



कृषि एवं किसान  
कल्याण मंत्रालय  
MINISTRY OF  
AGRICULTURE AND  
FARMERS WELFARE

सत्यमेव जयते



# Promising Agroforestry Models for Uttar Pradesh



**ICAR-Central Agroforestry Research Institute**

Jhansi-284003, Uttar Pradesh, India





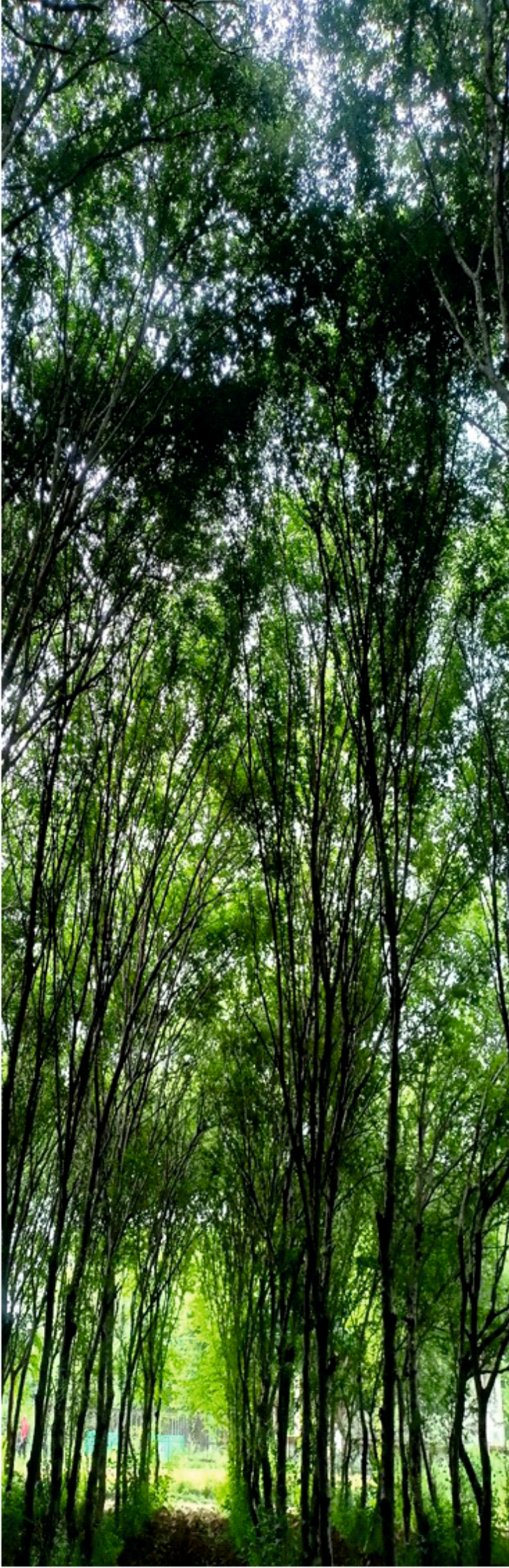


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### Contribution

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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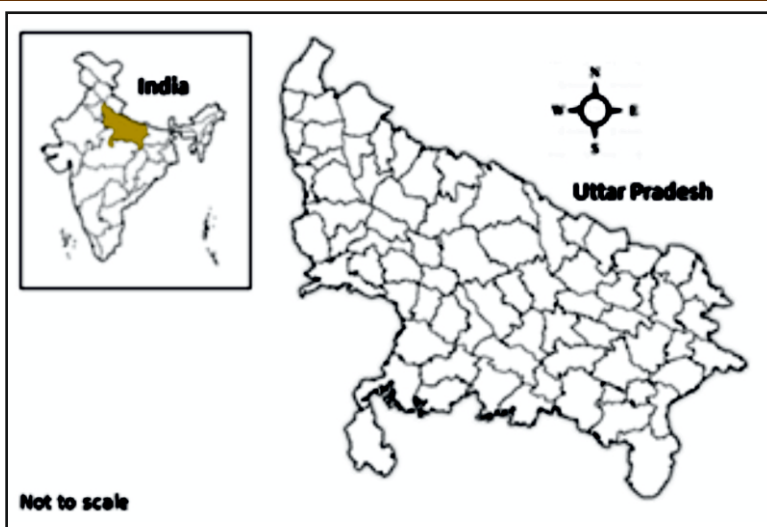
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# Promising Agroforestry Models for Uttar Pradesh

