कृषि एवं किसान
कल्याण मंत्रालय
MINISTRY OF
AGRICULTURE AND
FARMERS WELFARE

सत्यमेव जयते

भाकृअनुप
ICAR

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CAFRI

Promising Agroforestry Models for Assam

ICAR-Central Agroforestry Research Institute

Jhansi-284003, Uttar Pradesh, India

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Contribution

Agroforestry scientists working in ICAR-Central Agroforestry Research Institute, Jhansi and in the All India Coordinated Research Project on Agroforestry of the Indian Council of Agricultural Research, New Delhi.

Project Implementation Team

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Disclaimer

The document has been prepared fully in academic spirit for educational and ready reckoning purposes. The information in the document is based on primary observations and secondary information from published sources. The information provided in this document is to best of our knowledge, accurate although we do not guarantee the information not are we liable for any damages arising from use of information.

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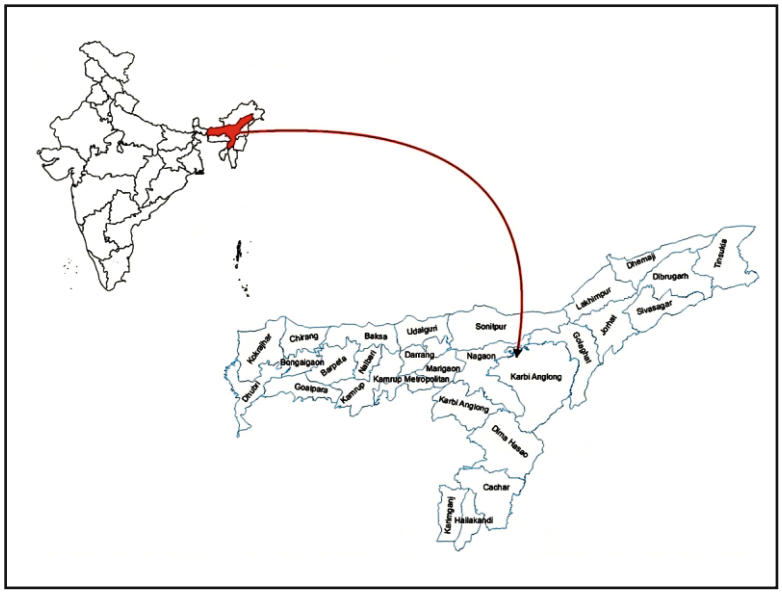
Promising Agroforestry Models for Assam



The gateway to Northeast India is the State of Assam, also referred to as the "land of the red river and blue hills." Geographically, the state extends 89°42' to 96°30' East Longitude and 22°19' to 28°16' North Latitude. This state in northeastern India, bordering two countries, Bangladesh and Bhutan, and seven other states, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and West Bengal. In 1950, Assam had been taken as a part of India and the state has a total area of 78,438 km^2, of which 98.4% is rural approximately. It accounts for 2.4% of the landmass of the country (Government of Assam, 2024).

Physiography

The State of Assam can be divided into three broad physiographical units:

1) The Brahmaputra valley in the north
2) The Central Hilly Regions of Karbi-Anglong and North Cachar
3) The Barak Valley in the south

The Brahmaputra valley in the north

The Brahmaputra valley is the eastern continuation of the Indo-Gangetic plain and separates Sub-Himalayan foot hills from Shillong plateau and Naga-Patkai hills. The valley covers an area of about 56,274 km^2 which accounts 69% of total area of Assam.

The Central Hilly Regions of Karbi- Anglong and North Cachar

The Central Hilly Region is a pear shaped highland and plateau region that lies between the Brahmaputra valley in the north and Barak valley to the South. The northern part of the hilly region, *i.e.* the Karbi plateau is essentially the north-eastern extension of the Shillong plateau. The southern part, *i.e.* the North Cachar Hills forms the western flanks of Naga – Barail ranges. The highest elevation of the Barails in Assam is 1713m above MSL near Haflong.

The Barak Valley in the south

The Barak Valley is located in the southern part of Assam. It is horse shoe shaped plain with east – west extension of 85 km and north south extension of 70 km. The elevation of the valley is low in the south western side and gradually rises towards east. Near Karimganj, elevation is 46.0 m and an altitude 75.0 m above MSL is recorded near Jiribam in the east (Directorate of Geology & Mining, 2024).

