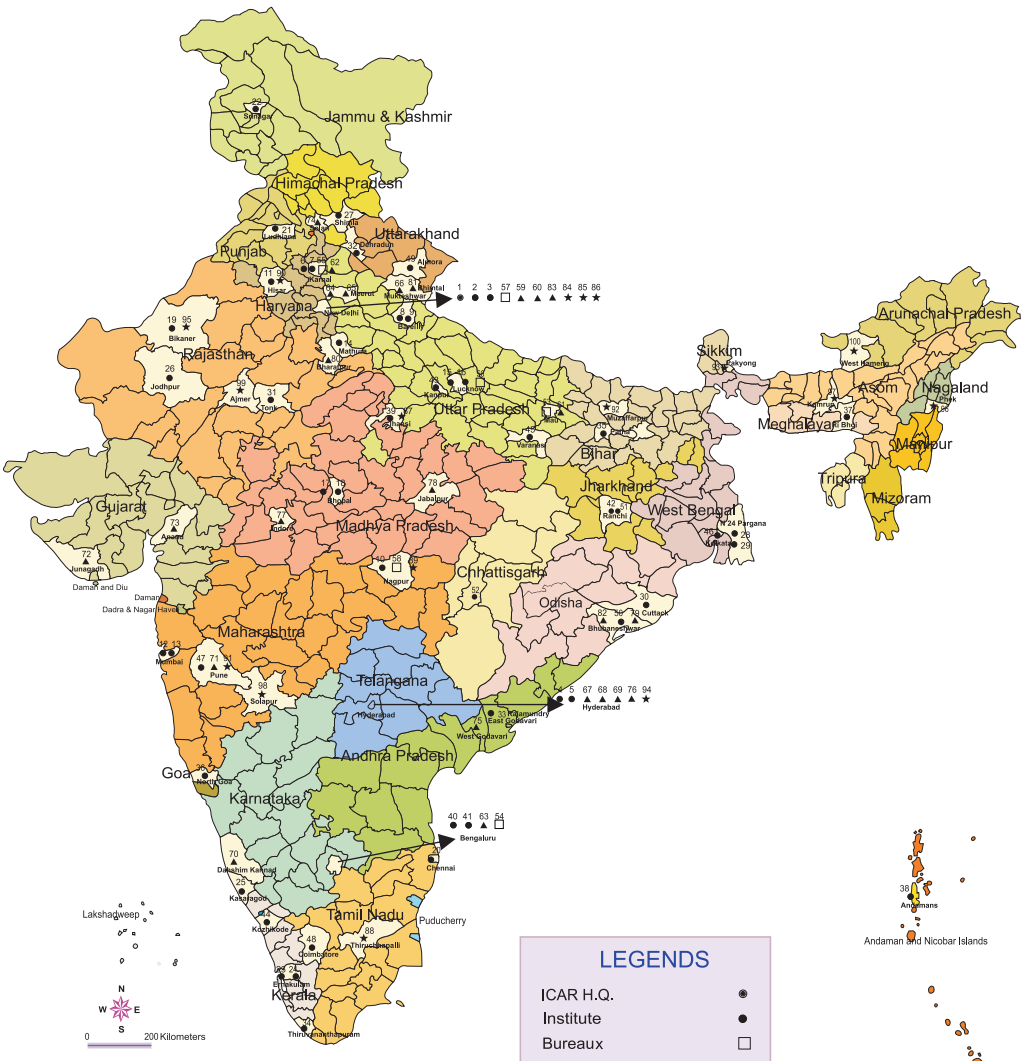
Vision 2050

Research Complex for Eastern Region

Indian Council of Agricultural Research

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates and National Research Centres



● 64 Research Institutes ● 6 Bureaux ● 15 National Research Centres ● 15 Project Directorates

Vision 2050

Research Complex for Eastern Region
(Indian Council of Agricultural Research)
ICAR Parisar, P.O. B.V. College,
Patna- 800014
www.icarrcer.in

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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Research Complex for Eastern Region (RCER), Patna has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
New Delhi 110 001

Preface

ICAR Research Complex for Eastern Region (ICAR-RCER), Patna is multi-commodity and multidisciplinary institute. The changing agricultural scenario of the eastern region and the country as a whole, the emerging opportunities of research, and the new government policies have necessitated visualization of institute's future role and the present document has been prepared in that context. It collates all the basic information on mission, mandate, achievements, impact, future scenario, emerging issues, perspective and strategies of the institute.

Eastern region is endowed with natural resources, however, its potential could not be harnessed in terms of agricultural productivity, poverty alleviation and livelihood improvement. The region has about 71% marginal farmers. Small and fragmented landholdings, soil acidity and sodicity, lack of mechanization and power, lowest per capita income, ever-increasing human population and thereby highest population density per sq km, poor infrastructure facilities for storage, processing and marketing, poor water management etc., limit adoption of modern farming practices in the region.

Keeping these facts in view, technology integration, scaling up and framing of demand driven and productivity enhancing research agenda, in a network mode, using both conventional and frontier technologies for ensuring scientific management of natural resources are essential especially because agriculture in the eastern region is complex, diverse and risk prone. Research priorities need to be re-oriented accordingly so as to address diverse researchable issues and also to achieve the target of food security.

I take this opportunity to express my indebtedness to Secretary, DARE and D.G. ICAR, Dr. S. Ayyappan, for his encouragement and guidance in bringing out this document. I express my sincerest thanks to Dr. A.K. Sikka, DDG (NRM), Dr. B. Mohan Kumar, A.D.G. (Agronomy and Agroforestry), Dr. S.K. Chaudhari, A.D.G. (S&WM) and Dr. Rajbir Singh for their keen interest, professional input and support while preparing the Vision document. Inputs from all the Heads of the Divisions and Research Centre of ICAR-RCER are thankfully acknowledged. While the Vision 2050 captures and reflects the collective wisdom of ICAR-RCER scientists, I wish to place on record the significant contribution of

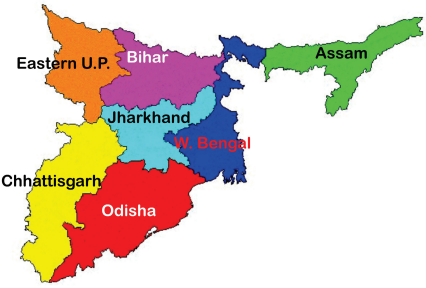
Dr. J.S. Mishra, Dr. A. Dey, Dr. Ujjwal Kumar, in compiling and editing the draft. Secretarial assistance rendered by Mr. Sarfaraj Ahmad is also acknowledged.

B.P. Bhatt
Director

Contents

Context

The eastern states, comprising of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal, occupy about 21.85% geographical area and supports 34% human and 31% livestock population of India (Fig. 1). Agriculture is the mainstay of economy in the eastern states, since 83 per cent population living in rural areas depends on it for their subsistence. Of the total geographical area of 71.84 million ha in eastern states, the net sown area is 31.43 million ha (22.2% of the country) with a cropping intensity of 150% (Fig. 2) as against 141% of the national average. The region has about 2.73 m ha total area under water constituting reservoirs, ponds, tanks and beels, oxbow lakes, brackish water, etc. besides 15046 km length of rivers and canals constituting about 18 per cent of country's utilizable water resources (10 per cent of surface water and 30 per cent of groundwater). The average rainfall in Eastern region varies from 1091 to 2477 mm with a regional average of 1526 mm, which is sufficient and substantial for growing a variety of crops. However, the irrigated area in the region is 39% as against 45% of the national average. In eastern region, about 10 m ha land is monocropped with rice, and remain fallow after harvest.



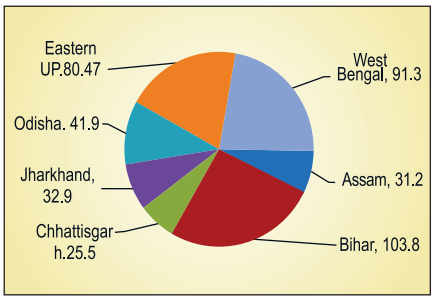


Fig. 1 Total population (million) in different Eastern states

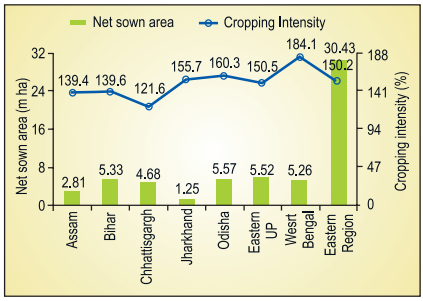


Fig. 2 Cropping intensity in different Eastern states

On an average, eastern states contribute about 50% of the total rice production of the country, followed by vegetables (44%) and inland fisheries (34%). It could be further improved with the adoption of technological interventions, multi-stake capacity building for achieving the potential yield of variety of agri-horti crops, crop diversification, rice-fallow management, and timeliness of the operations and supply of critical inputs etc. However, high population density (616 persons/ km^2 compared to 382 persons/km^2 at national level), poor supply of electricity to the agricultural sector, lowest per capita income (Rs. 38328/- per annum compared to the national average of Rs. 60,972/), maximum number of economically most backward districts (69 out of 150 at national level), and 32.1% population below poverty line (as against 21.9% of national average) in the region exert tremendous pressure on the natural resources of this region.

