

FARM SCIENCE TODAY

BRIDGING SCIENCE AND FARMING

ISSN: XXXX XXXX



SEPTEMBER 2026

VOLUME 1 ISSUE 2

LETTER FROM THE EDITOR'S DESK

Dear Readers,

Welcome to the September 2026 issue of Farm Science Today (Volume 1, Issue 2). Agriculture today stands at a complex crossroads. On one side are the urgent challenges of climate variability, soil degradation, labor shortages, and the need to produce more food with fewer resources. On the other side are exciting opportunities offered by digital tools, ecological knowledge, and the rich biodiversity that still thrives in many parts of our country—especially in the Northeast. This issue of Farm Science Today attempts to bring both sides of the story together in a way that is practical, readable, and useful for farmers, students, researchers, and extension workers. Our magazine's purpose remains simple and constant: to present scientific knowledge in a clear, accessible style so that it can travel easily from research stations and laboratories into the fields, home gardens, and community discussions where it truly matters.

In the following pages you will find a carefully curated selection of articles that reflect this dual focus on innovation and tradition. The opening contribution examines the growing role of artificial intelligence and big data analytics in agriculture. It shows how sensors, satellite imagery, and predictive algorithms can help farmers monitor crop health, detect pests early, optimize irrigation, and make better decisions about planting and marketing. At the same time, the article honestly discusses the barriers that still prevent many smallholders from benefiting—high initial costs, limited internet connectivity in rural areas, and the need for training. These challenges are real, and any technology that ignores them will remain incomplete. A complementary article extends the discussion of artificial intelligence into forestry. It explores how AI, remote sensing, drones, and machine learning are being used for carbon estimation, wildlife monitoring, early fire detection, precision silviculture, and reforestation planning. The piece also highlights promising Indian initiatives and the practical difficulties of connectivity, cost, and skill gaps in forest landscapes. Together, the two AI-focused articles remind us that digital tools must be designed and adapted for the people who will actually use them. Balancing the technology theme are several articles rooted in ecological and traditional knowledge. One contribution explains the important role of agroforestry systems in nutrient cycling. It describes how trees act as nutrient pumps, how litterfall and decomposition enrich the soil, and how the cycling of nitrogen, phosphorus, and carbon can be strengthened when trees, crops, and livestock are thoughtfully integrated. For farmers seeking to reduce dependence on external inputs while improving long-term soil fertility, these insights are highly relevant.

Another article focuses on biochar as a practical tool for engineering climate-resilient soils, particularly in the acidic and erosion-prone hills of northeastern India. It explains the science of pyrolysis, the benefits of local feedstocks, and the advantages of using enriched biochar in combination with organic manures. The discussion of soil acidity, water retention, and nutrient-holding capacity is especially useful for the region's small and fragmented holdings. Two further articles celebrate the biological and cultural wealth of North-East India. "Green Treasures of Northeast India" introduces readers to a range of traditional leafy vegetables—lai pat, fiddlehead fern, colocasia leaves, perilla, yongchak, bamboo shoots, and others—that have long formed part of local diets and health practices. The piece stresses the nutritional value of these greens while also calling for careful identification, sustainable harvesting, and respect for traditional knowledge. The article on lesser-known fruits continues this theme, showing how underutilized species can serve both as dietary supplements and as seasonal sources of income through fresh sales and simple processing into jams, pickles, and juices. In a country still grappling with malnutrition and the need for diversified livelihoods, these local resources deserve far greater attention. Taken together, the articles in this issue convey a clear message: the future of farming will not be built on technology alone, nor on tradition alone. Lasting progress will come from thoughtful integration—where digital tools help farmers manage resources more precisely, while agroforestry, biochar, kitchen gardens, and indigenous crops rebuild soil health, nutrition, and resilience from the ground up. We hope these pages will inform your thinking, spark discussion in your communities, and encourage practical action. Farm Science Today is meant to be a shared platform. We warmly invite you to write to us with your experiences, questions, success stories, or suggestions for future topics. Your feedback helps us remain relevant and useful to the farming community we serve.

Thank you for reading. May this issue contribute, in some small way, to more productive, sustainable, and equitable farming systems across the country.

Editor
Farm Science Today

Table of the content

S.No	Title of the article	Page No
1	Transforming agriculture: The impact of artificial intelligence and big data analytics	05-07
2	Potential role of agroforestry in nutrient cycling	08-10
3	Green Treasures of North-East India	11-12
4	Biochar: Engineering Climate-Resilient Soils in North-Eastern India	13-16
5	Lesser-Known Fruits: An Economic Booster and Dietary Supplements	17-20
6	Artificial intelligence: status and prospectus of its uses in forestry	21-24

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 04-08-2026

Published: 02-09-2026

Manisha Arya¹

Soil and Crop Management
ICAR-Central Soil Salinity
Research Institute, Karnal,
132001

Pankaj Singhroha²

Department of Soil Science
Guru Kashi University, Talwandi
Sabo, Bhatinda, 151302

Sakshi Vishvamitera¹

Soil and Crop Management
ICAR-Central Soil Salinity
Research Institute, Karnal,
132001

Kiran K. Khokar³

Department of Soil Science
Chaudhary Charam Singh
Haryana Agricultural University
Hisar, Haryana, 125004

Corresponding author e-mail:

agri.arya369@gmail.com

Transforming agriculture: The impact of artificial intelligence and big data analytics

Introduction

Currently, agriculture encounters numerous challenges and changes worldwide. It's a blend of technological advancements, sustainability concerns, and challenges posed by climate change. Farmers are increasingly adopting precision farming techniques and digital technologies to enhance productivity and address labour shortages, while also managing the impacts of climate change, such as extreme weather and changes in precipitation patterns. Sustainable agriculture practices are gaining popularity as stakeholders recognize the need to conserve natural resources and ensure food security for future generations. In spite of these initiatives, food insecurity, rural poverty, and global trade dynamics remain significant challenges that require comprehensive solutions and collaboration across sectors to achieve a resilient and sustainable agricultural system. Now imagine if AI could analyse data from satellites and sensors to inform farmers exactly when to plant their crops for the best results. Or if it could spot signs of pests or diseases at an early stage, so farmers could take action before they cause too much damage.

How AI Implementing in Agriculture:

AI is reforming agriculture in many ways. Here are some areas where AI is making a difference:

- AI analyses data from sensors and satellite imagery to assess crop health, soil conditions, and water requirements. This enables farmers to target resources more precisely, reducing waste and maximizing yield.
- AI-driven systems can detect early indications of pests and diseases through image recognition, assisting farmers in implementing preventive steps and reducing yield losses
- AI algorithms analyse historical data and weather forecasts to predict crop yields, market prices, and potential risks. This data aids farmers in making well-informed choices regarding planting, harvesting, and resource distribution.