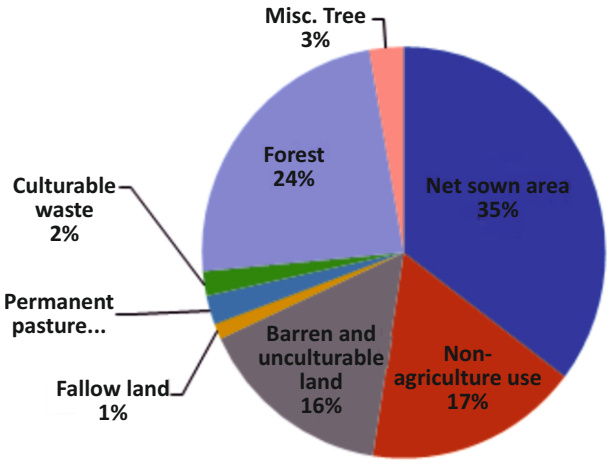
Climate

From a climatic perspective, the year in Assam can mainly be categorized into two seasons: the cold season and the rainy season. Additionally, there are two brief transitional periods: spring, which bridges the gap between the cold and rainy seasons, and autumn, which transitions between the rainy and cold seasons. Between March and May, Northern India experiences the least amount of precipitation. The highest temperature in the Assam plains does not exceed 32°C, while the lowest temperature is around

8°C in the winter. The temperature of the lowlands and sub-montane area becomes uncomfortable, particularly during the summer. This is due to the monsoon's excessive humidity. Summer temperatures in Assam's lowlands, particularly the Cachar region, may reach as low as 32°C degrees (ENVIS Assam, 2024).

Land use pattern

In Assam, with a total geographical area of 78440 km^2, forest cover accounts for only 23.62% of the land. Specifically, in 2023-24, the net sown area in Assam was 27490 km^2, accounting for 35.04% of the entire geographical area.



Source: Land Utilization Statistics of Assam (2021)

Forests and tree resources

Assam has five of India's 16 main forest types: Tropical wet evergreen, Tropical semi-evergreen, Tropical moist deciduous, Tropical dry deciduous, and Subtropical pine forests (ENVIS Assam, 2024). Assam has a total forest cover of 28,311.51 km², accounting for 36.09% of the entire geographical area. The state's forest cover includes very dense forest (3016.67 km²), moderately dense forest (9991.02 km²), and open forest (15303.82 km²). Dima Hasao is the hill district with the largest forest coverage, accounting for 84.94% of its geographical area (ISFR, 2021).

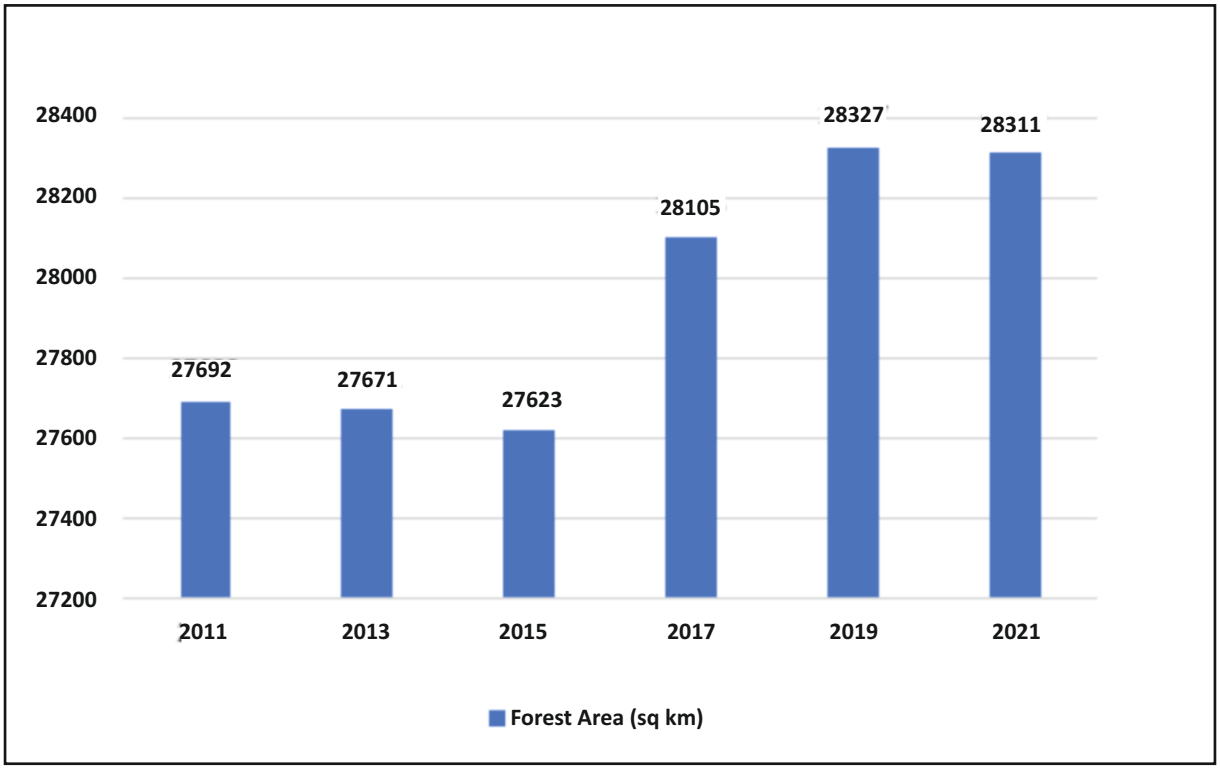
Assam contains 20003 km² inside the Recorded Forest Area (RFA) and 8309 km² outside the Recorded Forest Area. The area covered by trees in Assam increased from 1408 km² in 2019 to 1630 km² in 2021. Trees outside forests (TOF) encompass 9939 km², including both forest cover and tree coverage. The top five tree species in TOF for Assam rural regions are *Areca catechu* (33.68%), *Tectona grandis* (4.26%), *Gmelina arborea* (3.70%), *Albizia spp.* (3.55%), and *Mangifera indica* (3.23%), and in urban TOF regions, the top five tree species are *Areca catechu* (42.07%), *Cocos nucifera* (11.11%), *Mangifera indica* (8.90%), *Artocarpus heterophyllus* (3.62%), and *Anthocephalus cadamba* (3.23%). The overall carbon store of Assam's forests, including TOF patches bigger than 1 hectare, is 271.37 million tonnes, or 3.77% of the country's total carbon pool. Major Non-Timber Forest Produce (NTFP) species in Assam include *Shorea robusta, Bombax spp., Terminalia bellerica, Piper spp.,* and *Smilax china* (ISFR, 2021).