The production levels of agriculture, livestock and fisheries have remained low due mainly to lack of location-specific production technologies, natural calamities like floods, water logging, drought, inadequate timely supply of critical inputs and social constraints.

The eastern region has more than 40% cattle population, 36% goat population and 27% of the total poultry population. The region contributes 18.92% (23.05 m tonnes) of the total milk production (121.8 mt), but the per capita milk availability is very low (150 g/ day) as against national average of 281 g/day. Farmers mostly depend on unpredictable monsoon for crop production and owing to poor utilization of water resources the cropping intensity is low, particularly in rainfed upland ecosystems. Since water is one of the major resources for agricultural development, deliberation on water use potential of flood-affected and drought-prone areas of eastern India is essentially required.

In order to address the constraints pertaining to agricultural production in the eastern states, ICAR Research Complex for Eastern Region, Patna was established on 22nd February 2001 with a mandate "to conduct strategic and adaptive research for efficient integrated management of natural resources so as to enhance the productivity of agri-horti and aquatic crops, agroforestry, livestock, avian and fisheries in different agro-climatic zones". The institute has two regional research stations (Research Centre on Makhana, Darbhanga and Research Centre at Ranchi) and two Krishi Vigyan Kendras (Buxar and Ramgarh).

System mode research, integrating crop-livestock-fish-agroforestry-horticulture is the priority of the institute. So far, six integrated farming system models for waterlogged, Hill and Plateau, and irrigated uplands have been developed and found ecologically and economically viable.

Development of climate resilient farming system models is yet another priority of the institute since simulation studies have indicated significant decline in yield of rice and wheat in future scenario. Technologies have also been developed for multiple use of water and conjunctive use of water for higher water productivity. The institute has initiated work on Conservation Agriculture, which has demonstrated the profitability of farming besides savings in critical inputs and soil fertility build up.

The institute has pioneered research on makhana (*Euryale ferox* Salisb.) cultivation. Traditionally, makhana is cultivated in stagnant water bodies having water depth of 1.8 to 2.4 m. However, it has been made possible to grow this crop in a cropping system mode and varietal development in makhana also has been initiated.

In the field of agro-biodiversity conservation, 285 mango, 46 litchi, 11 sapota, 15 bael, 5 tamarind, 22 guava, 6 peach, 01 pear; 30 lesser-known wild edible spp., 18 mushroom spp., 32 strains of makhana, and the germplasm of rice bean, winged bean, faba bean, valvet bean, ivy gourd, spine gourd, pointed gourd, bottle gourd, *Moringa oleifera*, custard apple and jackfruit are being conserved at the institute. In addition, germplasm of various multi-purpose trees and the bamboo species is being maintained. Varietal development in litchi, makhana, faba bean, vegetables crops such as tomato, cow pea, brinjal, pointed gourd, ridge gourd etc., is one of the cardinal activities of the institute.

Keeping in view of the diverse agroclimatic conditions, latent opportunities for agricultural development, and resource endowments (Table 1), the research priorities need to be re-oriented to achieve the target of food and nutritional security with equity. With changing time, the institute will be facing a dynamic and changing environment. Capacity building would be as one of the key initiatives to ensure the quality of highly effective human capital so as to maintain the performance with social commitment in agricultural growth.

Table 1 Potential of natural resources in the region vis-à-vis national average

Particulars	Eastern region	India	Percentage
Total geographical area (m ha)	71.84	328.73	21.85
Net sown area	31.09	180.86	42.27
Wetland area (m ha)	4.05	15.26	26.50
Total fresh water area (m ha)	2.92	6.92	42.22
Marginal farmers (<1 ha) (%)	67.00	62.88	-
Large farmers (>10 ha) (%)	0.46	1.02	-
Total population (million)*	406	1210	33.54
Population density (no/sq km)	616	382	-
Rural population (%)	81.54	72.18	-
BPL (%)	32.10	21.90	-
Annual ground water availability (BCM)	145.12	399.25	36.35
Ground water draft (%)	36.00	58.00	-

*(2011 Census)

Source: Bhatt *et al.* 2011.

Challenges

India could be the World's largest economy by 2050 and by this time the country would have 1.6 billion people. Almost 800 million or 50% of the estimated population would live in urbanized territories. The contribution of agriculture in national GDP would come down to about 3% and the work force in agriculture (part time and full time) would be about 25%, many of these agricultural workers would have additional non- agricultural source of income to supplement their needs. Keeping the size of Indian economy in 2050 to be about US $ 86 trillion, agriculture's share would be about US $ 2.9 trillion if agricultural growth rate over the next 35 years is maintained at about 4%.

Agriculture in the 21st century faces multiple challenges: it has to produce more food and fibre to feed a growing population with a smaller rural labour force, skewed distribution of operational holdings, land degradation, imbalance use of water and nutrients, low fertilizer consumption, low productivity, low level of mechanization, climate change impact, non-remunerative prices and post-harvest losses. Nevertheless, the eastern region of the country holds promise for a second Green Revolution, which can be accomplished through holistic management of land, water, crops, biomass, horticultural, livestock, fishery and human resources. As the eastern states support 34% human and 31% livestock population of India from 21.85% of geographical area, there is tremendous pressure on natural resources to sustain the ever increasing human and animal population. Small (<1 ha) and fragmented landholdings limit the adoption of improved technologies. The total water demand is projected to increase 900 BCM and the groundwater withdrawal from 303 BCM in 2000 to 423 BCM by 2050. The coastal areas are vulnerable to sea-water intrusion and cyclones. Further, the wetlands, which occupy an area of 4.05 million ha, need restoration for sustainable food production and conservation of biodiversity.

The eastern region has about 163 million underprivileged people compared to 360 million at the national level, which need immediate attention so as to improve upon their livelihood options. The region also has about 36 million scheduled tribe (ST) population (30% of the total ST population at the national level) and, therefore, promising tribal agriculture practices needs to be replicated in similar agro-climatic

zones for better livelihood options of ST population (Fig. 3a). The scheduled caste population (Fig. 3b) of the region comprising 70.53 million (17.33%) of the total population of the region are predominantly landless workers and marginal farmers' with low resource base. Hence, livelihood improvement of SC population should also need to be given due importance.

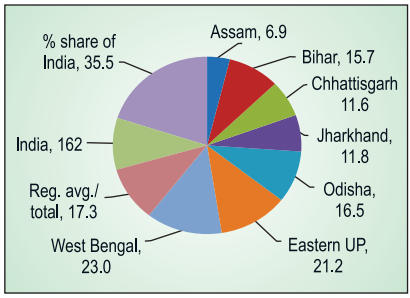


Fig. 3a Percentage of Scheduled Caste population

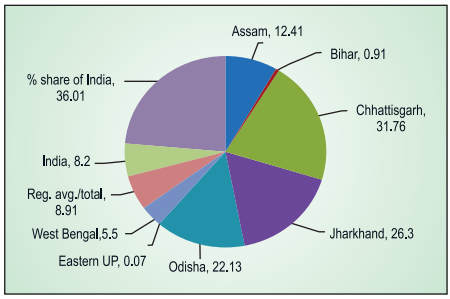


Fig. 3b Percentage of Scheduled Tribe population

The declining per capita land and water availability in agriculture would limit the food requirement of the burgeoning population by 2050 in the eastern states to a great extent. Water productivity is also very low (0.37 kg/m^3) in the region. Although the region has 165 million bovines, the crossbred cattle population is less than 5%. This sector has been almost neglected and its synergistic role in the farming practices has not been realized so far. The region also lacks quality feeds and fodder resources besides adequate animal health care mechanism. In case of fisheries sector, the total area under ponds and tanks in the eastern states is about 0.668 m ha with total fish production of only 1.43 m tonnes.

Low productivity in floodplain wetlands, 11.0 million ha of rice-fallow land, 7.5 million ha acidic and 3.81 million ha sodic soils also limits the crop productivity. Mono cropping, particularly in the Hill and Plateau region and Eastern Himalayas, is one of the major constraints to increase the cropping intensity. The wastelands/degraded lands (6.16 million ha) also need rehabilitation through agroforestry and horticulture interventions. Restoration of coal mining areas in the states like Jharkhand, Chhattisgarh and Odisha also needs to be addressed in the long run.