In Automation Farming:

- AI-powered drones, tractors, and robots are automating tasks like planting, weeding, and harvesting, improving efficiency and reducing labour costs.
- These systems use sensors and AI to monitor soil moisture and weather conditions, adjusting irrigation automatically to conserve water and ensure optimal crop growth.
- Wearables and sensors powered by AI monitor animal health metrics such as temperature, activity, and feeding habits, enabling early disease identification and enhancing animal welfare.

Other Areas:

- AI systems can automatically grade and sort fruits and vegetables based on size, colour, and quality, reducing manual labour and ensuring consistent product quality.
- AI assist farmers understand market trends and predict future prices, allowing them to make informed decisions about what to plant and when to sell.
- Logistics systems enhanced by AI can improve transportation routes and storage conditions, minimizing food waste and guaranteeing effective delivery of agricultural goods.

Limitations and Challenges of AI

Although AI's potential is huge, it has its fair share of challenges. There are hurdles to overcome. Estimates suggest there are around 570 million farms globally, and 84% of those are considered smallholdings, meaning they are less than 2 hectares (about 5 acres) in size. That translates to roughly 476 million small-scale farmers worldwide. The World Bank reports that 52% of the

global population still lacks internet access, and a significant portion of this gap resides in rural areas. Small scale farmers play a crucial role in global food security, contributing 28-31% of the world's total crop production despite facing various challenges. Here's what we need to think about:

1. Implementing AI technology in agriculture can require significant upfront investment in hardware, software, and training. For small-scale farmers with limited financial resources, this initial cost may be prohibitive. Moreover, continued maintenance and updates may increase the total cost.
2. Many AI solutions are designed with large-scale agriculture in mind, which may not be directly applicable to small land holdings. Adapting AI technologies for smaller farms while ensuring affordability presents a significant challenge.
3. AI models rely heavily on high-quality data for training and decision making. In numerous areas, access to reliable and pertinent data might be restricted, which can affect the accuracy and effectiveness of AI solutions.
4. Reliable internet connectivity is essential for accessing AI tools and transferring data, but many rural areas lack adequate infrastructure. Poor connectivity can hinder the adoption and effectiveness of AI solutions in agriculture.
5. For AI technology to be successfully implemented, farmers need to possess adequate education and technical expertise. Nonetheless, numerous farmers might not possess the required training and literacy to utilize these tools effectively.
6. There is a risk that AI solutions may primarily benefit large-scale farmers and corporations with greater financial resources and technical expertise, potentially exacerbating inequalities within the agricultural sector. Additional factors to consider include regulatory frameworks, intellectual property rights, environmental sustainability, and the long-term viability of AI solutions in agricultural systems. Addressing these challenges

requires a multi-prolonged approach.

To make AI work in farming, everyone needs to work together: policymakers, tech experts, farmers, and others. We should create solutions that fit the needs of small farmers and help them access technology. It's important to improve internet access in rural areas and train farmers to use AI effectively. We must also think about the environment and make sure AI helps farmers and doesn't harm the planet. And we need clear rules about how AI is used, including privacy and fairness.

But AI in farming isn't just about technology. It's about people, communities, and the future of our food. If we face the challenges and use the opportunities, AI can help farmers and make our food system better for everyone. The future of farming is up to all of us, and if we work together, it can be a successful one.

Conclusion:

In conclusion, the integration of artificial intelligence (AI) and big data analytics into agriculture is transforming the industry in profound ways. Algorithms

powered by AI are enabling more accurate and personalized nutritional insights, helping individuals make informed dietary choices while addressing global health concerns such as obesity and malnutrition. Conversely, big data analytics allows researchers and food manufacturers to examine extensive datasets for trends, patterns, and consumer preferences, leading to the creation of healthier, more sustainable food products.

AI and big data are also accelerating the development of precision agriculture, enhancing food production, and reducing waste through more efficient resource management. The integration of these technologies holds immense potential to address pressing challenges in food security, sustainability, and public health, paving the way for a future where food science is more efficient, data-driven, and customized to personal requirements. The continued advancements in AI and big data will shape the future of food, nutrition, and global health for generations to come.

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 06-08-2026

Published: 02-09-2026

Pankaj¹

¹ Assistant Professor, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab

Manisha Arya²

² M.Sc. Student, Department of Soil Science, CCS HAU, Hisar, Haryana

Anu³

³ Assistant Professor, School of Agriculture Sciences, Geeta University, Naultha, Panipat, Haryana

Corresponding author e-mail:

pankajsingroha95@gmail.com

Potential role of agroforestry in nutrient cycling

Introduction

In the developing world, different countries focused on self-sufficiency in food production and invited industrialized agriculture with new crop ideotypes/cultivars, chemical fertilizers and pesticides, creation of irrigation facilities and arrangement of farm mechanization. These practices were recognized as the green revolution and technologies were known as green revolution technologies. Thus, monoculture started to dominate replacing ancient practices. The new technologies adopted also resulted in quick enhancement of crop productivity and the developing countries witnessed a boost in food-grain production at that time it was believed that modern technology-based agriculture was the suitable option for alleviation of hunger. But after a few decades, it was further noticed that the supply-driven and high-input-based agriculture failed to assure agricultural sustainability and created degradation of the agro-ecosystem. Moreover, random deforestation caused due to the expansion of farmland for food-grain production ultimately created enormous social and environmental problems. Due to these limitations researchers started to search for suitable options for farming which will be sustainable, socially acceptable and economically viable. For the developing countries of the tropical and subtropical regions, Agroforestry System (AFS) may be considered as one of the suitable options because of its multifaceted benefits focusing on agricultural sustainability. Gradually, agroforestry gained the attention of researchers and policymakers of different countries.

Benefits of agroforestry:

Agroforestry is a sustainable land use system that involves the integration of trees, crops, and/or livestock in a single land use unit. Here are some basic concepts related to agroforestry:

- **Agroforestry systems:** There are different types of agroforestry systems, including alley cropping, silvopasture, forest farming, and home gardens.
- **Tree-crop interactions:** In agroforestry systems, trees and crops can interact in a variety of ways. For example, trees can provide shade and reduce soil erosion, while crops can provide additional income and improve soil fertility.
- **Environmental benefits:** Agroforestry can have a range of environmental benefits, such as improving soil health, reducing greenhouse gas emissions, and providing habitat for wildlife.
- **Economic benefits:** Agroforestry systems can also provide economic benefits, such

diversifying income streams for farmers and increasing the productivity of the land.