Forest types

S.No.	Type of Forest	Area (in sq km)	% of the total mapped area
1.	Assam Valley tropical wet evergreen forest (*Dipterocarpus*)	1006.79	3.51
2.	*Kayea* forest	216.12	0.75
3.	*Mesua* forest	5.53	0.02
4.	Cachar tropical evergreen forest	886.92	3.10
5.	Assam alluvial plains semi-evergreen forest	453.68	1.58

6.	Sub-Himalayan light alluvial semi-evergreen forest	356.00	1.24
7.	*Syzygium* parkland	19.43	0.07
8.	Pioneer Euphorbiaceous scrub	84.52	0.29
9.	Eastern alluvial secondary semi-evergreen forest	348.87	1.22
10.	Cachar semi-evergreen forest	10719.16	37.41
11.	Secondary moist bamboo brakes	857.76	2.99
12.	*Khasi* hill sal	40.39	0.14
13.	East Himalayan upper *bhabar* sal	670.56	2.34
14.	Kamrup sal	759.57	2.65
15.	East Himalayan moist mixed deciduous forest	5095.46	17.78
16.	North secondary moist mixed deciduous forest	505.65	1.76
17.	Low alluvial savannah woodland (*Salmalia-Albizia*)	13.69	0.05
18.	*Terminalia- Lagerstroemia*	2.83	0.01
19.	Creeper swamp forest	0.09	0.00
20.	Eastern seasonal swamp forest	0.88	0.00
21.	*Khair-sissu* forest	24.19	0.08
22.	Assam subtropical hill savannah woodland	9.79	0.03
23.	Assam subtropical pine forest	119.72	0.42
24.	TOF/Plantation	6302.34	21.99
25.	*Syzygium* parkland	0.65	0.00
26.	Eastern wet alluvial grassland	153.18	0.57
	Total	28653.77	100

Source: ISFR (2021)



Forest area in Assam

In the year 2011 to 2017, the forest area was slightly decreased by the encroachment in forest land, cutting of trees from the tea garden and shifting cultivation. Some positive change we can see in some districts due to plantation of trees and increase in the outside forest areas. In 2017 to 2021 the forest area increase by the plantation in farmland and promotion of the home garden in urban areas (ISFR, 2021).

Soil

Assam's diverse geological conditions, topography, climate, and vegetation have led to the formation of various soil types. Assam's soils are rich in nitrogen and organic matter. Alluvial soils in the Brahmaputra and Barak valleys are highly fertile, suitable for crops like cereals, pulses, and oilseeds. Upper Assam's well-drained, acidic alluvial soils are ideal for plantations, while new alluvial soils in charlands support oilseeds, pulses, and *rabi* crops. Hill slope soils are suitable for horticulture and plantations. The soils in Assam can be categorized into four main groups:

1. Alluvial soils
2. Piedmont soils
3. Hill soils
4. Lateritic soils

Alluvial Soils: These fertile soils cover the Brahmaputra and Barak plains. They are divided into

I. Young Alluvial Soils: Found in active floodplains, these are grey to mottled grey, sandy to silty loams, and slightly acidic.

II. Old Alluvial Soils: Found in patches across several districts, these are deep, fine to coarse loams, brownish to yellowish, and slightly to moderately acidic.

Piedmont Soils: Located along the Himalayan foothills, these soils include

I. Bhabar Soil: Comprising boulders, pebbles, cobbles, sand, and silt, it is deep and clay loamy.

II. Tarai Soil: Found in swamps, it is sandy to silty loams, supporting tall grasses.

Hill Soils: Present in the southern hilly areas, these soils vary in fertility

I. Red Sandy Soils: Found along borders with Meghalaya and other regions, these are deep, well-drained, and rich in organic matter, but strongly acidic.

II. Red Loamy Soils: Found along borders with Arunachal and Nagaland, these are deep, dark grayish brown to yellowish red, and slightly to moderately acidic.