The major challenges ahead in the agriculture sector consist of:

(i) development of sustainable agriculture for food & nutritional security,

(ii) climatic vulnerability and its adverse impact on crop, animal and fish productivity; water availability and biodiversity,
(iii) maintenance and improvement of the status and quality of natural resources,
(iv) development of technologies for improving agri-horti crop production and protection,
(v) development of integrated location specific multi-commodity farming system involving filed crops, horticulture, aquatic, livestock, fisheries and other enterprises,
(vi) management of problematic soils
(vii) improvement in access to genetic material, information, knowledge and resources,
(viii) small farm mechanization
(ix) post-harvest management and value addition of agri-horti and aquatic crops,
(x) technology assessment, refinement and dissemination,
(xi) human resources development to address emerging challenges.

In order to meet out the afore mentioned challenges, ICAR-RCER proposes to take up these issues in the holistic manner in the next three and half decades to meet the food and nutritional requirement of the eastern region through network/consortia approach involving other ICAR institutes, SAUs, and other agencies for generating location-specific agricultural production technologies through sustainable use of natural resources.

Some of the specific issues need to be addressed are listed hereunder.

Fallow Management

Rice-fallow management, particularly in Eastern Himalayas and Hill and Plateau region is a major concern. Some of the rice-fallow lands could be brought under second crop of pulses & oilseeds with low water requirements, utilizing residual moisture. Pasture management and agroforestry with deep rooted fodder crops in integrated farming system mode of food production, along with crop diversification is the need of the hour.

Natural Resources Management

Soil management needs to maintain soil cover and return organic matter to the soil along with chemical fertilizers, i.e., integrated soil fertility management (ISFM) and microbial inoculants. It would be the best option for ensuring long-term soil sustainability and biodiversity conservation. Micronutrient deficiency, particularly zinc, iron, boron,

manganese, copper and sulphur, also need to be addressed in the soils of Eastern Indo Gangetic Plains (EIGP).

Furthermore, organic carbon pools and C/N dynamics in the soils need to be studied as they are components of the global carbon cycle. Amelioration of acidic soils is posing major challenge, particularly in the Hill and Plateau regions and Eastern Himalayan region. Residue management in soil would help to improve physico-chemical properties of soil, particularly in EIGP. Nutrient and water use efficiency has to be improved for long-term sustainable production. Conservation agriculture needs to be strengthened in rice-wheat ecosystem. Since the region has large area under wastelands/degraded lands, rehabilitation of such areas through agroforestry and horticultural interventions is also required for soil fertility build up, biomass augmentation and livelihood sustainability.

The eastern states receive average rainfall of 1526 mm (varies from 1091 to 2477 mm); however, its distribution is very erratic. On an average, the region receives 18% of the country's utilizable water resources. The ultimate irrigation potential in Eastern Region has been accounted for 33.65 million ha-m; however, the utilization of the created irrigation potential is only about 65%. The region also has about 4.05 million ha of wetlands (Fig. 4), which are, by and large, underutilized (Fig. 5). The use of ground water for agriculture is low mainly due to the paucity of energy. The share of electricity to agriculture sector is hardly 0.50 (Jharkhand) to 15.49% (Chhattisgarh) indicating that power is one of the main constraints to increase food production in the Eastern Region (Rai *et. al.,* 2009). Integrated Water Resources Management strategies for rain water harvesting and on-farm water management along with conjunctive use of rain, surface and ground water, multiple use of irrigation water, use of water saving and energy efficient devices are the need of the hour in this region.

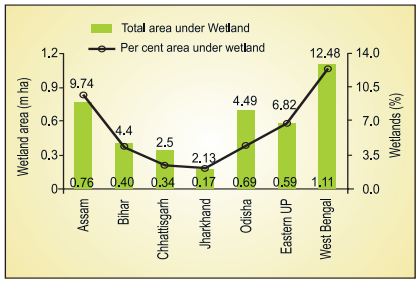


Fig. 4 Wetland area in different eastern states

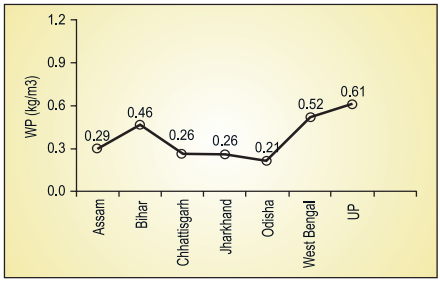


Fig. 5 Water productivity in different eastern states

Agro-biodiversity Conservation

Introduction of high yielding varieties for ushering second Green Revolution in eastern states may pose a threat to agrobiodiversity of the region. Conservation of important agri-horti and multipurpose tree-crop germplasm would help to achieve sustainable development, particularly in the projected climate change scenario. Traditional food crops including oilseeds, pulses, tuber crops, lesser known potential wild edibles etc. need to be conserved for sustainable food production in eastern region.

Reduction in post-harvest losses

According to the Food Corporation of India, some 23 million tonnes of food cereals, 12 million tonnes of fruits and 21 million tonnes of vegetables are lost each year, with a total estimated value of 240 billion Rupees. A recent estimate by the Ministry of Food Processing is that agricultural produce worth 580 billion Rupees is wasted in India each year. Necessary steps need to be taken to reduce these losses.

Livelihood Improvement of Landless Farmers

Although eastern states have only 21.85% geographical area of the country, it has very high number of economically most backward districts (Fig. 6). Livelihood of landless and underprivileged people of Eastern region is one of the major challenges ahead. Eastern states accounts for about 45% of the total underprivileged people at the national level. The livelihood options of these people need to be explored.

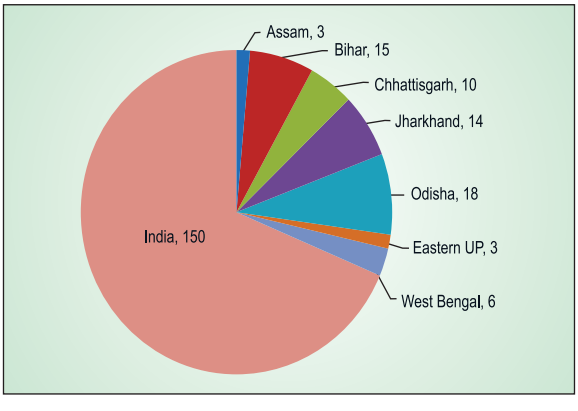


Fig. 6 Economically most backward districts in India and eastern states

GLOBAL SCENARIO

Food production must be doubled by 2050 to meet the demand of the world's growing population and innovative strategies are needed to help combat hunger, which has already affected more than 1 billion people in the world. The UN population projections indicate that the world total population could reach 9.15 billion in 2050. Globally, 90% of the growth in crop production is expected to be achieved only by increasing the yields together with increased cropping intensity and 80% of the increased production is likely to be contributed by the developing countries. Arable land would expand by some 70 m ha (or less than 5 per cent), with the expansion in developing countries by about 120 m ha (or 12 per cent) being offset by a decline of some 50 m ha (or 8 per cent) in the developed countries. Based on predicted population growth and urbanization, food and water demand will create greater challenges by 2050. According to one estimate, the average yield should reach nearly to 4.3 t/ha by 2050 compared to its present level of 3.2 t/ha.

INDIAN SCENARIO

India is the second most populated country in the world with over 1.2 billion people (Census of India, 2011). However, it is predicted that by 2050, it will be the most populous nation of the world with 1.6 billion populations. Whereas the population in Southern, Northern and Western states is expected to decline with varying degree, Eastern states like Bihar, Jharkhand, Chhattisgarh and Uttar Pradesh will continue with positive growth. To feed the burgeoning population, India will be required to produce around 377 million tonnes of food grains with less water and a declining rural work force.

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Operating Environment

The Eastern region of India is rich in natural resources. However, its potential could not be harnessed in terms of improving agricultural productivity, poverty alleviation and livelihood improvement. It is rightfully thought that the second Green Revolution would be started in the Eastern Region to ensure food security of the nation. To achieve this, the large untapped production reservoir should be exploited through an appropriate blend of technologies, services, input and output rising policies and above all farmer's participation.

The growing demand for food grains, vegetable, fruits, milk, poultry, fish and meat as well as cash crops is posing newer challenges to agriculture. The demand for food will depend largely on income growth and food consumption patterns. Total human population for the eastern states have been projected to be 556.24 million (Table 2).

Table 2 Rural urban population in Eastern India 2011 and projected in 2050 (Million nos.)