Uttar Pradesh is popularly known as the “Food Bowl of India”. Uttar Pradesh, the heart of India, is a land of holy rivers, epics, ancient cities, and pilgrimages. The history and culture of the state are very old and this fascinating state inspired two of India's major epics. Uttar Pradesh is located between 23°52'N - 30°24'N latitude and 77°05'E - 84°38'E longitude. Several culturally relevant cities are located in this most populous state of the country including Ayodhya, Prayagraj, Varanasi, and Mathura. The state is bordered by Uttarakhand and Himachal Pradesh in the north, Haryana, Delhi, and Rajasthan in the west, Madhya Pradesh and Chhattisgarh in the south, Jharkhand in the southeast, and Bihar in the east. It also shares an international border with Nepal. Comprising a total area of 240,928 km<sup>2</sup>, Uttar Pradesh covers about 7.3% of India's total geographical area (UPSBB, 2012).



## Physiography

Uttar Pradesh can be divided into three physiographic regions: (i) the Ganga Plain, (ii) the Sub-Himalayan Zone, and (iii) the Peninsular Region (Jha, 2008).

### The Ganga plain

The vast Ganga plain is the backbone of the state economy. This fertile plain is formed by the alluvial deposits brought by the Ganga River and its various tributaries and sub-tributaries like Yamuna, Ramganga, Gomti, Ghagra, Gandak, Chambal, Betwa, Son, Sind, and Ken. The Ganga plain comprises an alluvial tract of Pleistocene and recent deposits of clay and sand. The Plain is divided into two parts known as (a) Bangar, and (b) Khadar. The Bangar regions are old alluvial plains formed by old alluvium. Khadar are lowland alluvial deposits. This region is flood-prone and very fertile.

### The sub-Himalayan zone

The sub-Himalayan zone comprises the zone of Terai-Bhabar and the foothills of Siwalik. Siwalik of the outer Himalayas is rich in freshwater deposits of the middle Miocene to lower Pleistocene age (Jha, 2008). The northern strip of the Ganga plain which extends from Saharanpur in the west to Deoria in the east is known as the Bhabar and Terai region. The Bhabar is a piedmont plain in which coarse pebbles are intermixed with finer and extremely pervious detritus. In this region, smaller Himalayan rivers and streams vanish underground and these emerge again and create a marshy tract called the Terai. Wheat, rice, and sugarcane are major crops of the Bhabar and Terai region.