Lateritic Soils: These are common in the North Central Hills district and parts of the Karbi Plateau. They are dark, finely textured, heavy loams, but deficient in nitrogen, potash, phosphoric acid, and lime (ENVIS Assam, 2024).

Water Resources of Assam

Water is crucial for humans, animals, plants, agriculture, industry, animal husbandry, and overall economic development. In Assam, water is classified as surface water and groundwater, both derived from rainfall. Influenced by the south-west tropical monsoon from April to October, with some winter showers, Assam receives an average annual rainfall of 1780 to 3050 mm. The state's water resources are substantial and the annual extractable groundwater resource of Assam in 2020 was 21.96 Billion Cubic Meters (BCM). The current annual gross groundwater extraction for all uses is 2.57 BCM. The provision for domestic and industrial requirements up to 2025 is estimated at 0.66 BCM. The net groundwater available for future irrigation use is estimated at 19.33 BCM. The stage of groundwater extraction in the state is 11.73%, with the highest stage of 57.26% in the Kamrup Metro Urban area and the lowest of 0.70% in Karbi Anglong district. Based on the available resource and development, all the districts in Assam were categorized as "Safe".

Comparison between groundwater resources estimation for Assam for 2020 and 2022

S.No.	Water Resource	Status as on March 2020 (in BCM)	Status as on March 2022 (in BCM)	Comparison (in BCM)
1.	Annual rainfall recharge	25.56	24.45	-1.11
2.	Annual recharge from other sources	1.49	2.09	0.6
3.	Annual extractable groundwater Resource	21.96	21.39	-0.57
4.	Current annual gross G.W. Extraction for irrigation	1.97	2.06	0.09
5.	Current annual gross G.W. Extraction for domestic use	0.595	0.578	-0.018
6.	Current annual gross G.W. Extraction for industrial use	0.0058	0.0089	-0.0031
7.	Current annual gross G.W. Extraction for All uses	2.58	2.64	0.06
8.	Annual G.W. Allocation for Domestic water supply as on 2025	0.66	0.62	-0.04
9.	Net Annual G.W. availability for future use	19.33	18.72	-0.61
10.	Average stage of GW extraction (In %)	11.73	12.38	0.65

Source: Irrigation Department Government of Assam (2022)

Agriculture

Agriculture plays a very important role in the socio-economic development of Assam. It is the backbone of the state's economy and holds the key to the overall development of the state. Agriculture significantly contributes to the state's economy accounting for 54.11 percent of the total geographical area and provides as a main source of occupation and livelihood support and employing more than 80 percent of the total population, including those who work in plantations. As the state's population grows and agro-technology advances, many changes occur in the state's agricultural landscape and Assam agriculture is now focused on the horticultural sector of the state. Coconut, citrus, banana, black pepper, and papaya are among the main horticultural crops in Assam agriculture, and a variety of planting materials have been purchased to boost their output. Sugarcane is regarded as one of Assam's most important cash crops during the *Kharif* season.

Major crops in Assam

Crop	Production (tonnes)
Autumn Rice	168837
Winter Rice	3369720
Summer Rice	844141
Maize	170180
Wheat	11374
Other Cereals and Small Millets	3204
Gram	1593
Tur (Arhar)	4988
Rabi Pulses	104213
Sesamum	7887
Rape and Mustard	186129
Linseed	2974
Castor	329

Coconut	167409
Cotton	378
Jute	743403
Mesta	18105
Banana	950697
Pineapple	311331
Orange	175415
Papaya	172076
Potato	731287
Tapioca	33057
Arecanut	46974
Sugarcane	1160025
Tobacco	58
Total	9385784

Source: Statistical Handbook Assam, (2023)

Schemes of Assam

The Assam government has undertaken a number of initiatives and plans, including the National Food Security Mission (NFSM), *Rashtriya Krishi Vikas Yojana* (RKVY), National Mission on Agriculture Extension Technology (NMAET), and National Mission on Oil Seeds and Oil Palm (NMOOP). According to the 20th livestock census, livestock population of Assam is 64.75 million (Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, 2019).

S.No.	Scheme	Objective
1.	*Amrit Brikshya Andolan*	The Assam government, launched the *'Amrit Brikshya Andolan'* in 2023 as a campaign to enhance the state's environment by planting one crore seedlings and promoting a tree-based economy. The initiative aims to increase green cover, foster a tree-based economy, promote community engagement, and enhance environmental sustainability. The movement was officially inaugurated on June 8, 2023, and serves as the foundation for Assam's efforts to expand its green cover and develop a new tree-based economy.
2.	Sub-mission on Agricultural Mechanization (SMAM)	The scheme proposes establishing Village Level Farm Machinery Banks (VLFMB), Custom Hiring Centres (CHC), and High Tech Hubs (HTH) to ensure that farmers have easy access to farm implements and machinery for hire. The goal is to extend the benefits of farm mechanization to small and marginal farmers and to areas with low farm power availability
3.	Assam *Mukhyamantri Krishi Sa Sajuli Yojna*	Yojna was launched in 2018 by Government of Assam to boost agricultural productivity by procurement of scientific farm implement and financial assistance of Rs. 5000 will be provided to the eligible farmers in the state