States	2011			2050		
	Rural	Urban	Total	Rural	Urban	Total
Assam	26.78	4.38	31.16	33.71	7.19	40.90
Bihar	92.07	11.73	103.8	139.74	21.88	161.62
Chhattisgarh	19.60	5.93	25.53	23.16	10.95	34.11
Eastern UP	62.68	17.79	80.74	86.91	31.35	118.26
Jharkhand	25.04	7.93	32.97	32.28	13.43	45.71
Odisha	34.95	6.99	41.94	37.80	10.66	48.46
West Bengal	62.21	29.13	91.34	60.03	47.15	107.18
Eastern region	323.33	83.88	407.48	413.63	142.61	556.24

(Source: Anonymous, 2011)

There are variable estimates projecting the future demand for cereal commodities. The projected growth in incomes, urbanization and change in consumption pattern are likely to have a great impact on food security. The demand for food grains production for 2050 in the eastern region is estimated to be 84.42 million tonnes (m t) (Table 3).

Table 3 State wise present (2011) and projected (2050) food statistics

States	Food grain available in 2008 (million tonnes)	Per capita food grain availability by 2011 (kg/year)	Food grain required in 2050 (million tonnes)	Projected food grain production in 2050 (million tonnes)	Per capita food grain available in 2050 (kg/yr)	Per capita food grain required in 2050 (kg/yr)	Estimated deficit by 2050 (million tonnes)
Assam	3.47	113	6.24	4.19	103	153	-2.05
Bihar	10.86	105	24.68	10.99	68	153	-13.69
Chhattisgarh	5.30	209	5.14	5.84	174	153	0.70
Eastern UP	17.56	222	18.06	19.40	165	153	1.34
Jharkhand	4.17	126	6.90	4.22	94	153	-2.68
Odisha	8.14	194	7.37	7.89	164	153	0. 52
West Bengal	16.05	179	16.04	19.71	188	153	3.67
Eastern region	65.55	162	84.42	72.28	131	153	- 12.19

Eastern states are likely to be worst hit by climate change. Significant decline in wheat production is expected by 2050 due to climate change. It may result in price rise jeopardizing food and nutritional security. Simulation studies showed decreasing trends of potential yields of rice and wheat in the Indo-Gangetic Plains with increasing minimum temperature. It is reported that an increase in minimum temperature by 2°C could decrease rice yield by about 0.75 tonne/ha in the high yielding areas and about 0.06 tonne/ha in the low yield coastal regions (Sinha and Swaminathan, 1991). However, rice productivity can be maintained and slightly improved with medium duration varieties. Simulated yield of *rabi* maize may increase from 8 to 11 % by 2020 and 14 to 25% by 2050, respectively. Rice area in Eastern Region may increase slightly (from 21.7m ha to 22.9m ha by 2050) with 18% increase in production and 12.2% increase in productivity, respectively (Fig. 7).

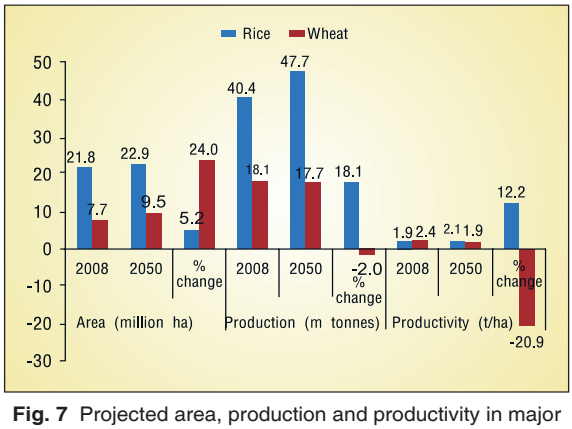


Fig. 7 Projected area, production and productivity in major cereals of eastern region

For wheat, although the area is projected to increase by 24% in 2050, the productivity may decline by 20%. However, there is scope for improving the productivity through adoption of improved varieties tolerant to abiotic stresses, adjustment in time of planting, duration and methods of planting etc.

The projected production of pulses and oilseeds is estimated to be 4.84 and 2.12 million tonnes, respectively, by the year 2050 compared to 2.77 million tonnes of pulses and 2.12 million of oilseeds during the year 2011 implying that production and productivity of pulses are expected to increase nearly by 75% from eastern states.

The area under fruit crops in eastern India is 1.30 million ha with total fruit production of 15.2 million tonnes against a projected demand of 17.8 million tonnes. By the year 2050, the projected fruit production would be 22.6 million tonnes with the help of large scale area expansion and productivity improvement programmes. However, a deficit of 1.6 million tonnes of fruits is projected by 2050 (Fig. 8 a).

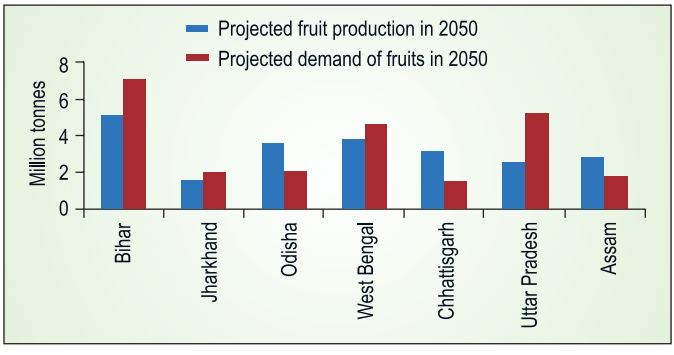


Fig. 8a Projected demand and supply of fruits by 2050

Likewise, as of now, the total vegetable production in eastern India is estimated to be 66.97 million tonnes from 3.92 million ha area. With a projected production of 90.4 million tonnes by 2050, eastern India will have a vegetable surplus of 30.0 million tonnes and the region will play a major role

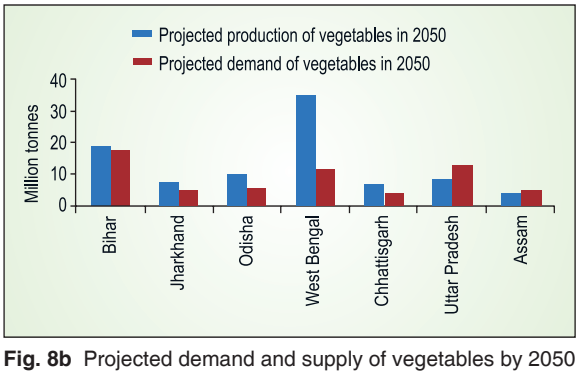


Fig. 8b Projected demand and supply of vegetables by 2050

in fulfilling the vegetable requirement of other parts of India (Fig.8b). However, it will require a significant investment and efforts to strengthen the infrastructure for transportation and post-harvest management.

In case of milk, the projected demand would be 60.41 million tonnes as against the supply of 48.92 million tonnes by 2050 (Fig. 9 a & b).

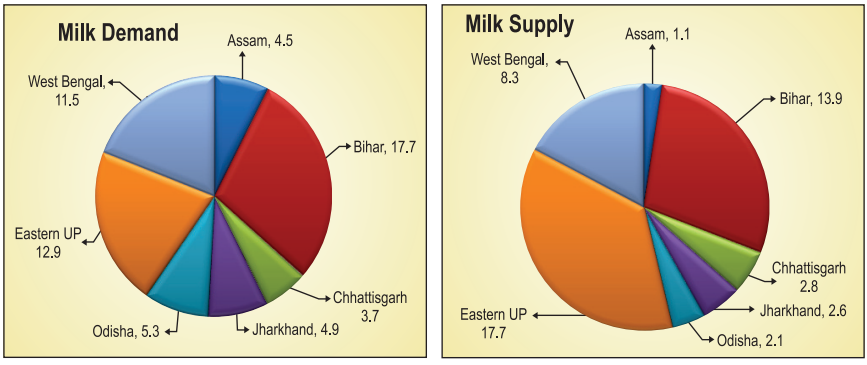


Fig. 9 a & b Demand and supply in milk production in eastern states

Demand for meat products is likely to be 6.08 million tonnes against the likely supply of 3.12 million tonnes. Demand for eggs would be 99.32 billion against a likely supply of 37.81 billion. Total fish requirement is projected to be 6.06 million tonnes by 2050 as against the current production of 2.71 million tonnes. However, it is expected that the region would be self sufficient to meet out the fish requirement (Fig. 10 a & b).