- **Social benefits:** Agroforestry systems can have social benefits, such as improving food security, enhancing cultural practices, and promoting community development.

- **Management practices:** Agroforestry systems require specific management practices, such as selecting appropriate tree and crop species, managing competition between trees and crops, and controlling pests and diseases.

- **Sustainability:** Agroforestry is a sustainable land management system that can help to address environmental, economic, and social challenges in agriculture. It can contribute to food security, poverty reduction, and environmental conservation. 16.4 Advantages and

Concept of nutrient cycling

Nutrient cycling simply states the continuous transfer of nutrients like N, P, K, C, Fe, Zn, Mn, etc. from the soil to plant acquisition and returning back to the soil through various means of activities of soil microflora (bacteria, fungi, algae, etc.) and macrofauna (ants, earthworm, snail, springtails, rats, spider, beetle, etc.), weathering of minerals and other transformation occurring within different components of the ecosystem. The role of AFS in nutrient cycling is more significant than other land use systems due to higher rates of turnover and lower rates of losses from the system. This enhancement of nutrient cycling was attributed to this system due to enhanced interception of nutrients by deep-rooted trees and subsequent addition of the captured nutrients on the surface by added litter. Further, due to the integration of trees, the loss of nutrients by harvest and dependence on external inputs were minimized.

How agroforestry systems help in nutrient cycling

1. **Trees as nutrient pump:** Nutrient pumping is very important ecological process in agroforestry where trees with deep root system uptake the nutrient from deeper soil depth that are beyond the access of field crops. These nutrients absorbed in the tree biomass and eventually returned to the soil surface through litterfall and hence improve nutrient cycling. This process also contributes to higher crop productivity, better soil health, and more sustainable agricultural systems.
2. **Litter production:** The litter consists of dead leaves, root, twigs, needles, flower, fruit and amorphous material of tree species that contain a considerable amount of different essential nutrients like N, P, K, C, S, Fe, Zn, Mg, etc. necessary for plant growth and development. Apart from this litter production in agroforestry that helps to accumulate the high amount of organic matter on the soil, which helps to compound the soil fertility status by releasing vital nutrients C, N, P, K, Mn and Zn to the soil as well as play a significant role in soil nutrient cycling process
3. **Decomposition of litter:** Litter break down into smaller trashes with the passage of time through physical, chemical and biological process by plummeting litter to water, CO₂ and mineral nutrients. The rate of decomposition is governed by various factors: the type of tree species (litter quality), physical factor (temperature, relative humidity, rainfall, aeration, etc.), biological factors (living entity, i.e. microflora and fauna) and soil nutrient availability (preferably C:N ratio) that confined areas of agroforestry

Cycling of different nutrients in agroforestry systems

1. Nitrogen cycling

Nitrogen is a crucial element for sustainable systems, which is involved in photosynthesis for sugar formation. In the agroforestry, component crop and trees continuously adding organic matter

(litter fall, roots and straw) are added in the soil and decomposed by soil microbes. Legume family has the capability to fix the atmospheric nitrogen into the soil, resulting to an increased N status in the soil. Trees have different abilities to fix nitrogen, depending upon species, age of trees, climatic condition and symbiotic association. Also, leguminous tree organic matters are N-rich which are converted into ammonical N-form and later to nitrate. These inorganic compounds are utilized by the plant (nitrate/ammonia) or lost to below root zone, surface runoff or atmosphere.

2. Phosphorus cycling

Phosphorus availability is the most essential and largely influences the productivity of an ecosystem. AFS's role in the addition of organic phosphorus was highly attributed by heavy litter addition subsequently transferring the nutrient-rich biomass. This added biomass acts as a reserve for organic phosphorus, namely, phosphates, monoesters and diesters which upon mineralization adds up to the inorganic phosphorus content. In an investigation, it was estimated that continuous addition of litter for a span of three years increased the organic phosphorus by 16% in the surface soil.

3. Carbon cycling

Most of the carbon enters the ecosystem through leaf photosynthesis. More than half of the assimilated carbon is finally transported via the

underground route root growth, root exudate (organic matter) and decomposition of litter. Therefore, the soil contains the largest C stock in the ecosystem. Organic carbon in soil agricultural field levels is depleted. Therefore, agroforestry practice will not only improve the quality of the soil but also increase the amount of carbon sequestration.

Conclusion

Agroforestry is a promising and sustainable land-use system that can improve nutrient cycling while providing environmental, economic, and social benefits. The integration of trees with crops and/or livestock enhances nutrient retention through deep-rooted nutrient uptake, litter production, and decomposition, thereby reducing nutrient losses and dependence on external inputs. Agroforestry also plays an important role in the cycling of essential nutrients such as nitrogen, phosphorus, and carbon, which contributes to improved soil fertility, soil health, and crop productivity. In addition, increased organic matter and carbon sequestration help support environmental conservation. Therefore, the adoption and proper management of agroforestry systems can contribute significantly to sustainable agriculture, food security, and long-term soil fertility.

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 12-08-2026

Published: 02-09-2026

Tabalique Yumkhaibam¹
Rapunga H Flory¹
Kalkame CH Momin¹

¹Department of Horticulture,
North Eastern Hill University,
Tura Campus, Meghalaya

T. Angami²

² ICAR Research Complex for
NEH Region, Arunachal
Pradesh Centre

Nobinchandra Moirangthem³

³Central Agricultural University,
Imphal, Manipur

Corresponding author e-mail:
tabaliquey@gmail.com

Green Treasures of North-East India

Introduction

North-East India is one of India's richest regions in plant diversity. In Assam, Manipur, Meghalaya, Nagaland, Mizoram, Tripura, Arunachal Pradesh and Sikkim, many vegetables are gathered from forests, wetlands, home gardens and shifting-cultivation fields. These foods are more than ingredients: they are part of local identity, seasonal traditions, household health practices and rural livelihoods. Studies have documented dozens of wild leafy vegetables in Manipur alone, many of which are eaten for both nourishment and traditional therapeutic purposes.

A colourful basket of local vegetables

Among the best-known greens is lai pat, or mustard leaf, commonly cooked with fermented fish, pulses or other vegetables. It provides vitamins A, C and K, folate, calcium and fibre. Tender shoots of fiddlehead fern (*Diplazium esculentum*), locally valued in several hill communities, are boiled or cooked as a vegetable. They supply fibre, minerals and plant compounds, while traditional knowledge associates them with digestive support. Colocasia or taro leaves are used in curries and stews after proper cooking; they contribute fibre and minerals, although cooking is important because raw leaves contain irritating calcium oxalate crystals.