4.	Mission Organic Value Chain Development in Assam (MOVCD)	This scheme aims to develop certified organic production through a value chain approach, bridging the gap between growers and consumers. It supports sustainable development throughout the entire value chain, from inputs, seeds, and planting materials to certification, and the establishment of facilities for collection, post-harvest management, aggregation, processing, and marketing
5.	Mission for Integrated Development of Horticulture	The Mission for Integrated Development of Horticulture (MIDH) is a Centrally Sponsored Scheme aimed at the comprehensive growth of the horticulture sector. It encompasses fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa, and bamboo. For the North Eastern and Himalayan States, the Government of India provides 100% funding
6.	Agricultural Technology Management Agency (ATMA)	Under this scheme a district level autonomous institution having membership of all key stakeholders involved in agricultural activities to formation and strengthening of farmer interest groups under ATMA
7.	*Rashtriya Krishi Vikas Yojana* (RKVY)	It is designed as a programme for achieving high growth in agricultural sector and for integrated development by focusing on food security, sustainable agriculture, production of oilseeds, oil palm through agricultural extension, as a part of *Krishonnati Yojana*.
8.	Assam Agricultural Competitiveness Project	The Agricultural Engineering Department provided shallow tube wells (STW) Pump sets to the willing farmers' group @ 50 % subsidy
9.	*Mukhya Mantri Matsya Bikash Achoni*	Under this scheme Government gave incentives for construction of new pond for fishery purpose (individual and community)
10.	*Mukhya Mantri Mohila Samridhi Achoni*	Under the scheme, capacity building training is provided to the women SHGs/Producers group so as to adopt modern weaving techniques
11.	*Mukhyamantri Axom Nirmal Aru Seuj Abhiyan* (MANASA)	Under this mission, the Government aims not only to eliminate garbage from the state but also to enhance the green canopy cover. This initiative focuses on comprehensive waste management, ensuring the state is clean and free from waste while simultaneously promoting environmental sustainability. By increasing the green canopy cover, the mission seeks to improve air quality, provide habitats for wildlife, and create a healthier, more aesthetically pleasing environment for residents
12.	Social Forestry Wing	This scheme aims to provide fuel wood, fodder, fruits, small timber for construction of huts and agricultural implements to the rural people. Social Forestry wing of this state has also given full importance to support the traditional cottage industry. For example, to support the "Eari & Muga" Silk industry in the rural areas plantations have been taken up extensively

13.	Integrated Sericulture Development Project (ISDP)	To protect sericulture species from drastic temperature changes and revive the industry in Assam, the Integrated Sericulture Development Project (ISDP) was introduced. The project aims to: • Increase production, quality and marketing of Muga and Eri silks • Revive and expand sericulture in Assam • Diversify sericulture processes to improve silk and cocoon quality and quantity • Implement skill development programs to boost production, upgrade technology and promote global marketing

Role of Assam Agroforestry Development Board (AADB)

The physiographic variations and agro-climatic conditions in Assam offer ample opportunities for agroforestry practices. Government of Assam is implementing various initiatives/projects aiming to promote Trees Outside Forests, doubling farmers' income, and making farming communities climate-resilient and sustainable. To support these objectives and improve agroforestry-based economy Government of Assam established 'Assam Agroforestry Development Board (AADB)' under the Companies Act on 22 June 2022. The major objectives of AADB are to (i) to popularize and encourage tree plantation in farmlands and various agroforestry practices among farmers, (ii) ensure availability of quality planting material (QPM) such as seeds, seedlings, clones, hybrids, and improved varieties, (iii) create a conducive business environment for wood-based industries, and (iv) minimize human-animal conflict in Assam by promoting a tree-based economy in forest fringe villages. Furthermore, AADB is promoting agroforestry as a nature based solution to reduce the impacts of flooding on farmers and society in Assam (AADB, 2024).

Biodiversity

India is one of the world's 17 Mega biodiversity countries, accounting for 7–8% of all documented species. Assam is one of the country's four biodiversity "hot spots" and a component unit of the Eastern Himalayan Biodiversity Region. Assam's climatic conditions and diverse physical characteristics have resulted in a diversity of natural habitats such as forests, grasslands, and wetlands that host and maintain a vast range of floral and faunal species. The Protected Area Network includes 5 National Parks and 17 Wildlife sanctuaries as well as 3 proposed Wildlife Sanctuaries, 4 Tiger Reserves, 5 Elephant Reserves, 2 Biosphere Reserves and 2 World Natural Heritage Sites and they play very important role in *in-situ* conservation of biodiversity (Assam State Biodiversity Board, 2024).

