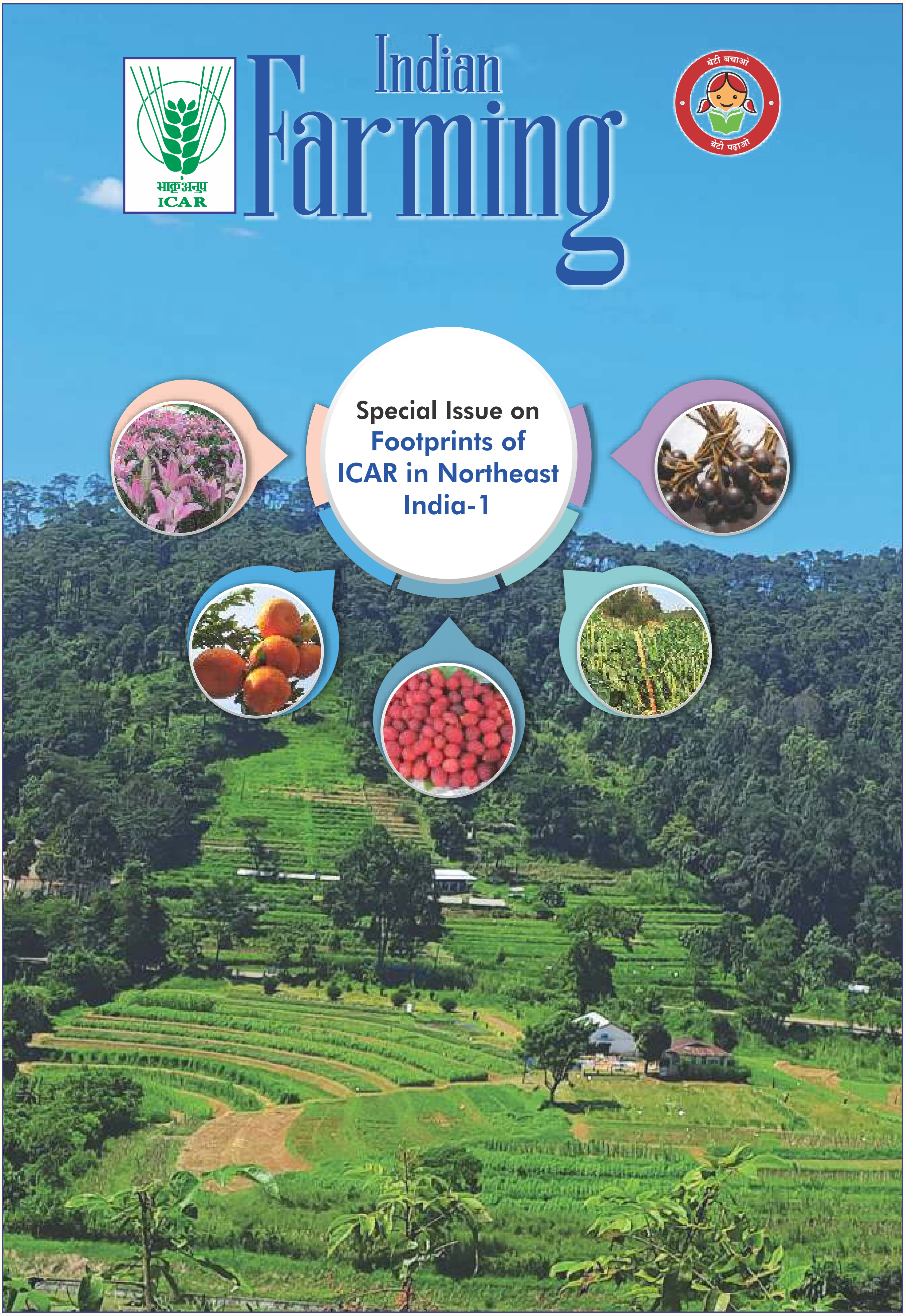
ISO 9001:2015 Organization

JULY 2025

भाकृअनुप ICAR

Indian Farming

बेटी बचाओ बेटी पढ़ाओ



Special Issue on Footprints of ICAR in Northeast India-1

GUIDELINES TO AUTHORS

Visit us https://epubs.icar.org.in/index.php/IndFarm

Online submissions of article :

- Alredy have a Username/Password for *Indian Farming*? GO TO LOGIN
- Need a Username/Password? GO TO REGISTRATION
- Registration and login are required to submit items on-line and to check the status of current submissions.

Author Guidelines

Title of the Article: Catchy, short and attractive, Compel the readers to read the article, Time-oriented, Serve the purpose of audience – means it should be audience-oriented, and News-oriented.

Intro/Introductory Paragraph :It has gist of the article, Preferably give answers of all 4 Ws and 1 H, Ws stands for: what, where, why and when, H stands for: how, and Intro paragraph should convey the complete message so that reader is satisfied.

Introduction: The very first paragraph of articles is known as Introduction, It is an introduction for the article, It shows the need of writing article, For example, we write an article on a new hybrid. We have to write its importance that it is better in such and such regards, and It should be really one paragraph or two paragraphs, if the subject is broader.

Text of Article: Remaining text should be in a descending order of importance, Emphasize on your own findings, Here follow proper heading scheme, Use key words in headings, Follow central heading, side heading, subheading, inset heading etc.

General Guidelines: Follow guidelines strictly, In popular articles, number of authors should not be more than 3. Stick to number of words required (2,500 words), Do not exceed page limit, Write captions separately, Give 1-2 tables or graphs (avoid repetition), Name(s) of author(s), Complete postal address(es) of affiliations (place where work was conducted). Complete correspondence address including e-mail address of authors should be provided (these are given as footnote on first page).

***Units in metric system*:** Full forms of all abbreviations used in table; source of data should be given in detail. Units of measurement, symbols and standard abbreviations should conform to those recommended by the International Union of Biochemistry (IUB) and the International Union of Pure and Applied Chemistry (IUPAC). Metric measurements are preferred, and dosages should be expressed entirely in metric units (SI units). In exceptional circumstances, others may be used, provided they are consistent.

Figures: Author is required to submit high-resolution (2 MB) images, preferably with the initial submission but no later than revision stage. Electronic (2 MB) images (figures and schemes) must be at a minimum resolution of 600 d.p.i. for line-drawings (black and white) and 300 d.p.i. for colour or gray-scale. Colour figures must be supplied in CMYK not RGB colors. Please ensure that the prepared electronic image files print at a legible size (with lettering of at least 2 mm).A number of different file formats are acceptable, including: PowerPoint (.ppt), Tagged Image File Format (.tif), Encapsulated PostScript (.eps), Joint Photographic Experts Group (.jpg), Graphics Interchange Format (.gif), Adobe Illustrator (.ai) (please save your files in Illustrator's EPS format), Portable Network Graphics (.png), Microsoft Word (.doc), Rich Text Format (.rtf), and Excel (.xls) but not Portable Document Format (PDF). Type in 1.5- space everywhere.

Rewrite Your Article

Language: Use simple words, Use short sentences in a logical order, Use active voice, Avoid passive voice, Relate all sentences with each other, Maintain coherence, Paragraphs should be short and readable, Short paragraphs give pause to readers, Give human touch to your article to make it interesting, and Give practical information

Writing for Success Stories: Who has got success in, Introducing new technology/methodology etc., Diversification of any farming system in a particular area for more return, How he/she is inspiration to other farmer, What is cost:benefit ratio of the farm produce?, What are the prospects of that farm commodity?, Show the difference in adoption of that particular technique, variety, seed, tool etc.,

Summary: Summary of article should be provided at the end of article under the heading "Summary", Papers should be composed in MS Word, and double spaced throughout (including references and tables). Article (including illustrations) should be uploaded on Indian Farming site (as given on top), after a careful check up of typographical errors.

Submission preparation checklist

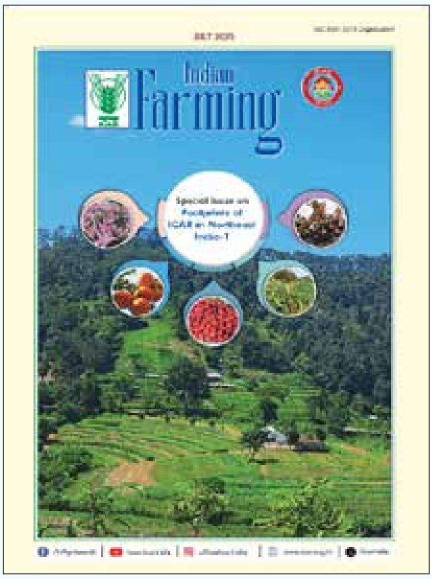
- ☑ As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.
- ☑ The submission has not been previously published, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor). ;and submission file should be in Microsoft Word file format.
- ☑ The text is 1.5-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate points, rather than at the end. Data is correct, authentic and updated.
- ☑ If submitting to a peer-reviewed section of the *Indian Farming*, the instructions in Ensuring a Blind Review have been followed.
- ☑ Article is based on recent experiments or practical experience of the author.
- ☑ Article should not be based on compiled matter or on some survey, report or record of extension education.
- ☑ Article should not be of theoretical nature or only of local relevance. Article text gives complete relevant details of practical utility to the farmer in clear and simple English.

IS/ISO 9001:2015 Organization

Volume 75, No. 07 JULY 2025

Indian Farming

In This Issue



Cover I: Northeast India

Cover IV: Tapping Biodiversity for Attaining SDGs in Eastern Himalayas

For editorial queries contact:
Editor (*Indian Farming*), ICAR-DKMA
011-2584 2828 Extn. 617
e-mail: editorindfarming@gmail.com

For Subscription and Advertisement contact:

Bhupender Dutt
In-charge, Business Unit, DKMA, ICAR
Krishi Anusandhan Bhavan I, Pusa
New Delhi 110 012
Telefax: 011-2584 3657
e-mail: bmicar@icar.org.in,
businessunititicar@gmail.com

Subscription

Single Copy	:	₹ **50**
Annual	:	₹ **500** (inland)
	:	US$ **100** (overseas)
Special issue	:	₹ **200**

Imprints of ICAR in Northeast India

OVER the decades, the agricultural landscape has changed with the advancement of technology, and incorporation of artificial intelligence. In India, various technologies are being developed such as improved varieties of crops as well as improved breeds of livestock, cost effective mechanization, and integrated farming system that adapt well to a given agro-climatic region. ICAR and its institutes, affiliated agricultural universities and Krishi Vigyan Kendras are a driving force that are bridging the gap between the farmers' problems and their solution. This special is brought with the help of NEH team in compiling the articles. A wide inter-connected network of ICAR Research Complex on North Eastern Hill Region, its regional centres, National Research Centres and KVKs is especially focussed on improving the livelihood of the farmers in northeast India with localised solutions.

The unique agro-climatic region is a home to various native species of plants as well as animals. The Geographical Indication (GI) tag helps to preserve those species and becomes an identity of the region. Northeast region receives high rainfall for which rice cultivation is a promising venture with improved cultivars for both upland and lowland conditions. However, the problem of soil acidic also arises, causing low productivity of crops. Thus, acid soil management practices such as incorporation of lime, green manure crops, alley cropping and low pH tolerant crops are to be promoted. Since rainfall is mostly in monsoon, water becomes scarce in the winter and summer season. Different mechanisms are built to counter water scarcity such as provision of *Jalkunds*, raised and sunken bed technology, along with their traditional water management practices like *Apatani*, *Zabo* and *Panikheti*.

In addition, agroforestry plays a pivotal role in enhancing the farmers' livelihood and maintaining food security in the times of crop failure, limited resources, and water scarcity. It is a part of climate resilient agriculture practices and integrated farming systems. Besides agroforestry, kiwifruit is becoming a game changer as the number of consumers are increasing day-by-day because of its high nutritive value.

High-value crops like orchids, gerbera and potato seed production offer lucrative opportunities for small and marginal farmers. Scientific cultivation under protected conditions, efficient use of inputs, and post-harvest value addition can substantially increase income and market competitiveness. Similarly, modern beekeeping provides an eco-friendly livelihood option that boosts farm productivity through pollination while generating income from honey and related products.

Traditional livestock such as the yak and mithun remain vital to the socio-economic fabric. These species supply meat, milk, fiber, and draft power, and contribute to cultural and ecological stability. Further, improved pig farming technologies have shown great promise in the northeast, where piggery is culturally accepted and economically viable. Adoption of superior breeds, balanced feeding, and proper disease management can ensure higher returns and livelihood security for rural households.

Overall, integrating scientific advancements, capacity building, and market linkages across agriculture and allied sectors can transform traditional practices into profitable, resilient, and sustainable rural enterprises.

AAgrawal

(Anuradha Agrawal)

Indian Farming 75 (07): 03-08; July 2025

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

Vinay Kumar Mishra* and Prabha Moirangthem

ICAR Research Complex for NEH Region, Umiam, Meghalaya 793 103

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.

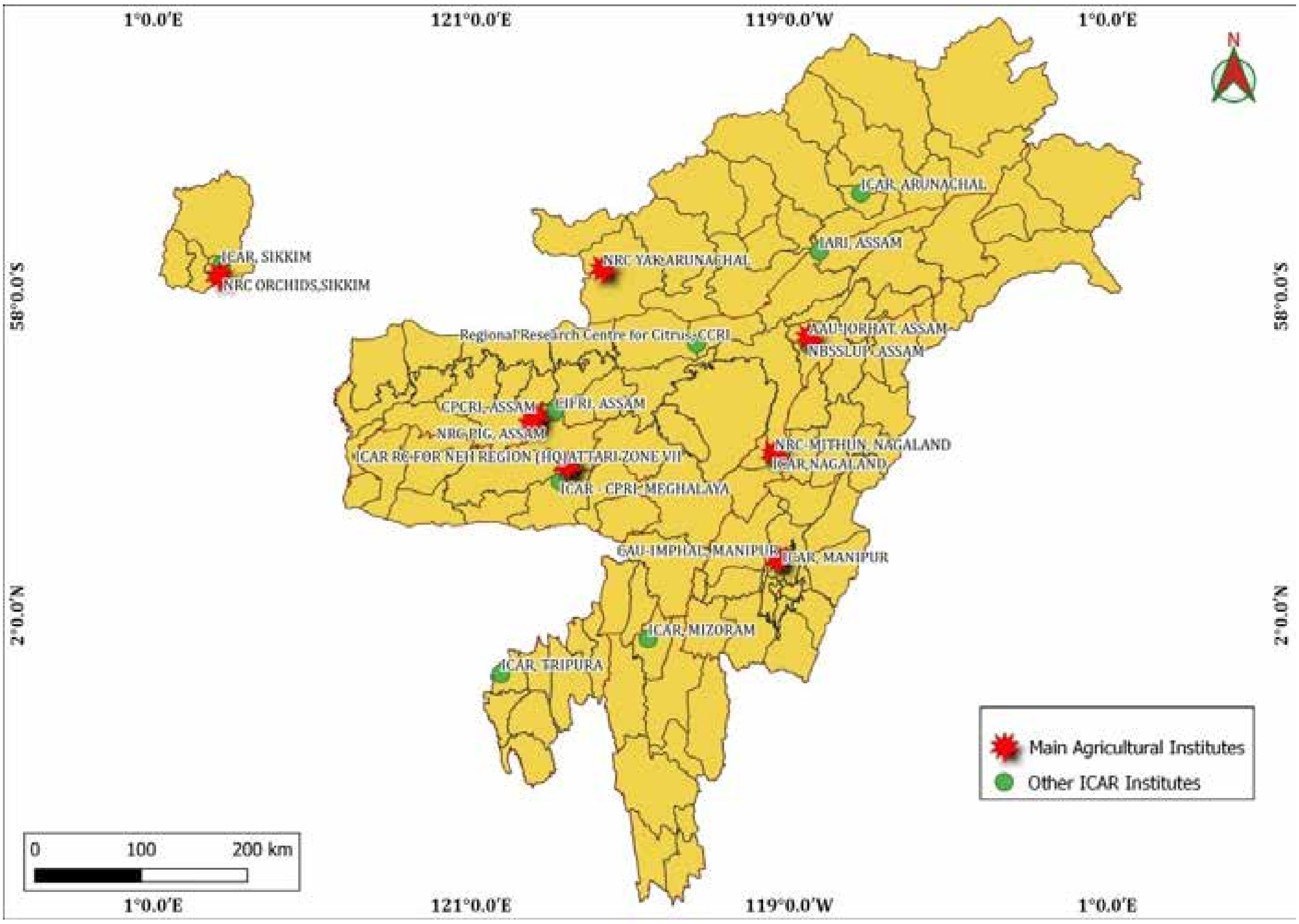
In NER, crop productivity remains below national averages due to reliance on traditional practices, limited use of improved seeds and fertilizers, low mechanization, and minimal irrigation. Small, fragmented landholdings and hilly terrain limit scope for commercial farming and adoption of modern technology. 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.

*Corresponding author email: vkmishra_63@yahoo.com

Indian Farming 75 (07): 09-11; July 2025

GI registered crops of northeast India:

Needs and focus

V. K. Mishra[1]* and S. S. Roy[2]

[1]*ICAR-Research Complex for NEH Region, Umiam, Meghalaya 793 103*
[2]*ICAR-Central Citrus Research Institute, Nagpur, Maharashtra 440 033*

Geographical Indication (GI) is an essential option for protecting the intellectual property rights of commercially important agricultural crops originated from specific geographical area and associated traditional knowledge in making the commodities distinguished based on their unique characteristics. During last two decades, various institutions and state agencies have taken proactive role in protecting the signature crops through GI registration. As per Sec 2 (f) of GI Act 1999, total 420 commodities have been GI tagged from April 2004 to March 2022 by the Office of the Controller General of Patents, Designs and Trademark, Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India. Of these, 128 commodities (30.47% of total GI registrations) come under agricultural crop category.

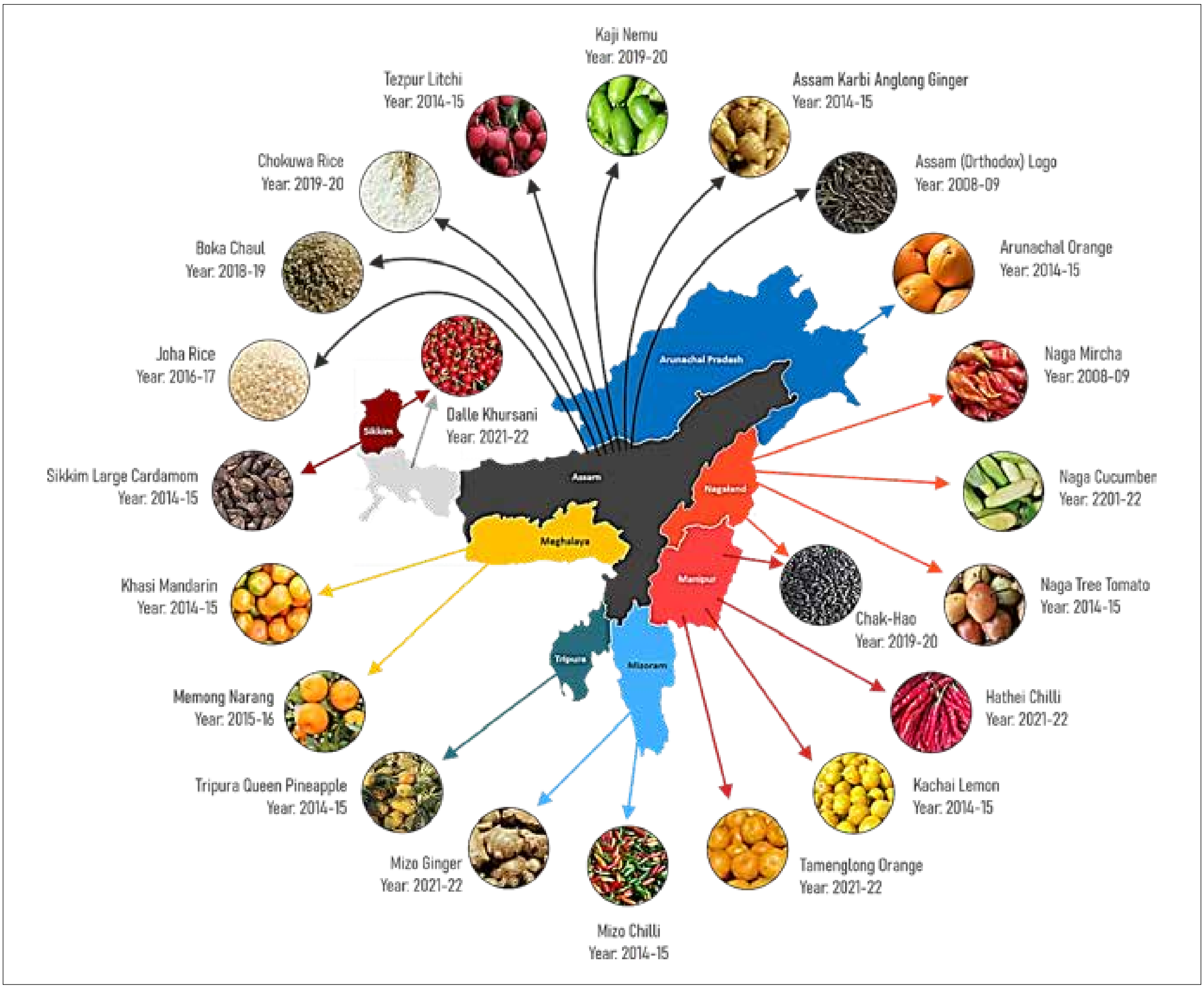
Keywords: Geographical indication, Patents, Trademark

THE north eastern region of India is a rich reservoir of indigenous agri-horticultural crops and many of the crops have immense commercial potential. However, the region, despite of its rich biodiversity, has not been able to take full advantage of GI tagging and shares only 17.18% of the total GI tagged crops. All total 22 specialty crops of NE India namely, 4 cereals (Chak-Hao, Chokuwa Rice, Boka Chaul and Joha Rice); 9 fruits (Arunachal Orange, Kachai Lemon, Kaji Nemu, Khasi Mandarin, Memong Narang, Naga Tree Tomato, Tamenglong Orange, Tezpur Litchi and Tripura Queen Pineapple); 7 spices (Assam Karbi Anglong Ginger, Dalle Khursani, Hathei Chilli, Mizo Chilli, Mizo Ginger, Naga Mircha and Sikkim Large Cardamom); 1 tea (Assam Orthodox) and 1 vegetable (Naga Cucumber) have been GI registered. Among these, 7 crops belong to Assam, 3 crops each belong to Manipur and Nagaland, 2 crops each belong to Meghalaya and Mizoram and 1 crop each belong to Arunachal Pradesh, Sikkim and Tripura. In addition, GI registration of Chak-hao is shared by Manipur and Nagaland and and Dalle Khursani is shared by Sikkim and West Bengal, respectively.

In addition, GI application for different crops of various north eastern states like Bebo Large Cardamom from Arunachal Pradesh; Gol Nemu and Bhimkol Banana from Assam; Yongchak and Manipur Black Cherry from Manipur; Lakadong Turmeric and Soh-Shang from Meghalaya; Rangkuai Mango from Mizoram; Sikkim Orange, Sikkim Orchids, Sikkim Temi Tea and Hee Goan Seremna Cardamom from Sikkim and Jampui Orange from Tripura, etc. are under examination.

All the 22 GI registered crops are unique gift of nature to this region. But only registration of these crops per se will not fulfil the objectives of the GI act, unless it is backed by sound enforcement mechanism. Here, the responsibility of ICAR Research Complex for NEH Region for Research and Development activities on GI crops cannot be undermined. Though most of the crops are presently being commercially exploited, but without adequate technology back-up, these crops may become vulnerable to various stresses in the future and eventually either lose their commercial value or lost over the time due to genetic erosion. Since many years, our institute has been working on some of these crops. However, it is the need of the hour to formulate a meaningful programme on GI tagged crops by converging multifaceted and multidisciplinary research activities.

First important aspect is standardization of location specific package of practices (including organic production package) for the GI tagged crops for maximizing the productivity through a seamless blending of traditional wisdom and modern scientific knowledge. Though package of practices for some crops have already been developed, considering the market potential and export opportunities, dedicated effort should be made on development of organic production packages of these crops with specific focus



GI crops of north eastern region of India

on nutrient management, plant protection and post-harvest management. The location specific rejuvenation packages for declining mandarin orange and large cardamom need to be refined and disseminated to the stakeholders.

These crops are indigenous to north-eastern ecology, well adapted to the local agro climate and contribute significantly to the ethnic food basket. Hence, these crops can be considered as suitable candidate for natural farming. Moreover, there is a great scope for discovery of new genes linked to unique traits including tolerance/resistance to various biotic and abiotic stresses which has been sporadically studied. Hence, identification and validation of the geo-linked genes and traits of GI tagged crops as well as other potential genetic resources should be undertaken. Despite the geographical restriction, there is still ample scope for evolving better varieties of GI registered crops and our institute has already started working in this direction.

Climate change is a reality having potential to derail the food production system and our GI registered crops are not the exceptions. Therefore, the impact of climate change on the GI tagged crops should be studied and mitigation strategies must be devised. Besides, the potential of perennial GI crops in reducing the carbon and water footprint needs to be worked out. Resource mapping using cutting-edge technology like GIS, remote sensing, nanotechnology and digital tools, etc. can also be attempted in GI crop research.

As GI tagged crops possess unique traits and many of the traits are linked to nutritional and health beneficial properties, there is a great scope for undertaking research on nutri-genomics and metabolomics using conventional, molecular and chromatographic approaches. Bioprospecting is another important research arena which can increase commercial value of the GI tagged crops by many folds. This must be followed by development of innovative processed products and functional foods to meet the industry needs and changing consumer preference. Like possibility of identifying novel genes, there is also an ample scope for discovery of novel bioactive compounds in these crops which will in turn contribute towards new drug discovery and healthy living. With all these information, a knowledge portal should be developed for GI crops of NER.

GI is not only an effective tool for rewarding the market potential of the protected commodities but also the traditional knowledge associated with them. Hence, the unique cultural aspects of custodian communities associated with the GI crops needs to be documented and highlighted. Besides, the determinants influencing the value chain of GI crops needs to be analysed and crop-wise marketing strategy should be formulated with specific focus on end-to-end customized supply chain management considering the registered proprietors, authorized users, collective rights, inclusive and representative rural-industry organization, governance mechanisms, market-hierarchy axis, quality signals, monitoring of production process, and use of digital platform for holistic improvement in income effect through expanding reach in national and international markets. Along with research, streamlined outreach activities on GI tagged crops are equally important. The social and economic significance of GI registered crops in the region has not been fully realized by the farmers, where our extension functionaries can play an instrumental role in awareness creation. Field gene bank may also be established at KVK farms for *in situ* conservation of the GI crops. Besides, a dedicated initiative should be undertaken for production of quality seed, agronomical practices and planting material of GI crops. Moreover, research institutes and universities must play a pivotal role in promotion of GI crops and GI crop based innovative products through commercialization and agripreneurship development under origin-labelled brand identity.

SUMMARY

GI crops have a significant potential to facilitate rural development in northeast India. Thus, a technology-led collective action is needed to derive benefits from still untapped commercial potential of GI tagged crops in premium niche markets. Then only legitimate rural producers will realize better monetary return which will not only foster the economic prosperity at local level but will also ensure sustainability for future GI registrations from the north eastern region of India.

*Corresponding author email: vkmishra_63@yahoo.com

Indian Farming 75 (07): 12-15; July 2025

Management of acid soil for sustainable agriculture in hilly ecosystems of eastern Himalaya

Ramesh T.[1]*, A. Balusamy[1], Divya Parisa[2], S. Hazarika[1], B. U. Choudhury[2] and V. K. Mishra[1]

[1]*ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103*
[2]*ICAR-Agricultural Technology Application Research Institute, Umiam, Meghalaya 793 103*

Soil acidity in hill ecosystems is one of the major constraints affecting crop productivity. It is developed due to the leaching of basic cations in the high rainfall receiving areas. More than 80% of soils in north eastern region are acidic. In hilly areas, low agricultural production is owing to low soil fertility due to soil acidity, erosion, continuous cropping, and inadequate sustainable soil fertility management. Acid soils are devoid of phosphorus, calcium, magnesium, boron and molybdenum while aluminium and iron are in toxic concentration. Crop production is significantly affected by soil acidity because of lack basic cations, poor microbial activity and toxicity of few micronutrients. There are several organic and inorganic management practices namely agricultural lime application, acid-tolerant crops, balanced fertilizer use, improved agronomic, cultural, and biological methods such as crop residue management, green manuring, agroforestry, integrated nutrient management, etc. For resilient, environmentally sensitive farming and long-term food security in India, especially in northeast India, these sustainable acid soil management strategies could be cost-effective, environment friendly solutions that improve crop yields while enhancing soil health.

Keywords: Balanced fertilizer use, Environment friendly, Soil acidity

HEALTHY soil is the cornerstone of lucrative, and ecologically sustainable agriculture systems. By comprehending the impact of management methods on soil processes that facilitate plant growth and govern environmental quality, one can devise a crop and soil management strategy that enhances and sustains soil health over time. Soil is an essential resource; its management can enhance or diminish its quality. Soil is a multifaceted environment in which living microorganisms and plant roots aggregate mineral particles and organic materials into a dynamic structure that governs water, air, and nutrient availability. In agriculture, soil health primarily denotes the soil's capacity to maintain agricultural productivity and safeguard environmental resources. Healthy soil performs numerous tasks that facilitate plant growth, including nutrient cycling, biological pest management, and regulation of water and air supply. These functions are affected by the interconnected physical, chemical, and biological characteristics of soil, many of which are responsive to soil management approaches.

Soil health management is crucial to long-term agricultural production. Healthy soil improves plant productivity, health, water and air quality, water and nutrient retention and release, erosion and nutrient loss resistance, soil biodiversity, and soil management techniques. The north eastern region soils are mostly acidic (>80%) and have many soil-related constraints, including soil acidity-induced soil health problems (physical, chemical, and biological), soil crusting, soil erosion and nutrient losses, waterlogging and nutrient leaching, and organic matter loss. Undulating geography and mountainous terrain threaten viable agriculture in the region. Soil acidity reduces availability of phosphorus, zinc, boron, and molybdenum and increases iron and aluminium toxicity. All plant species require 17 elements to complete their life cycle. These elements are essential for plant metabolism and cannot be replaced. Farmyard manure, composts, green manures, green leaf manures, intercropping, and other methods supplemented major nutrients (nitrogen, phosphorus, and potassium), secondary nutrients (calcium, magnesium, and sulphur), and micronutrients like boron, chlorine, copper, iron, manganese, sodium,

(A) Mulching and (B) Green manure crop (*Crotalaria juncea*)

zinc, molybdenum, and nickel in ancient agriculture. Micronutrients are deemed vital trace elements because their requirement is modest. Despite their minimal demand, plants cannot complete their life cycle without these micronutrients. Farmers often overlook nutrient supplementation in modern agricultural production systems. The north eastern region's strong rains and acidic soil exacerbate crop nutrient deficiencies. To maximize productivity sustainably, soil health management is crucial. Crop rotation, intercropping, green manuring, green leaf manuring, organic manure, lime treatment, etc. assist maintain soil health. Soil testing is one of the most significant tools for recommending and applying the proper quantity of customized fertilizers, organic manure, and micronutrients to crop plants.