### The Peninsular region

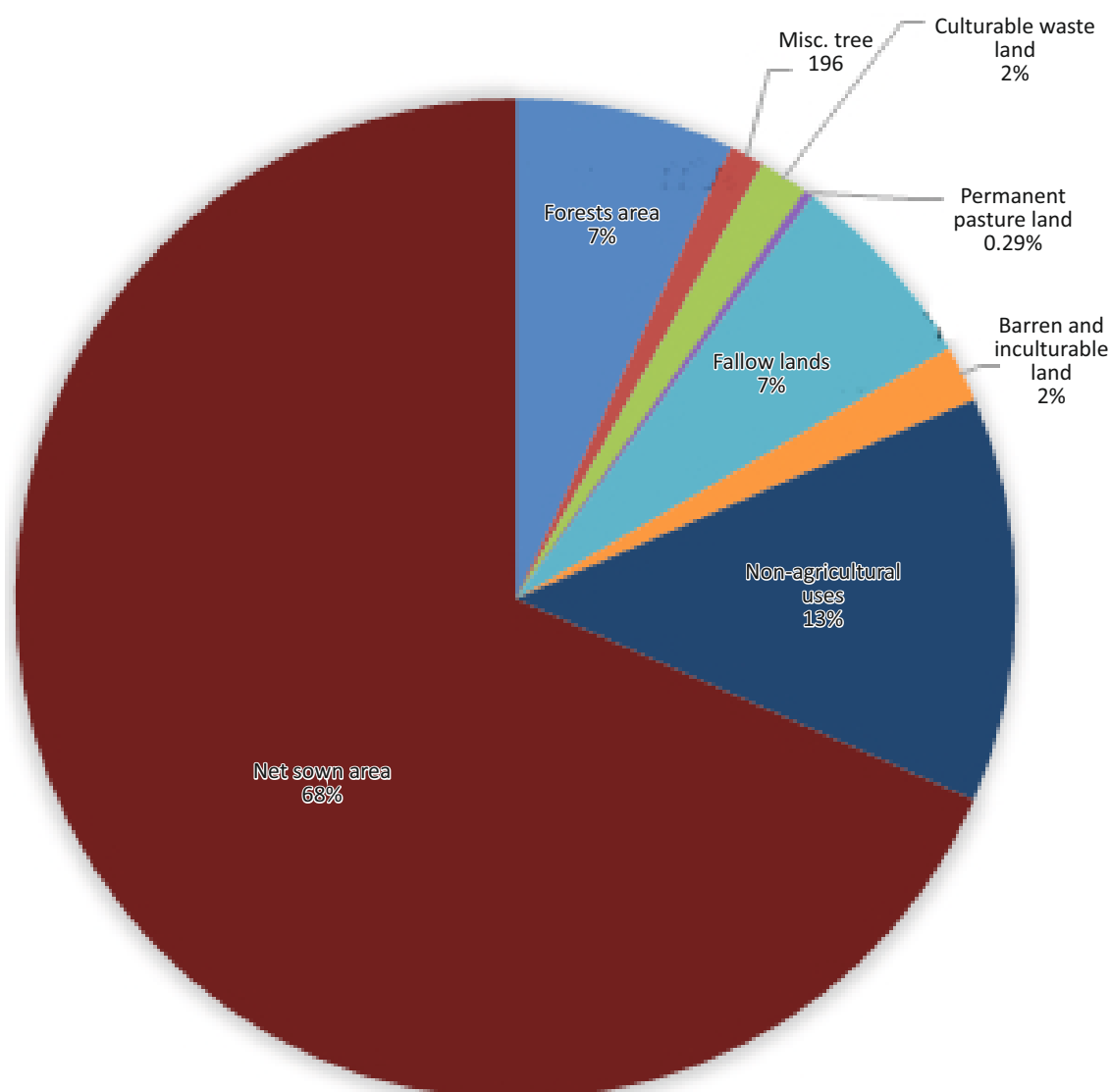
It is the southernmost region of Uttar Pradesh. The eastern part of the Peninsular region in Uttar Pradesh constitutes the Vindhyan mountains and the western part consists of a rocky highland plateau. The Vindhyan range constitutes sedimentary rocks of the Vindhyan system i.e., sandstone, limestone, and shales. Geologically Peninsular region is the most ancient region of the state. The rainfall is scanty in the entire region. Wheat, gram, and Juar are the major crops in the region.

## Climate

The climate of Uttar Pradesh is a tropical monsoon-type climate with an average temperature ranging from 3 to 4°C in January to 43-44°C in May-June (Jha, 2008). The climate in Bhabar and Tarai region is humid. The highest and lowest temperatures are recorded in the Bundelkhand region and Tarai regions, respectively. The climatic conditions of the state are indicated by three distinct seasons of the year (i) winter (October to February), (ii) Summer (March to mid-June), and (iii) Monsoon (Mid-June to September). North-western districts of the state experience extreme cold winters. Eastern districts and the Tarai region of the state enjoy good rainfall during the monsoon season. The Bundelkhand region is very hot in summer due to the barren and rocky nature of the terrain and this region is also characterized by low rainfall. More than 80% of the rainfall is recorded during the monsoon season derived by the South-west monsoon winds. The annual rainfall in the state varies from 1000 mm to 1200 mm (UPSBB, 2012). Torrid and scorching winds blow throughout the plains of Uttar Pradesh (Directorate of Sugarcane Development, 2024).