Group of organisms	Number of species in Assam
Angiosperm	3832
Gymnosperm	22
Orchids	328
Bamboo	42
Cane	14
Mammals	193
Primates	9

Birds	950
Migratory birds	280
Amphibians	70
Butterflies	1500
Moths	387
Reptiles	116
Mollusca	39
Fish	185
Mosquito	156

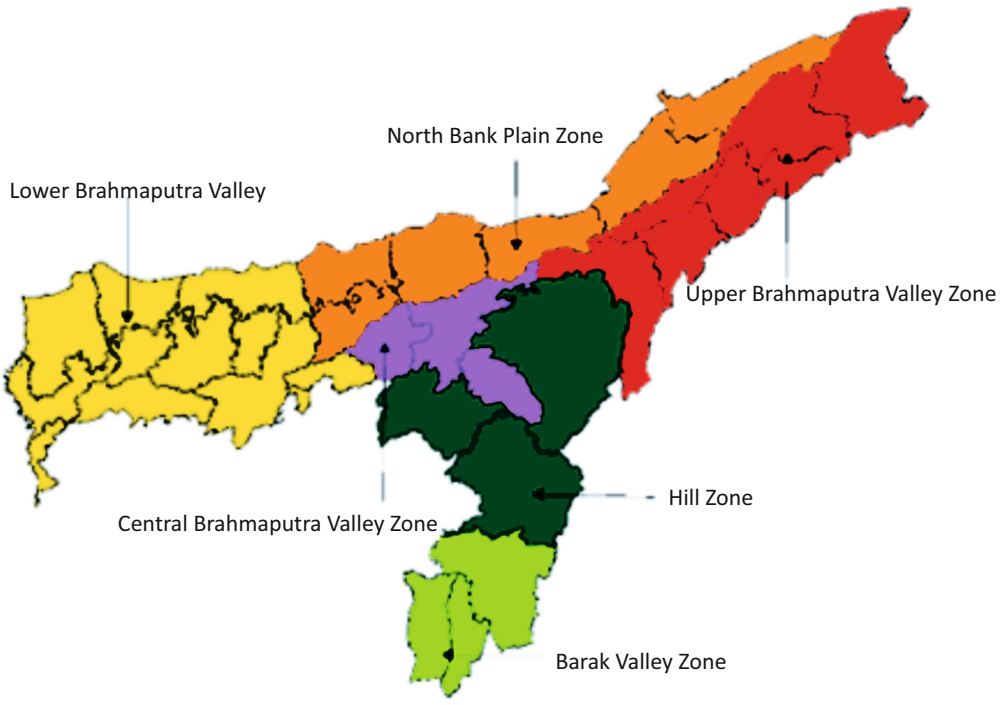
Source: ENVIS Assam (http://asmenvis.nic.in)

Agro-climatic Zones

Assam can be divided into six agro-climatic zones based on the following criteria: rainfall pattern, soil types, texture, depth, and physicochemical features, elevation and terrain, and major crop and vegetation. Assam has six agro-climatic regions: the North Bank Plains Zone (NBPZ), the Upper Brahmaputra Valley Zone (UBVZ), the Central Brahmaputra Valley Zone (CBVZ), the Lower Brahmaputra Valley Zone (LBVZ), the Barak Valley Zone (BVZ), and the Hills Zone.

S.No.	Name of the zones	Districts
1.	North Bank Plain Zone	Lakhimpur, Dhemaji, Sonitpur and Darrang
2.	Upper Brahmaputra Valley	Sibsagar, Jorhat, Golaghat, Dibrugarh and Tinsukia
3.	Central Brahmaputra Valley	Nagaon and Morigaon
4.	Lower Brahmaputra Valley	Kamrup, Borpeta, Bongaigaon, Nalbari, Goalpara, Dhubri and Kokrajhar
5.	Barak Valley	Cachar, Karimganj and Hailakandi
6.	Hill Zone	Karbi Anglong and North Cachar hills

Source: Government of Assam



Source: RS & GIS Lab, ICAR-CAFRI

Demography

According to the 2011 Indian Census, Assam's population is 3.12 crore, comprising 1.593 crore men and 1.526 crore women, representing 2.58% of India's total population of 121.09 crore. The population density in Assam is 398 people per square kilometer, slightly higher than the national average of 382 per square kilometer. The state has a literacy rate of 72.19% and a sex ratio of 958 females per 1,000 males, which exceeds the national average of 943 (Assam at a Glance, 2023).

Administrative profile

The enthusiastic participation of many courageous activists in Assam, the region became a constituent state of India in 1950. In 1951, Assam's area was further reduced when Dewangiri in North Kamrupa was surrendered to Bhutan. Originally, the capital of Assam was Shillong (now the capital of Meghalaya), but it was moved to Dispur, a suburb of Guwahati, in 1972. Subsequently, Meghalaya, Nagaland, Arunachal Pradesh, and Mizoram became separate states. Assam is divided into 35 districts, organized into five regional divisions: Barak Valley, Central Assam, Lower Assam, North Assam, and Upper Assam. The state has a long history of collaboration with significant planning bodies at the district and municipal levels. Rural self-government entities include 80 sub-divisions, 26 zila parishads, 219 blocks, 214 towns, 154 circles, 189 anchalik panchayats, and 2200 gaon panchayats. The name of 35 Administrative Districts are as follows: Baksa, Barpeta, Bongaigaon, Cachar, Charaideo, Chirang, Darrang, Dhubri, Dhemaji, Dibrugarh, Dima Hasao, East Karbi Anglong, Goalpara, Golaghat, Guwahati, Hailakandi, Jorhat, Kamrup Metropolitan, Kokrajhar, Kamrup Rural, Karimganj, Lakhimpur, Majuli Sivasagar, Morigaon, Nagaon, Nalbari, Silchar, Sonitpur, South Salmara-Mankachar, Tezpur, Tinsukia, Udalguri and West Karbi Anglong (Assam at a Glance, 2023).