Table 1. Distribution of acid soils in north eastern India

States	pH <5.5 (m ha)	pH 5.5–6 .5 (m ha)	Total acid soil (m ha)	Geographical Ar	% Geographical area under acid soil
Arunachal Pradesh	6.52	0.27	6.79	8.347	81.08
Assam	2.33	2.33	4.66	7.844	59.41
Manipur	1.87	0.32	2.19	2.233	98.07
Meghalaya	1.19	1.05	2.24	2.243	99.87
Mizoram	1.27	0.78	2.05	2.208	97.20
Nagaland	1.60	0.05	1.64	1.658	99.50
Sikkim	0.60	-	0.60	0.710	84.51
Tripura	0.81	0.24	1.05	1.049	100.00
Total NER	16.19	5.04	21.23	26.29	80. 79

Source: Annual Reports of AICRPDA

Acid soil health management practices

Crop residues management: crop plants need several macro and micro-nutrients for growth and development. Beyond the economic parts (grain, fruits, vegetables, etc.), crop leftovers (straw, stalks, leaves, etc.) contain most of the nutrients crop plants need. Using crop remains as mulch on succeeding crops reduces the nutrients taken from the land. Mulching the soil's open surface with straw, stalks, grass cuttings, bark chips, plastic, etc. is one of the easiest and most effective soil health management strategies. Mulching retains soil moisture and conserves water, regulates soil temperature, protects the soil from erosion, heavy wind, and intense sunlight, reduces weed growth, and protects crops from pests and diseases. It improves plant health and growth by reducing weed growth and maintaining soil moisture and temperature, improving soil structure by reducing soil compaction from heavy rainfall, and improving soil fertility by decomposing crop residues by microorganisms to release nutrients.

Green manuring: Green manuring improves soil physical, chemical, and biological health. It involves ploughing undecomposed green plant materials into the soil. Undecomposed green plant materials can be grown in the field (green manure crops like *Sesbania rostrata, Crotalaria juncea,* dhaincha, cowpea, cluster bean, black gram, ricebean, soybean, lentil, pea, etc.) or collected from outside and used there. Green manuring prevents nutrient leaching, increases water holding capacity, adds organic matter, extracts nutrients from deeper soil layers, improves microorganisms activity, fixes biological nitrogen, prevents soil erosion, reduces pest and disease incidence, improves soil structure, and releases nutrients during decomposition. Intercropping (growing two or more crops in a row) is another significant soil health management method. By efficiently using resources that would otherwise be consumed by a single crop, intercropping increases yield on a given amount of land.

Bulky organic manures: Bulky organic manures are made from animal and plant leftovers that contain less quantity of plant nutrients in complex form and are applied in huge volumes. When microbes degrade organic manures, plants can uptake their nutrients. Organic manures provide plant nutrients and sustain acid soil health, where the north eastern state governments promote organic farming. Organic produce is higher-quality and more expensive than inorganic. Since farmers cannot afford inorganic fertilisers due to their exorbitant pricing, it is a great alternative. Organic manures include farmyard manure

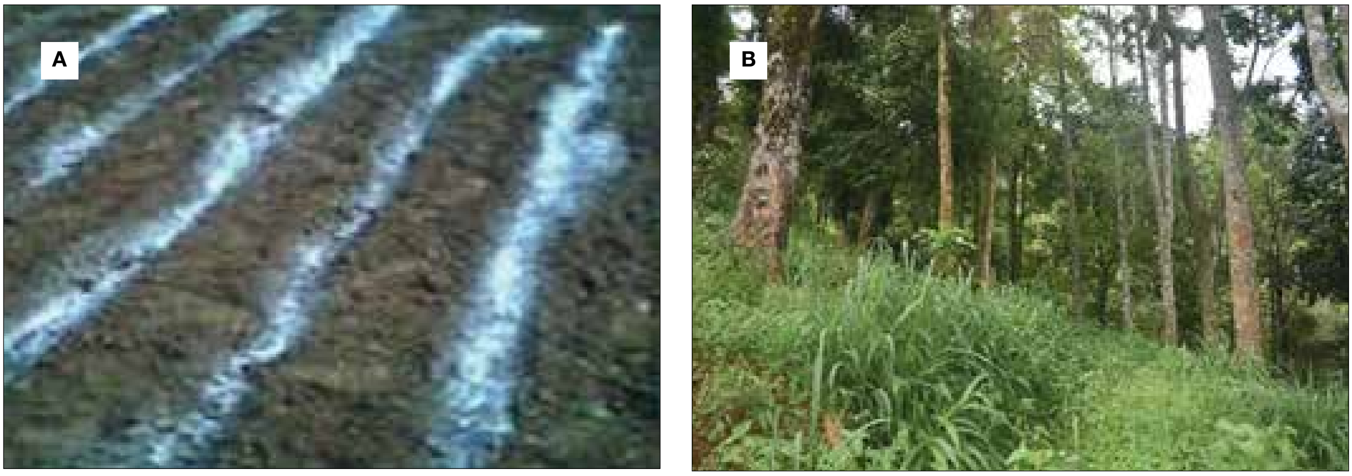
(A) FYM and (B) Vermicompost

(FYM), compost, vermicompost, poultry, and pig manures. While decomposing, it gives nutrients to crop plants, improves soil physical, chemical, and biological qualities, and increases soil plant nutrient availability by reacting organic acids generated by organic manures with soil nutrients comprising minerals. Besides being eco-friendly, it boosts soil microbial activity, which recycles nutrients. As mulch, it reduces soil moisture loss through evaporation. FYM, the decomposed mixture of farm animal excrement, urine, litter, and residual roughages or fodder provided to cattle, is the most frequent organic manure source to boost production and soil health. It contains a lot of plant nutrients that slowly feed agricultural plants. Unlike FYM, vermicompost is earthworm casts rich in macro and micronutrients, enzymes, and growth regulators. It is ideal for growing free-living and symbiotic bacteria that indirectly boost plant development and productivity.

Chemical fertilisers and liming: The soil is fertilized with natural or synthetic materials to provide plants with nutrients required for plant growth and development. It might be powder, crystal, granule, or liquid. urea, SSP, DAP, and MOP are the main solid fertilizers used in India including northeast region for nutrient control. Liquid fertilizer is usually applied by drip irrigation. Some north eastern states like Sikkim, Meghalaya, etc. consume no fertiliser in most crops, including fruits and vegetables. Applying fertilizer according to soil test results, crop needs, soil condition, etc. helps give nutrients without degrading the soil. Acid soil amelioration is crucial for maximum productivity and soil health in north eastern states, where over 80% of soils are acidic. Lime is used worldwide to improve acid soils, and north eastern farmers apply lime regardless of crop. Applying 500 kg of lime per hectare to furrows raises soil pH to neutral, enhancing nutrient availability and minimising nutrient toxicity. Lime is affordable, so farmers can afford it. Limestone reacts with soil to neutralize acidity, depending on particle size. Smaller particles have a larger surface area to react, modifying soil pH to promote crop plant nutrient uptake. The fundamental difficulty of phosphorus fixation can be minimized to enhance plant phosphorus availability.

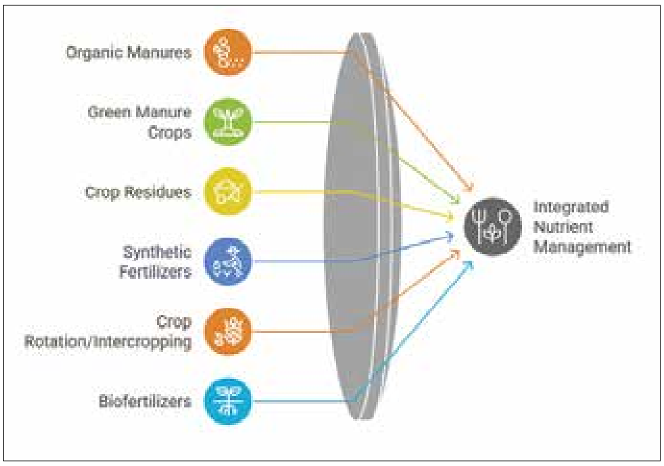
Agroforestry and alley cropping: In agroforestry, crops are cultivated on the same land management unit as woody perennials like trees, bushes, bamboo, palms, etc., in specific or chronological configurations. Alongside tree species such as Khasi pine, alder, areca nut, pear, peach, etc., north eastern region is home to a variety of crops, including pineapple, coffee, turmeric, ginger, vegetable crops, and coffee. The economic significance of the species and the local climate dictate crop and tree species selection processes. Soil nitrogen fixation by leguminous trees, erosion management by cover and barrier effects nutrient loss prevention are all parts of the agroforestry system that work together to keep soil healthy. Increased nutrient availability through nutrient cycling, decreased insect and disease incidence, improved biological activity of the soil, and preservation of good soil physical conditions are all outcomes. Agroforestry also has the potential to diversify farm economies, which means farmers can expect more consistent revenue. The practice of planting tree rows with a greater spacing and then growing agricultural products in the spaces between them is known as alley cropping. In addition to increasing or diversifying farm income, alley cropping has many other uses, such as reducing wind erosion, improving nutrient utilisation, improving wildlife habitat, protecting crops from erosion, improving the microclimate for improved crop production, and improving the area's aesthetics.

Integrated nutrient management: Increasing agricultural output while protecting the environment for the next generation is the goal of integrated nutrient management (INM). Soil health and plant nutrient supply are two aspects of INM or integrated plant nutrition management (IPNM) that aim to maximise the advantages from all potential sources in order to preserve the desired production. The system of land use and ecological, social, and economic conditions should be considered while determining the appropriate combination of chemical fertilisers, organic manures, green manures, crop residues, N_2-fixing crops (rice bean, black gram, soybean and groundnut), crop rotations, and biofertilizers. The cropping system rather than an individual crop, and farming system rather than an



(A) Furrow liming and (B) Agroforestry system

individual field, is the focus of attention in this approach for development of INM practices for various categories. Nutrient conservation and application, technological advancements that make nutrients more available to plants, and information sharing between researchers and farmers are the pillars upon which it rests. INM has several benefits, including making more applied and in-soil nutrients available, ensuring balanced crop nutrition, improving soil physical, chemical, and biological properties, and reducing soil and water erosion by increasing soil organic carbon and decreasing nutrient losses.



Components of integrated nutrient management (INM)

SUMMARY

The eastern Himalayan region faces significant agricultural challenges due to widespread soil acidity, affecting more than 80% of arable land. Acidic soils reduce nutrient availability, hinder microbial activity, and lower crop productivity. Various challenges still persist which hinder the continuous efforts of management of soil acidity. The absence of an umbrella policy to subsidize and promote ecological fertilization practices, high cost of bulky organic manures like vermicompost, shortage and low availability of FYM and seeds of green manure crops has hindered widespread adoption of acid soil management practices among the farming community of NEH region. To address this, sustainable soil management strategies have been developed by ICAR and agricultural universities. By choosing alternate approaches like *in situ* residue management, vermicomposting, biochar production, agroforestry systems, promotion of mechanised residue management and INM farmers in the eastern Himalayas can sustainably manage acid soils, improve crop productivity, and support long-term environmental and economic resilience. These integrated approaches ensure food security while conserving the fragile hilly ecosystems in a more sustainable way.

*Corresponding author email : rameshssac@yahoo.co.in

Indian Farming 75 (07): 16-20; July 2025

Strategies for mitigation of moisture stress

in winter season crops in hilly ecosystem

Debasish Chakraborty* and Koushik Bag

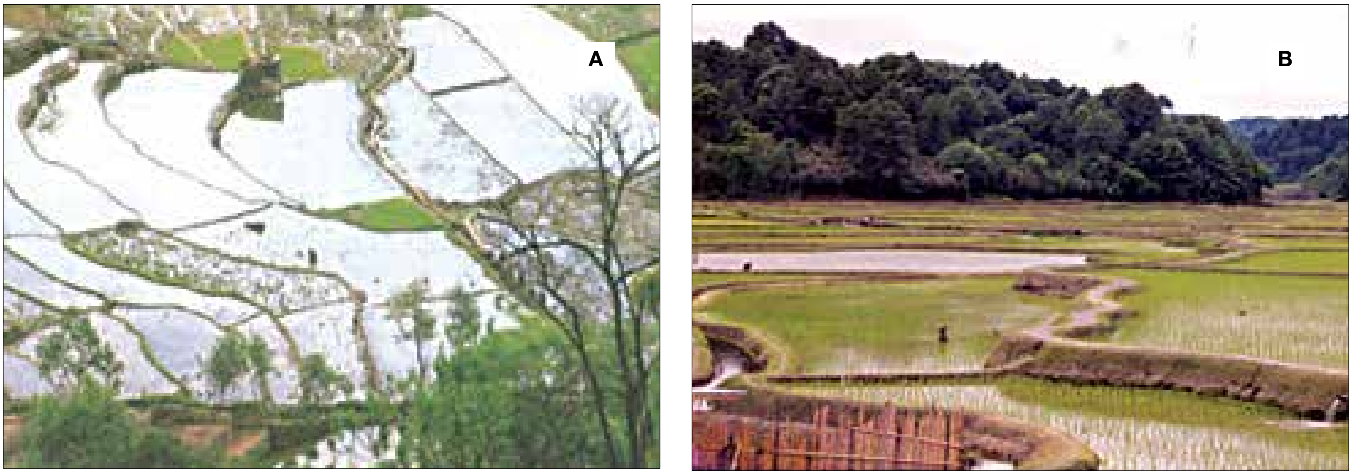
ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

The hilly ecosystem of northeast India experiences significant moisture stress during the winter season due to its unique topography, erratic rainfall distribution, and limited water retention capacity of soils. Although the region receives high annual rainfall, over 70% of it occurs during the monsoon months, leading to dry winter conditions that severely affect the growth and yield of rabi crops. Traditionally, farmers of these region practice several water management practices like Panikheti, Apatani, Zabo, Bamboo irrigation system, etc. focusing the judicious use of rainwater. However, range of agronomic, structural, and technological strategies can be adopted to cope up with these challenges during winter season. Efficient water management techniques such as drip and sprinkler irrigation, along with rainwater harvesting systems i.e. Jalkunds, ensure optimal use of available water resources. Conservation practices like contour farming, mulching, and minimum tillage help retain soil moisture and reduce runoff. The use of short-duration crop varieties enhances crop survival and productivity under limited water conditions. Agroforestry and intercropping systems further improve soil structure and moisture conservation. Thus, adopting an integrated approach that combines traditional knowledge with modern scientific practices is crucial for effectively mitigating moisture stress in winter crops of hilly ecosystems. These strategies not only enhance crop productivity but also contribute to the long-term sustainability of hill agriculture in the region.

Keywords: Bamboo irrigation system, Drip irrigation, Sustainability, Water productivity

SOIL moisture is one of the key factors in influencing optimum plant growth, development and yield. Water maintains turgidity of plant cells, regulates stomata and drives photosynthesis. Even a 10–20% reduction in available water during critical growth stages can lead to yield losses of 30–50% in major crops like wheat and rice. Irrigation significantly boosts productivity. The hill ecosystem occupies 72% area of north eastern India, comprising of the states like Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The North Eastern Hill (NEH) region of India exhibits a distinct dichotomy in its water cycle due to complex topography and climatic variability. The region hosts one of the highest annual rainfall receiving places in the world (e.g. Mawsynram near Cherrapunji receives about 12,000 mm/year). The rainfall over the region is more than sufficient for cultivation of *kharif* crops like rice, maize, vegetables like bhindi, capsicum, chillies, etc. However, as the rainwater gets drained off from hilly ecosystem, limited or no rainfall in *rabi* season leaves most part of these hilly region uncultivated due to moisture stress. Though, the region has a high groundwater potential, irrigation in crops becomes very expensive for marginal and small farmers. Thus, farmers practice mostly monocropping with rainfed *kharif* crops. With the available irrigation facilities, some farmers of the region cultivate crops like mustard, winter vegetable like cabbage, pea, cauliflower, potato, tomato, broccoli, knol-khol, etc. in some pockets. The water stress is the first and foremost challenge in the region for growing winter crops beside all other advantages like abundant land, fertile soils, favourable climate, rich biodiversity and high groundwater potential that supports the potential of the region for sustainable intensification. Therefore, development of farmer-friendly technologies for moisture conservation is the need of the hour for growing winter crops in these hilly ecosystems vis-à-vis increasing the cropping intensity as well as farmers' income.

Conservation tillage practices, such as minimum tillage and contour bunding, have been shown to reduce runoff by up to 40% and increase soil moisture



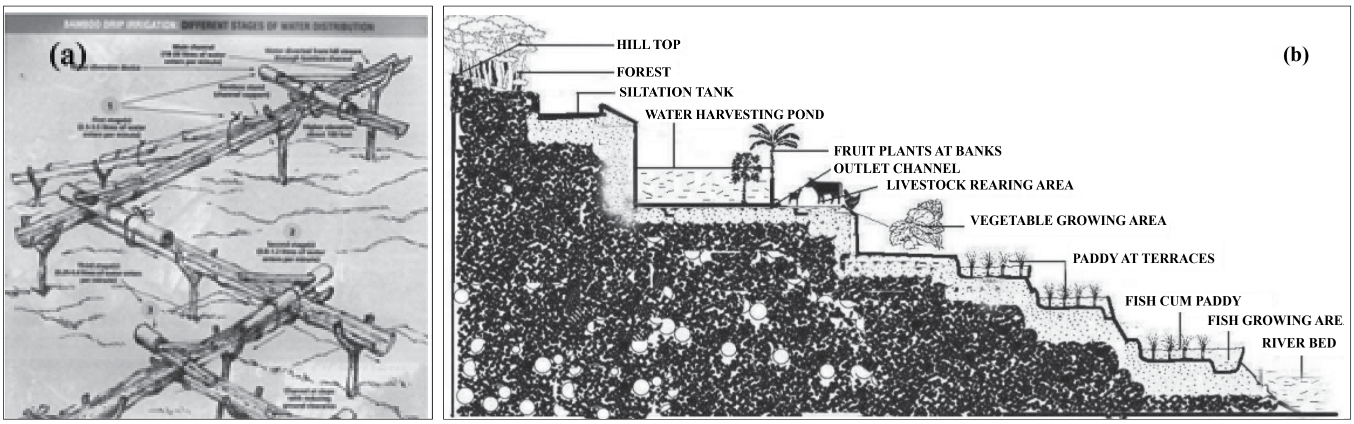
Panikheti (a) and *Apatani* (b) system of water management in northeast India (*Source:* Bundela 2007)

availability. Mulching with organic residues can decrease evaporation losses by 20–30% and improve soil temperature, promoting better root development. Use of short-duration and drought-tolerant varieties, intercropping, mixed cropping has enhanced yield stability under limited or excess moisture. Adoption of drip and sprinkler irrigation can improve water use efficiency by over 80% in vegetable crops grown on terraces. Rainwater harvesting through farm ponds and bamboo drip irrigation systems, traditional to the region, provide life-saving irrigation during critical growth stages. Together, these strategies form a sustainable framework to combat winter moisture stress and ensure food security in the hilly agro-ecosystems of northeast India.

Understanding moisture stress in winter season crops

The moisture stress during winter in crops is mostly caused by combined effect of no rainfall and high evaporation. Moreover, high hill slopes at the higher altitudes favours greater runoff and percolation losses. Moisture stress significantly affects crop growth and yield by limiting water availability for essential physiological processes like photosynthesis, nutrient uptake, etc. Prolonged drought conditions lead to reduced leaf area, stunted growth, and early senescence, ultimately decreasing biomass production. Yield losses occur due to lower grain filling, reduced seed size, and fewer reproductive structures. Crops under moisture stress also experience increased vulnerability to pests and diseases, further exacerbating yield decline. Moisture stress also negatively impacts soil health by reducing microbial activity, nutrient availability, and organic matter decomposition.

The farmers of these regions use indigenous technical knowledge to use the rain water judiciously during *kharif* seasons. These systems are very effective under hilly ecosystems of this region. Some of these systems are bamboo irrigation system, *Panikheti* system, *Zabo* system of Nagaland, *Apatani* system in Arunachal Pradesh, etc. In *Panikheti* system, water is diverted from upper terrace to lower terraces maintaining a desired water level to each terrace. These systems check erosion at high hill slopes and particularly suitable for rice cultivation. The integrated rice-fish farming in the terraces of Arunachal Pradesh is called *Apatani*. Here, stream water is supplied to rice fields through canals and the distant rice fields are connected to each other by draining pipes. In the bamboo irrigation system of Meghalaya, particularly practised in *Jaintia* hill district, farmers use to supply hill stream water from upper reaches through bamboo channels and irrigate arecanut and betelvine in the field particularly on steep hillslopes. *Zabo* system of farming typically consists of rainwater harvesting pond in the



Bamboo irrigation system (a) and *Zabo* (b) system of water management in northeast India
(*Source:* Bundela 2007, Singh *et al.* 2018)

steep hilly slopes, and application of harvested rainwater for agriculture, forestry and animal husbandry.

Farmer friendly strategies for mitigating moisture stress

Efficient soil and water conservation practices: Mitigating moisture stress in field conditions necessitates the need for conservation of *in situ* water resources. Maintaining adequate winter moisture supports critical crop growth stages like germination and tillering, ultimately leading to yield improvements of 15–35%. Ensuring water availability during these periods is thus essential for sustainable productivity. Here some of the farmers' friendly technologies are discussed.

- **Mulching:** The mulching with materials such as straw, crop residue, leaves, live plants, or plastic is most prominent strategy to conserve moisture *in situ* soil moisture, protect soil from erosion and improve fertility. Depending on climatic conditions, straw mulch can reduce evaporation by 70%, thereby significantly reduce the irrigation needs of crops. It also regulates soil temperature, suppress weed growth, and reduce evaporation, thereby promoting crop growth. Further, the decomposition of organic mulches enriches soil with nutrients and physical health.

Organic and plastic mulching in tomato

- **Contour farming and bench terracing:** Contour farming involves planting, and cultivating along the natural contours and across the slope of the land, which helps to slow down water runoff, reduce soil erosion, and enhance water infiltration in gentle to moderate slopy hilly terrains ranging from 2–10%, whereas, bench terracing involves converting steep slopes into a series of flat, step-like platforms (benches) particularly suitable for steep slopes of 16–33%. These practices can enhance moisture conservation by reducing runoff up to 50–60% and increasing water infiltration by 30–40%. Moreover, the soil moisture retention through these practices may be as high as 15–25%, leading to better crop performance in rainfed and hilly regions. Cover crop such as legumes (soybean, pea, groundnut, chickpea, lentil, etc.) are used widely besides non-legumes. The cover crops can retain soil moisture as high as 30% compared to bare soil, especially in dryland and rainfed systems. The dense canopy of cover crops acts as live mulches and significantly lowers evaporation rates. Additionally, the root systems of cover crops improve soil structure and porosity, facilitating greater water infiltration and storage.
- **Raised and sunken bed systems:** The raised and sunken bed system is an effective land configuration technique for optimizing water use, particularly in high rainfall areas. Raised beds facilitate better drainage and aeration for upland crops like bhindi, chilli, capsicum etc. while sunken beds retain water, making them ideal for rice cultivation. These systems can improve water use efficiency by 30–50% compared to conventional flat planting. The higher cropping intensity and diversification promotes higher income to farmers.

***Enhancing water availability*:** Conserving the excess rainfall of kharif for growing rabi crops during rainless periods is crucial for optimizing water use. Rabi (winter) crops are crucial for enhancing cropping intensity, food security, and farmer livelihoods in these fragile hill ecosystems. Some of the promising technologies are discussed below:

- **Jalkund (Rainwater harvesting):** *Jalkund* is a small, low-cost, dug-out rainwater harvesting structure designed to collect and store runoff water, which is particularly important for growing winter crops in the NEH region of India. The *Jalkunds* can store 20,000–40,000 of rainwater, providing a reliable water source for irrigation in winter. Utilization of *Jalkund* water for cultivating winter crops like vegetables, mustard, and pulses can enhance yield up to 30–50% and improve cropping intensity. Moreover, *Jalkunds* supports integrated farming systems by supplying water for livestock and horticulture. This simple, cost-effective technology can significantly enhance water security and income generation for small and marginal farmers in the hill region.
- **Check dams and farm ponds:** Like the Jalkunds, the check dams and farm ponds also act as storage tanks, collecting the rainwater and surface runoff. A farm pond can store up to 5,00,000 L of water. These systems not only improve water availability but also support groundwater recharge, livestock watering, and climate-resilient agriculture for small and marginal farmers in the region.
- **Micro-irrigation techniques:** Besides moisture conservation and rainwater harvesting, achieving high water-use efficiency is essential during rainless winters in hilly conditions. Micro irrigation (drip and sprinklers) ensures very high water use efficiency (80–90%) by delivering moisture directly to crop roots, enhancing productivity, conserving water, and enabling off-season cultivation for small and marginal farmers. High-value crops like potatoes, tomatoes, strawberries, fruit crops, and vegetables (cabbage, cauliflower) can be grown

Jalkund at the ICAR-Research Complex for NEH region *(Source:* ICAR)

successfully with 40–60% less water than with conventional irrigations. Under hilly slopes, the gravity-fed drips can be sustainable alternatives, saving power and money. By adopting micro-irrigation in high-value crop production, farmers can enhance their profitability, optimize input use, and support sustainable winter farming in the undulating topographies of the regions.

Crop management strategies: Crop management trategies are very effective in allevating soil moisture stress under dry conditions beside *in situ* and *ex situ* moisture conservation techniques. These practices often used as a contingency crop planning under drought conditions. There are several crop management strategies discussed herein.

- **Drought-tolerant and short-duration crop varieties:** Crops that require comparatively lower water for growth, such as mustard, millets, beans, and legumes should be included for *rabi* cropping in north eastern India. With lower cumulative ET, short duration, drought tolerant varieties are always preferred for water scare regions.
- **Zero-till farming in rice fallows:** Zero-till farming in rice fallows during winter is an important strategy for improving land and water use efficiency in the north eastern region of India, where large areas remain uncultivated after the *kharif* rice harvest due to limited soil moisture and delayed land preparation. By eliminating the need for ploughing, zero-tillage allows for the timely sowing of winter crops like lentil, chickpea, mustard, and linseed, making better use of residual soil moisture. Zero-till farming can reduce turnaround time between crops by 7/10 days and save up to 30–40% water compared to conventional tillage.

Jalkund, An alternative potential rainwater harvesting structure in Wokha district, Nagaland- A case study

Jalkund water can be a substantial source for winter kitchen gardening. To explore this possibility, Singh *et al.* (2018) conducted five on-farm trials involving *Jalkund* technology across Wokha district of Nagaland in 2018. The *Jalkund* water was used to meet livestock rearing and fish stocking beside diversified crop water requirements. The rainwater harvested at different *Jalkunds* can meet up 240.5 m² crop cultivated area in Vegetable Village, 415 m² area in Niroyo village, 385 m² area in Wokha, 375 m² area in Longsachung and 700 m² in Longsachung (LNH) with an average annual water availability of approximately 55,986 liters. The economic returns from these *Jalkund* based systems were also very impressive. The *Jalkund* at Vegetable Village showed the highest B:C ratio of 2.53, followed by LNH (2.25), Niroyo village (2.17), Longsachung (2.00), and Wokha (1.73). The average net income generated from all five *Jalkunds* was estimated at around ₹ 17,340.00.

Table 1. Utilization of Jalkund water for diversified farm activities and its economic analysis in Wokha village

Activity	No. of Plants/ Livestock	Cropping area (m²)	Water requirements	Total water requirements (L)	Crop/ Livestock Production	Gross Return (₹)	Net Return (₹)	B:C ratio
Cabbage	520	150	600 L/irrigation	15429	520 kg	10400	5600	2.17
Fish Stocking	500	20	-	-	500 nos	7500	5500	3.75
Nursery raising	500	200	1000 L/irrigation	52000	5000 nos	30000	10000	1.50
Pig	2	15	120 L/day	43800	140kg	21000	8000	1.62
Total		385		111229		68900	29100	1.73

Source: Singh *et al.* 2018

SUMMARY

The hill ecosystem presents a unique opportunity for sustainable agricultural intensification, with abundant natural resources such as land, water, and groundwater. With scientific interventions such as micro-irrigation, rainwater harvesting *(Jalkunds)*, and *in situ* moisture conservation practices, the problem of moisture stress in winter can be effectively addressed. Traditional practices, such as bamboo drip irrigation and mixed cropping, also offer valuable insights into sustainable water management. However, greater awareness, capacity building, and access to resources are needed to scale these practices effectively. Strengthening research-extension linkages and promoting participatory technology development can ensure that farmers adopt appropriate and affordable solutions. Additionally, the integration of real-time weather forecasting and soil moisture monitoring can help optimize irrigation scheduling and input use. Policy support in the form of subsidies for water-saving technologies and promotion of agroecological practices is vital for broader adoption. Going forward, a multidisciplinary, community-driven approach is essential to build resilience against moisture stress and ensure sustainable agricultural growth in the fragile hill ecosystems of northeast India.

*Corresponding author email: debasishagri@gmail.com

Indian Farming 75 (07): 21-26; July 2025

Agroforestry for improving livelihood security and climate resilience in northeast India

Nongmaithem Raju Singh[1]*, Bidyapati Thangjam[1], P. L. Bhutia[2], P. K. Sarkar[3], M. Prabha Devi[1], S. Hazarika[1] and V. K. Mishra[1]

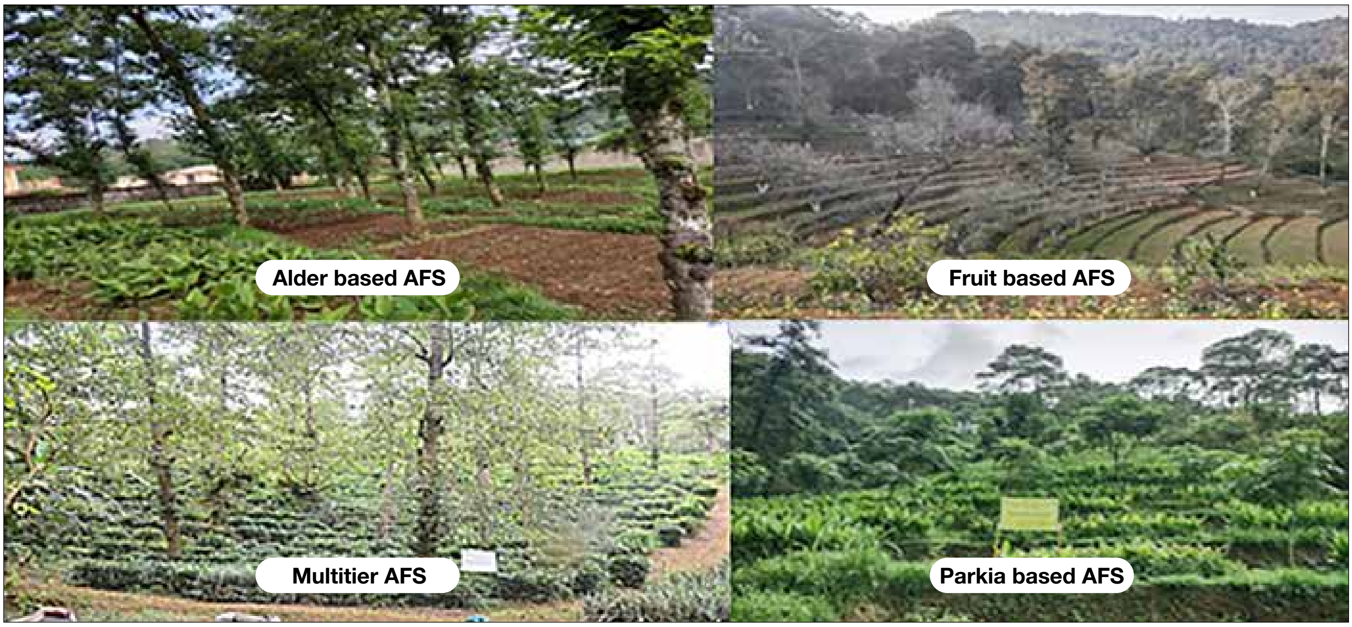
[1]*ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103*
[2]*ICAR Research Complex for North Eastern Hill Region, Nagaland Centre, Medziphema, Nagaland 797 106*
[3]*ICAR Research Complex for North Eastern Hill Region, Tripura Centre, Lembucherra, Tripura 799 210*

Agroforestry is a sustainable land-use practice combining agriculture and forestry to foster ecological, economic, and social benefits. In India, where 70% of the rural population consists of smallholder farmers, agroforestry plays a vital role in reducing pressures on natural forests while providing diversified income and improving climate resilience. Particularly in Northeast India, agroforestry has been integrated into traditional farming systems for centuries, offering solutions to land degradation, reduced agricultural productivity, and climate change adaptation. Diverse agroforestry systems practiced in the north eastern states provide valuable resources like timber, fruits, fodder, and medicinal plants. Furthermore, agroforestry contributes to rural socio-economic development, food security, and poverty alleviation. As climate change poses growing challenges, agroforestry offers a promising path toward sustainable livelihoods and enhanced environmental resilience in India, particularly for marginalized farming communities.