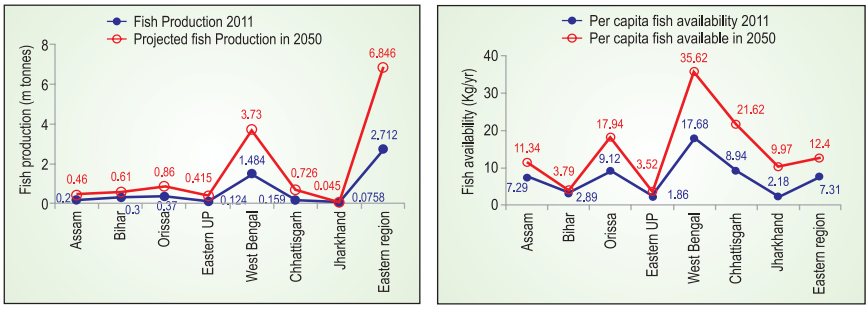


Fig. 10 a & b Fish production and per capita availability in eastern states

New Opportunities

Institute visualizes long-term sustainable production through integration of crop-water-animal-fish-agroforestry-horticulture in holistic manner. Public–private partnership for sustaining chain of producer to consumer and to minimize post-harvest losses, policy support for value chain in pulse and oilseeds marketing also fall under essential requirements.

Some of the new areas where the institute would like to focus on research and extension in the next three and half decade are discussed below:

System Mode Production

Eastern states have ample scope for increasing productivity in system mode, wherein the synergy of crop-livestock-fish-agroforestry-horticulture could be harnessed. Productivity of the system, however, will depend on recycling of renewable farm resources, which call for integrating livestock, fish, poultry and duckery so as to develop sustainable production systems. Hence, research strategies should aim at productivity enhancement, diversification, minimization of production losses through risk management, processing and value addition, and commercialization based on market intelligence.

Makhana Cultivation in Cropping and Farming System Mode

Makhana, an unique crop of the eastern Region, is grown in about 13000 ha of water bodies with a popped makhana production of 9360 tonnes. Its cultivation, however, is constrained by shrinking water bodies on the one hand and the skill required for collection of nuts, roasting and popping of nuts. The institute has developed technology for makhana cultivation in a cropping system mode, which has resulted into higher productivity with less water requirement and reduction in drudgery associated with makhana nut harvesting. Adoption of this technology could bring 1.10 million ha of waterlogged areas under makhana cultivation, which otherwise remained unutilized or underexploited. Promising strain of makhana has also been identified which has a productivity of 2.8 to 3.0 tonnes/ha compared to 1.4 to 1.6 tonnes/ha for the traditional cultivars. The technology of integrated farming of makhana with fish and water chestnut, developed by the institute, is

also gaining popularity among the farmers, particularly in north Bihar. Although production technologies for makhana are available now, its mechanization is still a major challenge. Therefore, development of a prototype for makhana grading and popping is essential for achieving value addition in this important crop.

Integrated Farming Systems

Integrated Farming System (IFS) is generally considered relevant to the rural poor. The emphasis in such system is on optimizing resource utilization rather than maximizing the productivity of a certain component in the system. The concept of IFS has come into picture in order to achieve food and nutrition security at household and even at individual level besides generating employment opportunities, increasing cropping intensity and net income of the farming family, and conservation of natural resources. Integrated farming system, also involves agricultural intensifications, diversification and value addition. It helps improve physical and economic access to food, thereby sustaining food security.

Management of Rice-fallows

About 11 M ha of land in the eastern region is mono-cropped with rice, and remains fallow after rice harvest. A second crop of oilseeds, pulses, vegetables and fodder crops can be raised through effective utilization of residual moisture and appropriate rainwater management/ conservation technologies in rice-fallow areas.

Organic farming

Some regions of the eastern states are moving towards adopting the policy of organic food production systems. Since the demand of organic food is increasing in markets, there is a need to strengthen the research on organic farming in specific crops. The Government policies provide new avenues of research in this direction. Chhattisgarh government has already launched an 'organic farming mission' in districts of Bastar, Bilaspur and Ambikapur. Under the mission, the government would provide infrastructure, certification and knowledge to farmers, who opt for organic farming.

Synergistic Role of Livestock in Farming Systems

Eastern states contribute about 31% of the total livestock and 27.2% of total poultry population of India, respectively (Fig. 11a &

b). Livestock has been an integral component of all farming situations implying its role in risk avoidance and providing some insurance against failure of crop/enterprise in adverse climatic conditions. The synergistic roles of livestock need to be understood in order to develop location-specific integrated farming systems for long-term sustainable production. Aspects relating to balanced feeding, based on locally available feed resources, mineral supplementation, deworming and vaccination, green fodder supply, maintaining improved breed, reproductive management, etc. need to be addressed for animal husbandry practices to be profitable in different farming situations.

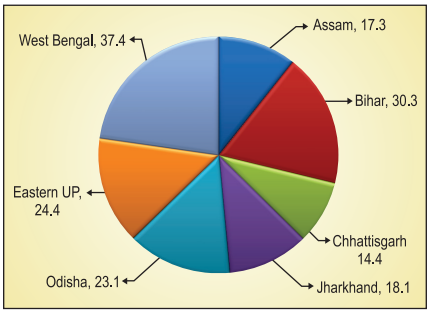


Fig. 11a Livestock population (million nos.) in eastern states

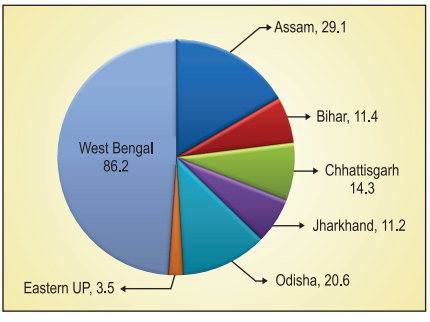


Fig. 11a Poultry population (million nos.) in eastern states

Integrated Fish Farming

The eastern region has 4.05 million ha of wetlands and 2.92 million ha of fresh water bodies, where fish-cum-duck, fish-cum-chicken, fish-cum-cattle, fish-cum-goat, fish-cum-pig, fish-cum-buffalo integrations are promising. It will play an important role in increasing employment opportunities, and income of rural populations. Such integrations are also feasible for *taal, chaur* and *maun* areas of Bihar. On an average, the fish production could increase by 3-4-fold when integrated fish farming is practised. However, quality seed production, brood management, diversification in aquaculture, standardization of stocking density of composite fish culture for diverse agroclimatic zones need to be studied and validated.

Conservation and Sustainable Use of Floodplain Wetlands

Eastern states have extensive freshwater wetlands, locally known as b*eels, mauns, tals, chaurs, jheels* and *pats* in the states of Assam, West Bengal, Bihar and Uttar Pradesh. These natural water bodies are integral

part of rivers and are formed as a result of the rivers changing their course. These floodplain wetlands are one of the prime resources for inland fisheries besides production of agricultural crops. These water bodies, however, are highly sensitive and fragile and need eco-friendly management to support the biological wealth. Considering the limited scope of capture fisheries from coastal waters and natural inland waters like rivers and estuaries, greater emphasis must be given for aquaculture and culture-based fisheries from reservoirs and floodplain wetlands to meet the targeted fish requirement of 6.06 million tonnes by 2050 as against the present level of 2.92 million tonnes for the eastern region. A systematic and integrated approach for fish culture in small and big reservoirs/rivers/*chaurs/mauns* on watershed approach supported by scientific studies is needed.

Conjunctive Use of Water

In order to address various issues related to assessment of spatial and temporal variability of water available from different sources, its conservation, storage, extraction, release, allocation, distribution, utilization and management in agriculture, there is a need to focus research efforts on the following aspects of water management.

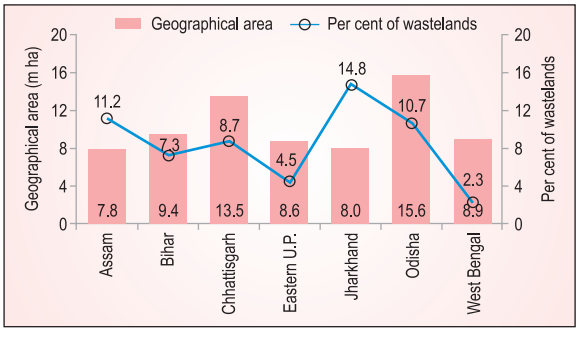
- Scientific and comprehensive assessment of water resources, monitoring and evaluation of water extraction, storage and use, and enhance income per unit of water consumed in eastern region.
- Promotion of sustainable use of groundwater resource in unexploited zone and conjunctive use of water.
- Development of decision support tools/systems to facilitate farmers to judiciously utilize rain, surface and ground water resources.
- Impact of climate change on water resources and coping up strategies.
- Institutionalize participatory management of water (Water Users Associations, including proactive women's participation), rationalize water pricing and operational and maintenance charges and distribution of irrigation water and equitable access to water as a common resource.

Scaling Up Water Productivity

Promotion of technologies related to multiple uses of water, on-farm water management, irrigation water management including irrigation methods for small holder irrigation, management of flood prone/water congested/ waterlogged areas, rainwater harvesting, ground water recharging techniques and participatory watershed management

in rainfed areas are required to augment water availability and improve productivity per drop of water in eastern region.