State symbols

Assam's state symbols include the One-horned Rhinoceros (*Rhinoceros unicornis*) as the state animal and the Black White-winged Wood Duck (*Asarcornis scutulata*) as the state bird. The state flower is the Foxtail Orchid *(Rhynchostylis retusa*), the state tree is the Hollong (*Dipterocarpus macrocarpus*), and the state fruit is Kaji Nemu (*Citrus lemon*). Tea (*Camellia sinensis*) is the state beverage, and Muga silk is the state fabric (Government of Assam). Ganges River Dolphin (*Platanista gangetica*) is the "State Aquatic Animal of Assam (National Fisheries Devlopment Board). The natives of the state of Assam are known as "Asomiya" (Assamese), which is also the state language of Assam. The state has a large number of tribes, each unique in its tradition, culture, dress and exotic way of life (Government of Assam).

Promising Agroforestry Models for Assam

S.No.	Agroforestry models	Tree component	Crop component	Economic returns/ Benefit Cost Ratio (BCR)
1.	Horti-agri system	Coconut	Rice seedling only, Sorghum, Maize and oat as fodder	The net income of the intercrop treatment, coconut+rice nursery-sorghum as fodder (T2) was Rs. 53,696/- while coconut + rice nursery – maize (T3) and coconut + rice nursery – oat (T4) recorded the net income of Rs. 49,261/- and Rs. 50,916/-, respectively.
2.	Agri-silvicultural system	*Acacia mangium*	Sesamum, Niger/Toria	The Maximum plant height (7.07m) and dbh (14.20 cm) is recorded in the widest spacing (5 m x 6 m) and the yield of sesamum and niger was higher as sole crop as compared to intercrop
3.	Agri-silvicultural system	Jackfruit	Sesamum and Toria	The higher B:C ratio 9.37 in sole tree plant as compared intercrop (5.57)

4.	Bamboo based agroforestry system	*Muli* bamboo (*Melocanna baccifer*)	-	*Muli* bamboo yielded 61.6 to 90.0 t/ha in 6th year after plantation from seed
5.	Bamboo based agroforestry system	Bamboo (*Bambusa tulda*) Pineapple, Banana	Turmeric	The higher B:C ratio is obtained in Bamboo + Banana system (9.60) followed by Bamboo + turmeric system (9.45).
6.	Agri-silvicultural system	*Gmelina arborea*	Arhar, Cowpea, Greengram and Toria	The higher yield of crops as sole crops; arhar, cowpea, greengram and toria (11.2 q/ha, 10.5 q/ha, 9.2 q/ha and 9.6-9.7 q/ha) as compared to intercroping of arhar, cowpea, greengram and toria recorded (11.0 q/ha, 10.0 q/ha, 9.0 q/ha and 9.2-9.3 q/ha.

Agroforestry Systems of Hill Zones in Assam

S.No	Type of plantation	Coordinates	Location	Land situation	Features
1.	Roadside plantation	25.445665°, 92.68612°	Village- Boro Lokhingdong, District- Dima Hasao	Upland land	Tree species and shrubs
2.	Homestead	25.492846°, 92.798127°	Village- Dorbin, Umransdisa District- Dima Hasao	Upland land	Mixed plantation with forestry tree species
3.	Horti-Silviculture with Livestock	25.444632°, 92.689427°	Village- Boro Lokhingdong, District- Dima Hasao	Upland land	Mixed plantation of Banana, Mango and forestry tree species
4.	Entrance of home (*Poduli*)	26.715855°, 94.003454°	Village- Komargaon District- Golaghat	Medium land	Agar tree
5.	Plantation crop	26.710445°, 94.003894°	Village- Komargaon District- Golaghat	Medium land	Tea plantation along with agar tree
6.	Block plantation	26.711941°, 94.003108°	Village- Komargaon District- Golaghat	Midland land	Plantation crop tea with agar as shade tree
7.	Aqua- silviculture	26.58047°, 93.988417°	Village- Chetiagaon District- Jorhat	Medium land	Pond dyke with Agar and other tree species
8.	Maronee: Block plantation	26.680673°, 94.004572°	Village- Dhodang Gari District- Jorhat	Upland land	Roadside plantation of forestry tree species