Keywords: Climate resilience, Land degradation, Sustainable livelihoods

IN India 70% of the total population belongs to marginal and small farmers, which are complementing the agricultural deficits from the forest resources, leading to qualitative and quantitative deteriorations in forest. Agroforestry contributes over 65% of India’s timber needs, reducing the pressure on natural forests. States like Uttar Pradesh, Haryana, and Punjab are leading in agroforestry practices, supported by government subsidies and corporate partnerships. In this context, agroforestry emerges as a promising approach to enhance climate resilience and foster sustainable livelihoods for the country. The key idea behind agroforestry is symbiotic land-use practice that combines agriculture and forestry, has become a crucial tool in India's fight against climate change, rural poverty, and environmental degradation. This holistic approach integrates trees and shrubs into farmlands, offering ecological, economic, and social benefits. Agroforestry is more than just planting trees, it is a sustainable pathway towards improving agricultural productivity, enhancing biodiversity, and ensuring environmental resilience. Approximately 25 million hectares of farmland in India is under agroforestry, contributing significantly to the economy and environment. This system of land use provides multiple ecosystem services such as improving soil fertility, enhancing biodiversity, conserving water, and sequestering carbon. Climate resilience and sustainability are essential for the future of agriculture, requiring practices that reduce environmental impact, such as lowering water usage and greenhouse gas emissions, while boosting resilience to climate shocks.

Northeast India, with a diverse range of climatic conditions, is highly vulnerable to changing weather patterns, which affects agricultural productivity, water resources, and local communities' livelihoods. Northeast states have a long history of traditional farming systems, with indigenous communities practicing agroforestry for centuries. These traditional systems are deeply rooted in the region's cultural and ecological landscapes. In particular, systems like shifting cultivation, home gardens, and mixed cropping have incorporated trees and other perennial vegetation alongside crops, ensuring



Some of the prominent AFS of northeast India

sustainable use of land and resources. However, rapid urbanization, population growth, and changes in land use have placed increasing pressure on the environment. In recent decades, traditional agroforestry practices have been disrupted, leading to land degradation, loss of biodiversity, and reduced resilience to climate change. This has resulted in lower agricultural yields and economic instability for farmers in the region. Agroforestry might be the best land-use system for sustainable livelihood in north-eastern states to cope with the present situation. It is a land based production system that is directly related to food security, employment, income opportunities and environmental issues.

Agroforestry for developing sustainable land use in northeast India

The region's economy is predominantly agrarian, with around 75% of the population relying on agriculture and related activities. However, traditional farming practices and an over-reliance on mono-cropping have resulted in declining soil fertility and heightened vulnerability to climate change. Some of the major challenges include:

- Heavy dependence on rainfed agriculture, leading to seasonal food insecurity
- Soil degradation caused by shifting cultivation, reducing productivity
- Deforestation, contributing to biodiversity loss and increased carbon emissions
- Increased frequency of floods and landslides, exacerbated by deforestation and climate change
- Limited access to modern agricultural technologies and financial resources
- Agroforestry, which integrates trees with crops and livestock, presents a promising solution. It enhances ecosystem services, boosts soil fertility, and provides farmers with diversified income opportunities, helping to address these pressing challenges while promoting environmental sustainability.

Agroforestry systems in the context of northeast India

In North Eastern Hill (NEH) region of India, agroforestry is an important agricultural practice, as it helps to conserve the region's fragile ecosystem and improve the livelihoods of local farmers. The NEH region of India is known for its diverse and challenging terrain, and this region has long tradition to several unique agroforestry systems (AFS). For instance, alder based AFS in Sikkim and Nagaland, arecanut with pineapple and black pepper in the mild tropical and plain region, khasi mandarin based AFS in Meghalaya, home gardens in Assam and Manipur plains, and Parkia based AFS across the region. These systems help to optimize several ecosystem functions including both tangible and intangible services. In other words, agroforestry practices, which blend crops, trees, and animals, are widely adopted across different regions of northeast India. These practices not only help boost agricultural productivity but also enhance the adoption of agroforestry among farmers.

Agroforestry for livelihood security

Agroforestry plays a pivotal role in promoting sustainable agriculture, improving livelihoods, and supporting climate resilience. Agroforestry practices traditionally provided interdependent benefits from trees, crops, and livestock, contributing to sustainability through the 6Fs: Food, Fruit, Fodder, Fuel, Fertilizer, and Fiber. These diversified systems integrate a variety of crops, trees, and livestock, enhancing soil fertility, reducing pest risks, and improving biodiversity. The selection of tree species and intercrops depends on the region's climate and the economic value of the species. Nitrogen-fixing trees like Alder improve soil health, while bamboo, a valuable non-timber resource, provides economic benefits. These systems offer farmers a steady income through crops such as fruits, vegetables, and timber, while also supporting food security by growing a variety of crops. Livelihoods are further bolstered by the cultivation of high-value crops such as ginger, turmeric, and cardamom, as well as fruit trees like mango and betel nut, which have significant cultural and economic value. The integration of agroforestry with fish farming boosts productivity and ensures sustainable land use. In AFS, trees also enhance livestock production by providing shade, fodder, and shelter, improving animal health and productivity, especially in regions with harsh climates. The findings of the earlier studies conducted in this region revealed that in tropical hill and plain areas, a combination of pineapple, black pepper, and arecanut generates a net return of

Table 1. Prominent improved agroforestry systems of northeast India

State	Agroforestry System	Key Tree Species	Crops Integrated
Nagaland	Agri-silvicultural system	*Alnus nepalensis*, Bamboo	Rice, Maize, Potatoes, Ginger, Turmeric, Mustard
	Agri-horticultural system	*Areca catechu, Citus* spp, *Amomum subulatum*	Ginger, Turmeric, Mustard, Pineapple, Vegetables
	Silvi-pastoral system	*Leuceana leucocephala, Sesbania grandiflora, Gliricidia sepium, Azadirachta indica, Morus alba*	Fodder Grasses
Meghalaya	Agri-silvicultural-pastoral system	*Alnus nepalensis, Parkia timoriana, Michelia champaca, Gmelina arborea, Schima wallichi, Pinus kesiya, Morus alba*	Ginger, Turmeric, Soybean, Rice Bean, Groundnut, Tiger Grass, Guinea Grass
	Horti-silvicultural system	*Alnus nepalensis, Grevillea robusta, Psidium guajava*	Pineapple, Black Pepper
	Agri-horti-pastoral system	*Citrus recticulata, Psidium guajava, Cirus recticulata*	*Tiger Grass, Guinea Grass, Broom Grass*
	Agri-horticultural system	*Citrus recticulata, Citrus limon, Psidium guajava, Prunus persica, Pyrus* spp	Ginger, Turmeric, Soybean, Pea
Arunachal Pradesh	Agri-Horti-Silvicultural System (Nyishi Community)	*Gliricidia sepium, Pinus wallichiana, Alnus nepalensis, Bamboo spp*	Finger Millet, Maize, Cassava, Yam, Chili, Potato, Eggplant, Taro, Betel Vine, Ginger.
	Bamboo-Based Silvicultural System (Apatani Community)	*Bamboo spp, Pinus wallichiana*	Vegetables
	Toko-Based Agroforestry (Adi Tribes)	*Livistona jenkinsiana, Citrus* spp	Ginger, Maize, Ragi, Tubers, Vegetables
Tripura	Agri-Silvicultural System	*Tectona grandis, Acacia auriculiformis, Gmelina arborea*	Upland Rice, Vegetables
	Silvi-Horticultural System	*Tectona grandis, Gmelina arborea, Azadirachta indica*	Pineapple, Ginger, Black Pepper, Banana,
	Waterlogged Agroforestry	*Areca catechu, Cocos nucifera, Artocarpus heteophyllus*	Wetland Crops (*Colocasia, Esculenta*), Ginger
	Silvi-pastoral system	*Tectona grandis, Gmelina arborea*	Fodder Grasses
Assam	Aqua based agroforestry system	*Artocarpus heterophyllus, Mangifera indica, Citrus spp, Cocos nucifera, Areca catechu*	Rice, Maize, Vegetables Pineapple, Banana
	Homestead/ homegarden	*Artocarpus heterophyllus, Mangifera indica, Citrus* spp, *Zizyphus mauritiana, Cocos nucifera, Areca catechu, Dillenia indica, Citrus Limon*	Vegetables, Rice ,Maize, Banana
	Agri-silvicultural system	*Acacia mangium, Michelia Champaca, Gmelina arborea, Tectona grandis*	Upland Rice, Maize, Vegetables
Mizoram	Home Gardens	*Parkia roxburghii,* banana, papaya, bamboo, citrus, guava	Tuber crops, vegetables, pineapple, livestock (pigs, poultry)
	Agri-silvi-horticultural	Teak, Subabul, Pigeon pea, Lemon	Paddy, fodder
	Agri-silvicultural	*Aleurites fordii, A. montane, Alnus nepalensis, Azadirachta indica , Gmelina arborea, Michelia champaca, Schima wallichi, Parkia timoriana*	*Maize, turmeric, ginger, chillies*
	Horti-silvicultural System	*Teak, Bauhinia, Subabul*	Pineapple, orange, guava, mango
	Bamboo and cane-based System	*Melocanna baccifera, Dendrocalamus strictus, Bambusa tulda*	Ginger, turmeric, soybean, mustard
	Coffee-based System	*Gmelina arborea, Schima wallichii, Michelia champaca, Toona ciliata, Bauhinia spp.*	Coffee

State	Agroforestry System	Key Tree Species	Crops Integrated
Manipur	Silvi-Pastoral System	*Albizia spp., Alnus nepalensis, Schima wallichii, Parkia roxburghii, Gmelina arborea, Quercus* spp.	Elephant grass, Desho grass, Teosinte, Changning
	Agri-Silvi-Pastoral System	*Litsea polyantha, Ficus spp., Alnus nepalensis, Bauhinia* spp., *Erythrina indica, E. suberosa*	Maize, Pigeon pea, Cowpea, Fodder grasses
	Agri-Horti-Pastoral System	*Parkia roxburghii, Elaeocarpus serratus, Phyllanthus emblica,*	*Fruit trees, Vegetables, Fodder grasses*
	Homegarden	*Clerodendrum colebrookeanum, Bambusa nutans, Hedychium flavum, Oroxylum indicum, Parkia timoriana, Zanthoxylum acanthopodium, Ziziphus jujuba, Mangifera indica, Psidium guajava*	Seasonal vegetables/crops, fodder grasses, fruit trees
Sikkim	Agri-silvicultural system	*Bamboo, Pine, Oak, Alder, and other local species.*	Rice, Maize, Millet, Pulses, Vegetables
	Cardamom-based Agroforestry	*Alnus nepalensis, Areca catechu*	Cardamom, Spices, Vegetables
	Agri-horticultural	Sikkim mandarin, *Citrus reticulata, Persea americana*	Maize, ginger, turmeric, vegetables, pulses, flowers
	Agri-horti-silvi-pastoral	*Citrus reticulata, Persea americana, Juglans regia, Ficus* sp., *Schima wallichii*	*Maize, ginger, vegetables, oilseeds, pulses*
	Homesteads	*Citrus reticulata, Citrus* spp, *Punica granatum, Moringa, Mangifera*	Vegetables, floriculture, fishery, mushroom, livestock

₹43,000/ha Similarly, in temperate zones, plum with potato or cole crops yields ₹19,000/ha. Mandarin trees, when optimally planted at 400 per hectare, show significant yield growth, from 12.8 kg/tree after 7 years to 57.3 kg/tree after 12 years. Between these trees, crops like groundnut, soybean, turmeric, ginger, and local taro can be grown for additional income. The studies conducted in *Parkia roxburghii* based AFS provided a yield of ₹ 1,854/tree and farmers could earn a total of ₹ 3.609 lakh/ha. Three-tier agroforestry systems with alder, tea, and crops like large cardamom, ginger, and black pepper generates a net benefit of ₹ 33,111/ha.

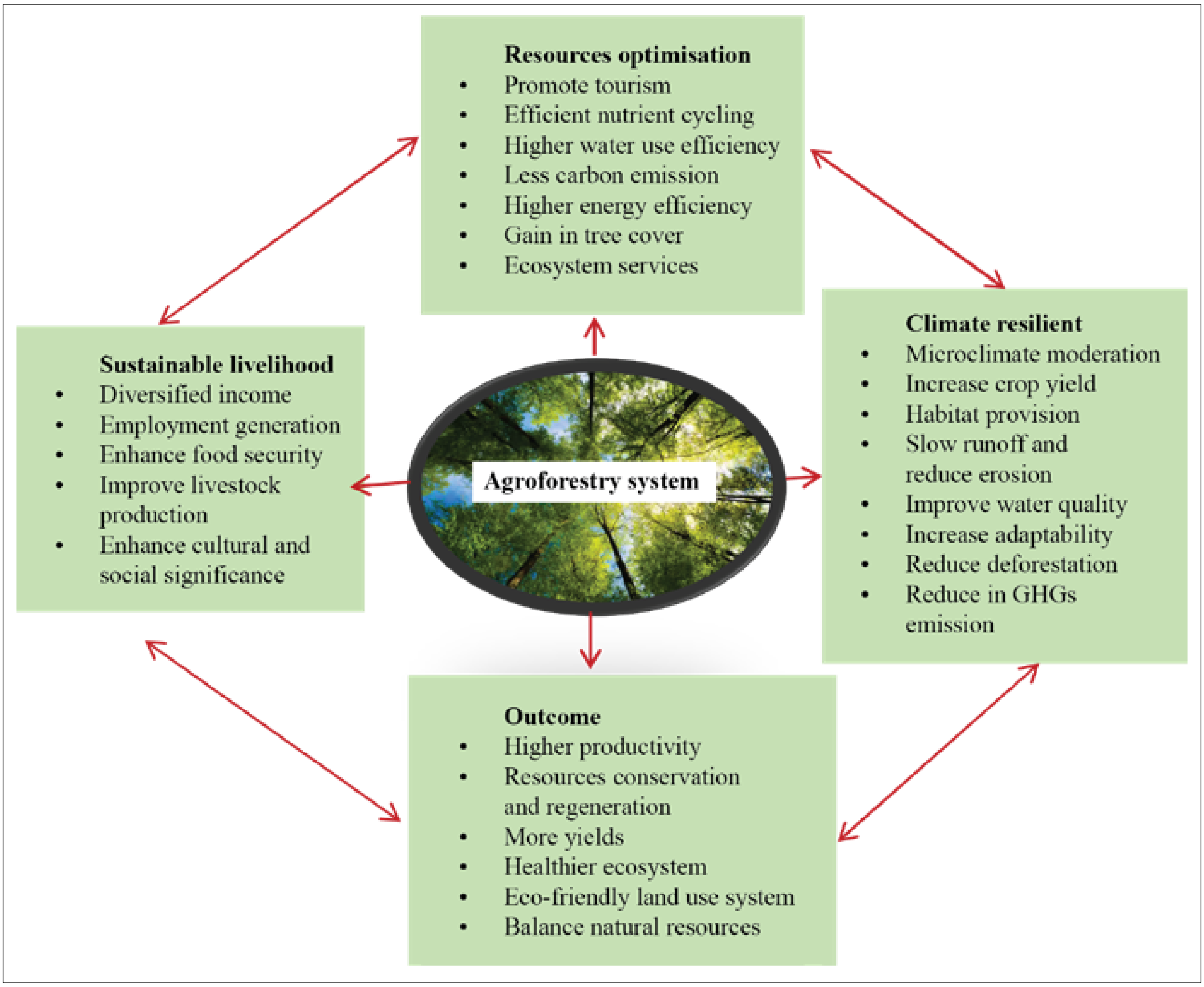
Carbon sequestration potential of AFS

The key feature of AFS is their significant contribution to carbon sequestration, a key strategy in addressing climate change. The trees within these systems act as efficient carbon sinks, capturing and storing carbon dioxide from the atmosphere. This dual function not only reduces the carbon footprint of agricultural practices but also aligns with global climate action efforts. As the trees grow, they sequester carbon in both their biomass and the soil, effectively serving as a natural reservoir for greenhouse gases. This approach highlights the synergy between agriculture and climate solutions, demonstrating how agroforestry can play a pivotal role in mitigating climate change and fostering environmental resilience.

Recent studies have shown that AFS can sequester carbon at rates that are much higher than those of monoculture cropping systems or natural forests. For instance, AFSs in the tropics can sequester carbon at rates of up to 20 tonnes of CO_2/ha/yr, while monoculture cropping systems typically sequester less than 1 tonne of CO_2/ha/yr. Another study in the temperate regions revealed that AFS can sequester carbon at rates of up to 10 tonnes of CO_2/ha/yr, while natural forests in the same region sequester around 5 tonnes of CO_2/ha/yr. Similarly, one of the studies conducted in north-eastern part of India estimated that AFS has the capacity to store carbon at rates of up to 15 tonnes of CO_2/ha/yr. Other studies conducted in this region found that the *P. roxburghii* based AFS have the carbon sequestration potential of about 0.23 Mg/ha/yr, suggesting as an important tree component (carbon sink) while restoring the degraded jhum lands of the region. Overall, this data clearly shows that agroforestry has a high potential for carbon sequestration, which will eventually help in reducing the CO_2 concentration of the atmosphere.

Agroforestry for soil improvement

The continuous accumulation of leaf litter and its decomposition in AFS enhance nutrient availability for intercrops by enriching soil fertility, promoting better nutrient uptake, and optimizing nutrient cycling processes. The research conducted in 26 years old Parkia-based AFS in Meghalaya revealed that this system produced 415.50 g/m^2 of root biomass and 353.92 ± 14.40 g/m^2 of annual litter biomass, thereby adding continuous carbon to the system. Similar results have been reported from AFSs of the NEH region of India where AFS produced have a substantial positive impact on soil quality by enhancing soil organic matter, soil structure, and soil fertility. A study conducted in the state of Meghalaya discovered that agroforestry systems elevated soil organic matter by as much as 40% in comparison to monoculture cropping systems. The study also found that these systems improved soil structure and fertility, resulting in higher crop yields. Another study in Meghalaya found that agroforestry



systems positively impacted soil quality by increasing soil organic matter, total nitrogen, and available phosphorous, as well as positively influencing the microbial population of the soil and increasing its capacity to retain water. These studies provide evidence that agroforestry can significantly improve soil quality in the NEH region of India, thereby increasing the productivity and protecting the limited available natural resources for the generation to come. Another study conducted in NEH region of India also found that AFS can increase the availability of nutrients to crops by up to 50% and the efficiency of nutrient cycling by up to 30% in comparison to monoculture cropping systems. Research also indicated that water-stable aggregates (>0.25 mm) increase under various multipurpose tree species. By offering multiple benefits, agroforestry systems reduce economic vulnerability and increase the well-being of rural communities, especially by buffering against shocks like droughts, floods, or pests. Recent studies show that conventional farmers perceive climate change negatively impacting food security and health. In contrast, smallholder agroforestry farmers rely on trees for income from fruits, firewood, fodder, timber, and medicine. Trees help farmers manage risks by storing financial capital for emergencies.

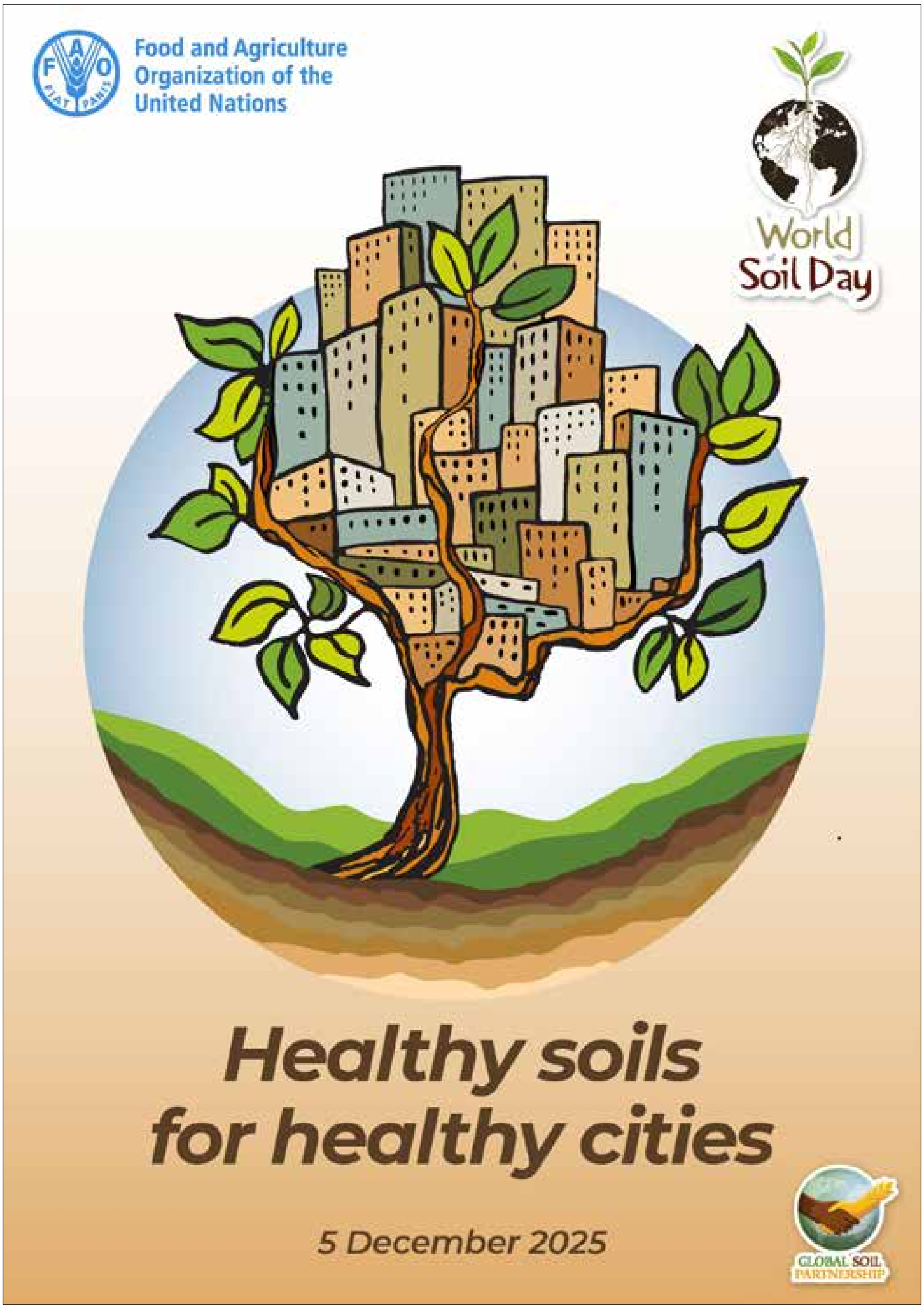
Agroforestry for climate resilient

Agroforestry systems diversify income, improving farmers' resilience to extreme weather events. Additionally, trees and shrubs in agroforestry systems create habitats for pollinators, such as bees and butterflies, boosting the yields of pollinator-dependent crops. By providing shade and reducing soil temperature fluctuations, agroforestry systems create microclimates that help maintain moisture levels, which is particularly beneficial in areas with extreme temperatures. Trees on farms provide timber, fodder, and fuel wood, offering a safety net during climate shocks. In times of crop failure, farmers turn to trees for livestock feed, reducing vulnerability. Agroforestry systems substitute timber, fodder, and fuel wood demands, helping farmers cope with climate change and forest degradation. These systems reduce deforestation of protected forests and enhance local income resilience. One-third of a household's income comes from trees on farmland, which is less impacted by climate hazards like drought. Agroforestry plays a vital role in improving farmers' resilience to climate change. In regions prone to soil erosion, the root systems of trees slow water runoff, reduce erosion, and prevent the loss of topsoil, especially in hilly areas. Agroforestry also contributes to improved water quality by filtering runoff, preventing contaminants from entering water sources, and promoting groundwater recharge.

SUMMARY

Agroforestry, integrating trees with crops and livestock, is a critical tool in addressing climate change, rural poverty, and environmental degradation in India. Agroforestry helps reduce pressure on natural forests by contributing over 65% of the country's timber needs. In northeast India, agroforestry has been a part of traditional farming systems for centuries, helping farmers cope with climate variability. These systems offer diverse benefits, such as improving soil fertility, conserving water, enhancing biodiversity, and sequestering carbon. Specific agroforestry practices in states like Nagaland, Meghalaya, and Manipur involve the integration of nitrogen-fixing trees, fruit trees, and crops like maize, ginger, turmeric, and cardamom, boosting productivity and resilience. As climate change impacts food security and health, agroforestry offers a way to diversify income sources, reduce vulnerabilities, and buffer against extreme weather events. Agroforestry also holds cultural significance, preserving traditional knowledge and strengthening communities' connection to the land.

*Corresponding author email: rajuforestry@gmail.com



Indian Farming 75 (07): 27-29; July 2025

Optimizing lowland agriculture:

Raised and sunken bed technology in the north eastern Himalayas

Niraj Biswakarma[1], Badapmain Makdoh[1]*, Jayanta Layek[2], Rahul Saikia[1], Anup Das[3], Christy B. K. Sangma[1] and S. Hazarika[1]

[1]*ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103*
[2]*ICAR-Indian Institute of Agricultural Biotechnology, Garhkhatanga, Ranchi, Jharkhand 834 003*
[3]*ICAR Research Complex for Eastern Region, Patna, Bihar 800 014*

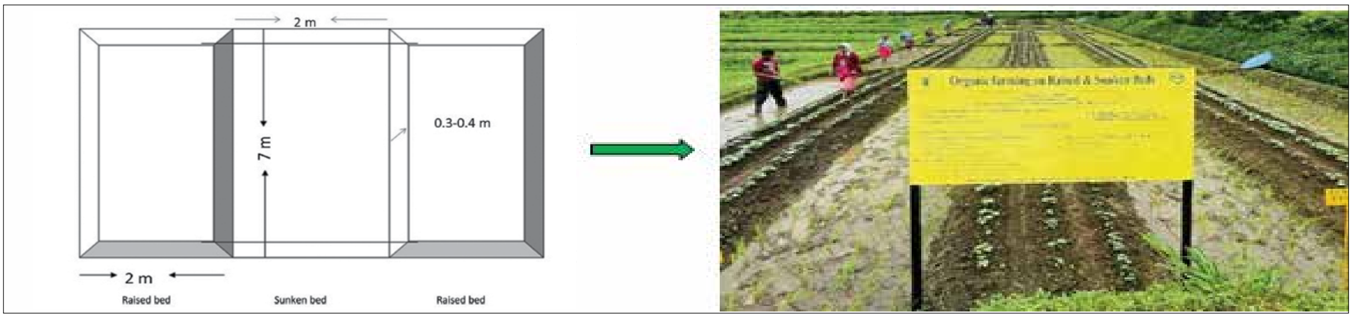
The north eastern region of India is blessed with diverse crops, high rainfall, and a suitable agro-climate. However, the region faces unique challenges such as waterlogging and poor drainage during summer, as well as water stress in the winter season. In this context, adoption of raised and sunken bed (RSB) technology in valley lands ensures the proper utilization of available land resources, increases cropping intensity by up to 300%, and enhances farm profitability for long-term benefits. Raised beds can be used for growing vegetables such as okra, tomato, potato, French beans, carrot, brinjal, and broccoli, while sunken beds can be utilized for cultivating rice, followed by vegetable peas, lentils, and other crops using proper resource conservation technologies. Field experiments conducted at ICAR Research Complex for North Eastern Hill Region, Meghalaya, have demonstrated the system's effectiveness in enhancing productivity, soil health, the sustainable yield index, and economic viability. However, its success depends on strategic crop selection and effective nutrient management practices. In summary, the adoption of RSB technology in valley lands could be a practical approach towards achieving food security, improving soil fertility, and enhancing economic resilience in the north eastern Himalayan region.

Keywords: Crop diversification, Economics, Raised and sunken beds, Soil health, System productivity

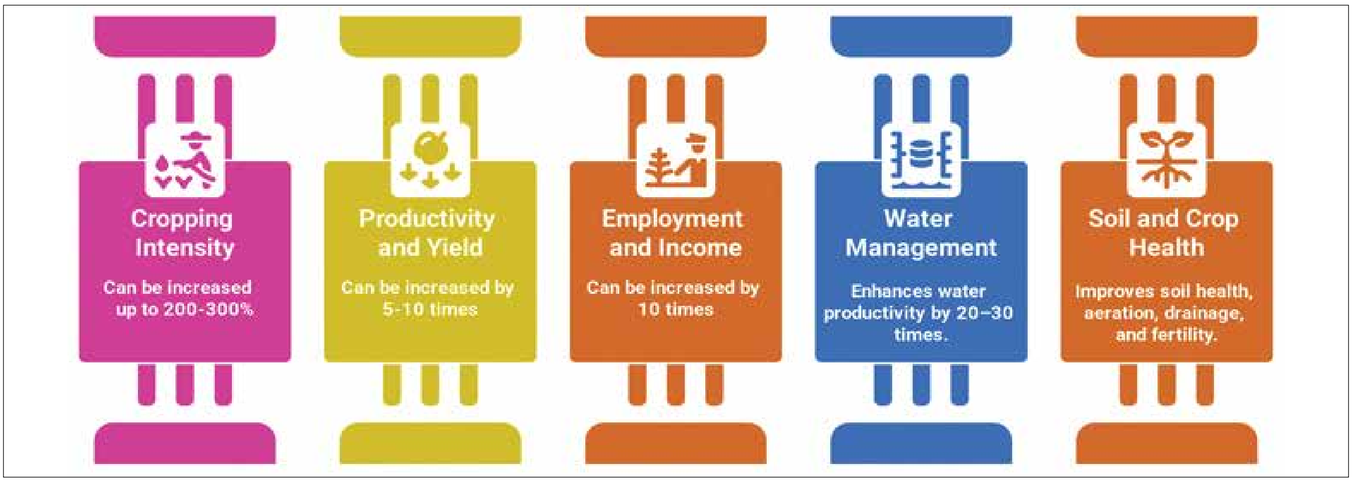
RAISED and Sunken Bed (RSB) technology is an innovative land configuration system designed to optimize crop production in waterlogged and poorly drained agricultural lands. This configuration effectively manages land and water by promoting inter-plot water harvesting, improving soil drainage, enhancing aeration, and facilitating year-round cultivation. It involves excavating surface soil from designated areas to form sunken beds, while depositing the removed soil onto adjacent sections to create raised beds. RSB technology is commonly known as 'high bed-low ditch (HBLD) system' or 'dike-ditch interactive system' in southern China, while in southeast Asia, it is referred to as 'dike-ditch system', or 'raised-bed-dike system (rong chin in Thai)'. In Java and Indonesian tidal wetland, this method is extensively practiced as 'Sorjan or Surjan system', where high value upland crops are grown on raised beds and rice in sunken beds. In India, this system has been successfully adopted in the Indo-Gangetic plains and North Eastern Region (NER), where excessive monsoon rainfall leads to prolonged soil saturation, restricting farmers to rice monocropping. Additionally, in coastal regions like the Sundarbans, RSB system aids in rainwater harvesting, soil salinity management, and dry-season crop production.

Raised and sunken beds in ICAR, Meghalaya

The low-lying areas can benefit from the configuration of lands generally known as RSB technology. In north eastern India, especially Meghalaya, the mono-cropping of rice is predominant in the valley ecosystem, and around 15,500 hectares of land remain under marshy conditions in the rainy season. Contrastingly, in the winter season, the farmers make temporary bun (broad beds) for growing vegetables such as tomato, potato, French bean etc. nevertheless, before the sowing of succeeding rice crops, the bun get dismantled, and levelled which not only escalates the production costs



Schematic illustration of alternate raised, and sunken beds system (RSB)



Advantages of raised, and sunken beds (RSB) technology

but also consumes greater energy. In this context, ICAR Research Complex for the NEH region has developed a permanent RSB by the cut-and-fill method by removing soil from individually sunken beds and depositing it in the adjacent area for creating raised beds. The dimensions of an individual plot were 7 m in length, 2 m in width, and 0.3 m in height, wherein 40% of the areas were allocated to raised beds and 60% to sunken beds.