Perilla leaves and seeds are used for flavouring chutneys, salads and meat preparations. Their aromatic oils and polyphenols contribute antioxidant potential. Tree bean (*Parkia roxburghii*), known in parts of Manipur as yongchak, is eaten fresh, roasted or added to salads and fermented preparations. Research on indigenous vegetables of Manipur found relatively high protein in *Parkia* and broad variation in fibre, folate, iron, calcium and other minerals. Bamboo shoots are another regional favourite, prepared as curry, pickle or fermented food. They are low in fat and provide fibre and useful phytochemicals; fresh shoots should be properly boiled or processed before eating.

Traditional uses and health significance

Gynura cusimbua, a leafy plant used by communities in Nagaland and Meghalaya, is cooked as a vegetable. Traditional healers have also used its leaf or stem preparations for minor wounds and headache. *Clerodendrum glandulosum*, often called phak chei in Manipur, is prepared as a vegetable stew. Its leaves are traditionally associated with management of blood pressure, blood sugar and body weight, but these uses should not

replace prescribed treatment. *Eryngium foetidum*, or Mexican coriander, is widely used as a culinary herb to season soups, chutneys and meat dishes. Its strong aroma comes from bioactive compounds, and it is traditionally valued for digestion.

Other useful plants include roselle leaves, which add a pleasant sour taste to curries and are sources of vitamin C and polyphenols; water spinach, eaten as a cooked green and valued for fibre and minerals; and amaranth leaves, which supply iron, calcium, folate, vitamin C and carotenoid pigments. Local communities also use tender shoots of *Elatostemma* and other forest greens in soups and boiled preparations. The exact nutrient content varies with species, soil, maturity, season and cooking method.

Why these vegetables matter

The nutritional value of local vegetables is especially important where diets may depend heavily on rice, meat or a few common crops. Leafy greens increase dietary diversity and can contribute iron, calcium, magnesium, potassium, folate, vitamins and protective plant compounds. A 2019 analysis of 19 indigenous vegetables from Manipur reported substantial dietary fibre and folate in several samples, together with notable mineral and antioxidant content. Reviews of North-East Indian foods also show that many traditional greens contain micronutrients and phytochemicals that may support normal immunity, digestion and protection from oxidative stress.

From traditional knowledge to responsible use

Traditional food knowledge should be respected and documented, but medicinal claims require scientific testing. A vegetable may support health as part of a balanced diet without being a cure for diabetes, hypertension, infection or any other disease. Correct identification is essential because some wild plants resemble toxic species. Greens should be collected from clean areas, washed carefully and cooked according to Farm Science Today, September 2026, V-1, I-2: 11-12

local practice. Fermentation, boiling and drying can improve flavour and safety, although they may also change nutrient levels.

Conclusion

The local vegetables of North-East India represent a valuable link between biodiversity, culture and nutrition. Promoting kitchen gardens, community seed banks, sustainable harvesting and small-scale value addition can conserve these plants while improving food security and income. Bringing traditional vegetables into everyday meals, along with cereals, pulses, fruits and other foods offers a practical way to preserve heritage and build healthier, more diverse diets.

Picture Table: Selected Local Vegetables

	
a) Lai Pata Mustard greens	b) Fiddlehead fern Tender fern shoots
	
c) Colocasia leaves	d) Perilla
	
e)Yongchak Tree bean	f) Bamboo shoot Edible young shoot

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 16-08-2026

Published: 02-09-2026

Rajesh Khan

ICAR RC for Region, Umiam,
Meghalaya

Corresponding author e-mail:

rajeshkhan68.rk@gmail.com

Biochar: Engineering Climate-Resilient Soils in North-Eastern India

➤ THE AGRICULTURAL PARADOX OF NORTH-EASTERN INDIA

- North-Eastern India has a unique agricultural environment characterized by mountainous landscapes, climatic heterogeneity, and rain-driven production. Agriculture is dominated by small, fragmented holdings and mixed farming systems. Yet, despite abundant rainfall, intense downpours trigger rapid runoff, soil erosion, and nutrient leaching. Consequently, crops face moisture stress during dry spells because the soil fails to store water efficiently within the root zone. Thus, resilience is not about increasing water supply, but enhancing the soil's capacity to capture and store rainfall. As climate variability alters rainfall patterns, improving soil carbon, water retention, and biological health is a critical regional priority.

2. THE CRITICAL SOIL-HEALTH CONSTRAINTS OF THE HILL REGION

The specific soil limitations that plague the Northeast are given below:

- **2.1 Widespread Soil Acidity:** Soil acidity is the single greatest barrier to crop productivity in the region. Approximately 26.22 million hectares of regional soils are acidic, with 21.26 million hectares directly affected by acidity. In the North-Eastern Hill region, acidity prevalence ranges from 80% to 100%. Acidic soils restrict root development and interfere with phosphorus availability because high acidity enhances the activity and solubility of aluminium and iron.
- **2.2 Nutrient Leaching and Fertilizer Inefficiency:** High-intensity rainfall washes mobile nutrients like nitrogen and potassium below the root zone or into runoff. Adding synthetic fertilizers alone is highly inefficient because the soil environment cannot retain them, causing financial loss for farmers and environmental runoff.

2.3 The Water Storage Gap: Coarse-textured, degraded hill soils struggle to maintain soil moisture. High-intensity rain quickly drains away, leaving soils dry and crops vulnerable during dry intervals between rain events.

3. WHAT IS BIOCHAR? SCIENCE, PRODUCTION, AND FUNCTIONAL PROPERTIES

Biochar as a multifunctional soil-health and climate-resilience management platform.

3.1 Thermochemical Transformation: Biochar is a porous, carbon-rich material produced through the thermochemical conversion of biomass under oxygen-limited conditions, a process known as pyrolysis. Unlike traditional burning, which releases carbon into the atmosphere, pyrolysis locks carbon into stable, solid structures.

3.2 The Importance of Feedstocks: Biochar is not a single, uniform product. Its chemical behavior, pH, and pore structure depend heavily on feedstock type and pyrolysis conditions (such as temperature and residence time). Lower pyrolysis temperatures produce materials that retain more nutrient and volatile compounds, whereas higher temperatures create highly stable carbon structures with high surface areas.

