species for aquaculture. • Production of quality fish seeds of commercial importance. • Development of low-cost feed for aquaculture. • Control of fish diseases. • Popularization of diversified and integrated fish culture. • Conservation of native fish species, both food and ornamental value through ex-situ and in-situ conservation. • Capacity building of farmers, entrepreneurs and extension officials etc.
Animal science sector **Pig, goat, dairy and**	• Inadequate breeding (Natural/Artificial) facilities especially in villages have to be given due care for promoting large number of pig breeder farmers. This can be achieved by establishment of co-operative of pig farmers and maintaining few superior boars per village with rotation of breeding boars from one area to other area to avoid inbreeding, establishment of semen banks, training of State veterinary Officials

poultry production aspect	and para-vets for large scale implementation of AI programme, to create awareness among the stakeholders about the benefit of the AI and demonstration under field condition. • The cattle breeding policy of India rely heavily on crossbreeding. However, today, often the cattle breeding policy is blamed for loss of valuable indigenous cattle germplasm and degradation and dilution of good qualities of indigenous breeds. The cattle breeding policy of India envisages pure breeding of outstanding recognized indigenous breeds and upgrading of poor native non-descript by crossing with exotic. Since northeastern region of India does not have any recognized indigenous cattle breed, therefore large scale crossbreeding programme should be implemented immediately by establishing semen banks at ICAR, State Veterinary Department and NGO's with sound extension and A.I services. • Raising small ruminants like sheep and goat is a valuable part of sustainable farming system. Sheep and goat can be incorporated in hill agro ecosystem for the resource poor farmers who can not afford to invest large sum of money in piggery and dairy. In NEH region, though the pork and beef contributes major portion of meat consumed, a little improvement in contribution of meat from small ruminants can push the region towards self reliant in meeting the animal protein demand. • Because of the remoteness of the state and inadequate transport facilities, transportation of fertile eggs or day old chicks from distant places is very expensive. Therefore, establishment of large scale poultry breeding farms with superior breeds of birds like Vanaraja and Gramapriya suitable for small scale intensive poultry rearing would be economical. Establishment of good number of mother units having adequate brooding facilities would help in reducing chick mortality. • Availability of good quality feed for pig and poultry is always a problem in this region. Therefore,

	research should be undertaken to formulate low cost feed for pig and poultry through incorporation of locally available ingredients, enrichment of the feed through mechanical, chemical and biological means and development of complete feed blocks. • The leading banks like NABARD should finance the bankable projects on establishment of small piggery, goatery, dairy and poultry units for marginal and small farmers
Animal health aspects	• The molecular diagnostic protocols standardized for diagnosis of various diseases are proposed to be used for quick diagnosis of important animal diseases so that ailing animals could be treated promptly or preventive measures against such diseases could be taken so that losses from both morbidity and mortality could be saved. • Development of viable thermo stable formulations to enhance the shelf life of biologicals especially on breakdown of cold chain. • To carry out studies to assess the bioremediation potential of bacteria in polluted skins and their characterization and defining the interfaces of animal-human microbial crossovers by characterization of phenomic and genomic traits. • To protect the human health from zoonotic diseases, research is proposed to be undertaken on various aspects of livestock product quality control measures. • Due to high rainfall and high humidity, various types of parasitic diseases are common in livestock. Forecasting model for parasitic diseases is proposed to undertaken. The study on cross reaction of diagnostic kit developed by the Institute is proposed to be undertaken. • Biotechnologically effective vaccines or vaccine candidates (strain specific) are proposed to be developed by 2030 so that the twin problems of non availability of vaccines and the loss of potency over storage are addressed. • For treatment of animal diseases, ethno-veterinary medicines is proposed to validate

PROGRAMMES AND PROJECTS

Soil health improvement	Preparation of soil health card and development of appropriate amelioration measures. Development of integrated nutrient management and software depicting the deficiencies and corrective measures shall be prepared. Collaboration with plant breeder for developing identified deficiency tolerant varieties.
Cereal improvement	To develop demand driven varieties and packages for rice, maize and millets and explore possibilities for wheat cultivation. Participatory varietal evaluation programme to be undertaken. Both conventional and molecular means of breeding to be adopted.
Pulse/oilseed improvement	To screen and develop suitable pulse and oilseed varieties together with methodologies for enhancing production through intercropping, relay cropping.
Fruit sector development	To increase per hectare productivity through appropriate technology and high density planting, to produce bud wood and rootstock of commercial fruit crops, to develop disease and pest management schedule and also to introduce fruit trees in forestation programmes in a participatory mode. Propagation of high value fruit crops like guava, strawberry, kiwi fruits through KVKs and state departments.
Vegetable sector improvement	Production enhancement of indigenous vegetables with simultaneous attempt to screen and develop high yielding varieties together with the needed agro-techniques to support higher production.
Spices sector improvement	Technology generation to support mass production of turmeric, ginger and chilli.