Case studies from ICAR Research Complex for NEH Region, Meghalaya

Case study 1 [Impact of RSB on productivity and soil health]: A long-term field experiment was conducted at ICAR-RC for NEH Region, Meghalaya, India to assess the impact of RSB system under different organic nutrient management. In the sunken beds, 03 rice varieties viz. Megha SA-1, Shahsarang 1, and IR-64 were cultivated, followed by pea under no-till conditions. Meanwhile, the raised beds were utilized for three vegetable-based cropping systems: okra-potato, okra-French bean, and okra-carrot along with organic nutrient sources: (i) 100% of the recommended dose of farmyard manure (FYM), (ii) 100% of the recommended dose of vermicompost (VC), and (iii) a combination of 50% FYM and 50% VC. The results of the study demonstrated that the system productivity increases in the Shahsarang 1-pea system by 5.55 14.0% compared to others. Among nutrient sources, application of FYM + VC resulted in 23.0% and 23.7% higher system productivity than VC and FYM alone, respectively. In raised beds, okra-carrot system exhibited the highest system productivity (24.7 t/ha), system production efficiency (67.7 kg/ha/day), and SYI (0.93). Similarly, the combined application of FYM + VC resulted in greater system productivity (21.9 t/ha), and SYI of 0.82. Further, highest soil organic carbon (SOC) content in the sunken bed system was recorded in the Shahsarang 1-pea system (26.6 g/kg) and FYM application (26.73 g/kg). Similar trend was observed in terms of nitrogen (N), phosphorus (P), and potassium (K). Further, the okra-french bean system (22.6 g/kg) and FYM-treated plots (22.7 g/kg) recorded the highest SOC, statistically similar to okra-potato (22.5 g/kg) and FYM + VC application. Among nutrient management practices, FYM application resulted in the highest available nitrogen (256.3 kg/ha), whereas the combined use of FYM + VC led to the highest available phosphorus (11.3 kg/ha) and potassium (264.8 kg/ha), followed by FYM and VC alone.

Case study 2 [Impact of RSB on economic profitability]: The long-term experiment on RSB technology was established in 2005 at ICAR-Research Complex for NEH Region, Meghalaya, India. The experiment consists of four rice cultivars-Megha Aromatic, Shahsarang 1, Ngoba, and Lampnah in sunken beds, while in raised beds, okra-tomato, okra-potato, okra-French bean, and okra-carrot were imposed along with four nutrient management strategies: (i) 75% recommended dose (RDF) through farmyard manure (FYM), (ii) ~100% RDF through FYM, (iii) integrated nutrient management (50% RDF from FYM and fertilizers), and (iv) ~100% RDF through fertilizers. The results revealed that, the highest gross, and net returns

Raised and sunken beds system in the farmers' field, and experimental site at ICAR-Research Complex for North Eastern Hill Region, Umiam, Meghalaya

were recorded in Lampnah (1,15,852) and 75,964 ₹/ha, respectively), while Shahsarang 1 yielded the lowest (1,04,063 and 64,087 ₹/ha). Among nutrient management practices, highest production cost was associated with 100% organic management (42,459 ₹/ha), whereas 75% organic incurred the least (36,342 ₹/ha). The highest gross return was achieved under 100% organic management (1,15,764 ₹/ha), with net returns following a similar trend, showing 5.56%, 6.16%, and 6.52% higher returns compared to 75% organic, integrated, and 100% inorganic management, respectively. In raised beds, among cropping systems, highest cost of cultivation was recorded under okra-potato (1,23,564 ₹/ha). The highest net returns were recorded in the okra-carrot system (4,33,006 ₹/ha), which was 1.67%–47.0% higher than other cropping systems. Among nutrient management strategies, the highest net return was observed under integrated nutrient management (1,23,564 ₹/ha), followed by 100% organic (3,83,368 ₹/ha), while 75% organic resulted in the lowest net return (2,86,041 ₹/ha).

SUMMARY

The adoption of Raised and Sunken Bed (RSB) system presents a promising approach to enhancing agricultural productivity, cropping intensity, and farm income. Since rice is a staple food, completely replacing it is not feasible. However, the "rice plus" system, which integrates rice with legumes in sunken beds and diverse vegetables in raised beds offers a sustainable intensification strategy. RSB technology is an economically viable solution for improving farm productivity and soil health through continuous organic farming. Recommended cropping sequences are particularly effective for enhancing system productivity along with higher economic returns. However, successful adoption depends on precise land configuration, as improper construction may reduce productivity. By implementing RSB systems correctly, farmers can achieve sustainable agricultural growth and significantly improve their livelihoods.

*Corresponding author email: bmakdohicar@gmail.com

Indian Farming 75 (07): 30-34; July 2025

Improved cultivars of rice for different

ecologies of north eastern India

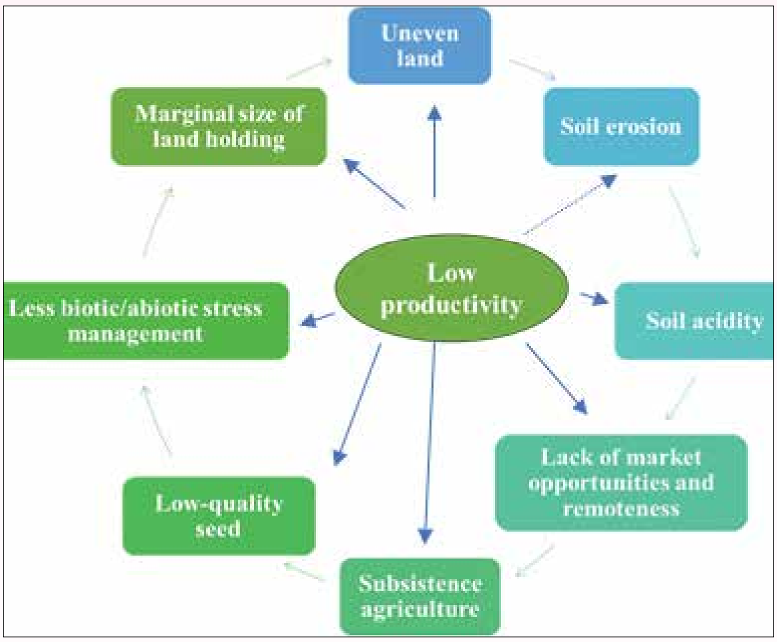
Amit Kumar[1]*, Letngam Touthang[1], Konsam Sarika[2], Simardeep Kaur[1] and S. P. Das[3]

[1]ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103
[2]ICAR Research Complex for North Eastern Hill Region, Manipur Centre, Imphal, Manipur 795 001
[3]ICAR-National Research Centre for Orchids, East Sikkim, Sikkim 737 106

Quality seeds of improved rice varieties play a significant role in augmenting the productivity in north eastern region of India. ICAR Research Complex for NEH region has developed a total of 42 high yielding varieties (HYVs) of rice. Among these, 16 varieties for lowland, 3 varieties for upland, 14 varieties for both lowland and upland, 1 black rice variety and 3 varieties for high altitude lowland conditions were developed. Farmers' orientation, field demonstration cum awareness programmes were conducted at Institute farm vis a vis farmers' field in order to augment the area under HYVs. Participatory seed production programme was also implemented with active involvement of progressive farmers in order to meet the seed requirement. As a result, more than 30 percent of area under paddy cultivation in north eastern region of India has been occupied by high yielding varieties developed by the institute.

Keywords: Paddy, Participatory seed production, Quality seeds, Varieties

RICE being an integral part of north eastern India as a source of food, income, customs, traditions and nutritional security signifies itself as most important food crop. The various tribes of the north eastern hill (NEH) region maintain around 10,000 landraces in diverse ecosystems like high altitude, upland rice in Jhum cultivation, steep terrace rice, cultivation in floodplains, and deep water. The seven sister states comprising of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Assam and Tripura, is surrounded by four countries namely, Bhutan, China, Myanmar and Bangladesh and considered as an Indo-Burma biodiversity hotspot. The rice crop is cultivated on 2.14 percent (0.99 m ha) area with the total production of 2.08 percent (2.70 m tonnes) of the total contribution of the country. The average productivity of these states is lesser (2.47 t/ha) as compared to national average and thus not able to fulfil the requirement of the growing population in NEH region, resulting in imports from other states. There are several constraints for reduced yield namely, rainfed conditions, less connectivity with transport facilities, poor market infrastructure, higher cultivation cost, less or marginal land holding, subsistence type of agriculture with low inputs in terms of nutrient, disease



Reasons for low productivity in north eastern hilly region of India and pest management, low/poor availability of quality seeds, etc.

Majority of constraints can be managed by adopting infrastructure and policy reformation vis a vis empowering farmer with scientific technologies and methods of scientific cultivation practices. Availability of quality seeds remains a problem; and ICAR-Research Complex for North Eastern Hill Region, Umiam, Meghalaya since its inception in 1975, has been consistently working on availability of quality seeds through development and release of numerous rice varieties suitable to the needs of local population.

As formal system of seed production is lacking in these states, ICAR-Research Complex for NEH Region, Umiam, Meghalaya has been consistently putting efforts in order to link the farmers with technologies by implementing participatory seed production techniques, training and orientation of farmers towards quality seed production, creation of seed villages under TSP and buyback of quality seeds after proper inspection from progressive farmers. As a result, the varieties developed by the institute has been grown on 324260 ha (32.65 percent of total rice area) in the seven sister states of NEH region. The Institute has developed 42 rice varieties suitable to various ecologies of NEH region.

Table 1. Improved varieties of rice released for NEH region

States	No.	Improved cultivars
Tripura	17	Gomati Dhan/ TRC 2005-1, Khowai/ TRC 2005-3, Tripura Chikan Dhan/ TRC 2008-4, Tripura Nirog/ TRC 2008-6, Tripura Hakuchuk-1/ TRC 2013-4, Tripura Hakuchuk-2/ TRC 2013-5, Tripura Jala/ TRC 2008-1, Tripua Aush/ TRC 2013-12, Tripura Khara Dhan-1, Tripura Khara Dhan-2, Tripura Sharat Dhan/ TRC 2008-5, Naveen/ CR-749-20-2, NICRA Aerobic Dhan-1/ TRC 2015-5, ICAR-NEH Hill Rice 14-8/ TRC 2014-8, ICAR NEH NICRA-Boro Dhan 1/ TRC 2016-14, ICAR-NEH NICRA Hill Rice 2022-2/ TRC PSM-1720-B-B-5-1, ICAR NEH NICRA Aerobic Dhan-2/ TRC 2020-14
Meghalaya	08	Bhalum 1, Bhalum 3, Bhalum 5, Shahsarang, Megha SA2, NEH Megha Rice 1, NEH Megha Rice 2, NEH Megha Rice 3
Manipur	12	RC- Maniphou 4, RC- Maniphou 5, RC- Maniphou 6, RC- Maniphou 7, RC- Maniphou 10, RC- Maniphou 11, RC- Maniphou 12, RC- Maniphou 13, RC Maniphou-14, RC Maniphou-15, RC Maniphou-16, RC Manichakhao 1 (black rice)
Sikkim	05	Sikkim Dhan-1, Sikkim Dhan-2, Sikkim Dhan-3, VL- Sikkim Dhan-4, Sikkim Organic Chirakey Selection-1

Description of varietal characteristics (Tripura state)

Lowland conditions:

- **Gomati Dhan/ TRC 2005-1:** The variety was released in 2012 and recommended for rainfed shallow lowlands and irrigated conditions in *kharif*. The variety was developed from a cross between Pyzam and BPT 5204. The variety is 105 cm tall with dark green foliage, and medium slender white grains. The maturity duration and yield potential of the variety is 130–135 days (seed to seed) and 5.8–6.0 t/ha, respectively.
- **Khowai/ TRC 2005-3:** The variety was released in 2012 and recommended for rainfed shallow lowlands and irrigated conditions for both *kharif* and boro season. The variety was developed from a cross between Jagannath and Jaya. The variety is 118 cm tall with dark green foliage, and medium slender white grains. The maturity duration and yield potential of the variety is 120–125 days, (seed to seed) and 5.4–6.0 t/ha, respectively.
- **Tripura Chikan Dhan/ TRC 2008-4:** The variety was released in 2014 for rainfed shallow lowlands and irrigated lands during *kharif* season. The variety was developed from a cross between C53 and IR 28224-3-2-3-2. The plant matures in 135 days with a yield of 6.2-6.4 t/ha. The height of plant is 106 cm.
- **Tripura Nirog/ TRC 2008-6:** The variety was released in 2014 for rainfed shallow lowlands and irrigated condition in *kharif*. The high-yielding variety was developed from a cross between IR 24594-204-1-2-3-2-6-2 and IR 28222-9-2-2-2-2. With a plant height of 113 cm, the variety matures in 122–125 days with a yield potential of 6.5 t/ha.
- **Tripura Sharat Dhan/ TRC 2008-5:** The variety was released in 2014 and recommended during both *kharif* and boro season. The variety was developed from a cross between IR 72870-120-1-2-2 and IR 72870-19-2-2-3. The variety is 104 cm tall with dark green foliage. The maturity duration and yield potential of the variety is 125 days (seed to seed) and 5.8 6.0 t/ha in *kharif* season and 6.0–6.2 t/ha in boro season, respectively.
- **ICAR NEH NICRA-Boro Dhan 1/ TRC 2016-14:** The variety was released in 2022 recommended for boro cultivation in Tripura, West Bengal, Assam and other neighbouring north eastern states. The variety was developed from a cross between Pyzum with Sambha Mahsuri. The plant matures in 150–155 days with a yield of 6.4 t/ha in boro season. The height of plants is 100 cm with good foliage.

Both lowland and upland conditions:

- **Tripura Hakuchuk-1/ TRC 2013-4:** The variety was released in 2014 and recommended for early rainfed lowland, uplands and jhum conditions. The variety was developed from a cross between IR 78877-208-B-1-2 and IR 74371-54-1-1. The variety is 123 cm tall with dark green foliage, and medium slender white grains. The maturity duration (90–92 days in direct seeded and 98–100 days in transplanted) and yield potential (6.2 t/ha in *kharif* and 7.2 t/ha in boro season) are quite comparable.
- **Tripura Hakuchuk-2/ TRC 2013-5:** It was released in 2014 for early rainfed lowland, uplands and Jhum conditions. The variety was developed from

ICAR NEH NICRA Aerobic Dhan-2

ICAR-NEH NICRA Hill Rice

ICAR NEH NICRA-Boro Dhan 1

a cross between IRRI 132 and IR 74371-54-1-1. The plant matures in 100–105 days under transplanting and 92–94 days under direct seeding with a yield of 5.7 t/ha in *kharif* and 6.8 t/ha in boro season. The height of plants is 124 cm with dark green foliage, compact panicles and long, slender white grains.

- **Tripura Jala/ TRC 2008-1:** It was released in 2014 for rainfed lowland, uplands and jhum conditions in *kharif*. The high-yielding variety was developed from a cross between TRC 229-F-41 and Jaya, and suitable for waterlogging conditions. With a plant height of 115 cm, the variety matures in 145 days with a yield potential of 4.9 t/ha.
- **Tripua Aush/ TRC 2013-12:** It was released in 2014 and developed from a cross between IR 78877-208-B-1-2 and IR 74371-54-1-1. The variety is 119 cm tall with dark green foliage. It matures in 98–100 days in transplanted and 90–92 days under direct seeded conditions. The yield potential is 5.7 t/ha in *kharif* and 6.1 t/ha in boro season.
- **Tripura Khara Dhan-1:** It was released in 2014 for shallow lowlands under drought stress conditions during *kharif* season. The variety was developed through marker-assisted backcrossing, incorporating drought tolerance QTLs namely, qDTY2.2 and qDTY4.1 in IR 64 background. The plant matures in 120–125 days with a yield of 5.3 t/ha and plant height of 140 cm.
- **Tripura Khara Dhan-2:** It was released in 2014 for shallow lowlands under drought stress conditions during *kharif* season. The high-yielding variety was developed by incorporating drought tolerance QTLs in IR 64 background. With a plant height of 105 cm, the variety matures in 115–120 days with a yield potential of 5.2 t/ha.
- **Naveen/ CR-749-20-2:** It was released in 2012 for rainfed shallow lowland, irrigated land and upland ecosystem in both aman and boro seasons. The variety was developed from a cross between Sattari and Jaya Sattari. The plant matures in 115–120 days with a yield of 5.0–5.5 t/ha in *kharif* season and 5.5-6.0 t/ha in boro season.
- **NICRA Aerobic Dhan-1/ TRC 2015-5:** It was released in 2021 for aerobic conditions of Jharkhand, Chhattisgarh, Karnataka, Tripura and other neigh boring north-eastern states. The high-yielding variety was developed from a cross between Naveen with a drought tolerant local jhum (shifting cultivation) variety-Kataktara. With a plant height of 100 cm the variety flowers in 85–86 days with a yield potential of 6.3 t/ha.
- **ICAR-NEH Hill Rice 14-8/ TRC 2014-8:** It was released in 2021 and recommended for lower hills of Himachal Pradesh, Karnataka, Tripura and other neighburing north eastern states. The variety was developed from a cross between IR 78878-208-B-1-2 and IR 74371-54-1-1. The variety is 93 cm tall with dark green foliage. The maturity duration and yield potential of the variety is 125–130 days (seed to seed) and 4.3 t/ha under hill ecologies, respectively.
- **ICAR-NEH NICRA Hill Rice 2022-2/ TRC PSM-1720-B-B-5-1:** It was released in 2022 for the upland hills of Himachal Manipur, Tripura and other neighboring north eastern states. The high-yielding variety was developed from a cross between Pyzum and BPT 5204. With a plant height of 95 cm, the variety matures in 120–125 days with a yield potential of 3.4 t/ha in hill ecology.®
- **ICAR NEH NICRA Aerobic Dhan-2/TRC 2020-14:** The variety was released in 2024 for aerobic conditions of Bihar, Haryana, Tripura and other neighboring north-eastern states. The high-yielding variety was developed from a cross between Hakuchuk-1 with Naveen. With a plant height of 101 cm, the variety matures in 117 days with a yield potential of 5.3 t/ha in hill ecology.

Description of varietal characteristics (Meghalaya state)

Upland conditions-mid altitudes:

- **Bhalum 1 (RCPL 1-29):** Released by state seed sub committee in year 2002 for Meghalaya state. The genotype is recommended for main *kharif* season for mid altitude upland conditions. Bhalum 1 is a high yielding, non-lodging and moderately resistance to blast. The plant height is intermediate (105–115 cm) with a maturity duration of 120–125 days and yield potential is 3.5–3.8 t/ha.
- **Bhalum 3 (RCPL 1-115):** Released by state seed sub committee in year 2010 for Meghalaya state. The genotype is recommended for main *kharif* season for mid altitude upland conditions. Bhalum 3 is a high yielding, non-lodging and moderately resistance to blast. The plant height is intermediate (100–105 cm) with a flowering duration of 100-105 days and yield

potential is 3.6–3.9 t/ha.

- **Bhalum 5 (RCPL 1-412):** Identified for Meghalaya and Himachal Pradesh by Varietal Identification Committee meeting in 2015. The genotype is recommended for main *kharif* season for mid altitude upland conditions. Bhalum 5 is a high yielding and non-lodging variety. The plant height is intermediate (100 cm) with a maturity duration of 130 days and yield potential is 3.6–3.9 t/ha.

Lowland conditions-mid altitudes:

- **Megha SA 2 (RCPL 1-160):** Released by state seed sub committee in year 2010 for mid altitude lowland conditions of Meghalaya state. The variety is high yielding, non-lodging and moderately resistance to blast. It maintains a moderate level of aroma when grows in hills. The maturity duration of this variety is 140–145 days with a yield potential of 3.8–4.0 t/ha.
- **Shahsarang 1 (RCPL 1-87-8):** Released by state seed sub committee held in year 2002 for Meghalaya state. The genotype is recommended for main *kharif* season for mid altitude lowland conditions. The variety is a high yielding, non-lodging with intermediate plant height (100 cm). The maturity duration and yield potential of the variety is 135–140 days and 4.0–4.2 t/ha, respectively.

Lowland conditions-high altitudes:

- **NEH Megha Rice 1:** Released by state seed sub committee held in year 1992 for Meghalaya state. The genotype is recommended for main *kharif* season for high altitude (1500-2000 m above msl) lowland conditions. NEH Megha Rice 1 is a high yielding, non-lodging and tolerant to low temperature and phosphorus deficiency. The plant height is intermediate (110 cm) with a flowering duration of 125–135 days and yield potential is 2.9–3.3 t/ha.
- **NEH Megha Rice 2:** Released by state seed sub committee held in year 2002 for Meghalaya state. The genotype is recommended for main *kharif* season for for high altitude (1500–2000 m above msl) lowland conditions. NEH Megha Rice 2 is a high yielding, non-lodging and tolerant to low temperature and phosphorus deficiency. The plant height is intermediate (115 cm) with a flowering duration of 120–130 days and yield potential is 2.8–3.1 t/ha.
- **NEH Megha Rice 3:** Released by state seed sub committee in year 2009 for Meghalaya state. The genotype is recommended for main kharif season for for high altitude (1500–2000 m above msl) lowland conditions. NEH Megha Rice 3 is a high yielding, tolerant to low temperature and phosphorus deficiency. The plant height is intermediate (110 cm) with a flowering duration of 117 days and yield potential is 3.0–3.2 t/ha.

Description of varietal characteristics (Manipur)

Lowland condition:

- **RC Maniphou-4:** The variety wass released in the year 1993 by state seed subcommittee and is recommended for early-*kharif*/*kharif*/summer/ boro season under medium low land area. The variety was evolved from a cross between Kalinga-2 and Palman. It is a fine grain variety bearing about 150–200 spikelets per panicle and yield ranges about 4–4.5 t/ha under good management. It's a short duration variety (110–120 days).
- **RC Maniphou-5 (RCM-8):** It was released in the year 1993 by state seed subcommittee and is recommended for early-*kharif*/*kharif*/summer/boro season under medium low land area of Manipur. Under irrigated and low land, it takes 125 days to mature and in rainfed, 110 days. It has a yield potential of 4.5–5.0 t/ha on an average.
- **RC Maniphou-7 (RCM-9):** It was released in the year 2008 by state seed subcommittee and is recommended for irrigated/waterlogged (5–15cm) low land with medium to high soil fertility, early to medium and early to late planting for main *kharif.* The variety was evolved as a mutant culture of Punshi. It matures in 135 to 145 days with high tillering ability (15–20/hill) and long panicles with 300–450 spikelets and yield potential of 5.5–7.0 t/ha.
- **RC Maniphou-12:** It was released in the year 2012 by state seed subcommittee and is recommended for pre-kharif as well as *kharif.* season in medium low land areas of Manipur valley. It is a derivative of the cross Leimaphou (KD-2-6-3) x Akhanphou and evolved. This variety matures in 90–105 days in summer (March-April sowing) season under Manipur conditions. This crop can successfully be followed by main *kharif* crop. It bears about 150–200 spikelets per panicle and yield about 4.0–5.0 t/ha under good management.

- **RC Maniphou-13:** It was released in the year 2016 and is recommended for irrigated/rainfed valley areas with medium to high soil fertility under normal sowing in main *kharif.* season. The variety was evolved from a cross between Leimaphou and Akhanphou. It is photo-insensitive with yield potential of 7–8 t/ha. It is resistant to leaf and neck blast diseases under natural disease pressure in Manipur. It has got good tillering ability and bears about 250 numbers of filled grains per panicle.
- **RC Maniphou-14:** It was released in the year 2021 by state seed subcommittee and is recommended for rainfed/irrigated ecosystem of Manipur. RC Maniphou-14 is a progeny of the biparental cross, IR 64 × Phougak. It is a semi-dwarf, medium duration fertilizer responsive variety and suitable for main *kharif* season of the Manipur state. It is photo-insensitive with a yield potential of 7 t/ha with 75% hulling percentage, 65% milling percentage, 53% head rice recovery and medium amylose content ~ 24 %.
- **RC Maniphou-15:** It was released in the year 2021 the rainfed/irrigated low land ecosystem of Manipur. RC Maniphou-15 is a derivative of a cross between KD 2-6-3 (Leimaphou) and Phougak. It is a semi-dwarf, medium duration fertilizer-responsive culture with a yield potential of 7.8 t/ha with 79% hulling percentage, 69% milling percentage and 57% head rice recovery.
- **RC Maniphou-16:** It was released in the year 2021 rainfed/irrigated low land ecosystem of Manipur. The variety was evolved from a cross between RCM 10 and RCM 9. It has photo-insensitive with a yield potential of 7.3 t/ha on average with 75% hulling percentage, 65% milling percentage and 52% head rice recovery and amylose content 16.7%. It has soft cooking quality.

Both lowland and upland conditions:

- **RC Maniphou-6:** The variety was released in the year 2000 by state seed subcommittee and is recommended for upland foot hill slopes, terraces and jhum area up to 1350 m above msl. The variety was evolved from a cross between CH-988 and IR-24. Grain quality is fine and sticky in nature. It exhibits moderately resistant to stem borer, gall midge, resistance to blast and BLB with yield potential of 5 t/ha.
- **RC Maniphou-10 (RCM-10):** The variety was released in the year 2008 by state seed subcommittee and is recommended for lowland/waterlogged and terraced land of hill areas up to and altitude of 1250 m above msl. The variety is medium tall (70–90 cm), maturity duration of 120–125 days and derivative of cross between Prasad and IR-24. Its average yield is 5 t/ha.
- **RC Maniphou–11 (RCM-21):** The variety was released in the year 2011 for valley and terraced areas of Meghalaya and Manipur up to an altitude of 1000 msl. RC Maniphou-11 is a medium tall (70–90 cm) derivative of cross between Prasad and IR-24. This variety matures in 120/125 days and is suitable for the main *kharif* season (110-120 days) with a potential yield of 6–7. 5t/ha.

Black rice variety for lowland condition:

- **RC Manichakhao 1:** The variety was released in the year 2024 for irrigated lowland ecosystem of Manipur. RC Manichakhao 1 is a progeny of the cross, Chakhao Poireiton × RC Maniphou 7. It is a semi-dwarf variety with a height of ~100 cm, effective tiller/hill of 11 with improved cooking quality of ASV value 6. It is a medium maturing variety of 130 days. It is tolerant to leaf and neck blast, and false smut diseases under the natural condition of Manipur. It is photo-insensitive with a yield potential of 4.5 to 5 t/ha on average with amylose content of 11%. It has soft cooking quality with the original Chakhao grain quality.

Description of varietal characteristics (Sikkim) under organic conditions

- ***Sikkim Dhan-1:*** It is suitable for rainfed upland and irrigated organic conditions of Sikkim. It has maturity duration of 135 days, plant height of 115 cm and average grain yield of 3.5 t/ha for upland and 4.5 t/ha for irrigated transplanted conditions.
- ***Sikkim Dhan-2:*** Suitable for irrigated organic conditions of Sikkim. It has a maturity duration of 135 days, plant height of 70 cm and average grain yield of 4.6 t/ha.
- ***Sikkim Dhan-3:*** Suitable for rainfed upland conditions of Sikkim. It has a maturity duration of 134 days, plant height of 90 cm and average grain yield of 2.9 t/ha.
- ***VL Sikkim Dhan-4:*** The variety is suitable for irrigated organic conditions of Sikkim. It has a maturity duration of 135 days, plant height of 89 cm and average grain yield of 4.8 t/ha.
- ***Sikkim Organic Chirakey Selection-1:*** Recommended for irrigated transplanted conditions of Sikkim (up to an altitude of 1350 m above msl). The variety is resistant to lodging and shattering, responsive to organic manures with a yield potential of 3.5 t/ha.

SUMMARY

In north eastern part of country, quality seed is the major bottleneck towards maximizing crop productivity. There are many reasons like insufficient seed production of seeds of high yielding varieties (HYVs), unavailability of quality HYVs seeds through market, inefficient distribution of seeds, lack of seed certification agencies and higher prices due to which farmers are forced to use low quality seeds of low/average yielding varieties. Understanding the importance of quality seeds of high yielding rice varieties suitable to NEH region is the key towards increasing productivity and profitability. ICAR-Research Complex for NEH region is continuously working towards development of varieties which in turn will increase the self-sufficiency in terms of rice production of the region.

*Corresponding author email: amit4118@gmail.com

Indian Farming 75 (07): 35-40; July 2025

Kiwifruit: A game changer crop for the farmers of Himalayan region

Sudip Kumar Dutta*

ICAR Research Complex for North Eastern Hill Region, Sikkim Centre, Tadong, Sikkim 737 102

The Chinese gooseberry, also known as kiwifruit, is referred to as "The horticultural wonder of New Zealand" and "China's miracle fruit." Kiwifruit is a dioecious plant that is being researched extensively because, in comparison to other fruits produced globally, its fruit has many nutritional benefits. It is considered as a crop of temperate region, therefore it can be suitably grown in north eastern parts of India in the range of 600–1500 m height above mean sea level where chilling of 0–7°C can be met for 500–800 h. Bruno, Allison, Monty, Hayward, Abbott and Tomuri are the cultivars suitable for the Himalayan region. So far, there are no reports of major pest and diseases of kiwifruit in this region. Adoption of scientific package of practice can improve the productivity and quality of kiwifruit and ultimately increasing the profitability of farmers of entire Himalayan region.

Keywords: *Actinidia deliciosa*, Himalayan, Kiwifruit, Northeast, Production

IN the world's mountain ecosystems, the Indian Himalayan region holds a unique position. These geo-dynamically young mountains support a diverse range of flora, fauna, human communities, and cultural diversity in addition to being significant from a climatic and life-giving perspective, providing water to a significant portion of the Indian subcontinent. The rich soil resources and agroclimatic conditions of the north eastern hills, which are a mega center for rich plant biodiversity, make them perfect for the horticultural industry. The wild relatives of apples, kiwi, and other temperate fruits and nuts can be found growing in their natural state in north eastern forests, illustrating the wide variety of adaptability of various temperate fruit crops. In the north eastern hilly states, especially in Arunachal Pradesh, Sikkim, Nagaland, and Meghalaya, fruits like apples, pears, plums, and peaches are grown on a semi-commercial basis. Strawberries, walnuts, and kiwi fruit are also introduced to new regions. In order to enhance the value of the produce, which has the potential to become a niche commodity for both domestic and international markets, farmers are increasingly integrating new technologies into organic farming systems, even though the majority of the crops are still grown traditionally. Kiwifruit [*Actinidia deliciosa* (A. Chev.) C. F. Liang and A. R. Ferguson] is dioicous plants and is widely being studied as its fruit has many nutritional values as compared to the other fruits produced worldwide. Chinese gooseberry, China's miracle and New Zealand's wonder are some other names for kiwifruit. Nowadays, this fruit is frequently called kiwi in all export packages. The fruit is packed with vitamins, minerals, sugar, and carbohydrates, making it incredibly nutrient-dense. Despite having nearly all the minerals, kiwifruit is especially rich in calcium, magnesium, potassium, and phosphorus. The leaves are a good source of protein, starch, and vitamin C, and they can also be fed to pigs. The fragrant flowers are used to create fragrances. In the early 1900, kiwifruit was first exported to Asia as an ornamental vine. Americans tasted the fruit in the year 1904 and it reached New Zealand in 1906. Kiwifruit is a relatively new fruit crop in India as it was first planted in Lal Bag garden in Bangalore. Commercial varieties were introduced by Plant Introduction Division, IARI and planted its center at Phagli, Shimla, Himachal Pradesh in 1963.