Agroforestry Interventions



Sustainability of production in the eastern region could be achieved through agroforestry, particularly in the rainfed Hill and Plateau region. Agri-silviculture, agri-horticulture, agri-horti-silvi-pastoral and silvi-pastoral systems hold promise for biomass augmentation, soil fertility build up, moisture conservation and availability of minor forest produce. Since, tribal communities of the region rely heavily on forests for their subsistence, location specific agroforestry systems need to be developed. Multi-storied agroforestry and horticulture models are already gaining popularity in the region. The region also has a large area under degraded lands (6.16 million ha) and rehabilitation of such areas through suitable agroforestry models and integrated watershed management should be given priority (Fig. 12).

Conservation Agriculture

Puddling in transplanted rice and excessive tillage in subsequent wheat crop, have changed the soil physical conditions of the region drastically. Conservation agriculture practices like direct sowing, laser levelling, retention of residues and minimum tillage hold promise in conserving moisture, nutrients and energy and thereby reducing the cost of cultivation apart from maintaining and improving carbon stock in the soil. There is potential to convert 2-3 million ha area under conservation agriculture in eastern region. Long-term studies are, however, required for adapting different crop production systems, including maize and pulses under conservation agriculture. Suitable varieties of different crops for conservation agriculture also need to be evolved.

Harnessing Green Energy

The annual average Direct Normal Irradiance (DNI) in the eastern region varies between 4.0-5.5 KWh/m2/day. There is scope for harnessing this abundant natural resource through photovoltaic technology. The

efficiency of photovoltaic technology, however, is reported to be in the range of 10-16%, which needs to be improved to make its use in various agricultural production systems. Biofuels, including biodiesel from palm oil and ethanol from sugarcane, sweet sorghum, corn, etc. need to be explored.

Secondary Agriculture

Post-harvest losses are very high, particularly in perishable commodities. Lack of market availability within reasonable distance from the production site and poor road network, storage and transportation infrastructure further adds to the problem. Except few crops, the potentialities for agro-based or bio-based industries have not been realized due to lack of infrastructure. Recently, agro-industrial potentialities of crops like makhana, maize, soybean, potato, litchi, etc. have been recognized. Tuber crops such as yams, sweet potato, taro, tapioca etc., can be used as source of carbohydrate, starch and protein not only for human consumption but also to sustain the traditional animal husbandry practices. Besides, sericulture, mushrooms, floriculture, apiculture, natural gum and resins opens great scope for widening of agro-based enterprises. Fiber crops such as jute, mesta, banana, flex, sun hemp etc., are also important. Agro-waste such as paddy husk, rice bran, rice straw, sugarcane bagasse, press mud, vermicompost, etc., can be good materials that require urgent consideration for development. Keeping these facts in view, there is ample opportunity in developing secondary agriculture, primary processing, value addition and increasing shelf-life of farm produce so as to improve upon the livelihood of the large population, particularly the landless farmers' of eastern states.

Mechanization

Like other parts of the country, the eastern region also faces acute labour shortage for agricultural operations, and non-availability of manpower during peak crop season is a growing problem. In small and marginal farms, except for tillage, other operations such as sowing/ transplanting, weeding, cotton picking, harvesting and threshing, etc. are normally manually performed. Mechanization also imparts capacity to the farmers to carry out farm operations, with ease and freedom from drudgery, making the farming agreeable vocation for educated youth as well. Therefore, development of need-based tools and implements need to be given priority to achieve timeliness and improves productivity and input-use efficiency.

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Goals and Targets

The necessity to grow enough food, feed, fuel and fibres to meet requirements of the ever-increasing population has put tremendous pressure on natural resources and their management. There is degradation of resource-base in the form of large scale soil and water erosion in the hill and plateau areas, appearance of wide-scale secondary salinization and water logging in the irrigated and flood-affected areas, deterioration in water quality, diminishing forest cover and inaccessibility to the costly inputs in agriculture.

Since pressure on available soil resources are increasing with time, its effective and rational use will be the core strategy to increase the productivity on sustainable basis. Soil health and fertility must also draw immediate attention of all concerned, especially when organic matter content has gone down (0.3-0.5 per cent), and several micro nutrient deficiencies are now surfacing prominently. Thus, there is a strong need for conserving soil and land resources, and preserving natural ecosystem in proper equilibrium so that short-term exploitative measures on soil resources do not jeopardize long-term sustenance of soil productivity and health.

Large productivity gaps, which exist in the region, could be met out through system approach of farming. On an average, productivity and total food production could be doubled in irrigated ecosystem through quality seed supply, timeliness in operations, improved water management practices, integrated nutrient management, pest control, post-harvest handling and storage. In case of rainfed agriculture, the productivity could increase by 60%. During next 40 years, the institute also envisages to improve upon the livelihood of landless and poorest of the poor population so as to make them self sufficient through agricultural innovations.

The seed replacement rate in most crops, particularly pulses and oilseeds in the eastern region, is extremely low (< 10%), which affects adversely its productivity. This is even more critical in the rainfed agro-ecosystems, particularly in Hill and Plateau region. Seed replacement rate is about 25% in case of rice and wheat. Hence, seed production may be adopted in participatory/ PPP mode and even truthfully labelled seeds may be produced.

About 75% farmers of the eastern states are small and marginal, small-farm mechanization implements like power tiller, weeder, small scale planters, laser leveller, mechanical transplanter for rice, seed drills, maize sheller, wheel hoe, sprayers, reaper etc. should be made available preferably through custom hiring and agri-service centres. With the help of small farm mechanization, conservation agriculture in rice-wheat cropping systems would be extended. Crop diversification and intensification through cultivation of spring/summer crops like pulses, maize, cowpea etc. will be another focal theme of the institute's research agenda.

Eastern states have nearly 19.42 million ha rainfed area, which has the potential of organic food production. It is expected that about 25% area (i.e., 4.85 mha) would be brought under organic category during the next 40 years. There is also ample scope for protected cultivation. High value and low volume crops would occupy an additional area of two lakh ha for export oriented production.

A significant breakthrough is expected in the production of makhana. It is expected that the makhana cultivation would be possible at least in 0.1 million ha with the additional seed production of 2,80,000 tonnes which would produce about 1,12,000 tonnes of popped makhana costing Rs 56,000 million in the domestic market. The region is also expected to be a leading exporter of vegetables in the next 40 years. Average vegetable productivity is expected to increase to 20.64 tonnes/ha during next 40 years from its present level of 15.88 tonnes/ha. Likewise, in case of fruit crops, the productivity is expected to reach 15.0 tonnes/ha from its present level of 11.70 tonnes/ha. Peri-urban horticulture and aquaculture would also increase in the region.

Integrated farming systems which involve agricultural intensification, diversification and value addition would be replicated in an area of 20,000 ha for sustainable food production during next 40 years. Potential wild edibles would be domesticated in the farming practices. Likewise, promising tribal farming systems would be replicated in similar agro-climatic zones for sustainable production. Integrated farming system models in irrigated and rainfed ecosystems would be scaled up incorporating location-specific climate-resilient features so as to achieve food and nutritional security, and also to mitigate adverse climate change impacts.

Livestock production and management

Eastern region is inhabited by large numbers of non-descript cattle, buffalo and poultry whose productivity is very low in comparison

to national average. By employing state of art technologies, the complex will focus on genetic improvement of dairy animals and small ruminants, management of fertility and health, improving immunity and reproductive efficiency of animals and birds, enhancement of production through optimized nutrients utilization, introduction of high yielding and nutritious fodder variety, feed quality and safety for better animal production, and application of precision production and management system for livestock and poultry. Amelioration of climatic stressor like high humidity and temperature will be addressed through better management and nutritional practices.

Livestock is an integral part of the farming system in the region as crop alone cannot sustain the farm families due to small and fragmented land holdings. However, synergistic role of livestock and poultry has not been worked out in diverse farming system with crop, horticulture, fisheries to support the livelihood of rural households. Since, the region is prone to frequent natural calamities particularly flood and drought, suitable management strategies will be developed for risk minimization. Crop-livestock-water interactions including livestock water productivity need attention in the region. Since, per capita land holding will decline and agrarian structure will be transformed, round the year fodder supply to livestock will be a critical issue in the region which needs to be addressed. Fodder production and feeding calendar in rainfed areas will be given importance.

Fishery management

Quality fish seed and fish feed are the major issues which need to be addressed through state of art technologies. Quality brood stock management as well as research on diversification of fish culture practices especially in flood prone and waterlogged areas like *chaurs, mauns* as well as popularisation of pen and cage culture practices for enhancing fish production are the need of the day. Integrated fish farming is also having enough scope in the region. Species diversification especially with *Bata, Puntius* etc can also be more remunerative and also need to be introduced in polyculture as well as integrated farming system. High value fishes like magur, prawn etc need to be cultured in large scale. Monitoring and timely diagnosis of fish diseases is also a major issue in the region.