## Land use pattern

In Uttar Pradesh, which covers 240930 km<sup>2</sup> total geographical area, the forest cover constitutes only 7.11% of the land. During 2018-19, the net sown area in Uttar Pradesh was 165380 km<sup>2</sup>, which accounts for 68.64% of the total geographical area. There was a slight decrease of 0.024% in the net sown area compared to the previous year.



Source: Land Use Statistics at a glance (2021)



## Forests and tree resources

Uttar Pradesh has a total recorded forest area of 14817.89 km<sup>2</sup>, which is 6.15% of its total geographical area (ISFR, 2021). The state's forest cover includes very dense forest (2626.61 km<sup>2</sup>), moderately dense forest (4029.37 km<sup>2</sup>), and open forest (8161.91 km<sup>2</sup>). Sonbhadra district has the highest forest cover, accounting for 35.29% of its geographical area (ISFR, 2021). Uttar Pradesh covers 9143 km<sup>2</sup> inside the Recorded Forest Area (RFA) and 5675 km<sup>2</sup> outside the RFA. Uttar Pradesh's tree cover increased from 7342 km<sup>2</sup> in 2019 to 7421 km<sup>2</sup> in the 2021 assessment.

Trees outside forests (TOF) occupy 13096km<sup>2</sup>, which includes both forest cover outside RFA and tree cover. The top five tree species in TOF for Uttar Pradesh's rural regions are *Mangifera indica* (30.25%), *Eucalyptus spp.* (18.52%), *Populus spp.* (7.74%), *Azadirachta indica* (4.90%), and *Dalbergia sissoo* (4.88%), and in the urban regions top five TOF species are *Azadirachta indica* (15.62%), *Mangifera indica* (12.03%), *Eucalyptus spp.* (10.64%), *Tectona grandis* (4.95%), and *Prosopis juliflora* (4.12%). The total carbon stock of forests in the state including TOF patches larger than 1 ha, amounts to 117.24 million tones (429.88 million tones of CO<sub>2</sub> equivalent) representing 1.63% of the country's total carbon stock. Major Non-Timber Forest Produce (NTFP) species in Uttar Pradesh include *Oscimum basilicum*, *Dasmotachya*, *Vettveria zizanoides*, *Helicteres isora*, and *Adhatoda vasica* (ISFR, 2021).

### Forest types

S.No	Types of forest	Area (km <sup>2</sup> )	% of the total mapped area
1.	Cane brakes	21.75	0.14
2.	Western light alluvium plains sal	1532.61	9.89
3.	Eastern heavy alluvium plains sal	638.37	4.12
4.	Western Gangetic Moist Mixed deciduous forest	399.97	2.58
5.	Northern secondary moist mixed deciduous forest	351.41	2.27
6.	Barringtonia swamp forest	0.29	0.0
7.	<i>Syzygium cumini</i> swamp low forest	199.21	1.29
8.	Dry teak forest	133.70	0.86
9.	Dry Siwalik sal forest	109.09	0.70
10.	Dry plains sal forest	60.87	0.39
11.	Dry peninsular sal forest	345.81	2.23
12.	Northern dry mixed deciduous forest	5422.03	35.00
13.	Dry deciduous scrub	415.43	2.68
14.	Dry savannah	1.97	0.01
15.	<i>Euphorbia scub</i>	1.03	0.01
16.	<i>Anogeissus pendula</i> forest	430.46	2.78
17.	<i>Anogeissus pendula</i> scrub	159.90	1.03
18.	Boswellia forest	113.30	0.73
19.	Babul forest	40.61	0.26
20.	Butea forest	7.72	0.05
21.	<i>Phoenix savannah</i>	2.11	0.01
22.	Babul savannah	14.46	0.09
23.	Dry bamboo brakes	70.63	0.46
24.	Dry tropical riverain forest	0.26	0.00
25.	Khair-sissu forest	153.25	1.00
26.	Ravine thorn forest	799.27	5.16

