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Agricultural transformation in northeast India: Challenges, opportunities, and institutional pathways

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The North Eastern Region (NER) of India, encompassing Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, spans approximately 2,62,179 km² and is a home to about 45.5 million people. Blessed with abundant biodiversity, fertile soils, and varied agro-climatic conditions, the region holds vast potential for agricultural growth while simultaneously facing enduring developmental challenges. Agriculture remains the backbone of the region, engaging more than 70% of its rural population, yet productivity and market integration lag behind national averages due to constraints such as fragmented landholdings, inadequate infrastructure, and increasing climate variability. This paper critically examines the challenges,, opportunities and institutional pathways shaping agricultural transformation in the NER. It highlights the role of key institutions such as ICAR Research Complex for North Eastern Hill Region, Central Agricultural University, Assam Agricultural University, and various National Research Centres and Krishi Vigyan Kendras in advancing research, education, extension, and agri-entrepreneurship. Their innovations in integrated and organic farming systems, climate resilient technologies, value addition, and youth engagement have contributed significantly to enhancing productivity and sustainability. The article concludes that a co-ordinated institutional approach, integrating traditional knowledge with modern science, and strengthening infrastructure and market linkages, is vital for ensuring a climate-resilient, inclusive, and sustainable agricultural future for the region.

Keywords: Agricultural transformation, Challenges, Institutional innovation, *Jhum* cultivation, Northeast India, Sustainable development

ASSAM leads the north eastern states in Net Sown Area (NSA) with 35% reflecting its fertile alluvial plains (Brahmaputra and Barak valleys), followed by Tripura (24.8%), while Arunachal Pradesh records the lowest (<3%), largely because of steep hilly terrain and forest cover. The regional average NSA as % of GA is ~14–15%, far below the national average (~42–43%). Based on the Land use Statistics (LUS) and state economic surveys (2022–23), the region's overall cropping intensity stands at 135%, with Tripura and Sikkim achieving the highest at 191% and Manipur at 139%. Major crops include cereals, pulses, and oilseeds, with rice as the dominant staple crop. Assam ranks among India's top ten rice-producing states, yet regional rice yields remain below the national average due to diverse ecological conditions.

Overall, the region presents a mixed scenario where some states are gradually advancing through niche and resilient agricultural practices, while others are grappling with declining productivity. Despite natural endowments such as acid soils, abundant rainfall, and rich biodiversity, agriculture in this region remains largely subsistence-oriented. The prevalence of traditional practices, limited mechanization, small landholdings, and inadequate infrastructure constrain modernization and market integration. Historical neglect and fragile ecosystems have also limited the pace of transformation. The transformation of agriculture in NER, therefore, is both an urgent necessity and a promising opportunity for sustainable development, poverty reduction, and ecological balance.

Challenges in agricultural transformation

A significant challenge in the NER is the widespread practice of *Jhum* (shifting) cultivation. The shorter fallow cycles (2–3 years) of *Jhum* have made it ecologically harmful, causing soil fertility decline, erosion,

Table 1. Key challenges in agriculture in NER and institutional responses

Challenge	Impact	Institutional response
Shifting cultivation (Jhum) with short fallow cycles	Soil erosion, fertility loss, biodiversity degradation	ICAR-NEHR promoted Integrated Farming Systems (IFS), Integrated Organic Farming Systems (IOFS), soil conservation models, and watershed management
Floods and riverbank erosion	Crop and land loss, livelihood insecurity	AAU developed flood-tolerant rice varieties; ICAR promoted riverbank stabilization and agroforestry
Low productivity due to traditional practices	Yields below national average	CAU and AAU released high-yielding varieties; KVKs trained farmers in improved practices
Infrastructure deficits (roads, storage, processing)	High post-harvest losses, weak market linkages	Agri-Business Incubation (ABI) Centres at AAU and ICAR; KVKs support value addition and FPOs
Climate change (erratic rainfall, floods, landslides)	Reduced stability of farming systems	Research on climate-resilient varieties, natural/organic farming, and agroforestry
Underdeveloped livestock and fisheries	Limited income diversification	NRC on Pig, Mithun, and Yak develop improved breeds and management; KVKs demonstrated integrated farming systems

deforestation, and biodiversity loss. Forest degradation, driven by shifting cultivation, logging, and fuelwood demand, has weakened ecological stability, reducing soil quality, water retention, and availability of fodder and non-timber resources essential for integrated farming. The Brahmaputra and Barak river systems frequently inundate agricultural lands, with thousands of hectares lost annually to erosion in Assam. Climate change impacts such as erratic rainfall, floods, and landslides further intensify risks for farming communities.