Postharvest technology	Capacity building to handle postharvest produce including necessary research to increase shelf life, add value and their storage and packaging with the needed protocol to maintain quality parameters.
Water management	Irrigation scheduling, rainwater harvesting and efficient use of water resource as well as development of modules for water conservation for enhancing water use efficiency and water productivity.
Agronomy and plant health research	To develop agronomical packages and pest and disease management schedules for all the target crops to provide the needed backstopping.
Conservation agriculture	To develop package of practices for resource conservation technology (RCT) *viz.* reduced tillage, residue management etc for target crop/cropping systems to provide the needed backstopping.
Climate resilient agriculture	Research in adaptation and mitigation strategies to combat effect of climate change through appropriate varietal interventions coupled with package of practices.
Agro-meteorology	To develop weather-disease-pest relationship and forecasting models to forewarn the client group for preparedness and to adopt the suggested steps.
Farm tools and machineries	Prototype manufacturing of improved farm tools and achineries for increased production, energy saving as well as drudgery reduction of women workforce.
Weed management	In addition to developing suitable technologies for weed management, preparation of bio-extracts from weedy plants as growth promoters and disease/pest control agents shall be the major objective.
Pig, poultry, goat and rabbit improvement	Augmentation of fertility in female pigs and goats through reproductive biotechnologies. Genetic up-gradation of non-descript pig and goats to enhance productivity. Development and use of animal disease diagnostic system through molecular means as well as to attempt

	preparation of strain specific vaccine. Development of control measures against zoonotic diseases shall be another programme. Propagation of already tested pig, poultry and rabbit breeds under field condition together with needed technologies and development of low cost feed formula for pig and poultry with better growth rate to increase profitability. Under climate change scenario efforts will be made to explore the relationship between livestock and the environment and the impacts of potential climate change on livestock production and how to minimize it.
Fishery sector development	Technology up scaling for fish seed production, ornamental fish breeding, cold water fish culture, reservoir and riverine fish culture as well as to identify and prepare fish feed based on locally available planktons.
Agroforestry	Collection and maintenance of MPTs and development of multi-tier agroforestry systems as well as development of technologies like intensive integrated farming for marshy / degraded lands.
Genetic improvement of mpts	Genetic improvement of the MPTs through modern biotechnological tools like molecular markers, transgenics, Marker assisted selection and association mapping.
Farming system research	Assessment and refinement of already developed farming system for natural resource conservation and utilization for identifying the best model for system productivity.
Research on bamboo	Identification of bamboo resources of the region, establishment of bamboo satum and development of technologies for bamboo product preparation.
Plant and animal biotechnology	Cataloguing of genetic resources through DNA fingerprinting to protect IPR, development of ecosystem constraint specific (acid, iron, aluminium etc tolerant) varieties, development of transgenics for biotic and

	abiotic stress tolerance and quality improvement, development of plant and animal disease diagnostic and also pregnancy diagnostic kits for animals using molecular means. Identification of new stress tolerance /quality improvement genes.
Organic agriculture	Development of technological package, crop / animal wise, for the crops that have national and global demands and where the region has the competitive advantage to produce those crops.
Extension methodology	Methodologies like transfer of information together with the transfer of technology with focus on cluster / community are planned to be developed for a planned production system that will be market driven.
Patenting	To gear up the research activities in such a way that under each programme patentable process / products are developed.
Bio-prospecting	N.E. Region being the home of around 7000 agri-horti crop species and a host of medicinal and aromatic plants, prospecting analysis of particularly the later shall be carried out during XI and subsequent plan period. Capacity to handle this programme shall be strengthened with equipment and trained manpower.
Crop diversification	Research on the scope of diversification into high value crops depending on agro-ecosystem strengths shall be carried out and the potential systems demonstrated.
Shifting cultivation	Together with the research on developing farming system models as an alternative to shifting cultivation, a concurrent programme on improving the system through the development of suitable varieties and packages specific to shifting cultivation areas shall be undertaken.
Nano-technology agriculture	Capacity of the institute shall be built in terms of infrastructure, equipment and HRD to work on this emerging area as the technology is currently being tried in medical and other fields.