9.	Multistoried system	26.880617°, 94.509115°	Village- Phupanisiga District- Sibsagar	Medium land	Arecanut, Banana, Agar etc.
10.	Entrance	26.814195°, 94.329216°	Village- Khatapathar District- Jorhat	Medium land	Bokul, Baniyan
11.	Institutional plantation	26.783357°, 94.291479°	Institution- Regional Rainforest Research Institute Village-Chenijaan District- Jorhat	Medium land	Mixed plantation of trees, Mango, Siris, boundary by ornamental bamboo species
12.	Homestead- aqua based agroforestry system	26.786996°, 94.240692°	Village- Kherem District- Jorhat	Medium land	Pond bounded by horti-silvi tree species
13.	Bio-fencing	26.786959°, 94.240659°	Village- Dhekial gaon, Nimati District- Jorhat	Medium	-
14.	Aqua-Horticulture	26.844979°, 94.247509°	Village- Komargaon District- Jorhat	Medium land	Banana
15.	Sacred place: Silviculture system	26.217481°, 93.827601°	Village- Deopani District- Karbi Anglong	Upland land	Mixtures of forest species
16.	Plantation Crop: Rubber	25°52'34'' 91°04'45''	Village- Kaulipara District- Kamrup	Upland	Pineapple as intercrop in Rubber plantation

Agroforestry Systems for Assam

Homegarden *(Bari/Baree)* System

Plants Name: Jackfruit, Mango, Litchi, Black berry, Aonla, Guava, Pomegranate, Pineapple, Banana and Assam lemon

Area of Bari system: 50m x 50m

Suitable Intercrops: *Kharif* and *Rabi* vegetables were grown

Economic Returns: The net profit of the Bari system is Rs. 54, 776.00 /ha

Source: HRS-AAU, AICRP, Annual Report (2014-15)

Tea-based Agroforestry System

Scientific Name: *Camellia sinensis*

Suitable Intercrops: Arecanut and Orange

Yield: The highest benefit:cost ratio in terms of intercropping system, is in Tea + Arecanut (2.62), followed by Tea + Orange (2.54) whereas the lowest is in sole Tea (2.01)

Source: Tanti *et al*. (2022)

Bamboo-based Agri-silvicultural System

Scientific Name: *Bambusa balcooa*

Suitable Spacing: 5m x 5m for edible shoot production and 7m x 7m for culm production. 12m x 10m for intercrop

Carbon sequestration: In a 7-year-old plantation of *Bambusa balcooa* the above- ground C stock is equivalent to 120.8 Mg/ha

Suitable Intercrops: Pineapple, Banana, Ginger and Turmeric

Yield: The higher B:C ratio was recorded in *Bambusa balcooa* + Pineapple (7.00) followed by *Bambusa balcooa* + Turmeric (4.07)

Source: Handa *et al*. (2020)

Agar-based Agroforestry System

Scientific Name: *Aquilaria malaccensis*

Suitable Spacing: 2.5m x 2.5m

Suitable Intercrops: Vegetables/pulses/fruits or medicinal and aromatic crops like Patchouli (*Pogostemon cablin*), Sugandh mantri (*Homalomena aromatica*), Kalmegh (*Andrographis paniculata*), Gathion (*Kaempferia galanga*) and pineapple etc.

Yield: The net income of Rs. 25-30 lakh/ha after 15 years may be generated giving an average of Rs. 1, 96,400/year/ha. Intercropping in the early stages of growth can generate extra income

Source: Handa *et al*. (2020)

Coconut-based Agroforestry System

Scientific Name: *Cocos nucifera*

Suitable Spacing: 8m x 8m

Suitable Intercrops: Vegetable, Turmeric, Pineapple, Fodder

Economic Returns: Coconut yield in intercropped plots was 10.75% to 14.78% higher in comparison to sole coconut plot (7250 nut/ha). French bean yielded 62.0 and 87.5 q/ha as intercrop and in open conditions. Turmeric intercropped in coconut is the most profitable B:C ratio 5.82 followed by pineapple as intercrop B:C ratio 5.27

Source: HRS-AAU, AICRP, Annual Report (2015-16)

Gmelina arborea-based Agroforestry System

Scientific Name: *Gmelina arborea*

Suitable Spacing: 8m x 2.5m

Suitable Intercrops: Arhar, Cowpea, Greengram and Toria

Yield: The higher yield recorded in the *Gmelina* + Arhar (11.2 q/ha) followed by *Gmelina* + greengram agrisilivicultural sytem (10.0 q/ha)

Source: HRS- AAU, AICRP, Annual Report (2021-22)

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Agroforestry Business Incubation Centre

ABiC

Institute Technology Management Unit (ITMU) of CAFRI facilitates incubation of new startup/entrepreneurs and enterprises for innovation technologies by providing need based physical, technical, business and networking support, facilities and services to test and validate business ventures of the incubates in agroforestry-based enterprises. Also, the IP/deemed IP are commercialized for creating an ecosystem for entrepreneurship. ABiC activities includes thematic areas like are plant nursery; semi-processed items like juice, jam, pulp, gum & resin, etc.; tree seed marketing; timber and wood-based products; fibre and flosses; biofuels and briquettes; essential oils; mini-clonal technology and agroforestry models.

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