Post- Harvest Processing and Value Addition

Post-harvest losses of fruits and vegetables account for about 25% of total loss. Efforts would be made to minimize post harvest losses

through improved post-harvest handling and storage in case of litchi, mango, guava, banana, aonla, jackfruit and other perishable commodities like tomato, brinjal, cauliflower, cabbage, peas, which have poor shelf life. Value addition through integrated value chains and market intelligence would also be priority of the institute. Research on developing suitable and economical post-harvest technologies for processing, preservation and value addition of important horticultural products is yet another priority of the complex.

Access to Information and Knowledge

Access to information and knowledge is vital for increasing food production. To equip personnel with state-of-the-art technology skill, expertise and knowledge, capacity building programmes in cutting-edge technologies and frontier areas viz. climate change impact modelling, risk analysis and management, intensive integrated faming system research, water productivity assessment, multiple use of water, bio-informatics, information and communication technology, behavioural science and research management skills, IPR issues, integrated water management, integrated aquaculture management and socio-economic and policy research are envisaged. Brainstorming meetings, effective co-ordination of multi-commodity, multi-disciplinary research and co-ordination with line departments of state/central government will be done to advocate policy issues for the benefit of stakeholders.

Institutions and Policies

Policy research will be an integral part of the mission of the Complex. In order to disseminate agricultural technologies, socio-economic constraints in adoption of biophysical solution will be identified. Principles and policy guidelines will be developed for integration of production technologies with socio-economic environment. Major emphasis will be given for socio-economic characterization of the region so as to identify the removable production constraints. Through its research and outreach activities and development of suitable service delivery system/mechanism, the policies shall be promoted to reduce poverty, improve food and nutritional security, and alleviate pressure on fragile natural resources. Taken together these activities will create a formidable matrix for advancing sustainable agricultural development in the region.

Women Empowerment through Agriculture

In general, decision making ability in connection with agriculture

remains with male farmers in spite of the fact that female farmers have a significant role in agricultural growth. Over 75% of the daily time of a rural woman is spent on farming related activities, including caring for livestock and the collection of water. Empowerment for women, therefore, would increase their capacity to define, analyse and act upon problems being faced by them in agriculture. Eastern states have about 28% rural womenfolk associated with agriculture and allied activities. To ensure the role of women farmers in agriculture, specific measures like assisting women to get exposure to create the mind set for change, assistance to access services, specific attention to the landless women households, access to timely and quality information, livelihood diversification, assistance for the marketing of farm produce etc. need to be undertaken.

Transfer of Technology

Technologies developed at research stations have to be assessed at micro level with greater involvement of farmers and accordingly modified to suit the needs of the clientele. To bridge the gap between the technologies developed at research stations and its adoption by major stakeholders especially by farmers, technology assessment, refinement and dissemination will be taken up. Research on policy, institutional support, value chain and markets will be on priority. Networking of research and extension machinery will be established with forward and backward linkages.

Given below are the strategies to achieve the targeted objectives to fulfil the desired output:

Goal	Approach	Performance measure
Development of sustainable agriculture for food & nutritional security	• Sustained agricultural intensification for higher productivity and quality output from shrinking land and water resources. • Appropriate crop sequences for efficient utilization of natural resources. • Enhancing potential of different irrigation systems in eastern India. • Developing technologies for affordable high - tech and precision agriculture. • Development of crop-livestock-fish based IFS models. • Development of technologies and value addition for improving keeping quality of livestock-fish products. • Improvement of livestock, fish and poultry breed through selection and/or crossbreeding.	• Contribution of research and development in resource conservation and productive utilization of resources. • Income and employment generation. • Improved growth and yield. • Increase in digestibility and feed conversion ratio.

Goal	Approach	Performance measure
	• Characterization of indigenous livestock, poultry and fish breeds/ species. • Improving feed utilization of livestock and fishery employing scientific techniques. • Sustained agricultural intensification for higher productivity and quality output from shrinking pond and water resources. • Enhancing potential of different water bodies through makhana based farming systems. • Increasing productivity of makhana for value added products, ensuring marketability and profitability.	
	• Approaches for climate change adaptation and mitigation. • Development of strategies and technologies for productive utilization of Tal, Diara, Chaur and Maun areas. • Resource mapping using GIS technique & remote sensing for better and efficient utilization of land and water resources. • Disaster management and mitigation strategies.	• Technologies and management strategies developed for flood and drought management. • Assess vulnerabilities of water management and selection of best strategy to compensate for climate change.
	Carbon sequestration to increase soil organic carbon pool • Enhancement of carbon stock of the native soil. • Development of suitable cropping system for enhanced C-stock in the soil.	• Increasing the C-stock in the soil leading to increasing soil fertility.
	• Management options to improve soil health and land quality. • Technological options to enhance water-use efficiencies, water quality, and increase water availability. • Quality assessment of soils and land characterization of different agro-ecosystems. • Ground water quality assessment and mitigation measures. • Location based integrated watershed management. • Ensuring environmental security using appropriate technology • Exploring options for conjunctive use of rain, surface and ground water in canal command. • Development of high producing low water consuming fodder varieties. • Restoration of degraded lands through agroforestry interventions. • Strengthening and assessing Decision Support System for optimizing use of critical inputs and enhancing productivity/ profitability.	• Improved water and input-use efficiencies • Reclaimed degraded soil, land and water resources. • Maintain and improve the status and quality of natural resources.

Goal	Approach	Performance measure
	Crop Improvement • Germplasm conservation: Collection and conservation of genetic resources of agri-horti crops including leafy, minor and underutilized vegetables. • Sustainable use of germplasm: Characterization genetic enhancement, pre-breeding, distant hybridization using tissue culture, functional genomics and proteomics. • Development of new cultivars specific to climate change induced biotic and abiotic stresses. • Development of cultivars with high nutritional and medicinal value including leafy vegetables. • Development of cultivars specific to agro industries and protected horticultural cultivation • DNA barcoding of public and private sector cultivars. • Maintenance breeding of parental lines and varieties-purity maintenance during seed production and DUS characteristics under PPV & FRA reguatories. • Seed quality enhancement and production of quality seed and planting material.	• Shared germplasm, new genes/cultivars. • Climate resilient horticulture. • Promote trade, avoid gene piracy and reduce malnutrition. • Quality seed production.
	Crop production • Rice-fallow management • Development of improved package of practices for agri-horti crops with respect to climate change by resource conservation technologies, INM etc of eco-friendly approaches. • Development of sustainable cropping, intercropping, multitier cropping systems for enhancing productivity. • Development of integrated farming system models by diversified cropping enterprise system. • Promoting small farm mechanization	• Improved livelihood of farmers by enhancing income. • Improved input use efficiency. • Food and nutritional security
	Development of quality cultivars of agri-horti crops • Exploration, collection, conservation, evaluation and utilization of genetic resources of agri-horti crops. • Widening genetic base through sexual reproduction in horticultural crops. • Ensuring supply of quality seed and planting material in case of fruit and vegetable crops.	• Identification of superior genotypes of different agri-horti crops so as to increase the production.
	Increased productivity of fruit based production system in eastern plateau and hill region with improved quality of produce • Standardization of technologies for high density orcharding of different fruit crops. • Participatory action research for ameliorating biotic and abiotic constraints in fruit based production system.	• Nutritional security and livelihood improvement in rainfed agro-ecosystems.

Goal	Approach	Performance measure
	• Development of fruit based multicommodity production system. • Development of protocol for organic cultivation of fruit crops.	
	Nutrient management for horticultural crops • Develop and evaluate site specific nutrient management for horticultural crops. • Development of nutrient deficiency soil map of the eastern plateau region with the support of state of the art tools like GIS and Remote Sensing. • Identification of limits of nutrient element for horticultural crops.	• Use of right source of nutrient at right time. • Balanced fertilization.
	Maintaining soil microbial health • Identification of native soil microorganisms promoting plant growth in the acid soil of eastern plateau region. • Exploring the possibilities of use of native microbial consortia for increasing the productivity of horticultural crops.	• Enhancement of the productivity and fertility status of the native acid soils.
Development of integrated location specific multi-commodity farming system involving filed crops, horticulture, aquatic, livestock, fisheries and other enterprises,	• Participatory development of integrated farming system models for food and nutritional security.	• Increased livelihood security of small holders, employment generation and natural resource management.
Management of problematic soils	• Identification of types of soil acidity in the surface and sub-surface horizon. • Identifying the agri-horti crops resistant to soil acidity. • Identification of toxic elements present in the soil and its effect on crops. • Integrated use of organic and inorganic material for management of soil acidity.	• Increasing the productivity of agri-horti crops in the acid soils of eastern plateau region.
Improve access to genetic material, information, knowledge and resources	**Makhana** • Collection & evaluation of Gorgon nut germplam. • Development of new genetic variability and improvement of makhana through induced mutagenesis. • Germplasm exploration and maintenance in gene bank. • Horizontal expansion of promising cultivars of makhana.	• Improve access to genetic material, information, knowledge and resources. • Crop diversification.