Area, distribution and production

Despite having originated in China, kiwifruit was fully commercialized in New Zealand before spreading to other countries. China, Belgium, Chile, Spain, India, United States of America, the Soviet Union, Italy, Australia, France, England, and Japan are all currently seeing prosperous growth of this crop. In India, it thrives well in Himachal Pradesh Sikkim, Uttarakhand, and Arunachal Pradesh. Its cultivation has now begun in Manipur, Nagaland, and Mizoram as a feasible alternative to other temperate fruit crops. Kiwifruit presents significant opportunities for growth in nearly all north eastern states, with the exception of Tripura and Assam, due to their warmer climate. Arunachal Pradesh stands as the leading producer of kiwifruit in India, encompassing an area of 3,558 hectares and yielding an annual output of 7,111 metric tonnes. Other states that cultivate kiwifruit include Manipur, with a production of 3,025 metric tonnes; Sikkim, contributing 2,159 metric tonnes; Nagaland, at 1,600 metric tonnes; Mizoram, with 1,030 metric tonnes; Himachal Pradesh, producing 116 metric tonnes; as well as certain regions in West Bengal and Jammu and Kashmir.

Botany and dioecism

Kiwifruit is a robust, woody vine or climbing shrub that can reach heights of up to 30 feet (9 m). Its deciduous leaves, which are arranged alternately and have long petioles, measure between 3 to 5 inches (7.5–12.5 cm) in length. These leaves are typically oval to nearly circular in shape, with a heart-like base. The mature foliage appears downy-white and features prominent light-coloured veins on the underside, while the young leaves and shoots are adorned with red hairs. In contrast, the upper surface of mature leaves is dark green and devoid of hair. The aromatic flowers, which can be bisexual or dioecious, appear either individually or in clusters within the leaf axils. Each flower features five to six petals, measuring between one to two inches (2.5–5 cm) in width, and contains a central tuft of numerous stamens in both male and female flowers; however, the male flowers lack viable pollen. Initially, the flowers are white but gradually change to a buff-yellow hue. The fruit, which can reach lengths of up to 2.5 inches (6.25 cm), is oval, ovoid, or oblong in shape, with a russet-brown skin densely covered in short, stiff brown hairs. In its early stages, the fruit is topped with a prominent, five-pointed calyx that eventually separates from the mature fruit, leaving behind five small sepals at the top. The flesh of the fruit is shiny, juicy, and delectable, typically bright green but may also appear yellow, brownish, or off-white, remaining firm until it is fully ripe. The interior is white and succulent, featuring numerous fine, pale lines. Scattered throughout these lines are tiny dark-purple or nearly black seeds, which are nearly indistinguishable when consumed.

Climate

Kiwifruit naturally thrives at altitudes ranging from 600–2000 m above sea level. In its dormant state, the plant can withstand temperatures as low as -12˚C; however, it requires time to acclimatize and is vulnerable to abrupt temperature drops. While the needs of various cultivars differ significantly, the Hayward cultivar specifically necessitates 800 h of winter dormancy at temperatures between 0 and 7˚C. If winter temperatures are excessively mild, the plant may retain its leaves and fail to produce flowers. Kiwifruit flourishes in regions where citrus, peaches, and almonds thrive, although its foliage and blossoms are more sensitive to cold compared to those of orange and peach trees. Fall frosts can impede new growth, damage developing flower buds, and, if they occur after flowering, prevent fruit set. It is noted that kiwifruit tends to have enhanced flavour following late winter frosts. Alternating warm and cold spells during winter can negatively impact flowering. For optimal dry matter accumulation and shoot development, conditions of long daylight hours and elevated temperatures are preferred, specifically around 16 h of light and 20°C. An annual rainfall of approximately 150 cm, distributed evenly throughout the growing season, is sufficient for the plant's needs.

Soil

Kiwifruit thrives best in deep, well-drained sandy loam soils that are abundant in organic matter and resistant to rapid drying during the summer months, as opposed to clay loam soils. The plants cannot tolerate heavy soils with poor drainage or saline conditions. Although kiwifruit can grow in soils with a pH range of 6.0–8.0, an optimal neutral pH of approximately 7.0 is preferred. Soils that are excessively alkaline may lead to nitrogen deficiencies in the foliage. Cultivation in waterlogged, heavy soils is entirely unsuitable. A substantial layer of humus contributes to improving soil texture and maintaining soil moisture.

Cultivars

Key pistillate cultivars cultivated for commercial use include Bruno, Hayward, Allison, Abbott, and Monty, while the staminate cultivars consist of Alpha, Matua, and Tomuri. The morphological traits of the stems, shoots, and leaves, along with the fruit's maturity and flowering, as well as the colour of the fruit and its flesh, do not permit the differentiation of one cultivar from another. Distinctions among cultivars have been made based on the fruit's shape, hairiness at the base of the style, and the petal shape.

Field preparation, layout and planting

A suitable location for establishing a kiwifruit orchard must be free from frost during spring and early autumn, possess well-drained soil, and have relatively high air humidity. To maximize sunlight exposure, the rows should be aligned in a north-south orientation. Successful establishment of a kiwifruit vineyard requires thorough soil preparation. It is essential to incorporate well-decomposed farmyard manure and to pulverize the soil to eliminate hard pans or stones during ploughing or digging. Pits approximately 0.6 m x 0.6 m x 0.6 m should be dug between September and October, with 20–30 kg of well-decomposed farmyard manure added to fill each pit completely. The choice of training system and cultivars will influence the spacing of the plants, which should generally be set 4–5 m apart. Kiwifruit is dioecious, meaning male and female flowers grow on separate vines. To ensure healthy orchards that produce fruit and receive sufficient pollination, it is important

Table 1. Distinguish traits of cultivars

Cultivars	Traits
Bruno	The fruit's slightly tapering shape towards the stem end allows it to be easily identified from other cultivars. Out of all the cultivars available in India, it is the longest. Ascorbic acid content is higher in fruit than in other cultivars. The plant has a lower chilling requirement and better bearing.
Allison	The fruits are a little bit wider than they are long. The fruits have a medium size and taper slightly on both ends. Compared to other cultivars, its average production and sweetness are likewise higher. It is appropriate for mid-hill regions and a heavy bearer. The edges of the flower's petals are crimped and overlap each other. Low levels of acidity and ascorbic acid.
Monty	Although the cultivar flowers late, it matures quickly. The fruits are medium-sized, oblong, equally thick, and flat on both ends, with a slight tapering. Prolific bearer that occasionally needs to be thinned to produce medium-sized fruits. It has a medium sugar blend and a higher acidity.
Hayward	This cultivar is most commonly grown due to its large, eye-catching oval fruit that has the best keeping quality. The fruit is flat and wide, with a much larger width than length. Its flavour is also regarded as superior, and its sugar and ascorbic acid content are relatively high. This cultivar matures slowly and is relatively shy. Therefore, for commercial production, close planting and late flowering pollinizer are needed. Due to the vine's longer chilling requirement, it is better suited for high hills.
Abbott	This cultivar matures and flowers early. Medium-sized, densely haired fruits have a sweet flavour, low ascorbic acid content, and medium titrable acidity. It grows well in mid-hill regions and requires little chilling time.
Tomuri	Late in the season, flowers typically appear in groups of five (1–7) and have long peduncle hairs. It is a best pollinator for the Hayward cultivar.
Bruno	Early in the season, flowers are typically borne in groups of three (1–5) and the peduncles have short hair. For early and mid-season pistillate cultivars, the cultivar is an effective pollinator.

to plant male and female plants in a ratio of 1:8. While hand pollination is labour-intensive, it leads to high-quality fruits and increased yields.

Propagation

Kiwifruit can be propagated through two primary methods: vegetative and seed propagation. Seedlings are cultivated to produce rootstocks suitable for grafting or budding. To enhance germination rates, seeds require a stratification period of 6–8 weeks at approximately 4.4°C. It is advisable to plant the seeds in late winter. The growing medium must be well-drained, adequately aerated, and consistently moist. Additionally, it should be sterilized to eliminate any pathogenic organisms. To shield the seeds from adverse weather conditions, it is prudent to sow them in a glasshouse or polyhouse. Effective techniques for propagating kiwifruit plants include grafting, budding, top working, and both softwood and hardwood cuttings. Among these, softwood cuttings represent a commercial propagation method that produces high-quality plants in a short time frame. Essential practices include misting, providing bottom heat, and utilizing growth hormones. Cuttings should be taken from the current season's semi-mature growth, with the most suitable cuttings measuring 0.5–1.0 cm in thickness, having relatively short internodes, and a length of 15–20 cm. A concentration of 2000–5000 ppm IAA is effective for promoting rooting. For hardwood cuttings, mature, dormant shoots measuring 15–20 cm in length and possessing at least 2–3 nodes are harvested from the previous summer's growth. The bases of these cuttings are wounded and treated with 5000 ppm IAA before being placed in a moist, coarse-textured rooting medium, either in the field under polythene film mulch or on a propagating bench. To prevent desiccation, the shoots should be provided with adequate shade and fine-mesh watering following their emergence.

Training and pruning

During the initial year of a vine's life, a single apical bud is allowed to grow until it reaches the wire, while the vine is pruned back to a height of 30–40 cm from the ground, establishing the main trunk. No additional branching is permitted on this trunk. In the second year, two shoots are selected and secured to the center wire from both sides, forming the secondary arms. In the third year, the tertiary fruiting arms, which will yield fruit in subsequent years, are chosen based on these secondary arms. To ensure stability, these tertiary arms should be tied to the outer trigger wire. The first crop will develop on these laterals, or they may be replaced by fruiting arms. It is important to avoid training fruiting arms parallel to the permanent leaders along the outer trigger wires, as this can lead to competition between the shoots from the leaders and the fruiting arms, resulting in dense growth that adversely affects vine management and development. Pruning is a vital aspect of managing kiwifruit vines to ensure a consistent production of high-quality fruit. Especially the flowers and fruits on wood that has grown from the previous season. For female vines undergoing dormant pruning, the fruiting canes from the previous year should be trimmed back to 10–12 buds beyond the last fruit. To promote the growth of new, robust canes, it is essential to severely prune small, weak wood after a few years. Canes that are broken, twisted, or tangled must be removed, as well as any that cross from one side of the plant to the other. Any growth that droops to the ground should be tied to the trellis or pruned away. Additionally, excess fruiting spurs should be eliminated to maintain a spacing of 8–12 inches between each cane. Male vines can be pruned more aggressively to manage growth, while care should be taken not to overcrowd the female vines. For male plants, heavier summer pruning is often practiced. It is advisable to refrain from pruning in early spring once the plant has begun to grow, as this may lead to excessive bleeding and potential harm to the plant.

Organic nutrient management

When nutrients are effectively managed, kiwifruits can thrive and produce abundantly through vegetative growth. Given that plants are significant consumers of nitrogen, it is advisable to add organic fertilizers generously during the initial half of the growing season. To ensure consistent high yields and quality, well-decomposed, dried cattle manure or compost should be utilized at a rate of 10–40 t/ha hectare from the time of planting until the peak fruit production stage. Farmyard manure should be administered at a rate of 25–100 kg/plant, divided into two applications in February and March. Additionally, neem cake should be applied at a rate of 2 t/ha in early spring, once the vines have developed several inches of new growth. As the plants mature, it is important to gradually increase the annual application of manure. During the active fruit growth phase, vermicompost should be applied at a rate of 4–10 kg/plant to enhance fruit quality and growth. Mulching with straw and/or manures offers numerous benefits; however, care should be taken to avoid direct contact between the mulch and the vine to prevent crown rot.

Irrigation

The robust requirement for moisture is reflected in the vigorous growth of the foliage. Foliage orchards demand substantial water, particularly during the initial two to three years following their establishment. Consequently, the entire soil surface of the foliage orchard acts as a mulch, which reduces the necessity for irrigation. Symptoms of drought stress during the summer include wilting leaves, browning at the leaf edges, and complete leaf drop accompanied by new shoot growth when the stress persists. Water-related issues are more likely to lead to plant mortality than any other cause. Commercial kiwifruit vineyards typically employ overhead sprinklers for both irrigation and frost protection, with sprinkler heads positioned approximately three feet above the training wire. Conversely, drip irrigation is a more efficient use of water. During the hot summer months, plants require watering every 10–15 days. Newly planted vines should receive deep watering once a week throughout the summer. It is crucial to avoid exposing plants to drought stress.

Mulching

Natural weed cover contributes significantly to the preservation of organic matter and soil conservation. To maintain soil moisture, it is essential to regularly clean and mulch the vine basin. In Sikkim, *Schima wallichi*, commonly known as *Chilaune*, is the most effective mulch material, while *Artemisia vulgaris*, referred locally as *Titepati*, serves as a strong alternative. Both of these plants help mitigate disease occurrence. Weeding should be performed just prior to mulching and the application of manure. Depending on the growth rate of the weeds, it may be necessary to conduct weeding two or three times.

Insect and their organic management

So far, no significant pests have been identified on kiwifruit plants in north eastern hill regions. Pests of the polyphagous family may cause some crop damage. Two major pests that cause significant losses are the leaf roller and greedy scale.

Diseases and their organic management

In the context of India, there are no recorded instances of severe disease affecting kiwifruit. While there have been observations of specific leaf spots, these do not lead to significant losses. Conversely, waterlogged conditions, which are more prevalent in clay soils, can lead to root rot. Consequently, it is essential to implement suitable drainage systems.

Harvesting and yield

Kiwifruit stands out as it exhibits no noticeable alteration in the colour of its flesh or skin. The flavour and aroma do not develop since the fruit is picked while still firm. Research indicated that a maturity index of 6.2% or greater in total soluble solids is optimal for harvesting. In Sikkim, kiwifruit harvesting commences in the first week of November. The process involves snapping the stalks at the abscission layer where they attach to the peduncle while the fruit remains firm. After harvesting, fruits are either shaken in a gunny bag or rubbed with a coarse cloth to eliminate any residual stiff hairs from the skin. The firmness of the fruit facilitates its transportation to distant markets. After a storage period of 10–15 days, fruits are ready to be served at room temperature. The average yield is significantly influenced by hand-pollination practices and effective orchard management, with a well-cultivated plant capable of producing up to 90 kg.

Grading

In India, kiwifruit grading typically involves classifying fruits based on weight, with common grades including:

- ***Grade A:*** Fruits weighing 70g or more are typically classified as Grade A. It is of premium quality and price.
- ***Grade B:*** Fruits weighing between 50 and 70g are usually categorized as Grade B. Price and quality considered lesser than Grade A.
- ***Grade C:*** Fruits weighing less than 50g are often designated as Grade C. This is the least quality fruit and can be used for juice, wine and other post-harvest processed products.

Storage

When stored in polythene bags containing ethylene absorbent, kiwifruit can be preserved for an extended period at room temperature by meticulously regulating temperature, humidity, and gas concentration. After four to six weeks of storage, fruit that is not adequately protected may show noticeable shrivelling on its surface due to moisture loss. Shrivelling typically occurs after the fruit has lost approximately 3–4 percent of its weight. No significant physiological disorders have

Table 2. Details of the insects attacking kiwifruit in hilly regions

Insects	Symptoms	Treatment
Leaf roller Numerous leaf roller species, including the green-headed leaf roller (*Planotortrix excessana*), the black-lyre leaf roller (*Cnephasia jactatana*), the brown-headed leaf roller (*Ctenopseustis obliquana)*, and the light brownm apple moth (*Epiphyas postvittana*), aresignificant and cause significant losses.	In the lower half of the canopy, on the smooth upper surface of mature leaves, are the eggs. The caterpillars eat folded, immature leaves early in the season and mature leaves later. Pupae are frequently observed near the base of the canopy.	It is found that two sprays of neem oil 0.15 EC (1500 ppm) @3 mL/L, spaced 15 days apart, are effective against leaf rollers.
Greedy scale (*Hemiber lesiarapax*)	It is primarily found on a variety of shrubs and trees in temperate to subtropical climates. It is primarily located on the leaf's upper surface, close to the petioles and the midrib. Early-season crawlers only cause damage to leaves or woody sections, and their populations colonize before the fruit ripens.	It is found that two sprays of either neem oil 0.15 EC (1500 ppm) @3 mL/L or petroleum-oil based spray @ 10 mL/L at intervals of 15 days are effective against the Greedy scale.

been reported during the storage of kiwifruit, even in cases of premature harvesting or accidental freezing of the fruit tissue.

Constraints

The favourable climate and soil conditions are present; however, the primary obstacles to enhancing the productivity of temperate fruits, especially kiwifruit, include the scarcity of high-quality planting materials, high cost of establishment of plantation, absence of comprehensive organic farming practices, lack of polliniser varieties and hand pollination, lack of modern precision farming technologies, lack of use of plant biostimulants and insufficiently trained labourers.

Prospects and thrust areas of kiwifruit in Himalayan region

Kiwifruit presents a promising future in our nation, particularly in the northeast region. It has been identified as a significant commercial fruit for the future, offering substantial returns per unit area, with farmers potentially earning between ₹4 to 5 lakhs/ha each year. The kiwifruit consistently yields abundant harvests annually, with no instances of crop failure reported. Renowned for its nutritional and medicinal benefits, it is particularly recommended for individuals with diabetes and heart conditions due to its numerous health-promoting properties. Furthermore, there have been no significant pest or disease issues associated with kiwifruit, enhancing its potential as an environmentally friendly commercial crop in the country. The fruit's tough, hairy skin protects it from damage by birds and monkeys. Additionally, kiwifruit boasts an extended shelf life, remaining viable for up to one month at room temperature and for 4–6 months when stored in cold conditions. The state wise potential areas are as follows:

- ***Arunachal Pradesh:*** Ziro Valley in lower Subansiri district is a key area for kiwifruit cultivation in Arunachal Pradesh. Kiwis are also grown in West Kameng, Lower Dibang Valley, Si-Yomi, Kamle, Papum Pare, and Pakke Kessang districts.
- ***Sikkim:*** The Lachung, Fakha Farey, and Lachen areas in north Sikkim are known for kiwifruit cultivation. Yuksom in west Sikkim is another area where kiwifruit cultivation is thriving.
- ***Manipur:*** The Purul sub-division in Senapati district is known as a prime area for kiwifruit cultivation in Manipur.
- ***Nagaland:*** Phek district has emerged as a significant kiwifruit-producing area, while Zunheboto, and other districts like Kohima, Wokha, and Peren are also contributing to the state's kiwi production.
- ***Mizoram:*** In Mizoram, Champhai district particularly and other higher elevated regions of districts like Aizawl, Lunglei, Serchhip, Saiha and Lawngtlai can be potential areas for kiwifruit cultivation.

A fully growing kiwifruit plantation in Sikkim

Kiwifruit in fruiting stage

Table 3. Details regarding some diseases that impact kiwifruit in the Himalayan region

Disease	Causal Organism	Symptoms	Disease Cycle	Management
Root rot, Collar rot and Crown rot	*Phytophthora coctorum, P. cinnamomi, P. citricola, P. lateralis, P. megasperma*	Delayed bud break, wilting and reduced leaf size, and dieback of twigs and shoots are the initial symptoms. When a plant is starved of water and nutrients, its leaves droop, and eventually the vine collapses. The infection begins at the outermost layer and progresses to the crown and main root.	Spring or early summer is when these fungus infections are most common. Sites with inadequate soil drainage are more prone to the disease. The fungus grows in the earth and disperses through contaminated plants, soils, tools, and irrigation water.	Spring or early summer is when these fungus infections are most common. Sites with inadequate soil drainage are more prone to the disease. The fungus grows in the earth and disperses through contaminated plants, soils, tools, and irrigation water.
Leaf spot	*Alternaria spp., Botryosphaeria spp., Fusarium spp., Cladosporium spp., Colletotrichum acutatum,* and *Phomopsis spp*	On the leaves, brown lesions are widespread and asymmetrical, while white lesions are confined. colonize only wounded	It is observed that pathogens leave tissues rather than directly attacking healthy tissues.	Cleaning up the field, gathering, and burning sick leaves. Removing diseased branches or shoots can help lessen the illness. Implementing the best training system possible to improve airflow and light penetration and stop the creation of a microclimate that encourages leaf diseases.Spraying copper oxychloride (0.25%) or Bordeaux mixture (1.0%) is advised if disease symptoms are observed, especially following wind or hailstorms that injure foliage.
Bacterial leaf blight and Blossom blight	*Pseudomonas viridiflava*	Only leaves and flowers are afflicted by this illness. The pathogen causes blossom blight, which significantly lowers the yield, but it has no effect on vine vigor. Dark, angular lesions with a yellow halo surrounding them are the primary symptoms on the leaves. Subsequently, the lesions could grow larger and the necrotic tissues might finally fall apart. The brown, sunken patches on the sepals of closed flower buds are the first signs of blossom blight. The filaments and sterile anthers of the severely infected female flowers are rotten. The hair is usually colored brown and stunted. Although partially infected flowers may produce tiny or distorted fruits, infected flowers typically shed.	Bacteria are thought to be present on the vines all year round. The infection is favored by wet conditions and rain during bud break and early flowering.	Keeping the field clean overall and trimming any afflicted areas aid in disease detection.

SUMMARY

It is highly advisable to pursue commercial-scale kiwi fruit production across all states in the northeast, excluding Assam and Tripura, provided that essential development prerequisites such as suitable self-sustaining technologies, infrastructure, and effective marketing facilities are systematically addressed. This initiative should be undertaken with a long-term vision and in a mission-oriented manner, involving the active collaboration of the local, regional and central agencies involved in development of horticulture. The temperate fruits found in the north eastern hill states, especially kiwi fruit, have the potential to be cultivated into a significant industry. This development could provide a sustainable economic foundation for the rural population of the hilly areas and contribute to the overall economy of the northeast region, enhancing livelihoods and facilitating exports to neighbouring countries.

*Corresponding author email: sudipiari@rediffmail.com

Indian Farming 75 (07): 41-43; July 2025

Converging innovations for resilient seed potato production in the northeast

Clarissa Challam*, Ngurasangzuala Sailo, Yvonne Angel Lyngdoh and P. Janani
ICAR-Central Potato Research Institute, Regional Station, Shillong, Meghalaya 793 009

Potato is a key crop in India, with the North Eastern Region (NER) offering significant potential for its cultivation due to favourable climatic conditions. However, potato farming in the NER is constrained by poor access to quality seed tubers, high costs, and reliance on long-distance transport, which leads to disease accumulation and reduced seed viability. To address these challenges, innovative seed production technologies such as micro-propagation, aeroponics, and apical rooted cuttings (ARC) are being promoted in the region. Micropropagation forms the basis for producing virus-free, genetically uniform planting material. These microplants are used in aeroponics systems to produce high-quality minitubers efficiently in controlled environments. In parallel, ARC technology provides a low-cost, decentralized method suited to smallholders, enabling the production of quality seed tubers at village level. The integration of aeroponics and ARC creates a complementary and scalable seed system that enhances local seed availability and reduces dependency on external sources, thereby enhancing the sustainability and productivity of potato farming in the NER.

Keywords: Aeroponic, ARC, Micropropagation, Potato, Seed

POTATO (*Solanum tuberosum* L.), the world's fourth most important food crop, plays a critical role in India's food and nutritional security. Among the country's diverse agro-ecological zones, the North Eastern Region (NER) holds considerable potential for potato cultivation due to its favourable climate. Despite this, potato farming in the region remains largely rainfed and faces significant challenges related to the untimely availability of quality seed tubers, which can account for 40–50% of the total cost of production.

Traditional seed systems in the NER often rely on seed tubers sourced from distant regions, which not only escalates production costs but also leads to quality deterioration due to disease accumulation from successive vegetative propagation. The logistical burden of transporting bulky seed tubers across hilly terrain further compromises seed viability and accessibility.

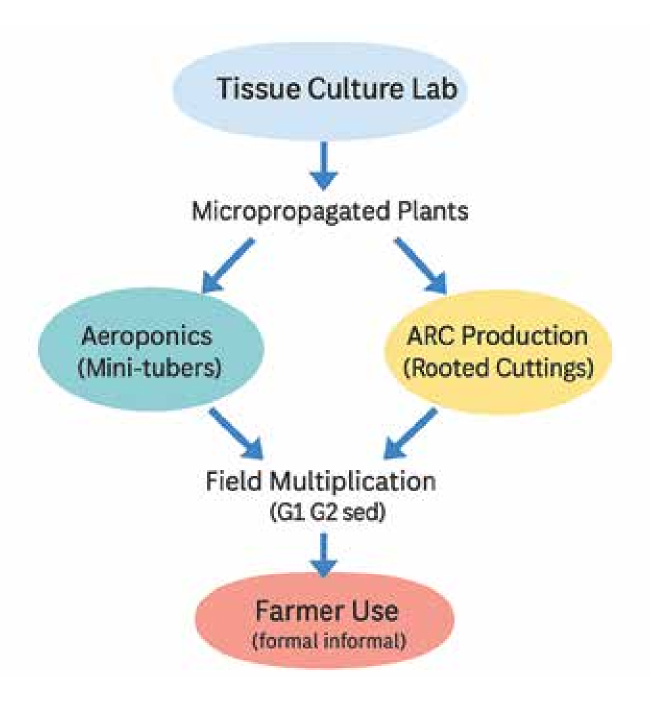
To address these challenges, innovative technologies such as micropropagation, aeroponics, and apical rooted cuttings (ARC) have emerged as transformative solutions. These methods facilitate the rapid and large-scale production of disease-free seed potato, significantly lowering input costs. This article explores how the convergence of these technologies customized for the unique conditions of the NER is contributing to a resilient, decentralized, and inclusive seed ecosystem.

Micropropagation: Foundation of clean planting material

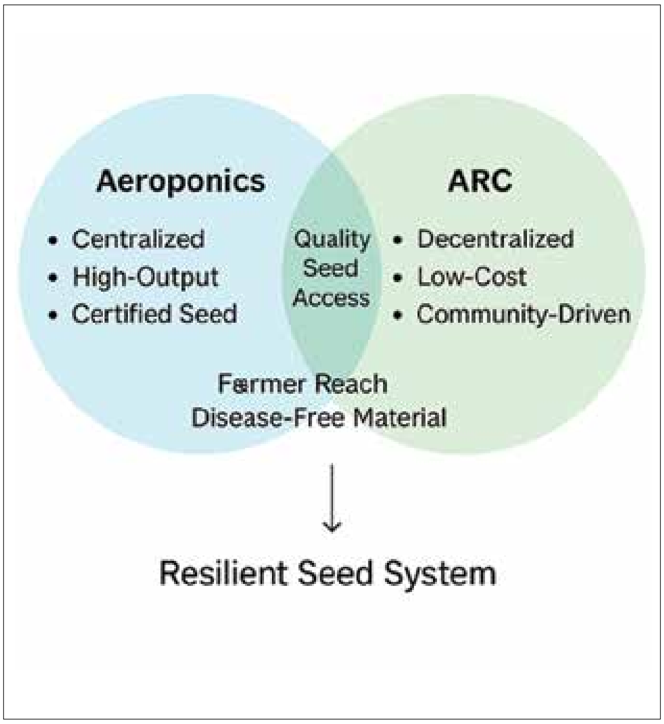
The foundation of both aeroponics and ARC-based seed systems lies in tissue culture-based micropropagation. This is a sterile, high-precision method for multiplying genetically uniform, disease-free planting material. In this process, virus-free mother plants are maintained under controlled laboratory conditions. Nodal explants, typically single nodes with a leaf, are excised and cultured in nutrient-rich media. This environment allows the generation of thousands of high-vigour microplants with identical genetic makeup. Prior to their use in seed production, these microplants are screened using diagnostic tools such as ELISA (Enzyme-Linked Immunosorbent Assay) or PCR (Polymerase Chain Reaction) to confirm they are free from major potato viruses like PVY, PVS, PLRV, and PSTVd. These validated microplants form the cornerstone of clean seed production systems, ensuring traceability, uniformity, and reliability throughout the chain.

Aeroponics: Efficient and controlled mini-tubers production

Aeroponics is a modern, soil-less cultivation technique where micro-plants are planted on top of the growth chamber, and the developing root zone inside the chamber is fogged with nutrient solution



A fully growing kiwifruit plantation in Sikkim



Aeroponics and ARC complementarity

periodically. This highly oxygenated root environment promotes vigorous plant growth and efficient nutrient uptake. The closed nature of the system minimizes contamination risk and enables year-round production in controlled conditions. In the context of seed potato production, aeroponics is capable of rapidly multiplying mini-tubers with uniform size and high health standards. A single micro-plant can yield 60–80 mini-tubers in a 90–100 day cycle. This method is also highly space-efficient and ideal for protected cultivation in NER, where maintaining seed purity and disease-free conditions is critical.

ARC technology: Decentralized and farmer-friendly

ARC (Apical Rooted Cuttings) is a low-cost, scalable technology tailored for decentralized seed production in remote and resource-limited areas such as the NEH region. It involves the sequential cutting of apical shoot tips, approximately 1.5–2 cm long with a node and a pair of true leaves from mother plants raised from tissue-cultured micro-plants. These shoot tips are rooted in pro-trays using soilless media like cocopeat under humid conditions in polyhouses or hardening chambers. Once rooted, they are transplanted into protected net houses or open fields at a spacing of 30 × 15 cm. Each rooted cutting produces 5–15 seed-grade tubers within 60–90 days, referred to as Generation-0 (G0). Under NEH condition, ARC allows staggered planting over a 7–8 months window, facilitating continuous production and efficient land use. It reduces reliance on seed imports, shortens multiplication cycles, and enables farmers, SHGs, and FPOs to become local seed producers. ARC has been widely demonstrated in NEH states through institutions like ICAR-CPRI, KVKs and SAUs.

Complementarity and convergence of aeroponics and ARC

While both systems originate from tissue culture microplants, aeroponics and ARC offer complementary advantages rather than serving as substitutes. Aeroponics is suited for centralized, high quality seed production under controlled environments. ARC, by contrast, is more accessible to small and mid-sized farmers, enabling localized, low-cost seed multiplication. The convergence of these technologies ensures efficiency, scalability, and inclusivity across the seed value chain ultimately contributing to a resilient and inclusive seed production network tailored for the NER.

Embedding technologies in formal and informal seed systems

In the formal seed system, aeroponics plays a vital role in producing high quality seed due to its controlled, pathogen-free environment. ARC-based systems, when developed from verified micro-plants and managed in protected conditions, can also be brought under certification, particularly for G0 and G1 seed classes. In the informal system, ARC has proven to be a transformative tool for community-led seed multiplication. SHGs, FPOs, and rural entrepreneurs can produce and distribute quality planting material without demanding certification processes. The system promotes seed self-sufficiency, enhances local livelihoods, and improves access to timely seed in remote hill regions.

Institutional and policy support

The advancement of aeroponics and ARC in NE India has been supported by a collaborative framework of institutions and government agencies. ICAR-CPRI, KVKs, and SAUs have contributed through research, training, and technology dissemination. The Meghalaya Basin Management Agency (MBMA) and

State Departments of Horticulture have supported infrastructure creation for net houses and nurseries. The Department of Horticulture, Government of Mizoram, has also adopted aeroponics to produce localized mini-tubers. These coordinated efforts are establishing a sustainable and region-specific seed system in the region.

Limitations and Research Gaps

Limited on-ground infrastructure for aeroponics: While aeroponics shows high potential in quality seed production, its adoption is constrained by initial setup costs, energy requirements, and technical expertise particularly in remote hill areas with unreliable power and limited skilled manpower.

Scalability of ARC technology: Although ARC is decentralized and farmer-friendly, the standardization of protocols for large-scale, uniform quality production across various microclimates in the NEH region is still a work in progress. In addition, variability in tuber output per rooted cutting can affect predictability and economic return.

Limited availability of virus-free mother plants: The entire system relies heavily on disease-free microplants as the starting point. Ensuring a consistent and decentralized supply of these validated mother plants remains a challenge, especially in the informal seed system.

Inadequate certification mechanisms for ARC: While aeroponics fits well into formal seed systems, ARC-based G0/G1 tubers often remain outside formal certification schemes. This lack of certification can hinder market acceptance and confidence among buyers.

Data deficiency on long-term performance: There is limited empirical data on the long-term field performance, yield stability, and economic viability of ARC-derived and aeroponically produced seed tubers under diverse NEH agro-climatic conditions.

SUMMARY

The north eastern region is on the threshold of a seed system transformation. Through the integration of high-tech (aeroponics) and low-cost (ARC) innovations, combined with institutional support, the region is building a resilient, decentralized, and inclusive seed production model. While aeroponics supports large-scale production of clean seed under controlled conditions, ARC offers a farmer-friendly and affordable way to multiply seed locally. Together, they create a flexible and efficient seed system suited to the region's needs. With continued support from research institutions, state departments, and community groups, these technologies can strengthen seed self-sufficiency, improve crop productivity, and support the livelihoods of farmers in the hill regions of northeast India.