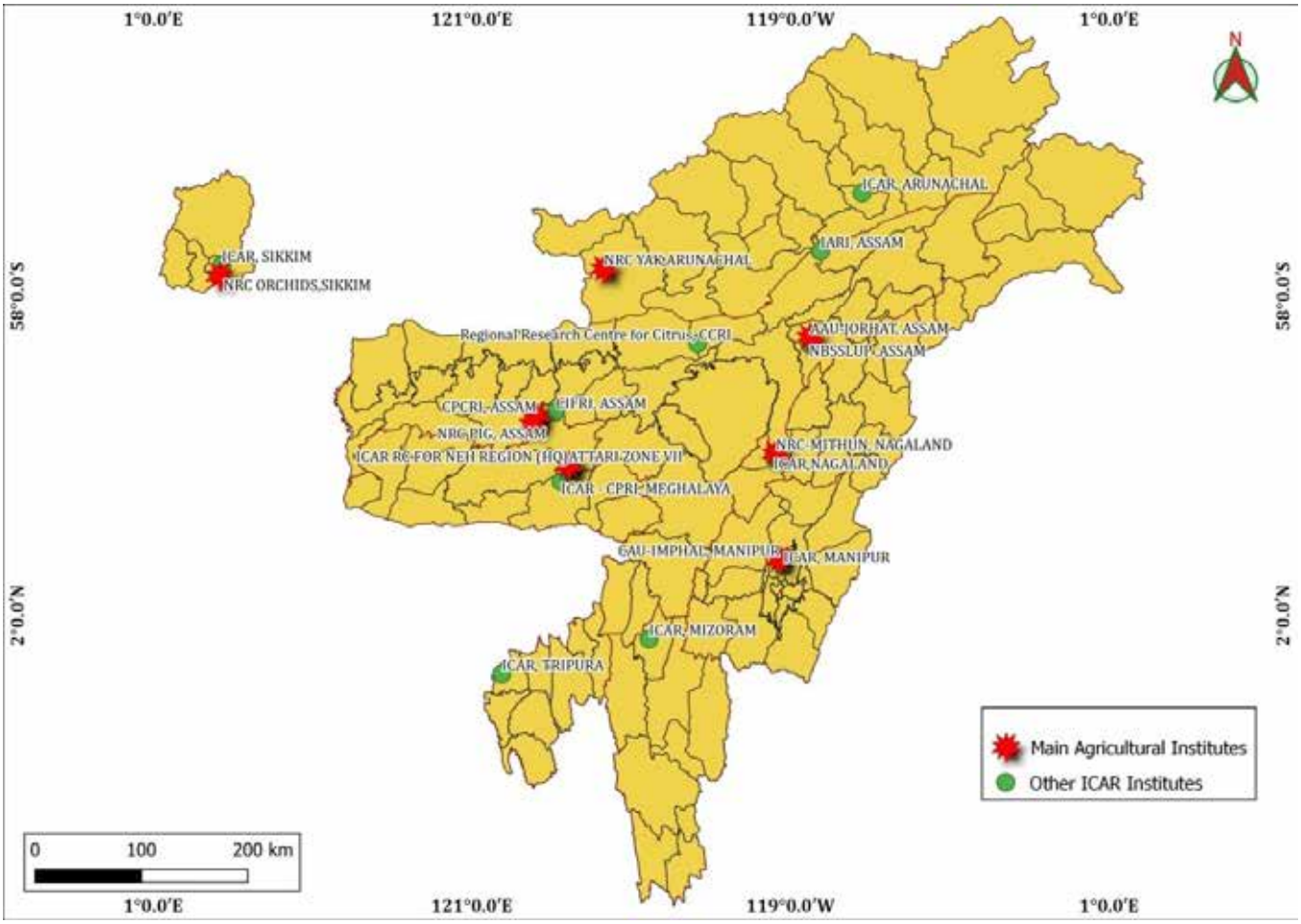
In NER, crop productivity remains below national averages due to reliance on traditional practices, limited use of improved seeds and fertilizers, low mechanization, and minimal irrigation. Small, fragmented landholdings and hilly terrain limit scope for commercial farming and adoption of modern technology. Infrastructure deficits, including poor roads, lack of cold storage, and minimal agro-processing facilities, exacerbate post-harvest losses and reduce incentives for high-value crop cultivation. Livestock and fisheries, though promising, are underdeveloped because of inadequate veterinary services, feed shortages, and limited resources. The region is very vulnerable to climate change with erratic rainfall, floods, and landslides disrupting farming. Communities dependent on subsistence agriculture are mainly vulnerable. Addressing these issues requires interventions in sustainable land use, infrastructure development, modernization of farming practices, and climate-resilient strategies to enhance productivity and livelihoods.