Market intelligence	Intelligence on rise and fall of markets for different commodities, likely demand of crops / commodities in regional, national and global markets, balancing of seed and planting material requirement etc. shall be gathered in a collaborative mode with state government and other agencies for issuing forewarning to the growers so as to avoid distress sell etc.
HRD programme	In addition to developing the existing human resources in the institute through orientation programmes, the institute shall also take up post graduate teaching and research initially in collaboration with Central Agricultural University.
Technology backstopping	Eleven KVKs attached to the institute shall be used to demonstrate technological support to augment food production by adopting five villages under each KVK. They would also take up market led extension and training programmes

ACTIVITY TIME FRAME

Programmes	2011-12	2012-17	2017-22	2022-27	2027-30
Soil Health Improvement	✓	✓	✓	✓	✓
Cereal Improvement	✓	✓	✓	✓	✓
Pulse Improvement	✓	✓	✓	✓	✓
Oilseed Improvement	✓	✓	✓	✓	✓
Fruit Sector Development	✓	✓	✓	✓	✓
Vegetable Sector Improvement	✓	✓	✓	✓	✓
Spices Sector Improvement	✓	✓	✓	✓	✓
Postharvest Technology	✓	✓	✓	✓	✓
Water Management	✓	✓	✓	✓	✓
Agronomy and Plant Protection Research	✓	✓	✓	✓	✓
Conservation agriculture	✓	✓	✓	✓	✓
Agro-meteorology	✓	✓	✓	✓	✓
Farm tools and machineries	✓	✓	✓	✓	✓
Weed management	✓	✓	✓	✓	✓
Pig, Poultry, Goat Improvement	✓	✓	✓	✓	✓
Fishery Sector Research	✓	✓	✓	✓	✓
Agroforestry	✓	✓	✓	✓	✓
Genetic improvement of MPTs	✓	✓	✓	✓	✓
Bamboo Research	✓	✓	✓	✓	✓
Farming System Research	✓	✓	✓	✓	✓
Genetic improvement of MPTs	✓	✓	✓	✓	✓
Plant and Animal Biotechnology	✓	✓	✓	✓	✓
Organic Agriculture	✓	✓	✓	✓	✓
IT in Agriculture	✓	✓	✓	✓	✓
Extension Methodology	✓	✓	✓	✓	✓
Patenting	✓	✓	✓	✓	✓
Bioprospecting	✓	✓	✓	✓	✓
Crop diversification	✓	✓	✓	✓	✓
Shifting cultivation	✓	✓	✓	✓	✓
Nano-technology in agriculture	✓	✓	✓	✓	✓
Climate resilient agriculture	✓	✓	✓	✓	✓
Market intelligence	✓	✓	✓	✓	✓
HRD Programme	✓	✓	✓	✓	✓
Technology backstopping	✓	✓	✓	✓	✓

EPILOGUE

Technological package for agri-horti-animal-fish crops for facilitating enhanced productivity to not only bridge the current deficiency gap but also to produce marketable surplus shall be one of the major outputs. Development and delivery of organic package backup, putting in place suitable cropping sequence for different ecosystems, information on crop diversification options, resource conservation technologies, adaptation and mitigation strategies to climate change, resource analysis, conservation and utilization through crop-animal-fish complementarities, development of a skilled manpower base to handle processing and value chain activities besides developing post graduates in the field of agriculture and allied sectors, bio-resource inventorization and characterization for IPR issues, introducing farm mechanization, improving shifting cultivation practices etc. shall be other major outputs. Expected situation shall be a shift from mono to multiple cropping, technology shy to technology responsive farming community, small scale household production systems to semi-commercial/commercial system of farming, information hungry to information rich farmers groups, organic by 'de fault' to organic by 'process', natural resource degradation to natural resource conservation and its resultant use in a system mode, conventional to advanced mode of farming using molecular tools, insufficient inputs (seed/ planting material/manures) to sufficient inputs production devices, local hut (market) oriented extension dissemination to market led extension etc Another situation shall be the placement of the region in organic map of the country/world, thereby paving the way towards evergreen revolution. Propagation of quality animals particularly the pig under the farming system approach at household level is expected to bring in a situation conducive of providing a meat revolution.