Goal	Approach	Performance measure
	ICTs • Improve access to technologies through effective use of Information and Communication Technology (ICT) and knowledge management. • Strengthening service delivery system through ICTs tools and farmers' service centre. • Access to location specific data and knowledge resources.	Access to information and knowledge on agricultural technologies.
Post-harvest management and value addition of agri-horti and aquatic crops	• Developing data base on traditional foods of eastern region especially of tribal societies. • Information generation on post harvest processing, preservation and value addition of food crops and to create/disseminate information to the related industries. • Design, fabrication & commercialization of makhana popping machine.	Increase in number of processing units in eastern region
	• Harnessing solar energy for irrigation and post-harvest technologies • Development of improved post harvest technology to minimize the post harvest losses in field, during storage and transportation. • Enhancing shelf life of horticultural commodity. • Development of diversified horticultural commodities.	Value addition
Human resources development to address emerging challenges	• Formulating network of Research Organizations for meeting R & D needs of prioritized researchable issues. • Capacity strengthening of scientists and technical personnel through training at the national and international level. • Organizing training programmes for various stakeholders. • Capacity strengthening through trainings on scaling up productivity of soil and water in different production system. • Organizing brainstorming meetings, effective co-ordination of multi-commodity, multi-disciplinary research and liaisoning with line departments of state/ central government.	• Improved research efficiency. • Qualified manpower in agriculture, agri-research and agri-business.

Way Forward

The approach for achieving food security in the Eastern Region would be sustainability, crop diversity and community based management of natural resources with technological backup. The necessity to grow enough food, feed, fuel and fibres to meet requirements of the ever-increasing population has put the soil, water and vegetation under severe stress. The problem of soil degradation through erosion, pollution and salinization is also growing and needs to be addressed. Since pressure on available limited soil resources will increase with time, effective and rational use of this resource will be the core strategy to increase future productivity on sustainable basis. Soil health and fertility must also draw immediate attention of all concerned, especially when organic matter content has gone as low (0.3 to 0.5%), and several micronutrient deficiencies are now surfacing prominently. Thus, there is a strong need for conserving soil and land resources and preserving natural ecosystem so that short-term exploitative measures on soil resources do not jeopardize long-term sustenance of soil productivity and health. Following strategies will be adopted to achieve the goals and targets in the changing scenario.

- Availability of water for agriculture will be limited in future to meet the domestic, industrial and other uses, which are increasing from year to year. It is estimated that even after achieving the full irrigation potential, nearly 50 to 55% of the total cultivated area will remain rainfed.
- Issues relating to management of supplies to improve availability of water in time and space, management of demands through improvement in storage, transport, water allocation, scheduling and application technologies, and preservation of integrity of water-dependent ecosystems through development of decision-support systems for disposal and reuse of waste water need to be addressed. Special efforts will have to be made to evolve technologies for prevention and amelioration of salinity in irrigation commands, which are based on harnessing synergy of hydraulics and plant biology. Also multiple use technologies that enhance water productivity without consumptive use such as fish production in irrigation storage and conveyance system will have to be planned. Research aimed at capturing technology-policy interactions in respect

of water market, pricing, security for quality and dependability will have to be undertaken to develop water management options. Judicious use of ground water and rain water harvesting is also need of the hour.

- Resource conservation technologies (RCTs) would be given due importance in order to meet out emerging challenges of sustainability. Technologies are available for holistic development of land through integrated watershed management, particularly in the Hill and Plateau region. Precision faming is also an emerging area of research for resource conservation. New technologies on value addition, food safety and greenhouse gas mitigation need to be tested and replicated in the region. Agroforestry in the context of energy farming and carbon trading provides opportunities in the region, particularly in the hilly and plateau regions.
- Horticultural crops would play a major role in market driven diversification of the existing production systems. Hence development of customized horticultural production system fitting the resource base of farmers with the objective of maximizing income and ensuring livelihood security of farming communities of eastern region will be imperative.
- With land resources becoming scarce in time to come, protected cultivation of high value crops in multitier systems, its nutrition and crop management strategies will become high priority area. Land use advisory service will be a priority area for effective utilization of scarce land resources of different agro-ecologies. Since higher production from rainfed areas is a priority for sustainable second green revolution, watershed based water management and budgeting will be taken up on priority basis.
- Second Green Revolution should focus on generation of employment for the small and marginal farmers and the landless, while enhancing agricultural production. Developing location-specific integrated farming system modules (IFS) having synergistic interaction of agri-horti crops, agroforestry, fishery, livestock, poultry, beekeeping and mushroom need to be replicated to enhance the income of the stakeholders of the Eastern region. Organic farming zones will be identified in the region.
- Livestock is an integral part of food and nutritional security and even landless farmers can derive livelihood through livestock farming. Agricultural biosecurity system will be developed to prevent pandemics in avian and animal population.
- Secondary agriculture promoting processing and value addition of

agricultural commodities and horticultural produce is another thrust area for economic upliftment of predominantly agrarian economy of Eastern region.

- Weather based forecast for land use planning is also required keeping in view of the vagaries of monsoon. Eastern region consists of very high percentage of small and marginal farmers and significant population below poverty line. Climate resilient crops, farming systems and enterprises are a major thrust area considering the changing climate scenario and agro ecological situations.
- Framing up forward looking research agenda on biotechnology and use of ICT in agriculture in the areas of innovative technology generation need to be focused for increase in food production.
- The strategies to meet the challenges will comprise of striving to harness the power of science for increasing productivity, enhancing input use efficiency, reducing cost and post -harvest losses, minimizing risks and improving quality of food commodities through conventional techniques as well as new science and tools.
- ICAR-RCER, Patna realizes the need to reengineer the process to bring improvements in order to ensure a firm new mind set to transform the organization to excellence. Building a capable organization will obviously require competent people, building core competencies and competitive abilities, restructuring the organization and work with efficient and effective support system, which will result in development of committed leadership, effective communication and team building. Regional networking with SAUs, KVKs, NGOs, line departments and other social organizations will create the foundation to address the challenges.

Human resources requirement and trainings

Overall growth of agricultural sector demands skilled and efficient human resources not only for the organizational needs of the sector but also to meet the requirements of R&D institutions for developing and evaluating newer technologies. Therefore, the Institute would give emphasis to strengthen its HRD programme by incorporating newer and need based course curriculum. Tailor made training programmes on integrated farming system, water productivity improvement, multiple uses of water, conservation agriculture, livestock, poultry and fish diagnostic and prevention, integrated aquaculture etc with emphasis on hands on training would be developed. Technology delivery systems with the latest ICTs mass communication tools would be developed and strengthened by developing linkages with SAUs, Govt. Departments, KVKs, NGOs,

private R&D organizations and international agencies. Participatory approaches would be employed for refining and demonstration of technologies to the stake holders. For quicker dissemination of information/ feedback, a common platform is required for the eastern region through a cyber-based information exchange system.

Infrastructure Requirement

Augmentation and modernization of infrastructure and establishment of wetland rehabilitation centre, hi-tech laboratories in the area of soil, disease and pest management, plant physiology and biotechnology, animal disease diagnostics and prevention, feed technology, tissue culture, post-harvest technology, meteorology, GIS, Agricultural Technology Information Centre (ATIC), Agriculture Mechanization and Development Centre (AMDC), Green Energy Harnessing Unit, Rainout Shelter, seed processing etc. following the norms of International Standard Organization to face the R&D challenges emerging from rising demands, instabilities in production-consumption systems, climate change and growing globalization etc. Emphasis will be given on creation of State of Art facilities for planting material production and establishment of 'Centre for Organic Farming'. Furthermore, to disseminate the diversified integrated farming system, water management, wetland management, multiples uses of water, conservation agriculture, climate resilient agriculture and useful implements for small farm mechanization, etc., research centres would be established. Institutional arrangements would also be strengthened to handle the issues concerning IPRs.

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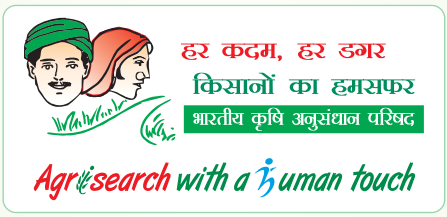
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