Opportunities for agricultural growth

NER has vast agricultural potential due to its natural resources, rich in biodiversity and agro-climatic diversity which remains underutilized. The tribal farmers of this region representing diverse communities, languages, and religions are still known for their penchant for the conservation of values, ITKs (Indigenous Technical Knowledge), and their cultural heritage. The conservation of bioresources (thousands of rice and maize cultivars' selections), natural resource management (e.g. paddy cum fish culture at *Apatani* in Arunachal Pradesh, *Zabo* system in Phek district of Nagaland, alder-based farming systems in Nagaland) are still at the core of the heart of the tribal community. By utilizing indigenous farming techniques and local resources, agricultural products from the region can meet both domestic and global demand, thereby strengthening community-based, sustainable livelihoods rooted in local identity. Integrating traditional knowledge with modern practices offers opportunities for rural economic growth while simultaneously ensuring ecological sustainability. A comprehensive strategy focusing on soil conservation, water management, introduction of climate-resilient agriculture, and market connectivity through storage, processing, and transport facilities is crucial for the region. Harnessing these potentials will not only strengthen rural livelihoods but also contribute

Table 2. Opportunities for agricultural transformation in NER

Opportunities	Strengths	Potential outcomes
Biodiversity and agro-climatic diversity	Traditional knowledge systems (*Zabo*, *Apatani*, Alder-based farming)	Sustainable farming, agro-ecotourism
Organic and natural farming	Low chemical input use, rich biodiversity	Premium markets, export opportunities
Integrated farming systems (IFS)	Crop-livestock-fish-horticulture integration	Year-round food and nutritional security
Agri-enterprises and start-ups	Spice processing, orchid floriculture, Bee-keeping, GI-tagged crops	Youth employment, rural entrepreneurship
Market connectivity and infrastructure	FPOs, value chains	Reduced post-harvest losses, income stability



ICAR and other agricultural institutes in northeast India

meaningfully to food and nutritional security of the NER.

Institutional pathways in agricultural transformation

NER is endowed with unique biodiversity, varied agro-climatic conditions, and rich traditional knowledge. To harness these strengths and address its agricultural challenges, several institutions have been established under the Indian Council of Agricultural Research (ICAR). These include the ICAR Research Complex for NEH Region at Barapani, Meghalaya, the National Research Centres on Orchids, Mithun, Yak, Pig, and, the Central Agricultural University (CAU), Imphal, Assam Agricultural University (AAU), Jorhat, IARI Assam, Agricultural Technology Application Research Institute (ATARI), Guwahati and ATARI, Umiam. These institutions have played a major role in strengthening agricultural research, education, and extension, and have had significant impacts on agricultural growth and livelihoods in the region.

ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya: The ICAR Research Complex for North Eastern Hill Region, Umiam was established in 1975. It is a pioneer institute in promoting agricultural growth in the hilly ecosystems of the region. The institute operates through six regional centres located at Basar (Arunachal Pradesh), Imphal (Manipur), Lembucherra (Tripura), Jharnapani (Nagaland), Gangtok (Sikkim) and Kolasib (Mizoram), addressing the diverse agro-climatic conditions of each state. It also coordinates a strong network of twenty (20) Krishi Vigyan Kendras (KVKs) across the region, which serve as frontline extension programme for transferring innovations and training of youth and farmers. Institute is also engaged in the human resources development by guiding the postgraduate and doctorate students in the field of agriculture and allied sectors enrolled in other institutes. High yielding crop varieties of rice, maize, mustard, buckwheat, vegetables suitable for hill farming, improved pig and poultry breeds, an d innovative fishery practices have been developed to support the nutritional security and rural livelihoods of tribal farmers of the region. Its integrated farming systems combining crops, vegetables, fruit, flowers, local and improved breed of livestock, and fishery, mushroom and bee-keeping, etc. have helped small and marginal farmers achieved food and income security throughout the year. In addition, soil and water conservation models particularly Jalkund and watershed management approach have supported the region's ecological balance and sustainable productivity. Its research on natural farming and organic farming system has been particularly impactful, as it aligns with the region's biodiversity and ecological needs while also improving soil health and farm profitability. It is noteworthy to mention that Integrated Organic Farming System (IOFS) models developed by the institute have been recognized at global level and it was highlighed in the publication entitled "Compedium

of Case Studies: Accelerating Transition to Sustainable Agriculture" published jointly by the World Bank, UN Climate Change Conference UK 2021 and Just Rural Transition.

The institute has also contributed towards value addition and post-harvest technologies, enabling better employment and market opportunities for GI crops spices, fruits, and vegetables. The Agribusiness Incubation Centres (ABI) and entrepreneurship development programmes encouraged youth to venture into agri-startups, processing, and value addition. This has not only created self-employment opportunities but also improved market linkages for farmers. The KVKs under the institute have played a crucial role in skill development of farmers, rural youth, and women. The institute has also expanded its research capabilities and given exposure to local scientists and students. Over the years, the ICAR Research Complex for NEH Region has played a transformative role in shifting farming from subsistence to a more scientific and sustainable farming for ensuring food security, soil conservation, biodiversity conservation, and socio-economic development of the region. Its impact can be seen in the reduction of jhum area in the region, productivity, diversification of farming systems, and empowerment of rural youth across the north eastern states.

Central Agricultural University (CAU), Imphal, Manipur : CAU, Imphal was established in 1993. At present, the university encompasses 13 constituent colleges located across seven states of the region, each focussing on specialized disciplines such as horticulture, forestry, veterinary science and animal husbandry, fisheries science, agricultural engineering, food technology and community science. Each college focuses on region-specific challenges while providing quality higher education and skill development opportunities. In the 2025 National Institutional Ranking Framework (NIRF) under the "Agriculture and Allied Sectors" category, CAU Imphal secured the 25th position in India. The students of the university showed excellent performance at national level competitive examinations and admissions in national/ premier institutes of higher studies. More than 73% of the passed-out students from the university are already employed/absorbed in government departments.

Over the years, CAU has achieved significant milestones including development of high-yielding rice varieties; CAU-R2, CAU-R3 and CAU-R4 suited to the hill ecosystem, improved livestock and fish breeds, and innovative sustainable farming practices. Through its network of six KVKs, the university has extended these innovations to farmers by conducting on-farm trials, demonstrations, and training programmes. Moreover, the university has fostered collaborations with reputed national and international institutions, promoting advanced research, faculty exchange, and student exposure. Its community outreach programmes, particularly among tribal and rural populations, have promoted gender inclusion, nutritional security, and sustainable rural livelihoods. This university has emerged as a hub of agricultural transformation in the northeast, contributing significantly to agricultural education, food security, environmental sustainability, and socio-economic development of the region.