	Sub Total (A)*	11425.51	73.74
27.	TOF/Plantation (B)	3966.66	25.61
	Total (Forest cover & scrub) (A+B)	15392.17	99.35
28.	Grassland Forest Types (Outside forest cover)		
	a) Low alluvial savannah woodland (Salmalia-Albizia)	5.06	0.03
	b) Eastern wet alluvial grassland	96.31	0.62
	Sub Total (C)	101.37	0.65
	Grand Total (A+B+C)	15493.54	100.00

Source: ISFR (2021); \*A= Sl. No. 1-26.

## Soil

Uttar Pradesh is known for its rich diversity of soils. Alluvial soil is the predominant type of soil in the state. It is found in 7 out of 9 agroclimatic zones of the state including Tarai and Bhabar, Western Plain Zone, Mid Western Plain Zone, South Western Semi-Arid Zone, Central Plain Zone, North East Plain Zone, Eastern Plain Zone. Alluvial soil is very fertile and has the highest productivity compared to other soils. It is formed by sediments brought down and deposited by rivers in the lowlands (Dwevedi *et al.*, 2017).

Soil type	Name of agroclimatic zones
Alluvial soil	Tarai and Bhabar, Western Plain Zone, Mid Western Plain Zone, South Western Semi-Arid Zone, Central Plain Zone, North East Plain Zone, Eastern Plain Zone
Salty/saline soil	Bundelkhand Zone
Sandy loam soil	Bundelkhand Zone
Red soil	Vindhyan Zone
Black or Regular soil (Mar & Kabar)	Bundelkhand Zone

Source: Directorate of Sugarcane Development (2024)

Bundelkhand zone is the most diverse agroclimatic zone in terms of soil types. Three types of soils are found in the Bundelkhand zone namely Salty/saline soil, Sandy loam soil, and Black or Regular soil. Saline soils are found in areas having little rainfall. The colour of black soil is due to the presence of titaniferous magnetite, derived from trap lava. It is rich in clay (60%) without gravel and coarse sand and contains alumina (10%), iron oxide (10%), lime, magnesium carbonates (8-10%), and potash (Dwevedi *et al.*, 2017). Red soil is found in the Vindhyan zone of Uttar Pradesh and it is rich in iron content which is responsible for its color. It is deficient in humus, phosphoric acid, nitrogen, magnesium, and lime but rich in potash, with pH ranging from neutral to acidic (Dwevedi *et al.*, 2017). Red soil is largely found in the Mirzapur and Sonbhadra districts of Uttar Pradesh. The red soils of the Vindhyan region are coarse in texture, poor in organic carbon, and deficient in nutrients (Singh *et al.*, 2011).

## Water Resources of Uttar Pradesh

The state is well drained by several rivers originating both from the Himalayas and Peninsular India. Major rivers of the state include Ganga, Yamuna, Ghagra, Gomti, Gandak, Son, and Sarada. The Ganga River basin, the largest basin of the country encompasses the entire state. Uttar Pradesh alone covers nearly 28.68% area of the entire Ganga River basin, which extends over 11 states of the country and comprises the most fertile and productive land, known to have vast water resource potential (GWAG, 2021). The Ganga River Basin can be subdivided into 8 sub-basins in Uttar Pradesh. Major river basins of Uttar Pradesh have been listed in the following table.



Basin name	Origin of river	Area of basin (km <sup>2</sup> )
Yamuna Basin	Yamunotri Glacier, Uttarakhand	69326.54
Ganga Basin	Gangotri Glacier, Uttarakhand	67773.02
Ghaghra Basin	The combined water of Sarda and Kauriala	31503.01
Gomti Basin	Manikot Pillibhit district, Uttar Pradesh	31433.67
Ramganga Basin	Garhwal district Uttarakhand	20416.66
Rapti Basin	Lower ranges of the Himalayas, Nepal	14658.21
Son Basin	Maikala ranges, Madhya Pradesh	5092.75
Gandak Basin	Tibet, China	974.38