3.3 Local Organic Wealth: The Northeast has rich biomass residues from crop residues, agroforestry, and wood processing. Instead of burning agricultural residues, farmers can convert local wastes such as

Farm Science Today, September 2026, V-1, I-2: 13-16

bamboo, rice husks, maize residues, sawdust, and horticultural residues into a valuable soil amendment. This turns a waste-disposal problem into a circular soil-management resource.

The Biochar Production & Soil Application Flow



4. THE EMPIRICAL EVIDENCE: HOW BIOCHAR HEALS ACIDIC SOILS

Scientific researches support the agronomic benefits of biochar, showing that it works as a physical, chemical, and biological catalyst for soil restoration.

4.1 Correcting Soil Acidity: Biochar possesses alkaline characteristics because of their ash and mineral fractions. When applied to acidic soils, they increase soil pH, act as a buffer, and improve the chemical environment surrounding plant roots, which influences phosphorus and micronutrient availability.

4.2 Enhancing Water Retention: Due to its highly porous structure, biochar creates additional pore space in the soil. A global meta-analysis of 37 studies demonstrated that biochar application increases the soil's available water capacity by 28.5%, field capacity by 20.4%, and permanent wilting point by 16.7%. This is especially beneficial for coarse-textured hill soils, giving crops a vital buffer during dry intervals.

4.3 Boosting Yields and Nutrient Retention: Biochar

holds onto cationic nutrients due to its high Cation Exchange Capacity (CEC). A global meta-analysis of 381 datasets from 63 studies showed that biochar application leads to average increases of 14.45% in crop yields, 14.28% in water-use efficiency, and 13.97% in nitrogen-use efficiency.

5. MOVING BEYOND STANDALONE APPLICATION: THE INTEGRATED BIOCHAR MODEL

The greatest opportunity for North-Eastern India lies in an integrated, biochar-based agricultural model. Standalone biochar has high carbon but can sometimes temporarily lock up nutrients if it has a high C:N ratio. Therefore, modern research advocates for “enriched” biochar.

By blending raw biochar with farmyard manure (FYM), compost, or organic fertilizers, farmers can create an enriched compound. In this system, biochar acts as a sponge, soaking up nutrients from the manure, while the porous structures protect beneficial soil microbes like nitrogen-fixing bacteria and phosphate-solubilizing biofertilizers. This synergy combines persistent carbon, organic nutrients, and active microbial inoculums in a single, targeted soil amendment, shifting farming from “applying biochar” to “designing tailored soil solutions”.

6. CLIMATIC BENEFITS, CONSTRAINTS, AND STRATEGIC NEXT STEPS

6.1 Carbon Sequestration and GHG Mitigation:

Biochar offers powerful climate benefits. Pyrolysis converts decomposable plant matter into stable carbon that remains locked in the soil for centuries. Meta-analyses show that biochar alone can reduce the soil’s global warming potential by 27.1%, and by 14.3% when combined with chemical fertilizers.

6.2 Practical Constraints: We must recognize practical limitations. Mountainous terrain makes transporting heavy organic materials and biochar expensive. Additionally, poorly managed pyrolysis can introduce harmful contaminants like polycyclic aromatic hydrocarbons.

6.3 Research Priorities: Future studies must prioritize creating a regional database matching specific local feedstocks with pyrolysis temperatures and soil types. Long-term multi-year field trials are essential to verify soil carbon persistence and crop yield stability over time.

7. CONCLUSION:

North-Eastern India’s agricultural future relies on moving away from input-heavy strategies toward regenerative soil-system management. Biochar, far from being a simple standalone fertilizer, serves as a comprehensive soil-water-nutrient-carbon management platform. By adopting a decentralized “biomass-to-biochar-to-soil” circular model, the region can clean up agricultural waste, restore acid-degraded soils, improve climate resilience, and guarantee stable crop yields for generations to come.

8. REFERENCES

Majumdar, S., Wanniang, S. K., & Behera, U. (2021).

Acid soil management in north eastern hill region of India. *Indian Farming*, 71(11), 27–30.

Paetsch, L., Amelung, W., & Wiesenberger, G. L. B.

(2020). A meta-analysis on biochar's effects on soil water properties – New insights and future research challenges. *Science of the Total*

Environment, 714, 136857.

Liu, Y., Li, H., Hu, T., Mahmoud, A., Li, J., Zhu, R., Jiao, X., & Jing, P. (2022). A quantitative review of the effects of biochar application on rice yield and nitrogen use efficiency in paddy fields: A meta-analysis. *Science of the Total Environment*, 830, 154792.

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 18-08-2026

Published: 02-09-2026

Songthat William Haokip¹

Moirangthem Nobinchandra Singh⁵

^{1,5}Department of Fruit Science,
College of Horticulture and
Forestry, Central Agricultural
University, Pasighat-791102,
Arunachal Pradesh, India

Thejangulie Angami²

²ICAR (RC) for NEH Region,
Arunachal Pradesh Centre, Basar
– 791101, Arunachal Pradesh

Kripa Shankar³

³ICAR-Indian Institute of Soil
and Water Conservation,
Research Centre, Datia (MP)-
475661

Koku K. Tara⁴

⁴Division of Vegetable Science,
ICAR-Indian Agricultural
Research Institute, New Delhi
(110 012)

Corresponding author e-mail:

theja219@gmail.com

Lesser-Known Fruits: An Economic Booster and Dietary Supplements

Introduction:

Numerous minor fruits have immeasurable prospects to fulfill the sustainable economic requirements and nutritional security. However, the importance of these minor fruits is often disregarded. The North-East India is blessed with a number of underutilized minor fruits and they have been used as a source of income by different communities of the region. For generations, they have been subjected to diverse medicinal uses to cure various ailments like diuretic, laxative, jaundice, diabetes, diarrhoea, dysentery, etc. Apart from their economic importance and medicinal values, they are also consumed as a very rich source of many essential nutrient elements, vitamins, minerals, proteins, fatty acids, carbohydrates, dietary fiber, etc. which in turn helps in nutritional security by helping to reduce the risk of various diseases related to several nutritional deficiencies. Therefore, it is very important to channelize their availability to enhance seasonal income of the farmers and also incorporate the easily available and seasonal underutilized minor fruits in our daily diet to minimize the risk of various infirmities and to mitigate the dietary supplements of rural population.