*Corresponding author email: clarissachallam@gmail.com

Indian Farming 75 (07): 44-47; July 2025

Optimizing orchid cultivation:

Strategies for enhancing production and profitability

S. P. Das*, A. Nikhila Vaagdevi, N. S. Kalaivanan, C. Gowda H., S. Natta, S. S. Biswas, A. Kumar and L. C. De

ICAR-National Research Centre for Orchids, Pakyong, Sikkim 737 106

Orchidaceae, one of the largest and most diverse flowering plant families, comprises approximately 28,000 species and over 100,000 cultivated hybrids, thriving in ecosystems ranging from tropical rainforests to arid regions. Orchids exhibit remarkable ecological adaptability, growing as epiphytes, lithophytes, or terrestrials, and rely on specific mycorrhizal fungi and specialized pollinators for survival and reproduction. This ecological specialization highlights their crucial role in maintaining biodiversity and ecosystem balance.

Keywords: Ecological adaptability, Ecosystem balance, Flowering plant

THE global market of orchids is a dynamic and rapidly expanding segment of the ornamental plant industry, driven by the exceptional diversity, adaptability, and aesthetic appeal of orchids. Their intricate floral structures and captivating beauty have cemented their status as one of the most valued groups of flowering plants, widely used in traditional and modern industries.

The market thrives on cultivating diverse varieties and hybrids, catering to an increasing consumer preference for rare and exotic species, alongside standardized commercial varieties. The Asia-Pacific region dominates global orchid production and export, with Thailand, Taiwan, and China leading the industry. Thailand, in particular, has established itself as a major exporter, specializing in the mass cultivation of Dendrobium and other commercially significant species. Taiwan and Malaysia also play pivotal roles in supplying high-quality potted and cut orchids to international markets. In Europe, the Netherlands serves as a critical hub for orchid trade, excelling in the production, distribution, and re-export of both cut flowers and potted plants. Consumer trends indicate a growing interest in unique and exotic orchids. This rising preference is further supported by advancements in tissue culture and hybridization technologies, which enable large-scale production of uniform, disease-free plants and the development of novel hybrids with enhanced traits such as vibrant colours, prolonged shelf life, and resilience to environmental stresses.

India's position in the global orchid market

India has increasingly recognized orchids as a high-value crops, presenting significant economic opportunities, particularly in the northeast region. The rising demand for medicinal orchids in states like Sikkim and other north eastern States underscores their potential in both traditional and commercial markets. While India harbours a vast diversity of orchid species, many with unique medicinal properties, their commercialization remains limited. Sustainable practices and conservation efforts must be prioritized to ensure biodiversity protection while fostering economic growth. Over the past decade, India has made substantial progress in orchid cultivation. The area under orchid farming expanded from just 10 hectares in 2012–2013 to 3,040 hectares in 2022–2023. Similarly, orchid cut flower production surged from 180 metric tonnes (MT) to 10,730 MT over the same period. Initially, orchid cultivation was concentrated in the northeast, with states like Assam, Mizoram, Meghalaya, and Sikkim covering 43 ha and producing 5,480 MT of cut flowers in 2013–2014. However, in recent years, cultivation has extended to Karnataka, Kerala, Madhya Pradesh, Telangana, Goa, and West Bengal, where orchids are grown for both cut flower and loose flower production.

While India has made notable contributions to orchid taxonomy, species discovery, and academic research, these efforts have not yet translated into substantial economic benefits. Unlike other nations that have successfully leveraged their orchid resources for large-scale commercial trade, India's orchid sector remains underdeveloped. To bridge this gap, a stronger focus on market-driven cultivation, large-scale commercial production, and integration into the global supply chain is essential. Without strategic interventions in breeding, tissue culture, and export infrastructure, India's orchid industry will continue to lag despite its rich biodiversity. By prioritizing research-driven innovation and aligning cultivation practices with international market standards, India has the potential to emerge as a significant player in the global orchid trade.

Selection of suitable orchid species and hybrids

- ***Stress and climate adaptability:*** Selection of orchids with resilience to abiotic and biotic stresses, ensuring sustainable cultivation across diverse environmental conditions.
- ***Market and economic viability:*** Selection based on demand for cut flowers, potted plants, and medicinal applications, with emphasis on high-yielding and commercially valuable species.
- ***Growth, flowering, and post-harvest performance:*** Preference for species with rapid growth, frequent blooming, extended shelf life, and high transportability.

Commercially viable orchid species

Orchids for cut flower production: *Cymbidium eburneum, Cymbidium ensifolium, Paphiopedilum hirsutissimum, Paphiopedilum insigne, Paphiopedilum venustum, Paphiopedilum villosum, Vanda coerulea, Vanda stangeana* and *Vanda tessellata;* along with intergenic hybrid groups such as *Mokara, Aranda* and *Arachnis.*

Orchids for potted plant industry: *Phalaenopsis, Oncidium, Miltonia, Cymbidium, Paphiopedilum, Dendrobium, Cattleya, Ascocenda, Vanda, Brassia, Epidendrum, Lycaste, Rhyncostylis, Renanthera.*

Optimal light and temperature requirements for orchids

Orchids have diverse light and temperature requirements depending on their genus.

- ***Light requirements:*** Cymbidiums thrive under bright morning sunlight and require varying light intensities across seasons, with mature plants needing 50–55% shade in hot weather. Dendrobiums prefer warm, bright light with at least 12–14 h of exposure daily, while Phalaenopsis can be cultivated indoors under artificial light, requiring 1000–1500 foot candles in winter and lower intensities in summer. Cattleyas and Oncidiums require moderate to bright light with 30–50% shade, whereas Vanda orchids demand high light levels, with shading requirements varying by leaf type Paphiopedilum orchids grow best under low to medium light (60–70% shade).
- ***Temperature:*** Plays a crucial role in orchid growth and flowering. Cymbidiums tolerate temperatures as low as 7°C, with flowering initiated at 10–15°C, while Dendrobiums exhibit varied preferences based on species, ranging from cool-growing types (10–24°C) to warm-growing ones (22–32°C). Phalaenopsis thrives best at 26–27°C during growth and 19–21°C for flowering, with a minimum of 15°C in winter. Cattleya, Oncidium, and Paphiopedilum orchids have adaptable temperature ranges, though most require moderate warmth, with some Paphiopedilum hybrids tolerating up to 36°C. Vanda orchids, highly sensitive to cold, need warm temperatures year-round, with cylindrical types requiring a minimum of 16–17°C at night and flat-leaved types preferring 10–12°C in winter.
- ***Humidity and watering requirements for orchids:*** Proper water management is crucial for orchid cultivation, as overwatering leads to root rot and disease susceptibility. Most orchid species prefer water with a pH range of 5.0–6.5, with rainwater being optimal. Watering frequency varies with environmental factors, pot size, and substrate type. High humidity (50–80%) is essential for optimal growth and flowering, with misting, fogging, and companion plants aiding in humidity maintenance. Cymbidium requires year-round watering, while Dendrobium and Phalaenopsis perform best at 50–70% humidity. Oncidium watering depends on root morphology, with fleshy-rooted species requiring less frequent irrigation. Paphiopedilum requires 65–75% humidity, with gradual reduction in winter. Vanda orchids demand high humidity (70–75%) and frequent irrigation, especially in warmer months.

Potting media, containers, and repotting strategies

The selection of appropriate potting media, containers, and repotting techniques plays a crucial role in optimizing orchid growth, health, and productivity. Orchids thrive in well-draining, aerated substrates such as bark, sphagnum moss, charcoal, perlite, and coconut husk, which facilitate proper root respiration and prevent waterlogging. The choice of media should align with species-specific requirements, environmental conditions, and cultivation systems. Equally important is the selection of containers, which should ensure adequate drainage and airflow. Regular repotting is necessary to replenish nutrients, remove decomposed media, and accommodate root expansion, ensuring sustained plant vigour and optimal flowering. Proper repotting techniques, including the use of sterilized tools, minimal root disturbance, and careful handling, contribute to faster recovery and growth.

Advanced cultivation techniques for yield optimization

Advancements in bioreactor-based micropropagation for orchid mass multiplication: Bioreactor technology has revolutionized large-scale orchid propagation by providing a controlled, sterile environment that enhances micropropagation efficiency. Temporary Immersion Bioreactor Systems (TIBs) have proven particularly effective in optimizing nutrient uptake, minimizing contamination risks, and ensuring uniform plantlet development. This approach accelerates the production of high-quality, market-ready plantlets while reducing labour and production costs. To maximize the benefits of bioreactor systems, future research should focus on species-specific optimization of key parameters such as nutrient composition, immersion cycles, and aeration strategies. The development of customized culture media tailored to different orchid species is crucial for improving seed germination and *in vitro* propagation. Refining protocols for recalcitrant species will enhance explant survival and genotype-specific responses, addressing challenges associated with their propagation.

Precision-controlled environment cultivation for orchid production: Polyhouse cultivation offers a controlled environment by regulating temperature, humidity, and light, ensuring optimal growth conditions for orchids. Automated irrigation and fertigation systems enhance resource efficiency by delivering precise amounts of water and nutrients, minimizing waste and improving plant health.

The integration of IoT-based real-time monitoring enables continuous tracking of environmental parameters, facilitating data-driven decision-making for cultivation optimization. Microclimate control strategies, including misting, shading, and ventilation, play a crucial role in maintaining stable growing conditions, reducing plant stress, and maximizing productivity.sssss

In commercial orchid production, precision and digital farming technologies are instrumental in improving sustainability and efficiency. Real-time monitoring through remote sensing and drone-based assessments enables precise management of key environmental factors, directly influencing plant growth and yield. Advanced precision irrigation systems, supported by soil moisture sensors, ensure water is applied efficiently, optimizing plant hydration while preventing overwatering. Automated climate control systems further stabilize growth conditions, reducing labour requirements and mitigating environmental stress. AI-driven data analytics refine breeding strategies and resource management, while GIS-based mapping aids in strategic planning for both commercial expansion and conservation initiatives.

Phalaenopsis Orchid Biowall at ICAR-NRC for Orchids, Pakyong, Sikkim

High-density planting: High-density planting and space optimization techniques enhance orchid cultivation efficiency by maximizing available space. Vertical farming systems allow orchids to be grown in stacked layers, optimizing land use. Multi-layered rack cultivation is particularly beneficial in controlled environments, increasing productivity per unit area. Hanging baskets are effective for epiphytic orchids like Vanda, promoting better aeration and growth. Additionally, emerging soilless cultivation methods such as aeroponics and hydroponics improve root aeration and nutrient uptake efficiency, further enhancing plant health and yield.

Nutrient management

Proper nutrient management is essential for optimal orchid growth and development. A balanced supply of nitrogen (N), phosphorus (P), and potassium (K) is required at different growth stages to support foliage, root, and flower development. The use of biofertilizers enhances soil microbiota, promoting nutrient absorption and sustainable cultivation. Slow-release fertilizers provide a steady nutrient supply, preventing excessive leaching and ensuring long-term plant health.

Post-harvest management and value addition

Effective post-harvest management is critical for maintaining quality and extending the marketability of orchids. Harvesting at the optimal bud initiation stage significantly prolongs vase life, preserving floral aesthetics and commercial value. Cold chain logistics, including vacuum pre-cooling and refrigerated transport, play a crucial role in minimizing post-harvest losses by reducing ethylene production and microbial spoilage.

Beyond fresh flower markets, orchids offer significant potential for value addition. The extraction of bioactive compounds from orchids supports the development of perfumes, essential oils, and nutraceutical products, expanding commercial applications. Further, ongoing research into the pharmacological properties of highlights their potential applications in medicine, particularly in the development of novel therapeutics. Strengthening post-harvest protocols and value-chain strategies will enhance the economic sustainability of orchid cultivation while fostering innovations in product diversification.

Market-driven strategies for enhancing orchid trade:

Expanding the domestic orchid market requires strategic interventions to strengthen trade networks and improve market accessibility. Targeting high-demand regions such as Europe, Japan, and the Middle East can significantly enhance global market penetration. Establishing direct sales channels through supermarkets, florists, and e-commerce platforms streamlines distribution, ensuring better price realization for producers.

Furthermore, the adoption of fair-trade certification improves consumer confidence and facilitates entry into premium markets, aligning with sustainability and ethical trade standards. Digital marketing and branding play a crucial role in enhancing market visibility and consumer engagement. Leveraging e-commerce platforms and social media campaigns can increase accessibility and global outreach, fostering direct interaction with consumers. Strengthening these market-driven approaches will boost trade opportunities, enhance profitability, and establish a sustainable commercial model for orchid cultivation.

SUMMARY

The future of orchid cultivation relies on the integration of advanced technologies, sustainable practices, and market-driven strategies to enhance productivity and profitability. Smart farming solutions, such as AI-based analytics, precision irrigation, and automated climate control, optimize resource utilization while improving efficiency. Biotechnological advancements, including micropropagation, somatic embryogenesis, and targeted breeding using genomic tools, accelerate the development of superior hybrids with desirable traits. Innovations in post-harvest management, such as advanced packaging, eco-friendly preservatives, and optimized cold storage, ensure extended vase life and reduced post-harvest losses. The adoption of digital marketing, e-commerce platforms, and participation in international trade fairs strengthens market reach, enabling better access to global consumers. Additionally, integrating value-added products like orchid-based perfumes, nutraceuticals, and floriculture tourism diversifies revenue streams, making orchid cultivation a more lucrative and sustainable enterprise. By optimizing production techniques and aligning with evolving market demands, the orchid industry can achieve greater efficiency, profitability, and long-term growth.

*Corresponding author email: drspdas@gmail.com

Indian Farming 75 (07): 48-51; July 2025

Gerbera as a potential crop for income generation in north eastern India

P. Raviteja*, H. Rymbai, H. D. Talang, M. B. Devi, V. K. Verma and Praveen G.

ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

Gerbera a vibrant ornamental and cut flower belonging to the Asteraceae family, has gained considerable recognition in the global floriculture market, where it ranks fifth in international trade and sixth in India. The north eastern region of India, characterized by its unique climatic conditions and rich biodiversity, offers an ideal environment for gerbera cultivation, providing farmers with opportunities to diversify their income sources in response to the growing urban demand for ornamental plants. This chapter delves into the potential of gerbera as a lucrative crop in north eastern India, emphasizing agronomic practices, economic viability, and market opportunities. It discusses key aspects such as suitable varieties, propagation methods, soil requirements, climatic conditions, and effective management strategies to ensure optimal growth and yield. Furthermore, the economic analysis reveals that cultivating gerbera in low-cost bamboo houses can lead to substantial profits, with a break-even point achievable within the first year. By integrating sustainable practices, gerbera farming has the potential to significantly enhance the livelihoods of small and marginal farmers in the region, fostering economic development and promoting ecological balance. This comprehensive overview aims to empower stakeholders in the floriculture sector and contribute to the sustainable development of the agricultural landscape in north eastern India.

Keywords: Agronomic practices, Low cost polyhouse, Ornamental plants

GERBERA (*Gerbera Jamesonii* Bolus), a member of the Asteraceae family, is a popular ornamental flower known for its vibrant colours and diverse varieties. Originating from South Africa, gerbera has gained global prominence due to its aesthetic appeal and long vase life, making it a favoured choice in floral arrangements and landscaping. In recent years, the north eastern region of India, characterized by its unique climatic conditions, fertile soil, and rich biodiversity, has emerged as a potential hub for floriculture, particularly for cultivating gerbera. The diverse climate of north eastern India, with its subtropical to temperate conditions, provides an ideal environment for the cultivation of gerbera. The region experiences adequate rainfall, moderate temperatures, and distinct seasons, which are conducive to the growth of various floricultural crops. Moreover, the rising demand for ornamental plants driven by urbanization, changing consumer preferences, and increased disposable incomes, presents significant opportunities for farmers to diversify their income sources in this region. Additionally, gerbera cultivation aligns with sustainable agricultural practices, as it can be integrated into existing farming systems, providing economic benefits without compromising the ecological balance. The flower's relatively low input costs, coupled with the potential for high returns, make it an attractive option for small and marginal farmers, who constitute a significant portion of the agricultural community in north eastern India.

Area and production

Among the global floriculture industry, gerbera cut flower ranks fifth in international flower trade, while it holds sixth position in India, with an area of 1,150.05 ha and a production of 25,554.76 MT, respectively. In the north eastern states of India, the production of gerbera in Meghalaya was recorded at 0.02 MT in 2021. Sikkim has an area of 0.031 ha, while Arunachal Pradesh's data reached an all-time high of 0.004 ha in 2015 and a record low of 0.001 hectares in 2025.

Varieties

The suitable varieties identified for the north eastern region include Pink Elegance, Sangria, Red Monarch,

RCGH -117

RCGH -114

RCGH -22

RCGH -28

Piton, Goliath, Rosalin, Tiramisu, Salvador, Tropic Blend, and Savannah for polyhouses. Additionally, the Gerbera hybrids developed from ICAR RC for the NEH Region, Umiam, are RCGH-12, RCGH-28, RCGH-114, and RCGH-117, which are suitable for both open and protected conditions in Meghalaya.

Propagation

Gerbera is propagated using both sexual and asexual methods. However, seed (sexual) propagation is generally not desirable due to the resulting variation and longer time required for the plants to flower. The most common method of asexual propagation involves dividing clumps. Additionally, suckers are utilized for the commercial production of flowers. For rapid, large-scale, and uniform plant production, tissue culture techniques are increasingly popular in gerbera propagation. Various explants, such as shoot tips, inflorescence buds, flower heads, capitulum, and mid ribs, can be used for tissue culture.

Soil

The optimum soil pH for growing gerbera plants should be maintained between 5.5 and 6.5. Additionally, the electrical conductivity of both the soil and irrigation water should fall within the range of 0.5–2.0 dS/cm^2. For ideal growth conditions, gerberas thrive in well-drained, highly porous loamy soil that is rich in organic matter. This type of soil not only provides essential nutrients but also ensures adequate moisture retention, which is crucial for the plants' overall health. Such soil conditions facilitate better root development and allow roots to penetrate deeply, reaching depths of 50–60 cm. Deep root growth is vital for gerbera plants as it enhances their ability to access water and nutrients, ultimately contributing to stronger and more vibrant blooms.

Climate

Gerbera is typically cultivated in open conditions however, most commercial varieties are grown under polyhouses or shade net houses to ensure they meet the quality standards required for both domestic and export markets. Utilizing a 50% shade net can effectively control light intensity and solar radiation, which is crucial for optimal growth. The ideal temperature for the initiation of flowering is around 23°C, while leaf unfolding occurs best at temperatures between 25°C and 27°C. Flowering initiation can be negatively impacted by temperatures below 12°C and above 35°C. For optimal growth and flower production, day temperature should be maintained between 22°C and 25°C, with night temperature ideally ranging from 12°C–16°C. Maintaining an optimum relative humidity of approximately 60–70% inside the polyhouse is essential, as higher humidity levels can increase the incidence of diseases and lead to flower deformities. Additionally, ensuring good internal air circulation at night and adequate ventilation during the day is critical for the health of the plants in a polyhouse environment.

Soil preparation

The optimal growing medium for Gerbera requires a fine tilth soil thoroughly mixed with well-rotted farmyard manure (FYM) in a ratio of 2:1 (soil to FYM). This mixture enriches the soil with essential nutrients, improving its fertility and structure. Alternatively, a growing medium can be created by combining FYM, sand, and coconut coir, pith, or paddy husk in a 2:1:1 ratio. This combination enhances aeration and drainage, which are critical for healthy root development. Soil sterilization is a crucial step in this process, as it significantly reduces the risk of infestation by soil-borne pathogens such as *Phytophthora, Fusarium,* and *Pythium.* These pathogens can cause severe crop losses and hinder plant growth. The beds should be drenched or fumigated with 2% formaldehyde (100 ml of formalin in 5 L water/m^2) or methyl bromide (70 g/m^2) and then covered with a plastic sheet for a minimum of 2–3 days. The beds should subsequently be watered thoroughly to drain the chemicals before planting. This sealing process allows the formaldehyde to work effectively, killing off harmful pathogens.

Transplanting

Gerbera is grown on 1 m wide and 30 cm high raised beds of convenient length, leaving 40 cm space between beds. Spacing between rows and within rows should be 30 cm, in 3 rows per 1 m wide bed, accommodating 9 plants/m^2. Planting is done with root ball and crown is kept 1 cm above soil surface. Similarly, tissue cultured plug plants (4–5 leaf stage) should also be transplanted in such a way that their crown is slightly above the surrounding soil. The crown must be dried out between two watering to avoid infection of fungus *Phytophthora cryptogea.* Irrigate lightly following planting.

Irrigation

Irrigation should be provided using overhead sprinklers for up to one month after transplanting, after which it should gradually transition to drip irrigation. Generally, one dripper per plant is required, with an average water requirement of 500–700 mL/day/plant (4.5–6 L/m^2), depending on the season and stage of the crop.

Manures and fertilizers

Gerbera requires a plenty of organic matter (7.5 kg/m^2) and essential nutrients. Application of 10:15:20 g NPK/m^2/month during the first three months of planting and 15:10:30 g NPK/m^2/month from the fourth month (start of first flowering) is good for vegetative growth and improved flower production. Besides major nutrients, spraying of micronutrients like boron, calcium, magnesium and copper @0.15% (1.5 mL/L water) once in a month is desirable for obtaining good quality blooms.

Plant protection (Insect pest and diseases management)

- ***White flies:*** Nymphs and adults of whiteflies appear on the lower surface of leaves. They suck sap, causing the plants to become chlorotic. while, excretion by the insects promotes sooty mold growth, which interferes with photosynthesis. Spraying methomyl and triazophos at 0.05%, along with imidacloprid at 0.004%, is effective, and available botanicals can also be used.
- ***Thrips:*** Thrips feed by scraping the leaf or bud surface and sucking the oozing cell sap. This feeding causes white specks or stripes on ray florets, silvery or greyish spots on leaves, brown spots on leaf petioles or mid veins, and deformed flower heads. Spraying oxydemeton methyl or acephate at 0.1%, along with drenching with chlorpyrifos at 0.1%, is highly effective. The spraying of imidacloprid at 0.004% is also effective.
- ***Aphids:*** It causes deformities in leaves by sucking the cell sap, resulting in necrosis and lesions. Spraying metasystox at 0.1% helps in controlling the pest infestation.
- ***Mites:*** The visual symptoms of mite infestations include curling of older leaves, deformed and leathery appearance of younger leaves, and deformed flowers or missing petals. Spraying abamectin at 0.5 mL/L is effective against mites.
- ***Leaf miner:*** Maggots tunnel through the leaf, creating typical mines. Leaf mining interferes with photosynthesis and affects flower production. Spraying abamectin at 0.004% or Triazophos at 1.5 mL/L is effective. Additionally, spraying botanicals like neem or pongamia oil at 3 mL/L also helps keep the insect population under control.
- ***Crown or root rot:*** The pathogens responsible are *Pythium spp.* and *Rhizoctonia solani.* This disease causes the entire plant to wilt, and the crown of the plants becomes black. Soil sterilization is effective in controlling it.
- ***Foot rot:*** The causal agents of foot rot are *Phytophthora* and *Fusarium.* Infected plants exhibit short stems that turn black and rot, leading to the death of leaves and flowers. To manage this, avoid excessive watering and temperatures that favur pathogen growth. Monthly drenches with metalaxyl (0.15%) and captan (0.2%) can also effectively control the disease.

Harvesting

Gerbera plants start flowering about three months after planting. Flowers should be harvested when the outer two rows of disc florets are fully developed or when the outer row of disc florets is perpendicular to the stalk. In young plantations, flower stalks may be pulled loose while picking flowers. It is recommended to pull the cut flowers rather than cut them, as cutting leaves a stem stub on the growing plant that encourages disease development. The basal 5– 6 cm portion should be cut using a very sharp knife before placing the flowers in a harvesting bucket containing fresh chlorinated water. Under a low-cost naturally ventilated polyhouse, the average yield is 250–300 flowers/m^2/year, and properly managed healthy plants can provide cut blooms for 2–3 years.

Table 1. Economics of gerbera cultivation in low cost bamboo poly house per 100 m^2

S. No	Amount	Location
A. Fixed cost (first year)		
1.	Low-cost polyhouse @450/m^2	45000
2.	Soil sterilization	3500
3.	Planting material @10/ plant (total 600 plants)	6000
4.	Total fixed cost	54500
B. Recurring cost (first three years)		
	Labour skilled (one) @₹ 300/ day) for 120 days	36,000
	FYM, fertilizers and micronutrients Pesticides, fungicides, etc.	42,950
	Total recurring cost	78950
C. Gross income (first three years)		
	Total flower production (250–300 flowers/year/1m^2	1500
	Sale of flower @₹ 5/flower	150000
	Total sucker production (4-5 suckers/plant/ year)	
	Sale of sucker @10/ sucker	30000
	Gross income	1,80,000
	BCR	1.85
D.	Net income = C - (A + B) First year	46550
	Net income = C - B) Second year	1,01,050
	Net income = C - B) Third year	1,01,050

Storage

For long duration storage of 3–4 weeks, dry cold storage at 40°C is preferred over wet storage.

Economics

Year-round production of gerbera under bamboo low-cost polyhouse is highly profitable. The break-even can be achieved within the first year of production. At the end of the first year of production, net income ₹ 46650 in 100 m^2 unit can be obtained. However, at the end of third year, a profit of ₹2,48,650 can be obtained with cost benefit ratio of 1:1.85. Further, polyhouse structure durability is up to 6 years without any maintenance cost. Estimates are indicative of approximate economic return from gerbera cultivation under polyhouse in north east region of the country.

SUMMARY

Gerbera cultivation presents a viable opportunity for income generation in northeastern India, given the region's favourable climatic and soil conditions. Through proper agronomic practices, pest management, and post-harvest care, gerbera can become a significant contributor to the local economy, enhancing the livelihoods of farmers and stakeholders in the floriculture sector.

*Corresponding author email: ravitejapalavalasa50@gmail.com

Indian Farming 75 (07): 52-55; July 2025

Modern beekeeping for sustainable livelihood improvement in north eastern India

Sandip Patra*, Rumki H. Ch. Sangma, K. Kuotsu, P. Baiswar, H. Rymbai, H. D. Talang and S. Hazarika

ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

Beekeeping is an agro-based activity which is being undertaken for producing honey and other hive products. It is considered as a non-land based income generating tiny industrial sector and it can be defined as a single job with several benefits. It supplements income and employment generation and nutritional intake of rural population. Modern beekeeping has developed significantly through the integration of technology; scientific advancements and sustainable practices. The beekeeping is one of the important sectors among various agri-entrepreneurs in the northeast hilly (NEH) region. It has been a part of the traditional agricultural practices in this region for centuries. It can promote economic growth and protect biodiversity. The NEH region of India with its rich floral diversity, ideal climate and traditional knowledge of beekeeping offers immense potential for this sector. Therefore, with sustainable practices, modern management techniques, and government initiatives, beekeeping can play an important role for sustainable livelihood improvement and entrepreneurship development in this region.

Keywords: Beekeeping, Entrepreneurship, Honey, NEH Region, Sustainable livelihood

BEEKEEPING is also known as apiculture involves care and management of honeybees commonly in artificial beehives, producing honey, and their by-products while promoting pollination. Beekeeping has been practiced for ages throughout the world. Honeybees were previously reared in traditional boxes composed of wood, bamboo, log hives, and clay pots. With the introduction of L. L. Langstroth's wooden hive and the invention of honey extractor marked the beginning of the commercialization of beekeeping in the 19th century. Scientific boxes with movable frames are increasingly being used with the aid of scientific understanding. Honey and other by-products from apiculture, such as wax, pollens, propolis, royal jelly, etc. are utilized extensively in the pharmaceutical, cosmetic, and confectionery sectors, among others. In addition to these, bees perform pollination, which is one of the most significant ecological services. Honeybees support the growth and survival of a variety of plants, promote sustainability and boost the quantity and quality of agricultural products by facilitating pollination. Beekeeping has spread throughout the world, with many beekeepers depending on honeybees for their livelihood. However in the recent years, beekeeping has faced issues such as pests, diseases, climate change, loss of habitat, etc. Modern beekeeping techniques have developed to address these problems with sustainable practices and technological developments. Modern techniques such as organic beekeeping methods, integrated pest management, selective breeding, hive monitoring systems, etc. have improved and made beekeeping more efficient. A comprehensive awareness of bee biology, skill, adherence to key principles and management practices are essential for a sustainable beekeeping. With the right support, training, and infrastructure investment, beekeeping can promote economic growth, protect biodiversity, and generate employment.

Advantages of beekeeping

- Less investment is required to start beekeeping
- Requires less time as compared to other ventures
- Uncultivable agricultural land can be used
- It does not compete for resources with any other agricultural enterprise
- Provide pollination services for terrestrial ecosystem

- It can be initiated by individuals or groups
- The market potential for honey and other by products area is high

Modern Beekeeping

Modern beekeeping has developed significantly through the integration of technology, scientific advancements and sustainable practices in beekeeping. The modern beehive with movable frames made of wood is an important innovation in beekeeping providing a structured and efficient environment for honeybee colonies to thrive. Modern beehives in contrast to traditional hives are designed to improve hive management, promote colony health and increase honey production. Traditional hives have been used for beekeeping since time immemorial. Bee colony management techniques have been handed down through the centuries, relying on traditional hives designs, cultural practices, and local expertise. Despite its benefits and cultural significance, traditional beekeeping has drawbacks, including low productivity, unhygienic extraction, destructive harvesting, vulnerability to pests and diseases, and poor shelf-life of the honey. Modern beekeeping methods, equipment, and knowledge can be used to alleviate some of these problems. Modern beekeeping has many advantages, including increased honey production, better pollination, and production of hive products, etc. which are discussed below:

Hive management: The movable-frame hives make it easier to manage and inspect bee colonies. This provides more control, increases honey extraction efficiency, and minimizes bee disturbance in comparison to traditional fixed-comb hives. Modern hive designs facilitates better ventilation and insulation which helps in maintaining temperature and humidity, essential for brood development and storage of honey. Bees also can be fed artificially during dearth period.

Honey production: Modern hives with moveable frames can produce more honey. The volume of the hive can be altered according to necessity. The capacity to produce honey can be increased by adding supers. High-quality honey is produced by separating pollen and brood combs from honeycombs.

Honey extraction: Mechanical honey extractors are used for honey extraction from the frames without damaging the combs which can be reused by bees leading to faster honey production.

Pest and disease management: Integrated pest management practices can be implemented for managing pests and diseases by putting into practice a combination of methods like monitoring, use of natural enemies, modifying hive management practices and need based chemical control aimed at minimizing harm to bees and the environment.

Pollination services: Transporting hives is made easier by their compact size. By transferring hives to different locations, modern beekeeping maximizes the benefits of crop pollination. The value of pollination services is much higher than the value of hive products as the production of many crops get reduced tremendously without bee pollination.

Table 1. Crop loss without honey bee pollination

Crop	Crop loss in percent	Crop	Crop loss in percent
Soybean	10	Asparagus	90
Tomato	10	Grape fruit	80
Peanut	10	Cabbage	90
Cotton	20	Pumpkin	90
Lemon	20	Vegetable seed	100
Strawberry	30	Almond	100
Lime	30	Niger	100
Watermelon	40–70	Rapeseed	100
Pear	50	Safflower	100
Carrot	60	Alfalfa hay	100
Cherry	60	Cucumber	100
Apple	70–100	Sunflower	100

Source: Morse and Calderone (2000), Sharma *et al.* (2015)

Components of a modern bee box

The modern bee box also known as the "Movable frame hive," is constructed from a wooden box. There are multiple frames hanging vertically inside the box which can be removed independently. The space between two frames is called bee space and it helps in movement of bees. The modern bee box consists of the following parts:

Basal platform: It is composed of one or two pieces of wood joined together to form the hive's floor.

Brood chamber: It's a rectangular wooden box with four sides and no top or bottom. It is kept on the basal platform. The purpose of brood chamber is to hold brood frames and provide queen with enough room to lay eggs and raise brood.