Source: MWR (2014); UPWMRC (2020)

In Uttar Pradesh, about 70% of irrigated agriculture is groundwater dependent, and additionally, groundwater also sustains the needs of drinking water, industrial, commercial, infrastructural, and horticultural uses (GWAG, 2021). A relative scenario of groundwater resources in India and Uttar Pradesh is given below:

Status of groundwater	India	Uttar Pradesh
Annual Extractable Groundwater (Billion Cubic Meters)	392.70 BCM	65.32 BCM
Annual Groundwater Extraction	248.69 BCM	45.84 BCM
1. Irrigation/agriculture use	221.45 BCM	40.89 BCM
2. Domestic use	24.86 BCM	4.95 BCM
3. Industrial use	2.38 BCM	Not reported
Net Availability for Future Use	144.01 BCM	19.48 BCM
Stage of Groundwater Extraction	63.33 %	70.18 %
OCS Units (Over-exploited, Critical and Semi-critical)	2471 nos.	290 nos.

Source: GWAG (2021)

## Agriculture

As stated earlier, the state is the frontrunner in the total foodgrain production. The state has a pivotal role in Indian Agriculture as it contributes about 20% of foodgrain production to the national food basket. Rice, Wheat, Jowar, Bajra, and Sugarcane are the primary crops of the state. Total foodgrain production in Uttar Pradesh was recorded 58.11 million tonnes during 2020-21. During 2020-21, total milk, meat, and egg production in the state were 31359000 tonnes, 1038000 tonnes, and 36289 lakh numbers, respectively. Uttar Pradesh produced 886.281 tonnes of wool during 2020-21, while fish production was recorded 7.46 lakh tonnes during 2020-21.

Crops	Area (Million ha)	Production (Million tonnes)
Rice	5.68	15.52
Wheat	9.85	35.51
Nutri/Coarse Cereals	2.02	4.60
Jowar	0.17	0.27

Bajra	0.91	2.01
Total Pulses	2.38	2.48
Nine Oilseeds	1.20	1.28
Sugarcane	2.18	178.34
Tobacco	35.00	98.00
Potato	0.620	15.81
Onion	0.028	0.470

Source: Agricultural Statistics at a Glance (2022)

### Schemes of Uttar Pradesh

The government of Uttar Pradesh has implemented several schemes and plans such as National Food Security Mission (NFSM), *Rashtriya Krishi Vikas Yojana* (RKVY), National Horticulture Mission, and National Mission for a Green India. According to the 20<sup>th</sup> livestock census, the livestock population of Uttar Pradesh is 67.80 million (DAHD, 2019).

S.No.	Schemes	Objectives
1.	Social forestry scheme	This is a major scheme funded by Uttar Pradesh Government for tree plantation. This scheme has been implemented in all the districts of the state. Industrial pulp wood plantation scheme implemented till the year 2011-12 has come to an end during the year 2012-13. The committed works of the scheme have been included in the social forestry scheme. Plantation is carried out on various types of community land, canals, rail, and land available on the roadside to ensure the availability of timber, fuel wood, fodder, small forest produce, etc., in rural areas of all the districts in the state.
2.	Social forestry in urban areas	In this scheme trees of ornamental and shade value are planted on the unused land alongside the roads and parks for beautification and environment protection in urban areas.
3.	Green Belt Development Scheme	Green belt development has been implemented in the entire state. Under this scheme, tree plantations have been carried out through financing from forest corporations.
4.	Building construction scheme	This scheme aims to construct residential houses, departmental offices, and non-residential buildings for the forest employees working in forests.
5.	Nursery Management Scheme	This scheme is being implemented in the entire Uttar Pradesh. In the Nursery Management Scheme nurseries of 8 to 12 feet height are being raised for plantations.
6.	Forest settlement Scheme	Forest settlement Scheme aims to survey and demarcate forest areas and protect them from encroachment in Uttar Pradesh. This scheme covers specific districts such as Agra, Firozabad, Hamirpur, Mahoba, Banda, Chitrakoot, Hardoi, Khiri, Unnao, and Chandauli. Important tasks covered by this scheme are bush clearance, construction of RCC pillars, barbed wire fencing along the sensitive borders, and generation of a Geospatial Database.