A seasonal economic booster

Minor fruit crops in the North Eastern part of India can help in boosting the economic condition of the region. The seasonal availability of the fruits can help in sustaining the economic life of the people in the region. These fruits have both food and market value and different delicious processed products like jam, jelly, squash, pickle and juice with high economic importance can be produced from these fruits. A few minor fruits are available throughout the year. However, the availability of most of the minor fruits is highly seasonal. The availability of the minor fruits in the off season of the major fruits can bridge the economic and livelihood of the region. With better exploitation of the fruits and improving the market facilities for the minor fruits, plenty can be done to enhance the financial condition and food security of the region. So, increased production of minor and underutilized fruits and extending their growing season would help in offering a huge opportunity in the region and nutritional security of the large population as well.

MINOR FRUIT CROPS AS DIETARY SUPPLEMENT AND NUTRITIONAL SECURITY:

Underutilized fruits are highly beneficial and valuable. These underutilized plants can help to make diets more balanced by enhancing nutritional quality of the food. In rural areas of India including North East region, there is high prevalence of malnutrition and also being underweight, especially among children and women. These problems can be tackled by consumption of underutilized fruits and vegetables which are known sources of minerals portions and vitamins. The most concentrated form of vitamin C (500-600mg/g) is found, along with high antioxidant properties in Aonla which is a known minor fruit of India. Fig is another important fruit used from ancient time, which is very rich in proteins and carbohydrates. Another widely available fruit, which is popular among locals due to its exclusive flavour and aroma is Passion fruit, is a great source of ascorbic acid, vitamin A, high mineral content, niacin and riboflavin. Jujube is also underutilized fruit which has the ability to enrich the food by providing essential minerals including potassium, phosphorus, manganese and also iron, zinc and copper. Jujube can provide 79 Kcal per 100 gm of fruit. Ber also comes under the underutilized fruit category but is packed with carotene, calcium, protein, phosphorus, and Vitamin C, which is higher than many major fruits like apple.

➤ The required amount of protein for male is 60 gm and 50 gm for female in diet day as part of 2000 calorie diet as they are one of the building blocks of body tissue. Many underutilized fruits of NE India are rich in protein which can contribute a lot to the dietary supplement of poor people.

➤ Fat is one of the essential constituent of diet. Fat provide more than half of the body's energy needs, absorbs certain nutrient (Vitamin A, D, E and K require fat to function), and maintains the core body

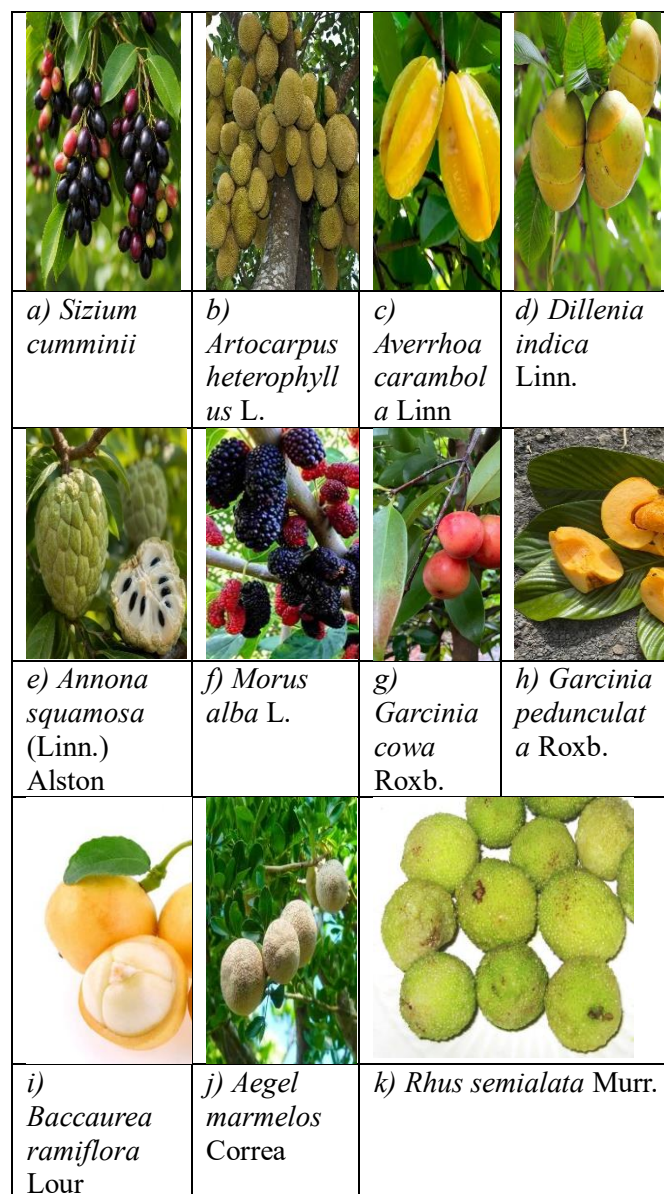
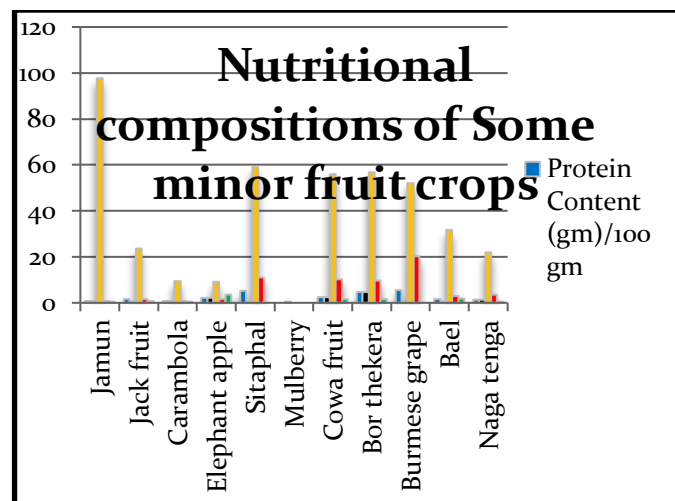
temperature and hence can be considered as vital. The fat intake should be 15–25 g/day in terms of oil content of fruits and other food products. For people below poverty line, deficiency of fat in the diet is a major concern which can be mitigated by adding traditionally available underutilized minor fruits.

- The human body requires carbohydrates to function properly as along with fat and protein it one of major macro nutrients that provide energy. The per day intake of carbohydrates should be 225-325 gm which can be addressed by consumption of minor fruits.
- Dietary fibre is significant in a healthy diet as it can provide many benefits to the body. Fibre helps to maintain the bowel health, lowers the cholesterol levels, helps control the blood sugar level and maintain weight.
- Minerals supplement is a must in diet as it is required to perform various functions in a body. Calcium is required for healthy bones, phosphorus is needed to maintain the acid-base balance, Sodium for nerve transmission and magnesium is needed by the immune system.