Assam Agricultural University (AAU), Jorhat, Assam: AAU, established in 1969 at Jorhat, is ranked 18th in the NIRF, Agriculture and Allied Sectors category, 2025. It encompasses a broad network of constituent colleges, covering agriculture, horticulture, veterinary science, fisheries, sericulture, and community science, along with regional research stations across Assam. Over the years, university has produced a large pool of graduates and postgraduates who contribute significantly as professionals in agriculture and allied fields nationwide. The university has been instrumental in developing and releasing numerous high-yielding and disease-resistant varieties of rice (Joymati, Aghoni, Ketaki Ranjit, Bahadur, Kanaklata, and Mulagabhoru), pulses, oilseeds, and vegetables suited to Assam's agro-climatic conditions. The Package of Practices (PoP) for *kharif*, *rabi* and horticultural crops as well as organic farming for selected crops are well documented by university. Its veterinary and fisheries colleges have introduced improved breeds, health management practices, and aquaculture technologies that have benefited livestock and fish farmers. The university also manages a strong network of 23 KVKs located in different districts of Assam. Through these KVKs, AAU directly reaches to the farming community for dissemination of improved POP. In recent years, the university has promoted agri-preneurship through ABI Centre, which provides mentoring, training, and financial support to startups in agriculture, food processing, and allied enterprises. This initiative has encouraged many young entrepreneurs and FPOs to take up innovative agri-business ventures. The university also contributes to sustainable development through its research in organic farming, integrated farming systems, natural resource management, rice fallow management and climate-resilient agriculture. Its outreach programmes have focused on empowering rural women farmers and promoting nutritional and social security. Over the years, AAU has emerged as a hub of agricultural excellence in the northeast, making an impact on agricultural education and crop productivity in Assam.

National Research Centres (NRCs): The National Research Centre for Orchids (NRCO) at Pakyong, Sikkim plays a vital role in strengthening in orchid development programme. The institute has enriched the genetic base of orchids by developing and releasing new hybrids such as *Paphiopedilum* varieties NRCO Paph1-9, the *Phalaenopsis* varieties NRCO Phal. 1, 2, 3, 4, 5, 7, 10, 13, 15, 16, 18, 20, and 22, a Vanda variety NRCO Vanda 1. The centre has also facilitated scientific orchid production, enabling commercial floriculture, emerging as a viable enterprise for the farmers of Sikkim. By providing training, technical support, and market linkages, NRCO strengthens livelihoods and promotes India's standing in the global orchid trade. Its work not only preserves and enhances orchid biodiversity but also

An improved variety of cymbidium orchid developed by NRC Orchid, Sikkim

Nagami breed mithun

Arunachali yak

Rani Pig breed developed by NRC Pig, Assam

supports sustainable agriculture and rural development by orchid production.

The National Research Centre on Yak (NRCY), Dirang, Arunachal Pradesh, is a premier research institute exclusively engaged in research and development of Yak (*Peophagus grunniens* L.) which is one of the most resilient creatures on earth and plays a significant role in sustaining high-altitude livelihoods and strengthening India's livestock economy. The institute has achieved pioneering advances in reproductive biotechnology, including the production of test-tube yak calves; the first being *"Nonrgayal"*, using *in vitro* fertilization (IVF) and embryo transfer via ovum pick-up methods. The center has developed protocol for synchronization of estrus (Ovsynch protocol) in yak. It has also developed innovative feeding strategies, such as complete feed blocks for winter months, ensuring better nutrition and survival of yaks under harsh conditions. Economically, yaks provide a range of high-value products: milk, butter, cheese, meat and fiber. The yak hair contributes significantly to the local markets and income generation for rural communities. By integrating agriculture with traditional yak husbandry, the center strengthens high-altitude food security systems to promotes biodiversity conservation, and boosts the economic condition of farmers. The institute has also developed market linkages with a Geographical Indication (GI) tag for Arunachal Pradesh Yak Churpi with the support of state government. Recently, the center has initiated Yak insurance policy to shield the Yak rearers against uncertainties and mishaps.

Mithun, though generally regarded as a wild species, has been domesticated through innovative husbandry models developed by the National Research Centre on Mithun (NRCM), Medziphema, Nagaland, by integrating it with diverse agricultural components. The institute has made notable progress in advanced reproductive technologies such as embryo transfer and artificial insemination, contributing to genetic enhancement and sustainable growth of mithun populations. From an economic perspective, mithun offers high-value products including meat, milk, hides, and various by-products that play a crucial role in household nutrition and income security. These initiatives not only promote the sustainable utilization of mithun but also conserve biodiversity and strengthen socio-economic resilience of tribal communities living in the forested and high-altitude regions of northeast India. The National Research Centre on Pig (NRCP), Rani, Assam, has developed improved pig varieties, notably Rani pig, which exhibits higher growth rates and better feed conversion efficiency.