Super chamber: This chamber is meant for the storage of honey only. Its construction is similar to that of the brood chamber, and it is kept above it.

Frame for brood and super chamber: It is a structural component that keeps the honeycomb or brood comb inside the box. The purpose of the frames is to keep bees from affixing honeycombs to the hive walls and also to provide space in between them for bees to move.

Inner top cover: It is a board that is the same size as a brood or super chamber. There is a wire gauge-covered opening in the center. It is kept on super or brood chamber. Its purpose is to provide ventilation and prevent bees from forming combs on the hive cover.

Hive cover/roof: It is shaped like a box and has an opening at the bottom. Sheets of tin or zinc cover the top section of the box. The brood or super chamber is fully covered by the bottom open section that fits over them. For ventilation, there are two openings on the front and back sides. It protects the hive against rain and sun.

Other accessories

- ***Comb-foundation sheet:*** It is made of wax and is artificially attached in the frames to provide foundation for the bees to construct combs.

- **Queen excluder:** A metallic wire net is used as a queen excluder to keep the queen from moving from the brood to the super chamber.
- ***Queen gate:*** It is a piece of queen excluder sheet that is installed in the entrance gate's slot. It helps in preventing swarming and absconding by keeping the queen inside the hive.
- ***Hive stand:*** It helps to protect the bottom board of the box from rotting due to direct contact with soil.
- ***Smoker:*** It is an equipment used by the beekeepers to control the bees if they become agitated during inspection/harvesting.
- ***Bee veil:*** It is a cap made of cloth and wire net. It is useful for face protection against stings.
- ***Hand gloves:*** They cover the fore arms and useful for protection from sting bite.
- ***Brush:*** It is used to brush the bees from comb before extraction.
- ***Knife:*** Sharp steel knife is used for removing wax capping from the comb.
- ***Extractor:*** This equipment is made up of a cylindrical drum that holds the super frames in a rack or box inside. It is used for extraction of honey by the action of the centrifugal force without destroying the comb.

Management practices of beekeeping

Successful beekeeping requires thorough understanding of bee behaviour, hive management, and familiarity with nectar and pollen plants. The beekeepers must initially rely on local knowledge and traditions before progressively implementing modern methods. A beekeeper must be aware of the factors that can affect beekeeping through continuous learning, staying up to date with the latest research and best practices. The following key management practices are essential for successful beekeeping:

Site selection: The production and well-being of bee colonies depend on the apiary's location. The location should be well-drained open area, rich in plants that yield ample pollen and nectar with a reliable water source. Additionally, the site should be away from traffic and human or animal disturbance.

General apiary management practices: For bee colonies to remain healthy and productive, routine hive maintenance and inspection are crucial.

- At least twice a week, beekeepers should check the hive for diseases, mites, wax moths, and other pests.
- Keep the hives clean and well-ventilated.
- When the brood chamber is full and every frame is covered with bees, more frames should be added to the super chamber.
- During dearth period/food scarcity artificial feeding becomes essential. Prepare 1:1 sugar dilution in water and use for feeding. To prevent robbing, feed all the colonies in the apiary at the same time.
- Provide enough space, regular inspections to prevent and control swarming. Beekeepers can control swarming by clipping special queen brood cells and redistributing brood frames from strong colonies to weaker ones.
- Use honey extractor and strainers to remove wax and debris for honey extraction. Before extraction, brush off the bees from the combs and uncapped the cells using uncapping knife.

Seasonal management

Honey flow season: Provide sugar syrup before honey flow and build sufficient population to produce honey. Strong colonies can be split up into two or three new colonies if needed. A queen excluder should be used to keep the queen in the brood chamber and prevent her from laying eggs in the honey supers. Combs that are completely sealed or at least two-thirds capped with honey can be removed for extraction and put back in the supers after extraction.

Summer season: The hives should be shielded from extreme heat, which can be achieved by artificial structures or natural tree cover. Sprinkle water around the colonies in the apiary and cover top cover with wet gunny bags to increase relative humidity and reduce heat. Proper ventilation is also essential, and this can be improved by placing a small splinter between the brood and super chambers to enhance airflow within the hive.

Winter season: Provide winter packing for weak colonies, especially in cooler hilly places. New queen may be provided to the hives.

Rainy season: Keep the apiary site dry to prevent diseases and mold growth. Ensure adequate drainage.

Management during dearth period: Remove the

Modern beekeeping equipment

Apiary with modern beehives

Table 2. Different honey bee species and their yield potential

Species	Description
Rock bee, *Apis dorsata* (Apidae)	It is known as Giant honey bee. They are very ferocious and not good for domestication. They produced about 20–40 kg honey per colony per year.
Indian hive bee, *Apis cerana indica* (Apidae)	It is known as Indian bee. They are easy to domesticate. Average honey production of 3.6–4.5 kg honey per colony per year.
European bee, *Apis mellifera (Apidae)*	European bee or Italian bee has ability to acclimatize to even semi-desert tropics as well as to cold temperate zones; has made of more global in distribution. The average production is 20–25 kg honey per colony per year but yield may be increase up to 50 kg.
Dwarf bee, *Apis florea* (Apidae)	Commonly called as little Bee. They produced about 0.5 kg honey per colony per year.
Dammer bee or stingless bee, *Melipona irridipennis (Meliporidae).*	Two species of stingless, viz. *Melipona* and *Trigona* occur in our country in abundance. These bees are much smaller than the true honey bees. The honey production is 100g honey per hive per year.

supers and pack the brood chamber with all of the healthy broods that are currently available. Discard the old and dark combs that cannot be reused. If necessary, destroy drone cells and queen cells. Provide sugar syrup, pollen supplement and substitute.

Scope of beekeeping in NEH region

The northeast hill (NEH) region of India has a rich biodiversity consisting of agro-ecosystem, diverse forests, and flora. Beekeeping is one of the various agri-entrepreneurs in this region. It has been a part of the traditional agricultural practices in northeast India for centuries. It is deeply rooted in the culture and livelihood of the region which paved the way for the development as an agri-business. There are several factors that contribute to the scope of beekeeping in this region.

Floral diversity: The flora of India's north eastern states is incredibly diverse. A wide variety of nectar and pollen are available to bees. The region's abundance of wild and cultivated plants, such as a variety of fruit trees, flowering shrubs, and medicinal herbs, provides bees with year-round foraging alternatives.

Species diversity: Due to its rich floral diversity and ideal climate, the area is home to many different species of honeybees. Honeybee species such as *Apis cerana, A. dorsata, A. mellifera, A. florae* and stingless bees are found thriving well in the region. The native species *A. cerana,* is well adapted to the local environmental conditions.

Traditional knowledge: Beekeeping is an integral part of many tribes' cultures and tradition. Indigenous knowledge and customs have been handed down through the generations and are an invaluable resource for the development of modern beekeeping techniques.

Employment generation: Beekeeping offers various economic opportunities providing opportunities for self-employment. Employment can be generated in honey production, hive maintenance and pollination services, bee colony business, honey processing, and marketing.

Export potential: The demand for honey and other bee-related products is growing globally. Beekeepers can tap into this market, offering unique and high-quality products. A vast variety of premium honey varieties, including multifloral, monofloral (such mustard and litchi honey), and specialty honey, can be produced in the region.

Challenges faced by tribal beekeepers

Although beekeeping has great potential in the region, there are several challenges that affect the sustainability of beekeeping and well-being of bee colonies.

- The variations in the climate of the region with high rainfall and high humidity affect beekeeping operations.
- Most of the beekeepers still follow traditional methods. Lack of awareness about modern techniques, limited access to equipment and technology affects the quality and quantity of production.
- The lack of knowledge about pest and diseases of honeybees and their management results in colony losses and decreased productivity.
- Limited research and extension services specific to the northeast region, leading to a lack of region-specific knowledge and solutions.

Economics of modern beekeeping

The economic benefit of modern beekeeping for this region has been estimated based on local market prices and found that scientific beekeeping may be a profitable and lucrative agribusiness venture for the unemployed rural youth for this region. Under optimum weather and floral conditions, on average revenue of ₹ 2.5–3.0 lakhs/year may be made from hundred modern bee hives of *Apis cerana* with proper scientific management practices in this region.

SUMMARY

From traditional methods to modern scientific methods, beekeeping has significantly evolved through the years. Beekeeping has been transformed by the introduction of modern beehives along with scientific management practices making it more reliable and sustainable. The role of honeybees in pollination assist in the growth and survival of a wide range of plants, encourage sustainability, and increase the quantity and quality of agricultural goods. The northeast hill region of India with its rich floral diversity, ideal climate and traditional knowledge of beekeeping offers immense potential for beekeeping. With sustainable practices, modern management techniques, and government initiatives, beekeeping can become a valuable livelihood source, a key contributor to economic development while supporting ecological balance and food security.

*Corresponding author email: sandippatra47@gmail.com

Indian Farming 75 (07): 56-61; July 2025

Importance of yak in the high-altitude agriculture

Shubham Loat and Mihir Sarkar*

ICAR-National Research Centre on Yak, Dirang, West Kameng District, Arunachal Pradesh 790 101

Livestock is an essential component of the Indian agricultural sector. The distinct physical, economic, and sociocultural features of the eight states that make up the north eastern region of India-the seven sisters namely, Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, and Tripura, as well as their single brother state, Sikkim-give it a distinct identity. Numerous animal genetic resources, such as cattle, buffalo, sheep, goats, pigs, horses, and many more are found in north eastern India. In addition to these conventional livestock species, NEH region has an accountable population of the yaks. Thus, this manuscript's primary focus will be on the importance of yaks in the high-altitude agriculture and ultimately to the sustainable development of the northeastern Indian region.

Keywords: High-altitude agriculture, Livestock, Sustainable development

THE northeast region of India occupies 7% of total land area and is also one of the world's most bio-diverse regions, reflecting ecological and cultural contrasts between the hills and the plains. Arunachal Pradesh, Meghalaya, Mizoram, Sikkim, and Nagaland are almost entirely covered by hilly areas, 40–50% of Assam by plains, whereas Manipur and Tripura have both plains and hilly regions. Agriculture is the prime source of livelihood for the majority of the rural population in this region, followed by animal husbandry. Livestock production in the northeast is predominantly the endeavour of small holders. Almost 90% of the rural households keep livestock of one species or the other. The importance of the livestock of NE India is more pronounced owing to limited arable land, a high proportion of the meat-eating population, and rapid urbanization. Animal production plays a significant role in the sustainable development of northeast India by economic contribution, employment generation, and nutritional security.

Contribution of livestock to agricultural economy of NER

Livestock plays a significant role in the economy of the northeast region of India by providing a vital source of income for many rural households. It contributes to livelihoods through dairy, meat and egg production. Livestock also contributes to food security and nutrition and thereby supplying essential proteins through dairy products, meat and eggs crucial for the local population. Also, the contribution of livestock in the agricultural GDP for the country increased from 24% in TE 1992–93 to 28% in TE 2002–03, whereas, the share of livestock in agriculture of NER had declined from 20% to 18% during the period.

Yak- The unique bovid of NER

Even though yaks make up a very small portion of the NER livestock, they are very important to the socio-economy of the NER ethnic communities. Yak is a very important animal in northeast India, both traditionally and commercially. The herding communities view yaks (*Peophagus grunniens*) as the "almighty livestock" because of their profound cultural, socio-economic and customary links. Yaks are well suited to the severe weather and hypoxia that come with grazing at elevations greater than 3,000 m above mean sea level in the Himalayan mountains. Yaks are the largest creatures found in frigid climates and they can withstand temperatures as low as -40 °C.

The native high-altitude yak has evolved multiple unique adaptations, including morphological, physiological, biochemical, and genetic changes due to long-term selection. Yaks require only 33% of the feed as consumed by the cattle and does not compete with any livestock. Yak is regarded as the multi-purpose bovid as they provide livelihood and nutritional security to the communities rearing them. Yak is a multi-purpose animal as it is primarily raised for milk, meat, fibre, and

Yak *(Poephagus grunniens)*

Farm of ICAR-NRC on Yak

draft purpose. Yaks are also used as pack animals for transportation. Yak wool is also used to make traditional clothing and handicrafts.

Distribution of yaks

In India, around 58 thousand yaks are reared under transhumance by various pastoral nomads of UT of Ladakh, Jammu and Kashmir, and states like Arunachal Pradesh, Sikkim, Himachal Pradesh and West Bengal for their livelihood and nutritional security. The pastoral nomads are known by different names in the respective regions namely, *Brokpas* in Arunachal Pradesh, *Dokpas* in Sikkim and *Changpas* in Ladakh. Yaks primarily inhabit in higher altitudes of the Himalayas especially states like Arunachal Pradesh and Sikkim. Yak is also somewhat responsible for the national security as it is reared across the high-altitude international borders vis-a-vis Indo-China, Indo-Bhutan, Nepal and Pakistan. Therefore, Yak is also a very strategic animal for keeping vigilance on the borders in the States of Ladakh, Jammu and Kashmir, Arunachal Pradesh, Sikkim and Himachal Pradesh. Yaks are also integral to the livelihood of pastoral communities and feature in local traditions and festivities. Therefore, yaks are inherently associated with the religion, culture, sentiment and social life of the pastoral nomads and ethnic communities. Indian yaks have been phenotypically categorized into five types; White, Bare Back, Bisonian, Hairy Forehead and common type. However, based on genetic characterisation all the types are similar. Yak population of Arunachal Pradesh was characterized for its production and physical traits

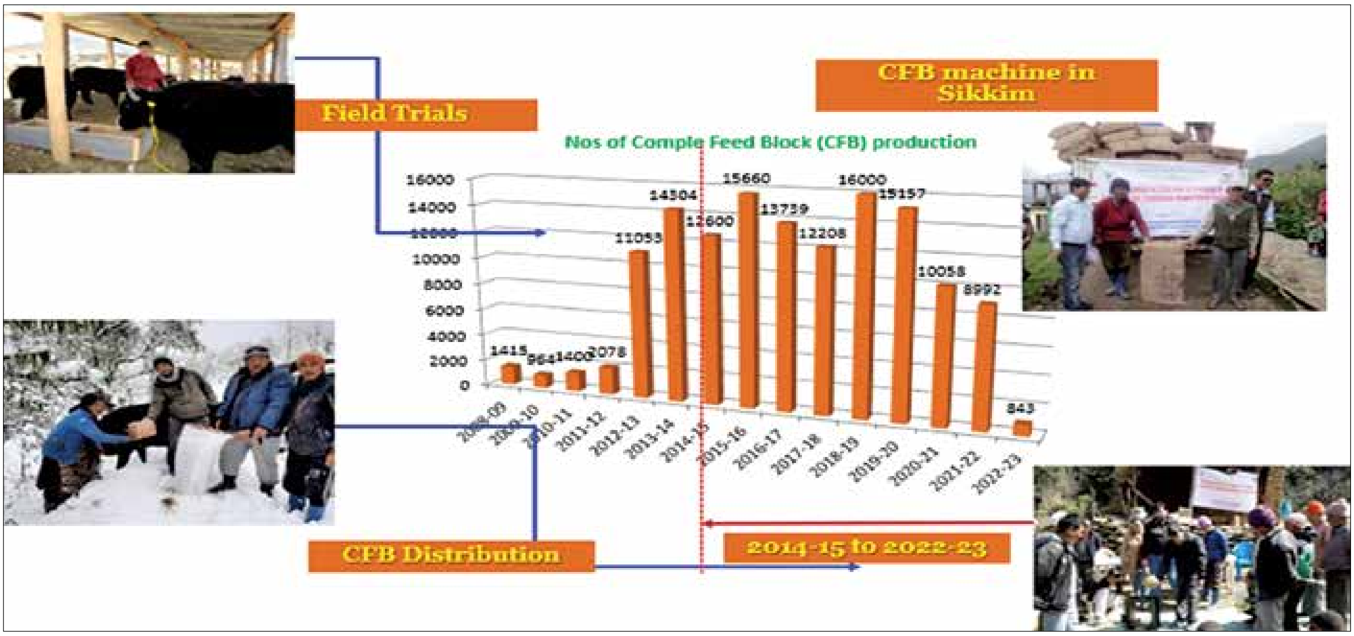
for breed registration and sub-sequentially based on unique characters the first breed named “Arunachali” was registered in year 2018.

Traditionally, Yaks are raised under transhumance system of rearing on highland pastures and during summers, yaks have the availability of lush green pastures whereas during winters, only dry pastures and tree fodder is feasible. As far as the population of yaks is concerned in the NER, there are around 24,075 yaks in the Tawang and West Kameng districts of Arunachal Pradesh and 5,219 in the North, East and Western districts of Sikkim according to the Livestock Census 2019.

Constraints and challenges of yak production

Yak production faces several constraints and issues as a lot of hard-work is required in hostile geo-climatic conditions.

- There is inadequate nutrition during lean period due to the reduction in grazing areas and reduced forest covers.
- Limited genetic variation leads to inbreeding and reduced resilience to diseases.
- Changing weather patterns affects grazing lands and water availability and thereby impacting livestock health and productivity.
- Seasonal availability of quality forage limits livestock nutrition and overall health.
- Diseases like brucellosis and infestation by parasites significantly affect yak and population leading to reduced productivity and increased mortality.
- Traditional grazing and husbandry practices may also hinder modern and improved production techniques.
- Lack of infrastructure such as veterinary services and transportation can impede growth and productivity.
- Predators attack is also another major concern for the livestock herders along with inadequate government policies and support systems hindering the development of sustainable yak farming.
- Remote areas often have limited access to markets making it difficult for producers to sell their animal products and hence get refrained from the well-deserved economic returns.



"Complete Feed Block technology" has been extensively popularized among the yak rearers. For the maintaining the continuous supply of feed, 6 manual CFB making machines and around 35000 CFBs were distributed among the tribal farmers of Arunachal Pradesh and Sikkim

Technological support for yak farmers by ICAR-NRC on Yak in collaboration with other government organizations

Technological support for yak farmers can significantly enhance productivity and sustainability by utilizing artificial insemination and genetic selection to improve herd quality and disease resistance, by implementing digital health tracking systems for early disease detection and management. There are other key areas where improvements can lead to further enhancement in the productivity of the yak farming and these include:

- Sustainability and improvement of yak farming
- Genetic improvement of yak
- Conservation and multiplication of yak germplasm
- Value addition of yak products and developing market linkages
- Livelihood security improvement of yak farmers

Sustainability and improvement of livestock farming

- ***Cultivation and propagation of the fodder:*** In order to ameliorate the degraded high altitude pasture, suitable grasses and legumes have been propagated. Further to mitigate the winter fodder scarcity, complete feed block technology has been implemented in parts of Arunachal Pradesh and Sikkim complemented with conservation of the green foliage through ensiling in poly-bags especially maize and salix.
- ***Animal health care:*** Effective healthcare for Yak is essential for their productivity and well-being which has been achieved up to some extent by the timely vaccinations against common diseases like brucellosis, FMD, Lumpy skin disease, Haemorrhagic septicaemia (HS) and Black quarter to reduce the disease incidences. Besides this, deworming programmes have also been implemented along with regular health check-ups for signs of illness enabling early detection and treatment of the various health issues.
- ***Preparedness for winter:*** Preparing feed for yak is extremely crucial for their health and survival in the harsh cold conditions for the peak winters.
- ***Genetic improvement, conservation and multiplication of germplasm:*** Yak germplasm exchange with Sikkim is being done. Yak semen straws conservation and distribution to AHD of different yak tracts is also a regular practice.
- ***Breed characterization of yak population of NER:*** Yak population faces challenges due to climate change, habitat loss and changing agricultural practices. Therefore, conservation efforts are crucial to ensure sustainability of this species. Hence, supply or exchange of superior yak bulls to farmer of NER for breeding purpose is being done, breeding programmes are implemented and awareness about these species is inculcated among the herders from time to time in the rearing regions.

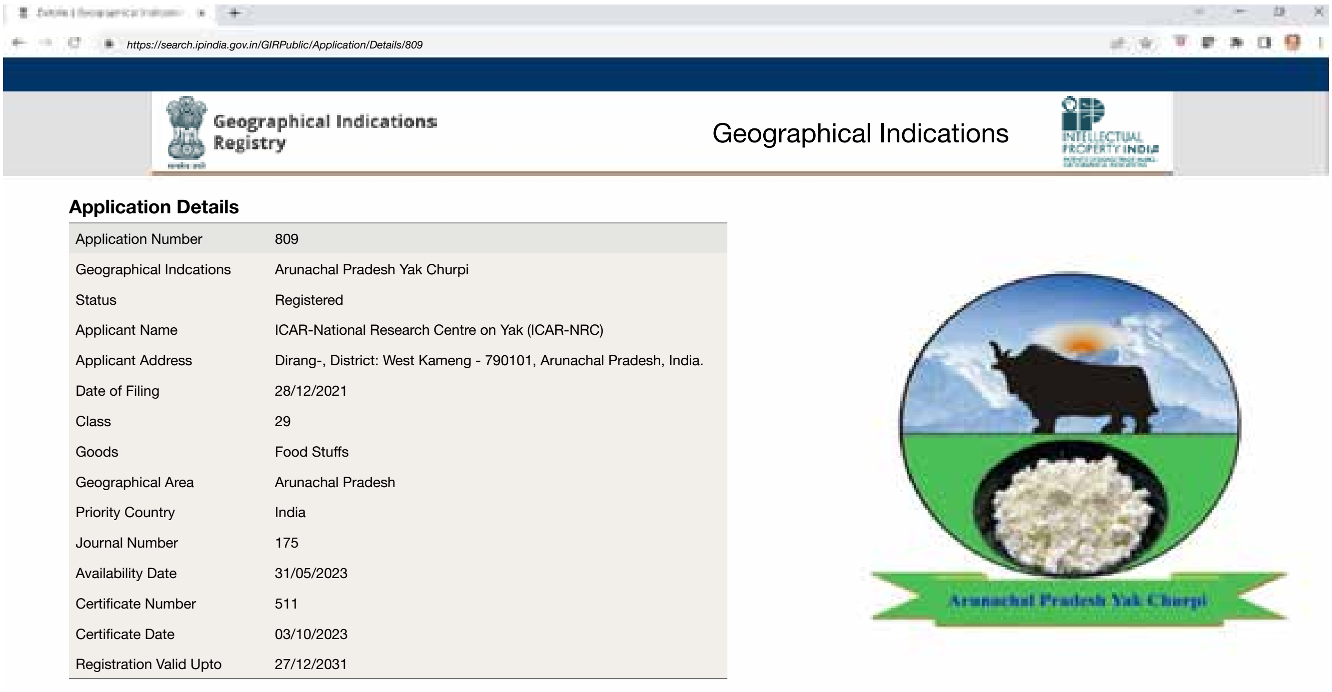
Germplasm conservation and upgradation through biotechnological tools

Biotechnological tools play a significant role in these efforts, providing advanced methods for genetic conservation, breeding and enhancement. Therefore, various biotechnological interventions have been done for germplasm conservation and upgradation including:

- Frozen semen technology and artificial insemination
- Estrus synchronization and timed artificial insemination (TAI)
- Multiple ovulation and embryo transfer (MOET) and *in vitro* embryo production (OPU-IVF).
- First IVF yak calf "NORGYAL" was born on 15th July, 2013 using OPU, IVF and Embryo transfer technology.

Curd/yoghurt Ghee Ripened Yak Cheddar cheese Mozzarella cheese

Diary products from yak



Application Details

Application Number	809
Geographical Indcations	Arunachal Pradesh Yak Churpi
Status	Registered
Applicant Name	ICAR-National Research Centre on Yak (ICAR-NRC)
Applicant Address	Dirang-, District: West Kameng - 790101, Arunachal Pradesh, India.
Date of Filing	28/12/2021
Class	29
Goods	Food Stuffs
Geographical Area	Arunachal Pradesh
Priority Country	India
Journal Number	175
Availability Date	31/05/2023
Certificate Number	511
Certificate Date	03/10/2023
Registration Valid Upto	27/12/2031

https://search.ipindia.gov.in/GIRPublic/Application/Details/809

Value addition of yak products

Yak-milk and its products: Yak milk and dairy products such butter *(Mar)*, ghee, curd, wet cheese *(chhurpi)* and hard cheese *(Churkam)* gives the pastoral nomads an essential source of vitamins and nutrients Therefore, various value-addition strategies have been incorporated to the Yak milk and its products for enhancing its market-value such as:

- Yak milk whey beverages incorporated with Kiwi fruit pulp
- Flavoured Churkam

Technology has been developed for health-conscious consumers to develop low fat dietary fibre enriched paneer from yak milk. The technology has additional benefit of utilizing the separated milk cream for Ghee making. ICAR-NRC on Yak is further developing processed cheese from yak milk.

For their constant efforts for working on the yak and to enhance the yak milk production along with its value-addition, ICAR-National Research Centre on Yak, Dirang could secure the first ever yak milk product "Arunachal Pradesh Yak Churpi" with the Geographical indicator tag with the collaboration of the yak herders.

Yak fibre (A boon to the brokpas): Yak fibre also known as yak wool is a natural textile derived from the coat of the yak. This unique fibre is highly valued for its warmth, softness and durability making it an important resource for local communities and the textile industry. Yak produces three types of fibre: coarse outer hair, a mid-type and a fine down fibre, which grows prior to the onset of winter as additional protection for the yak against cold. The amount of fibre produced by individuals and the proportions of coarse hair and down varies with the region where the yaks are kept and the associated climate, and with breed, sex, age and the season and method of harvesting the fibre. The average age of clipping is 12–18 months. A mature yak can produce 250–750g fine/down fibre and 1.5–5.0 kg coarse fibre.

Value addition of yak fibre: Yak fibres open up new possibilities to help and improve the economic conditions of herdsmen through value addition. Value addition of yak fibre is very crucial to achieve 3–4 times better economic returns and for this yak fibres can be blended with other natural fibres like wool (sheep and angora wool) and jute to form yarn and fabric with different designs.

Keeping all these aspects in mind, ICAR-National Research Centre on Yak has come up with various yak fibre value-added products like yak fine fibre-sheep wool blended products and yak-jute blended garments and products such as Chitpa Jaamu, Phachung (bags), knitted caps, mats, charmar, coats, etc.

Table 1. Fibre types: Down, mid-type and coarse fibre

Characteristics	Fibre types		
	Down fine fibre	Mid-type fibre	Coarse fibre
Fibre diameter (μ)	< 25	25–52.5	25–52.5
Length (cm)	3.7–4.1	5.3–13.0	5.3–13.0
Medulla	Unmedullated	Latticed	Latticed
Lustre	Soft	Good	Good
Crimp	Irregular	A few large	A few large

Yak as a pack animal

Yak is the exclusive beast of burden in the high Himalaya due to their high-altitude adaptations, legendary strength and endurance, and sure footedness. Male yaks can carry a load up to 35% of its live body weight and walk 14 km, with a speed of 4–6 km/h.

Recent initiatives taken for promotion of yak farming

In recent years, various initiatives have been undertaken in India to promote yak focusing on their conservation, breeding and utilization such as:

Government Schemes and programmes: National Livestock Mission (NLM) launched by the Indian government aims to promote sustainable development of the livestock sector by focusing on the conservation and development of indigenous species like yak. States like Arunachal Pradesh and Sikkim have implemented integrated livestock development schemes that include provisions for the promotion of yak through financial assistance, veterinary care and access to improved breeding policies.

Research and development: The Indian Council of Agricultural Research has undertaken various research programs focused on yak. Further, ICAR-National Research Centre on yak, Dirang focusses on yak breeding, conservation and research and conducts various awareness and training programmes for farmers.

Training and capacity building: Various organizations conduct training programmes for farmers and herders and covers practices in yak management, veterinary care, feed management and marketing of product.

Promotion of yak products: Initiatives have been introduced to promote the processing of yak products including meat, milk and fibre.

Promotion of semi-intensive farming: Sedentarization of yak to bypass trans-humance migration grazing patterns keeping in m the climate change and lesser availability of the grazing grounds. Following the semi-intensive system, the daily body weight gain in yaks has increased from 95–120g/day to 400-550 g/day. Similarly, age of attaining puberty has decreased from 3.5–4.5 years to 2.0–2.5 years, calf production by a yak has increased from 1 calf per 3 years to 1 calf per year, yaks have started to come into estrus regularly throughout the year and milk yield has increased from 400–500 g/day to 1.5–2.5 kg/day. Additionally, after nutritional interventions the adult body weight has drastically increased from 200-300 kg to 450–550 kg for male and from 150–200 kg to 250–350 kg for female.

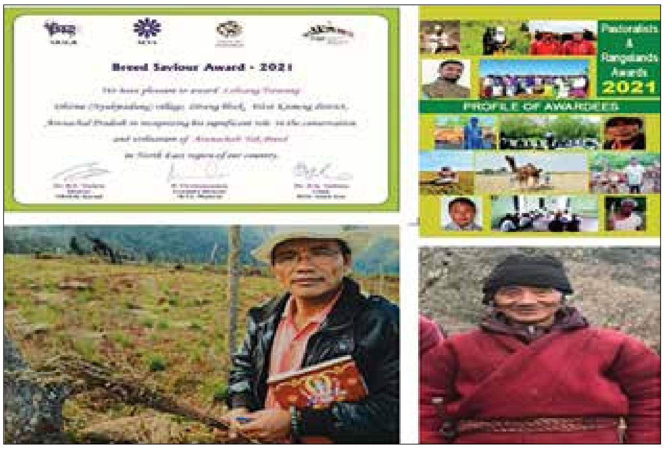
Developing bankable scheme for yak farming

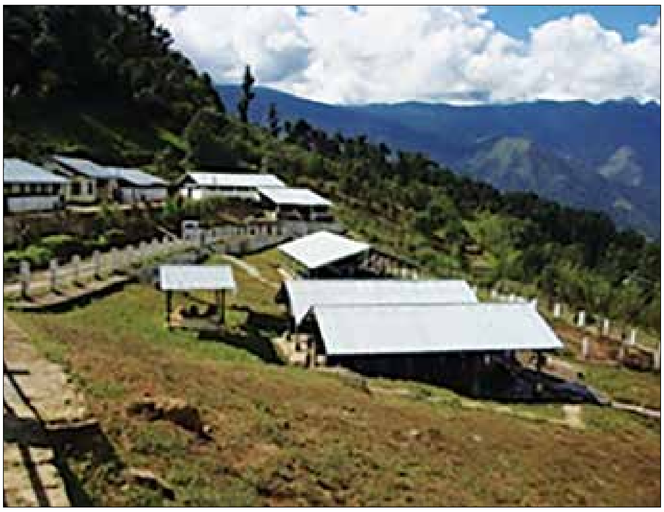
Yak insurance policy: The National Insurance Company Ltd. has approved an insurance policy for yaks, following relentless efforts by the National Research Centre on Yak (NRCY) here in West Kameng district. The insurance policy will shield yak owners against the risks posed by weather calamities, diseases, in-transit mishaps, surgical operations and strike or riots.

- ***Creating awareness about the diversified use of these unique bovines:*** Formation of herder's cooperative society and self-help groups.
- ***Extension and Other STC activities:*** ICAR-NRC on Yak, Dirang in collaboration with Department of Animal Husbandry, Livestock, Fisheries and Veterinary Services conducts various awareness and training programmes under the Scheduled Tribe Component (STC) as well as the NEH schemes of ICAR.

  In collaboration, Govt. of Sikkim also supported yak farmers by providing immediate remedial support to recover the health of surviving starved yaks due to unprecedented continuous and heavy snow during Dec 2018 to March 2019.
- ***Recognition to yak pastoralists:*** Yak pastoralists have rich cultural traditions tied to their livestock. Their practices include unique herding techniques, seasonal migrations, and rituals that honour their animals.