Table: Proximate principles of some underutilized minor fruits of North East India

Common Name	Scientific Name	Protein Content (gm)/100 gm	Fat Content (gm)/100 gm	Carbohydrate Content (gm)/100 gm	Fibre Content (gm)/100 gm	Mineral Content (gm)/100 gm
Jamun	<i>Syzium cumminii</i>	0.70	0.70	97.59	0.90	0.40
Jack fruit	<i>Artocarpus hetero</i>	1.74	0.64	23.5	1.5	0.90

	<i>phyllus</i> L.					
Carambola	<i>Averrhoa carambola</i> Linn	0.85	0.85	9.38	0.90	0.40
Elephant apple	<i>Dillenia indica</i> Linn.	2.30	2.30	9.05	1.60	3.54
Sitaphal	<i>Annona squamosa</i> (Linn.) Alston	5.2	725 mg	59	11	-
Mulberry	<i>Morus alba</i> L.	0.5–1.4	.48	7.8–9.0	0.9–1.3	-
Cowa fruit	<i>Garcinia cowa</i> Roxb.	2.43	2.43	55.84	10.34	1.75
Bortheke	<i>Garcinia pedunculata</i> Roxb.	4.65	4.65	56.85	9.57	1.63
Burmese grape	<i>Baccaurea ramiflora</i> Lour	5.58	-	51.9	20.4	-
Bael	<i>Aegle marmelos</i> Correa	1.6	0.2	31.80	2.90	1.9
Naga tenga	<i>Rhus semialata</i> Murr.	1.36	1.36	21.89	3.51	0.387



CONCLUSION:

The most significant fact about the underutilized fruit spp. is that they are capable of taking the on challenge of malnutrition and hunger to a great extent especially in

economically poor countries. These crops can be grown in a wide range of climactic and soil conditions and are cost effective. Underutilized crop species, if explored properly, can not only help in improving the livelihood of poor people but also intensify the horticultural production of a nation. India has about 150 spp. of consumable underutilized fruits but their commercial cultivation has not yet been promoted. To eradicate the problem of malnutrition and hunger from the world, it is necessary to concentrate on production of indigenous and underutilized fruits so that the deficiency in nutrition intake in food can be minimized by adding these minor fruits into the diet. Sustainable exploration of the minor underutilized fruits will also lessen the burden of over dependency on the major fruit crops. So there is an urgent need to focus on the benefits of minor neglected fruits of the region from the researchers, policy makers and extension personnel.

REFERENCES

1. Annon (2002). Final report of Ad-hoc Scheme on preservation and processing of some important indigenous fruits of Northeast India with especial

reference to Assam (1999-2002). Assam Agricultural University

2. Gohain, S. and Neog, A. (2020). Dietary Contribution Of Underutilized Minor Fruit Crops of Assam In Nutritional Security-A Review. *Int. J. Agric.Sci. Res.*, Vol. 10(4): 2250–0057
3. Kumar, R., Nishant, M. P., & Saurabh, A. (2024). Exotic and Lesser-Known Fruits: Exploring New Horizons. *A Collaborative Insight*, 278.
4. Moa, A.A., Hynniewta ,T.M. and Sanjappa, M. (2009). Plant wealth of North-East India with reference to ethnobotany. *In. J. Tradt. Knowl.*, 8: 96-103.
<https://api.semanticscholar.org/CorpusID:6436703>
5. Ritika, Bora, B., Ismail, B. B., Garba, U., Mishra, S., Jha, A. K., and Gupta, A. K. (2024). Himalayan fruit and circular economy: nutraceutical potential, traditional uses, challenges and opportunities. *Food Production, Processing and Nutrition*, 6(1), 71.
<https://doi.org/10.1186/s43014-023-00220-6>
6. Singh, S.R., Phurailatpam, A.K., Wangchu, L., Ngangbam, P. and Chanu, T.M. (2014). Traditional medicinal knowledge of underutilized minor fruits as medicine in Manipur. *Int. J. Agric. Sci.*, Vol. 4 (8): 241-247

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 24-08-2026

Published: 02-09-2026

Akanksha Yadav ¹

Sneha Shree²

^{1,2} Pandit Deendayal Upadhyay
College of Horticulture &
Forestry, Piprakothi, East
Champaran, Bihar

Corresponding author e-mail:

akankshay403@gmail.com,

snehashree5mgr@gmail.com

Artificial intelligence: status and prospectus of its uses in forestry

Introduction:

What is forestry?

The branch of science that deals with creating, managing, conserving and utilising forests and its products is forestry. While earlier it focused on timber extraction and wood-fuel production, modern forestry works on a wider prospectus. It encompasses silviculture, agroforestry, watershed management, and ecosystem restoration.

Forest ecosystems cover approximately 31% of the land area serving as the terrestrial bedrock for life on earth. They host over 80% of all terrestrial biodiversity, preserve freshwater catchments, prevent soil erosion, regulate hydrological cycles and economically support the livelihood of around 1.6 billion people around the globe with timber and non-timber products.

Modern forestry

The dynamic shift in today's climatic conditions and various increasing needs of people, has been asking for changes in forestry context. As discussed earlier, forestry has increased its value to wider prospectus driven by new, modern sensing and analytics. Modern Forestry integrates advanced technologies such as GIS (Geographic Information Systems), Remote sensing, drones, Artificial Intelligence and Satellite monitoring. In India, Modern forestry is supported by ICFR (Indian Council of Forestry Research) and FSI (Forest Survey of India). These organisations supported by many other such units have taken the initiatives to modern integrations in Indian Forestry.

What is Artificial Intelligence (AI) ?

The branch of computer science that focuses on developing machines and computer programmes capable of performing tasks that normally require human intelligence such as reasoning, learning, problem solving etc. It has become one of the most transformative technologies of the 21st century and is being applied across sectors including education, finance, healthcare, manufacturing, agriculture and forestry.

With its ability to process large amounts of data quickly artificial intelligence in forestry has made its management more accurate, efficient, and sustainable. It helps in monitoring forest health, detecting wildfires, carbon biomass and stocks, and also promoting conservation efforts.

Uses of AI in Forestry

The integration of AI into forestry has unlocked unprecedented capabilities across ecological and conservative patterns. Below are six crucial, practical, applications currently revolutionizing the forestry sector.

1. Carbon sequestration measurement and Carbon Credit Verification

Carbon sequestration measurement is the process of estimating the amount of CO₂ absorbed and stored by forests in trees via vegetation, roots and soils. It removes CO₂ from the air, and protects the Earth's climate. Traditionally, estimating forest biomass required manual, Diameter at Breast Height (DBH) measurements across small sample plots, which required more labours, high costs, more time and gave little results.