Further, the centre has standardized feeding systems tailored to local resources, including balanced rations and supplementary feeding strategies that enhance productivity throughout the year. Through the

distribution of quality germplasm, training programmes on artificial insemination and demonstration units, institute has enhanced nutritional security in the region. The centre has also developed protocols for comprehensive disease control measures, including vaccination programmes, bio-security, and preventive health-care practices to minimize the mortality of piglets.

Krishi Vigyan Kendras (KVKs): KVKs in the NER have been instrumental in bridging the gap between agricultural research and farmers' fields. About 90 KVKs operate under the coordination of Agricultural Technology Application Research Institute (ATARI), Guwahati and ATARI, Umiam (Barapani), covering all eight states of the region. They have successfully introduced high-yielding and stress-tolerant crop varieties of rice, maize, pulses, oilseeds, and vegetables, and demonstrated integrated farming systems. The technology demonstrations and trainings helped small and marginal farmers for getting food and nutritional security year-round. In livestock and poultry, KVKs have promoted improved breeds, backyard rearing, fodder production, and health management practices. In fisheries, they have implemented integrated fish farming and conservation of indigenous species for enhancing the income. KVKs have also emphasized and promoted organic farming, natural farming, soil health management, biofertilizers, and vermicomposting, contributing to environmentally sustainable agriculture. Beyond technology dissemination, they have played a key role in implementing national agricultural programmes such as the Viksit Krishi Sankalp Programme (VKSP), Rashtriya Krishi Vikas Yojana (RKVY), Soil Health Card Scheme (SHCS), National Food Security Mission (NFSM), Mission on Integrated Development of Horticulture (MIDH), National Mission on Sustainable Agriculture (NMSA), Pradhan Mantri Fasal Bima Yojana (PMFBY) and Pradhan Mantri Krishi Sinchai Yojana (PMKSY).They also facilitate skill development, agri-entrepreneurship and formation of farmer producer organizations (FPOs), especially among rural youth and women for supporting food processing, value addition, and small-scale agribusinesses.

SUMMARY

The NER of India stands at a crossroads in its agricultural journey. The agricultural trajectory of northeast India over the past decade reflects both opportunities such as abundant natural resources, rich biodiversity, fertile soils, abundant water resources, diverse agro-climatic conditions and strong institutional support, and challenges such as shifting cultivation, soil erosion, low productivity, fragmented landholdings, inadequate infrastructure, and climate change impacts. Food grain production in the region has shown mixed trends, with states like Mizoram, Meghalaya, Tripura, and Arunachal Pradesh recording positive growth, while others such as Manipur, Sikkim, Nagaland, and Assam have faced declines, underscoring the structural and environmental constraints that need urgent attention. Nevertheless, sectors like horticulture, livestock, poultry, eggs, and fisheries have emerged as major growth engines, with consistently strong CAGRs across states, signaling diversification and resilience in regional agriculture. The increasing production of vegetables, fruits, spices, meat, poultry, and fish highlights the potential of the region not only to strengthen food and nutritional security but also to build sustainable livelihoods.

At this juncture, agricultural transformation in the NER is being shaped by the collaborative responsibilities of research institutions, universities, KVKs, policymakers, and local communities of the region. Institutions such as ICAR Research Complex for NEH Region, Central Agricultural University, Assam Agricultural University, and national research centers on niche resources like orchids, mithun, yak, pig and many other government and private universities and research institutions, etc. have collectively contributed to advancing research, education, extension, and innovations tailored to the unique agro-ecological conditions of the region. Their efforts in promoting integrated farming systems, developing climate-resilient practices, conserving biodiversity, and encouraging entrepreneurship have been instrumental in driving progress. However, realizing the full potential of the region's agriculture requires stronger infrastructure for storage, processing, and marketing, along with empowerment of youth, women, and tribal farmers through skills and entrepreneurship. It is only through such coordinated action among institutions, stakeholders, and farming communities that northeast India can transition towards a more inclusive, climate-resilient, and commercially viable agricultural future, ensuring food security and sustainable socio-economic growth for the region.

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