Some of the awards to honour the hardships and challenges faced by the pastoralists to sustain yak rearing:





- Breed Saviour Award 2021-Mr. Lobsang Tsewang
- Pastoralists and Rangeland Award
- 2021 Dungkharpa Welfare Society

SUMMARY

Yak is a livestock species that is specially raised by many ethnic people in NER for their livelihood and nutritional security. Although, livestock sector has slower growth in NER than at national level, but a significant proportion of landless, small and marginal farmers has access to livestock, which offer opportunities for household income augmentation and employment generation. In a nutshell, the scientific raising of yak will enable their impoverished rearers to make ends meet by providing additional money to meet their basic amenities. Thus, it is essential to encourage scientific farming in states where yak raising has a long history by offering institutional, technical, and legislative measures that enhance breeds, feed availability, disease management, food safety, and private investments in NER. The latest advancements in artificial insemination, oestrus synchronisation, timed AI and embryo transfer technologies along with other extension activities will undoubtedly contribute significantly to the goal of generating high-quality germplasm in farmers' fields. Overall, recognizing yak pastoralists is also imperative for safeguarding their way of life, supporting biodiversity and fostering sustainable development.

*Corresponding author email: msarkar24@gmail.com/yakdirector@gmail.com

Indian Farming 75 (07): 62-65; July 2025

Mithun farming:

A boon for the tribal farmers of eastern Himalaya

Girish Patil S.*, Harshit Kumar and Jagdish Chaudhary

ICAR-National Research Centre on Mithun, Medziphema, Nagaland 797 106

In the misty, verdant hills of the eastern Himalaya, where dense forests meet rugged terrains, a unique bovine species thrives- The mithun (Bos frontalis). *Revered as the equally important to humans, this unique genetic bioresource holds immense cultural, economic, and ecological significance for the tribal communities of northeast India, Bhutan, Myanmar, Bangladesh, and parts of China. For centuries, mithun has been more than just livestock; it's a symbol of pride, a measure of wealth, and a cornerstone of tribal traditions. Today, as the world shifts towards sustainable livelihoods and eco-friendly practices, mithun farming emerges as a potential boon for the tribal farmers of this region, offering economic opportunities, cultural preservation, and environmental benefits. This article explores how mithun farming empowers tribal communities across the eastern Himalaya, delving into its socio-economic advantages, challenges, and future potential. With a population estimated at around 0.28 million in India (based on the 2003 livestock census), mithun farming is concentrated in states like Arunachal Pradesh, Nagaland, Manipur, and Mizoram. It's growing recognition as a "food animal" by the Food Safety and Standards Authority of India (FSSAI) in 2023 further underscores its commercial promise. Through sustainable practices and scientific interventions, mithun farming could transform the lives of tribal farmers, ensuring both prosperity and the preservation of their rich heritage.*

Keywords: Economic opportunities, Environmental benefits, Heritage, Tribal farmers

OFTEN mistaken for a domesticated form of the Indian Gaur due to its similar appearance, mithun (Gayal) is a distinct bovine species native to northeast India, Bangladesh, China, and Myanmar. It holds significant cultural and economic value for the ethnic tribes of northeast India, particularly in Arunachal Pradesh and Nagaland. Unlike other domesticated bovines, mithun is predominantly reared under free-range conditions in forested areas. In India, its population is unevenly distributed across Arunachal Pradesh, Nagaland, Mizoram, and Manipur, with Arunachal Pradesh hosting the largest share, followed by Nagaland. This large and majestic species typically produces two calves over a three-year period and plays a multifaceted role in tribal communities. It is regarded as a symbol of prestige and is traditionally used as a medium of exchange in barter transactions.

Mithun thrives in the hilly forests of northeast India at elevations ranging from 300–3,000 meters. Known for its adaptability, it can survive across diverse climatic zones, from tropical and subtropical plains to sub-temperate and temperate regions. Indigenous tribes in Arunachal Pradesh, Nagaland, Mizoram, and Manipur are the primary caretakers of mithun, and its rearing is deeply integrated into their sustainable livelihood practices. More than just livestock, mithun is a cultural emblem, representing wealth and social status among tribal communities. Phylogenetically distinct from other Bos species, its origin remains complex and somewhat ambiguous. Research from ICAR-National Research Centre on Mithun, Nagaland, suggests a shared ancestry between mithun and Gaur, tracing back to an ancient and now-extinct bovine species. Locally, mithun is known by different names 'Eso', 'Hoho', or 'Sebe' in Arunachal Pradesh, 'Sial' in Mizoram, 'Sandong' in Manipur, and 'Wei' or 'Seizang' among Naga tribes.

Mithun is a medium to large-sized ruminant, typically characterized by a black coat with an ash-colored forehead and white stockings on the legs. However, variations exist in coat colour, horn shape and placement, and frontal bone structure across different populations. Coat colour ranges from solid black to pure white, with some individuals displaying a mix of both.

As per the 2019 Livestock Census, the total mithun population in India stands at 3.8 lakh. Arunachal Pradesh accounts for approximately 90% of the total mithun population, followed by Nagaland (5.98%), Manipur (2.36%), and Mizoram (1.02%). The 20th Livestock Census (2019) recorded a significant 30.6% increase in mithun numbers, highlighting its growing importance in the region (Basic Animal Husbandry Statistics 2018–19, Government of India 2020).

Cultural and historical significance of mithun

Mithun is deeply woven into the socio-cultural fabric of the tribal communities in the eastern Himalaya. For tribes such as the Adi, Nyishi, Galo, and Apatani in Arunachal Pradesh, Angami and Chakhesang in Nagaland, and Zo in Myanmar, mithun is more than an animal, it's a living emblem of status and identity. Historically, the number of mithuns a person owns has been a marker of wealth and influence. In many villages, it serves as a traditional currency, used in barter trade, settling disputes, or paying bride prices during marriages.

Festivals and rituals often revolve around mithun. For instance, the Nyishi tribe's Nyokum festival includes mithun sacrifices to appease deities, while Adi community uses it in communal feasts to mark significant occasions. Beyond its ceremonial role, Mithun provides practical benefits, viz. its meat is a delicacy, its milk (though underutilized) is nutritious, and its hide offers leather potential. This multi-faceted utility has made mithun a lifeline for tribal households, often dubbed the "family bank" due to its economic reliability during emergencies.

The forest free nature of mithun adds to its mystique. Unlike conventional cattle, mithuns roam freely in community forests, requiring minimal human intervention. This free-range system aligns with the tribal ethics of living in harmony with nature, a practice honed over generations. However, as modernization encroaches and forest habitats shrink, this traditional rearing method faces challenges, prompting a need for innovation to sustain its benefits.

Economic potential: A pathway to prosperity

Mithun farming holds untapped economic potential for tribal farmers, particularly as demand for its products grows. The meat, known for its lean texture and low fat content (2–4% compared to 20% in mutton), is a sought-after delicacy in northeast India, fetching prices as high as ₹ 300/kg in local markets. An adult mithun, weighing between 400 and 650 kg, can be sold for ₹2 lakh or more, offering substantial returns for farmers who traditionally slaughter it only for special occasions like festivals or weddings.

The FSSAI's recognition of mithun as a "food animal" in September 2023 has opened new commercial avenues. Entrepreneurs and startups, such as North East Farm Sales Promotion in Guwahati, are exploring value-added products like vacuum-packed dry meat, pickles, soups, and instant biryani, aiming to position mithun meat as a premium product for health-conscious consumers beyond the region. This diversification could elevate mithun farming from a subsistence activity to a profitable enterprise, boosting the income of tribal households.

Table 1. Economic contributions of mithun farming to tribal communities

Aspect	Contribution	Economic Value (Approximate)
Meat Sales	High demand in local markets	₹ 300/kg; ₹ 2 lakh per adult
Cultural Transactions	Used as bride price, dispute settlement	Varies by community
Potential Dairy Products	Nutritious milk (underutilized currently)	Yet to be commercialized
Hide and Leather	Source of raw material	₹ 5,000–10,000 per animal

Beyond direct sales, mithun farming supports ancillary livelihoods. For instance, the construction of "living fences"made from barbed wire and orchid tree stumps to protect grazing areas has created jobs for local artisans and labourers. Initiatives like the ICAR-National Research Centre on Mithun's (NRCM) training programmes further equip farmers with skills to process meat and adopt semi-intensive rearing, enhancing productivity and market reach.

Ecological benefits: Guardians of the forest

Mithun's ecological role is as significant as its economic one. As a free-ranging animal, it thrives in the sub-tropical broadleaf forests of the eastern Himalaya, contributing to biodiversity conservation. Its grazing habits help disperse seeds and enrich soil through manure, promoting forest regeneration. Studies suggest that silvo-pastural systems integrating trees and pasture-used in mithun rearing can sequester carbon dioxide, mitigating climate change. A 2023 study in the eastern US estimated that such systems could capture 4.9 to 25.6 million metric tonnes of CO_2 annually if scaled up, hinting at similar potential in the Himalayas.

Mithuns thrive in the Eastern Himalaya's forests, blending tradition with ecology

The Nagaland government has recognized this synergy, promoting mithun farming as an alternative to slash-and-burn agriculture *(Jhum)*, which depletes forests and causes landslides. By designating "Mithun forests" near villages, communities preserve natural habitats while sustaining their livestock, striking a balance between livelihood and environmental stewardship.

Challenges in mithun farming

Despite its promising benefits, mithun farming faces significant hurdles. Habitat loss due to deforestation and agricultural expansion has reduced grazing areas, pushing mithuns into conflict with farmers as they forage on crops. Diseases like foot and mouth disease (FMD) pose a severe threat, with outbreaks decimating herds due to the animals' free-ranging nature and limited vaccination coverage. A study in Nagaland and Manipur identified FMD as a primary reason for population decline, emphasizing the need for awareness and veterinary support. Traditional rearing practices also limit scalability. The zero-input, free-range system, while sustainable, offers little control over breeding or health, leading to low productivity. Predators like wild dogs further endanger young calves, as seen in the case of Yang Ering Moyong, an Adi tribe farmer in Arunachal Pradesh, who lost nearly half her herd of 50 mithuns to attacks. Additionally, lack of institutional support such as credit facilities, insurance, or marketing networks deters farmers from transitioning to commercial models.

Innovations and interventions

To unlock mithun farming's full potential, scientific and community-driven interventions are underway. The ICAR-NRCM in Nagaland has been a pioneer, developing technologies like semen cryopreservation and estrus synchronization to improve breeding outcomes. Their M-ANITRA app, launched in 2023, connects mithun farmers as buyers and sellers, fostering a competitive market. Training programmes, such as those attended by farmers like Kewiribam from Tening village, teach modern practices like fencing and meat processing, shifting the focus from ritual slaughter to sustainable commerce. Community-led efforts complement these initiatives. The Adi tribe's "living fences" in Arunachal Pradesh, supported by ICAR-NRCM, protect mithuns from straying while enhancing grazing areas. Night shelters made from bamboo sheets safeguard calves, reducing predation losses. These innovations not only boost productivity but also empower women like Yang Ering Moyong, who, as the sole female herder in her village, exemplifies resilience and adaptability (ICAR-NRC on Mithun 2020).

Living fences blend innovation with tradition, safeguarding mithuns and forests

The future of mithun farming

The future of mithun farming lies in balancing tradition with modernity. Scaling up semi-intensive rearing systems—where mithuns are partially confined with supplementary feeding—could enhance productivity without losing their ecological benefits. Commercializing dairy products, given mithun milk's nutritional value, offers another revenue stream, though cultural reluctance to milk must be addressed through awareness campaigns.

Transboundary cooperation among eastern Himalayan countries could further amplify benefits. Cross-border festivals showcasing mithun culture might attract tourists, boosting rural economies, while collaborative research could tackle shared challenges like disease and habitat loss. The NRCM remains the world's only dedicated mithun research institute, underscoring the need for global investment to elevate its status.

SUMMARY

Mithun farming is more than a livelihood, it's a legacy that binds the tribal farmers of the Eastern Himalaya to their land and traditions. As a source of income, a cultural icon, and an ecological ally, mithun offers a sustainable path to prosperity amid the region's challenges. By addressing hurdles like habitat loss and disease through innovation and support, and by tapping into its commercial potential, mithun farming can uplift tribal communities while preserving their unique way of

Table 2. Key challenges and proposed solutions

Challenge	Impact	Proposed Solution
Habitat Loss	Reduced grazing areas, human-wildlife conflict	Reforestation, designated Mithun forests
Disease (e.g. FMD)	High mortality rates	Vaccination drives, farmer education
Predation	Loss of calves	Living fences, night shelters
Limited Commercialization	Subsistence-focused, low income	Training, value-added product development

life. For these farmers, the Nature's garderner- Mithun is not just a boon, it's a bridge to a thriving, resilient future. Mithun can be fully exploited to its marketable potential only if the farmers shift from the traditional method of rearing. The constraints of the high cost of inputs involved in fencing and predator attack may be mitigated by adopting a scientific and alternative semi-intensive method of rearing wherein the diversified use of mithun for meat, milk, hide, and draught potential can be encouraged. The state government should also work for inclusion of mithun under the National Livestock Mission and take initiatives to frame policies, strategies and legislative laws so that mithun can be a constant source of their livelihood security for the farmers without having any impact on the population conservation and propagation.

*Corresponding author email: girishlpt@gmail.com

Articles invited for Special Issues of *Indian Farming* and *Indian Horticulture*

On the occasion of the 98th ICAR Foundation Day

ICAR invites articles for two Special Issues of its flagship magazines, *Indian Farming* and *Indian Horticulture*, to be published on the occasion of the 98th ICAR Foundation Day. Researchers, scientists, and subject matter experts are encouraged to contribute high-quality articles aligned with the themes given below.

1. Special Issue of *Indian Farming* on "Environmental Sustainability"

This issue will focus on innovations, technologies, and products that contribute to Environmental Sustainability and support the attainment of the Sustainable Development Goals (SDGs). Articles should present a clear and complete storyline demonstrating how the described method advances specific SDGs and promotes sustainable agricultural practices.

Authors are requested to follow the submission guidelines available on the *Indian Farming* ePubs portal: https://epubs.icar.org.in/index.php/IndFarm/about/submissions

2. Special Issue of *Indian Horticulture* on "Nutrition and Health"

This issue will highlight advancements that enhance nutrition, improve health outcomes, and promote sustainable food systems, contributing to relevant SDGs. Articles should present a coherent narrative demonstrating how the work supports better nutrition and health through horticultural innovations.

Authors are requested to follow the submission guidelines available on the *Indian Horticulture* ePubs portal: https://epubs.icar.org.in/index.php/IndHort/about/submissions

While submitting the article, please clearly mention that the submission is for the **Special Issue**.

Last date for submission: 28th February 2026

Indian Farming 75 (07): 66-68; July 2025

Improved technologies for pig farming in north eastern India

Sourabh Deori* and Rahul Katiyar

ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

Pig farming is most important rural livelihood source in entire north eastern India. However, majority of the pigs are reared in backyard system with minimum input. Implementation of scientific pig husbandry practices with location specific improved technologies will improve the scenario of piggery in the region. The article is aimed to discuss some of the location specific improved technologies for sustainable pig husbandry. Some of technologies related to improved pig breeds, housing models, feed formulations, value addition of pork products and artificial insemination techniques are mentioned. Dissemination and adoption of these technologies will improve pig husbandry in the region.

Keywords: Artificial insemination, Scientific pig husbandry, Value addition

NORTHEAST India has 42,42,597 or 46.85% of India's total pig population (20th Livestock Census). In the NER, highest pig population is in Assam followed by Meghalaya and Nagaland. The pig farming is mostly traditional and reared by the native tribal population of the region. Besides Assam, very few commercial pig farming is practised. Some of the inherent problems with the pig farming in the region include unavailability of superior or improved germplasm, high feed cost, and low productivity of the indigenous pigs, traditional management practices, disease outbreak and poor biosecurity measures under field condition. Though the demand of pork is very high in the region but due to inherent problems associated with the pig farming, the demand for pork is met by supply of live pigs from outside of the region.

Table 1. Pig population in northeast India as per 20th Livestock Census, DAHD, 2019

States	Indigenous	Exotic/Crossbred	Total
Arunachal Pradesh	257785	13678	271463
Assam	1640760	458240	2099000
Manipur	207772	27483	235255
Meghalaya	430311	276053	706364
Mizoram	29404	263061	292465
Nagaland	197605	207090	404695
Sikkim	15302	12018	27320
Tripura	101408	104627	206035
NER	2880347	1362250	4242597
All India	7158544	1896944	9055488

Around 67.89 percent of pig in northeast India constitutes of indigenous pigs and the rest 32.11 percent are exotic/crossbred. The indigenous pigs are well adapted to the local climate, traditional rearing practices and resistant to infections in comparison to exotic/ crossbred. However, poor litter size and body weight are the limiting factors of the indigenous pigs. From the region, a total of seven indigenous pig breeds are registered and gazette notified.

Table 2. Pig breeds registered from the northeast India

Sl. No	Breed	State	Accession number
1.	Doom	Assam	INDIA_PIG_0200_ DOOM_09006
2.	Manipuri Black	Manipur	INDIA_PIG_1200_ MANIPURIBLACK_09012
3.	Wak Chambil	Meghalaya	INDIA_PIG_1300_ WAKCHAMBIL_09013
4.	Niang Megha	Meghalaya	INDIA_PIG_1300_ NIANGMEGHA_09002
5.	Zovawk	Mizoram	INDIA_PIG_2700_ ZOVAWK_09007
6.	Tenyi Vo	Nagaland	INDIA_PIG_1400_ TENYIVO_09004
7.	Mali	Tripura	INDIA_PIG_1900_ MALI_09009

Lumsniang boar

Lumsniang sow with piglets

Improved technologies for pig farming

Pig variety (Lumsniang): A pig variety has been developed that demonstrates improved productivity compared to local or indigenous pigs and exhibits better adaptability to the hilly regions of the northeastern states. The synthetic pig variety named Lumsniang was developed by crossing Hampshire and Niang Megha pigs. The selection process involved evaluating crossbred pigs with varying genetic inheritance, ultimately choosing those with 75% Hampshire and 25% Niang Megha for further development. Inter-sex mating and continuous selection were conducted over six generations, leading to genetic gain and stability in economic traits. Released on March 6, 2017, Lumsniang is particularly suited for the hilly regions of the north eastern states, exhibiting improved performance in traits such as litter size, weight at birth, and weaning, alongside favourable growth rates at various ages. The introduction of the Lumsniang synthetic pig variety, enhances productivity and adaptability for pig farmers in the north eastern states, contributing to improved livelihoods and sustainable livestock management in hilly regions.

Table 3. Production and reproduction performances of Lumsniang pig

Traits	Mean
Litter size at birth (no.)	9.57 ± 0.21
Litter weight at birth (kg)	8.25 ± 0.42
Litter size at weaning (no.)	8.36 ± 0.37
Litter weight at weaning (kg)	81.06 ± 1.31
Adult weight (kg): Male	69.63 ± 0.01
Adult weight (kg): Female	65.59 ± 0.04
Dressing %	72.33 ± 0.87
Age at first mating (days): Male	197.76 ± 1.76
Age at first mating (days): Female	247.53 ± 0.43
Age at first Oestrus (days)	217.43 ± 0.43
Oestrous cycle duration (days)	21.34 ± 0.43
Age at first farrowing (days)	419.17 ± 1.23

Climate resilient pigpen for high altitude areas with rain water harvesting system: The low-cost, climate-resilient pigpen is constructed from locally sourced, eco-friendly materials, promoting sustainability. Its innovative design enhances animal welfare and hygiene while incorporating a rainwater harvesting system to ensure water availability in high-altitude regions. The climate-resilient pigpen is designed with a dual-area layout to create a comfortable microenvironment for pigs. It features an elevated bedding system that enhances hygiene by preventing waste transfer and promoting animal welfare. This innovative pigpen supports sustainable livestock farming and enhances the resilience of local farmers for challenging climatic conditions in the north eastern states. Cost of construction is around ₹2000 per unit that houses two pigs and durability is 2 years. It requires 83 times less water as compared to conventional housing model as there is limited washing and cleaning of shed similarly, 48.3% less labour intensive compared to conventional models. This technology reduces capital investment in constructing pig sheds while enhancing animal welfare and resilience against climate impacts.

Innovative functional pork products with bloodfruit, chameleon leaves and perilla seeds: These functional pork products uniquely combine traditional and locally sourced ingredients such as bloodfruit, chameleon leaves, and perilla seeds, which are known for their health benefits. This innovative approach enhances nutritional value, flavour, and antioxidant properties while catering to the rising consumer demand for healthier and functional food options. Bloodfruit *(Haematocarpus validus)* is rich in beta carotene, anthocyanins, and iron, providing antioxidant properties that combat free radicals in the body. Incorporating bloodfruit pulp into conventional sausages enhances their nutritional profile, resulting in higher levels of beta carotene, anthocyanins, flavonoids, iron, fibre, and ascorbic acid. Chameleon plant (fish mint) adds further antioxidant benefits, improving the physicochemical properties of emulsified meat products. Additionally, perilla seeds enhance the nutritional value of sausages by increasing protein and polyunsaturated fatty acids (PUFAs), known for their cholesterol-lowering effects and cardiovascular benefits. These innovations create functional pork products

Climate resilient pigpen

Pork sausage incorporated with blood fruit and perilla seeds

appealing to health-conscious consumers. Incorporating traditional ingredients into pork products increases local customer acceptability and promotes healthier dietary options.

Nanoparticle fortified BTS extender for enhanced boar semen preservation: The beltsville thawing solution (BTS) serves as a short-term extender for boar semen preservation, traditionally effective for up to three days at temperatures between 15–18°C. This innovative technology introduces a nanoparticle-fortified extender that includes 1 μm/mL of selenium nanoparticles, significantly enhancing sperm motility and viability. The modified extender maintains sperm motility at 50.12% for up to four days and has demonstrated a 100% conception rate in trials conducted at the ICAR Research Complex for NEH Region in Umiam, Meghalaya, thereby improving the effectiveness of artificial insemination practices. This technology enables the preservation of boar semen in BTS extender for up to four days while significantly enhancing fertility rates, thereby improving the efficiency of artificial insemination in pig farming

Table 4. Composition of the boar semen extender

Ingredients	Quantity
Glucose – D (g)	3.715
Tri-sodium citrate (g)	0.600
E.D.T.A. di-sodium salt (g)	0.125
Sodium Hydrogen carbonate (g)	0.125
Potassium chloride (g)	0.075
Gentamicin sulphate (μg/mL)	150
Selenium nanoparticles	1 μm/mL
Distilled water (mL)	up to 100

Low-cost feed formulation for grower pigs: The north eastern region boasts an abundance of wild banana trees, making incorporation of banana pseudostems into pig feed a cost-effective strategy. This innovative feed formulation allows for the partial replacement of dietary maize with sun-dried banana pseudostem (BP), enabling up to 20% substitution without compromising the growth, blood biochemical parameters, reproductive performance, or carcass quality of crossbred grower pigs. Utilizing 20% sun-dried BP significantly reduces feed costs compared to traditional maize-based diets, thus offering a sustainable feeding alternative for pig farmers.

Table 5. Composition of banana pseudostem incorporated ration for growing pig

Ingredients	Composition %
Maize	35.00
Banana pseudostem	20.00
Wheat bran	14.00
Ground nut Cake	18.50
Soybean meal	10.00
Mineral mixture	2.00
Salt	0.50
Total	100

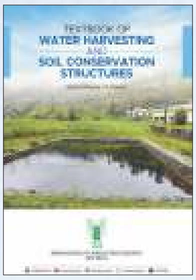
SUMMARY

Majority of the pig farming in the north eastern states is still traditional resulting in poor productivity and income to the pig farmers. Development of improved technologies related to location pig varieties, housing models and feeding strategies are crucial to improve the pig farming in the region. Development of suitable artificial insemination techniques is another important area in pig breeding as being meat animal most of the male piglets are castrated for fattening purpose. This has resulted in non-availability of good breeding boars under field condition for mating.

*Corresponding author email: sourabhd1@rediffmail.com

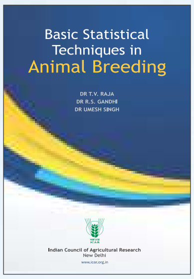
ICAR

ICAR New Arrivals



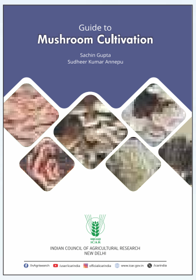
Textbook of Water Harvesting and Soil Conservation Structures

Page	viii+376
Rs	₹1000
Postage	₹100
US	$150



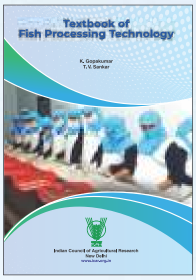
Basic Statistical Techniques in Animal Breeding

Page	viii+211
Rs	₹700
Postage	₹100
US	$90



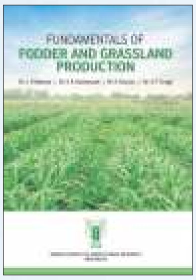
Mushroom Cultivation

Page	x+134
Rs	₹600
Postage	₹100
US	$85



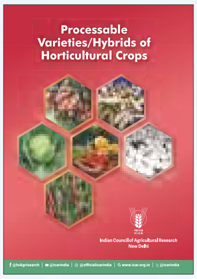
Textbook of Fish Processing Technology (REVISED EDITION)

Page	xii+640
Rs	₹1200
Postage	₹100
US	$185



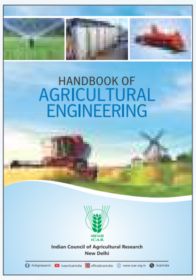
Fundamentals of Fodder and Grassland Production

Page	vi+354
Rs	₹600
Postage	₹100
US	$90



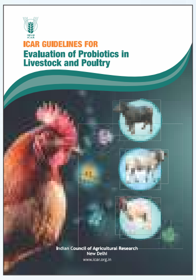
Processable Varieties/ Hybrids of Horticultural Crops

Page	viii+168
Rs	₹100
Postage	₹50
US	$15



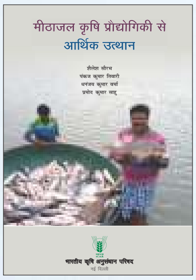
Handbook of Agricultural Engineering (Revised Edition)

Page	xii+1188
Rs	₹2000
Postage	₹200
US	$300



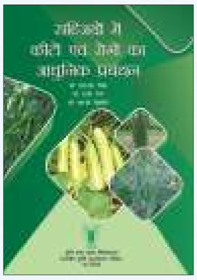
ICAR Guidelines for Evaluation of Probiotics in Livestock and Poultry

Page	x+22
Rs	₹50
Postage	₹50
US	$8



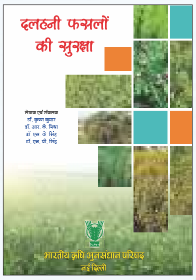
मीठाजल कृषि प्रौद्योगिकी से आर्थिक उत्थान

Page	xii+320
Rs	₹800
Postage	₹100



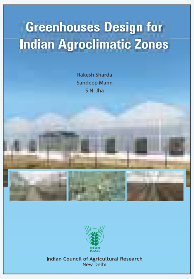
सब्जियों में कीटों एवं रोगों का आधुनिक प्रबंधन

Page	xii+448
Rs	₹860
Postage	₹50



दलहनी फसलों की सुरक्षा

Page	xii+448
Rs	₹1000
Postage	₹100



Greenhouses Design for Indian Agroclimatic Zones

Page	x+149
Rs	₹800
Postage	₹100
US	$100

1. Payment should be made through Bank Draft in favour of "Business Manager, ICAR, New Delhi".
2. A 10% discount will be admissible on direct purchase of Books (only) from sales counter (DKMA) at Ground Floor, KAB-I, Pusa Campus, New Delhi-110012.
3. Libraries are entitled for discount of 15% excluding Magazines/Journals.
4. Textbooks and other publications can be purchased online also (QR code at bottom).
5. Payment through RTGS/NEFT mode is accepted.

Name and address of organization	DKMA Revolving Fund Scheme
Bank Name	Canara Bank
Bank Address	Pusa Campus, New Delhi 110012
IFSC Code	CNRB0019029
MICR No.	110015391
Current Account No.	24131010000043
PFMS Unique Code:	DLND00001925 (Only for Govt. Department & ICAR Institutes)

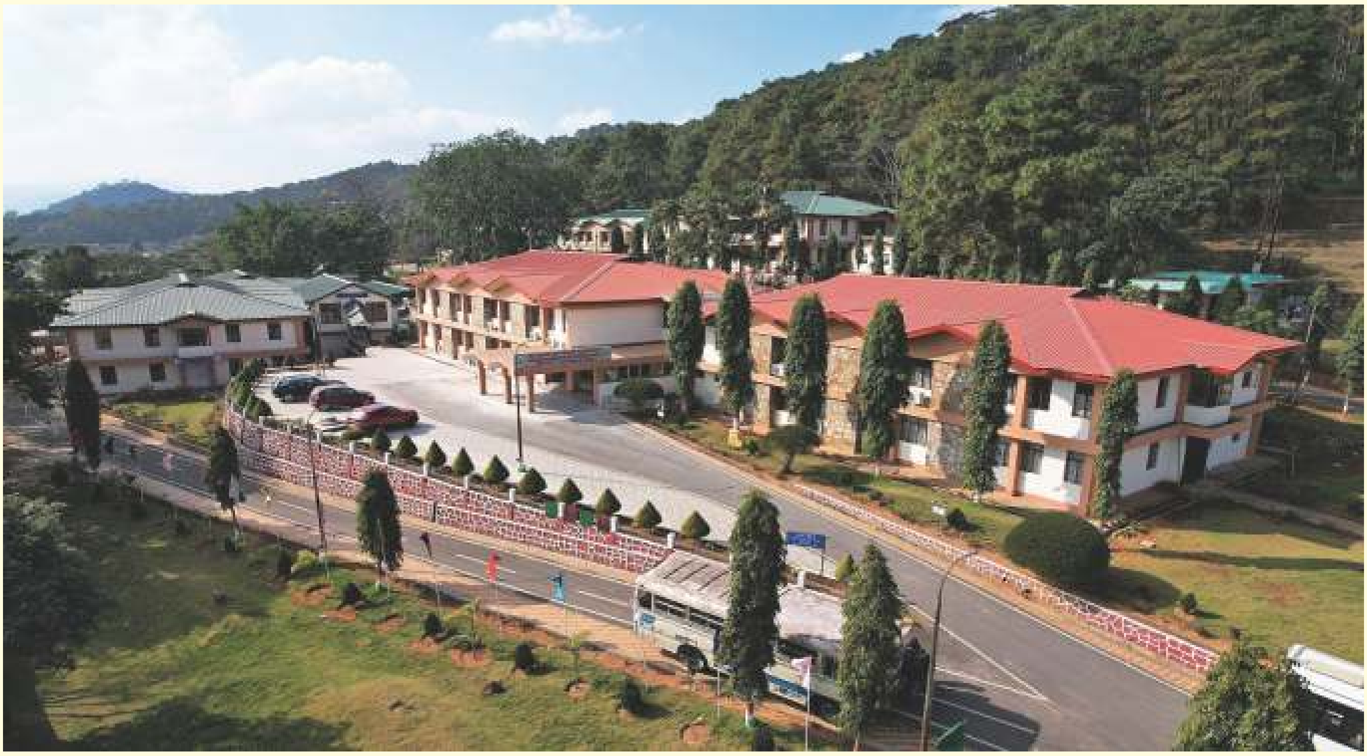
For Publications and Advertisement please contact

Incharge, Business Unit
Directorate of Knowledge Management in Agriculture
Indian Council of Agricultural Research
Krishi Anusandhan Bhawan-I, Pusa Campus, New Delhi 110012
Tel: 011-25843657; bhupinder.icar@nic.in; businessuniticar@gmail.com
Website: **www.icar.org.in**

SCAN QR Code to Purchase Online

ISSN: 0019–4786
Regd. No. 14247/57
Delhi Postal Regd. No. DL(C)-12/1147/2007-2010
Price : ₹ 50.00

Tapping Biodiversity for Attaining SDGs in Eastern Himalayas



Published by Dr Anuradha Agrawal, Project Director (DKMA), on behalf of Indian Council of Agricultural Research, Krishi Anusandhan Bhavan I, Pusa Campus, New Delhi 110012, and printed at M/s Viba Press Pvt. Ltd., C-66/3, Okhla Industrial Area, Phase-II, New Delhi 110020. Editor : Dr Anu Rahal