Modern AI has significantly improved the measurement and monitoring of carbon sequestration in forests. AI can process vast amounts of data quickly, detect changes in forest cover in lesser time, and even predict future carbon sequestration potential. Multi-source remote sensing data such as NASA GEDI LiDAR etc., have helped overcome many limitations.

2. Wildlife Conservation and Biodiversity Monitoring

AI is revolutionizing wildlife conservation and biodiversity monitoring by enabling faster, more accurate and continuous observation of ecosystems. Motion-activated camera traps and monitoring units, have helped detect early animal behaviors, count animal population and track mitigation patterns. It has helped keep in check poaching and illegal activities thus identifying threats, habitat loss, and detect endangered species.

3. Precision Silviculture and Tree Species Mapping

Silviculture is the branch of forestry focusing solely on timber production or to produce wood with value.

Precision silviculture is the application of AI, Geographic Information Systems (GIS), drones and sensor technologies to manage forests with better accuracy. This helps with easy tree species mapping around a forest establishment which further helps in better and more timber production. AI helps with identifying weather conditions, soil conditions, tree growth and different growth conditions suitable for different species. This enables rapid and accurate forest inventories, biodiversity assessment, and planning a proper tree plantation planning according to suitable conditions and areas.

4. Agroforestry and Soil Health Optimization

Agroforestry means integration of forest trees with agriculture crops to enhance biodiversity and land productivity. AI models have helped analyze soil moisture patterns, nutrient competition and availability. This helps sort optimal intercropping patterns with the types of species to be planted together as the identification of which trees should be grown with which crop plays an important role in proper growth and better yield.

5. Early Forest Fire Detection

Wildfires are a common cause for destruction of hectares of forests annually, releasing tonnes of CO₂ and affecting the wildlife of the area. With real-time thermal infrared sensors and optimal satellite images integrated with AI visions can detect the area of fire, cause of destruction and help accordingly with plan of action. The wind direction, the extent and intensity of fire when identified can give better idea on where to plan the demolishing of the fire and whether there are human populations affected or not.

6. Reforestation Site Selection and Seed Bombing Patterns

Restoring degraded forest patterns at global levels require a large-scale planning and automated solutions.

While traditionally the process was done by planning through labouring manpower and checking different conditions over years, today this is done in an automated way through AI integrated systems. As seen before in this article, AI helps monitor different tree growth conditions and even helps with identifying a structural pattern for cropping. We get to easily study and research on a site and then navigate the complex terrain to drop nutrient rich seed pods (seed bombs) into ideal locations for quick and assured growth of the tree and their survival than in normal conditions.

Common Modern Technologies in Current Practical Use

- 1. Computer Vision** – Processes images from drones, satellites, camera settings around the forest area for monitoring and analysing.
- 2. Remote Sensing** – Uses solely satellite images for images and analyzing of forest areas.
- 3. Machine learning** – Analyzes data to predict tree growth, diseases and estimate biomass along with forest management decisions.
- 4. Drones** – Captures high resolution images from a wider range aerially easily and with no risk of damage.
- 5. LiDAR (Lights Detection and Ranging)** – Uses laser light fluctuations to measure distances and creates precise 3D maps for canopy management, timber volume estimation and topographic surveys.
- 6. Cloud Computing and Big Data Analysis** – Stores and processes large volumes of forestry data, enabling rapid analysis and informed decision making.

Some case studies and successful ideas

1. SukhaRakshakAI

- Developed by IWMI (International Water Management Institute) alongside ICAR-CRIDA.
- India's 1st AI-Powered early warning and localised advisory system to predict and plan for droughts.
- Combines satellite images, thermal drone imagery and other sources for data integration.

2. VanRakshakAI

Developed by **Akshaya Rathore**, a divisional forest officer in MP.

Works entirely on basic Android smartphones even in zero connectivity zones without internet.

Uses satellite imaging for deforestation and illegal logging detection.

22+ languages supported, with 300K+ forest officers working.

Institutional Leadership and initiatives by ICAR

Indian Council of Agricultural Research (ICAR) and Central Agroforestry Institute (CAFRI) has pioneered the integration of AI and GIS spatial modelling in Indian forestry. For example :

- Tree canopy cover, timber volume and carbon stocks in poplar and eucalyptus agroforestry systems across Punjab, Haryana and Uttar Pradesh.
- ICAR researchers deployed AI models which included soil slope, pH, rainfall patterns, temperature to map bamboo based agroforestry in Bundelkhand.

Challenges in AI Implementation in Forestry

Despite immense potential and scope in AI implementations in Forestry, the reality comes down to restrained techniques and lack of proper machinery and technologies in real world. While there are many technologies already working, there are still factors we need to discover and work upon. Some of them are –

- 1. Climatic disruptions** : Satellite sensors are often disrupted by clouds and climatic factors which hinders with the digital processes.
- 2. Lower connectivity** : Forest areas usually have very less to no connectivity which leaves deep forests unattended and often leads to misleads on certain informations.
- 3. Higher costs** : The laying of these connections and infrastructure often costs more.
- 4. Skill deficits** : There is a significant gap between AI

specialists and Forestry Field Officers leading to effective mismanagement and communication.

5. Data Privacy and Rights : Local data privacy and other customary land rights are often challenged and misused and leaked.

6. Lack of proper technologies : This sector is still a developing and flourishing one globally and thus technologies related are yet being introduced.

Conclusion

Artificial Intelligence is reshaping forestry by enabling data-driven opportunities that were difficult to achieve. As AI technologies continue to advance future forestry continue to advance, future forestry will rely on these technologies with proper and sustainable utilization of these resources. The future integration of certain upcoming technologies such as :

1. Quantum computing
2. Advanced robotics
3. Next generation satellite systems

is expected to enhance the ease of the forest related processes.

While AI is facing certain drawbacks in today's world in all aspects and sectors with the concern of depleting job opportunities due to introduction of its various uses, there are still various loopholes in the plannings of its implementations. Therefore, to fill these loopholes and utilise its full potential with human skills we need to plan our future plans accordingly.

We need to make sure AI shall not replace our foresters but coordinate with them to transform our ideas into more practical, modern ways. To train our professionals to work efficiently and coordinate our modern techniques is important. This partnership will play an important a crucial role in building resilient forests, conserving biodiversity, combating climatic conditions and ensuring that forest resources continue to benefit both present and future generations.