7.	Promotion of cultivation of medicinal plants on the Ganga Basin	This scheme promotes the cultivation of medicinal plants in the Ganga Basin in Uttar Pradesh.
8.	<i>Nagar Van Yojana</i>	The scheme, Nagar Van Yojana (NVY) was launched during the year 2020, for the creation of Nagar Vans in urban areas, which supports urban forestry by incorporating several stakeholders like local communities, NGOs, educational institutions, and local bodies. Nagar Van Yojana envisages creating 1000 Nagar Van/Nagar Vatika in Cities having Municipal Corporations/Municipal council/Municipality/Urban Local Bodies (ULBs) to improve the healthy living environment and thus contribute to the growth of clean, green, healthy, and sustainable cities. Twenty-six projects have been approved in Uttar Pradesh under NVY and a fund of 1968.3 lakhs Ruppes was released during 2020-21.
9.	National Mission on Oil seeds and Oil Palm scheme	National Mission on Oil Seeds and Oil Palm scheme is being implemented from 2014-15 for an increase in oil seed crop production and its productivity in the state. The primary objectives of the scheme are: (i) the planning of crops based on agro-climatic zone, e.g. oil seed crop in Rabi, Kharif, and Jaid in Bundelkhand, and (ii) an Increase in the area of crop, production, and production and productivity.
10.	<i>Rashtriya Krishi Vikas Yojana</i>	To provide all-round development to the horticulture sector wherein research, technical progress, expansion, post-harvesting management, processing, and marketing are included through the area-based local differentiated strategy along with the comparative advantage of every state/area and its harmony with various farming weather specialties. To make an increase in horticultural production, improvement in nutritional safety, and assistance in income generation for the farmers.
11.	Green India Mission (GIM)	This is a Centrally Sponsored Scheme of Green India Mission (GIM) is one of the eight Missions identified under the National Action Plan on Climate Change (NAPCC). The GIM aims to address key concerns related to Climate Change in the forest sector, namely: Adaptation, Mitigation, Vulnerability and Ecosystem Services.

## Biodiversity

India is one of the mega-diverse countries of the world, housing about 7-8% of the recorded species of the world (CBD, 2024) and representing 4 of the 36 globally identified biodiversity hotspots (Himalaya, Indo-Burma, Western Ghats, and Sundaland). Uttar Pradesh located in the Northern plains of India is rich in both flora and fauna diversity. The state has one National Park and 24 Wildlife Sanctuaries covering 5712 km<sup>2</sup> which constitutes 2.37% of the state's geographical area (UPSBB, 2012). Uttar Pradesh also has one Tiger Reserve, namely Dudhwa Katarniaghat (extension) which is also an important habitat for Swamp deers and Rhinoceros.

### Plant diversity of Uttar Pradesh

The recorded plant diversity of Uttar Pradesh includes 1017 genera and 2932 species of plants (lower and higher) with 301 species of algae; 135 species of lichens; 935 species of parasitic fungi; 72 species of bryophytes; 41 species of pteridophytes; 6 species of gymnosperms; and 1442 species of angiosperms (UPSBB, 2024). Overall, the plant diversity of the state is about 6.45% of India's floral diversity.

Groups of plant kingdom	No. of species in the World	No. of species in India	No. of species in Uttar Pradesh	% of species in U.P. with respect to world	% of species in U.P. with respect to India
Algae	40,000	7,182	301	0.75	4.19
Fungi	72,000	14,588	935	1.29	6.40
Lichens	13,500	2,268	135	1.0	5.95
Bryophytes	16,600	2,451	72	0.43	2.93
Pteridophytes	10,000	1,236	41	0.41	3.31
Gymnosperms	650	69	06	0.92	8.69
Angiosperms	2,50,000	17,643	1442	0.57	8.11
<b>Total</b>	<b>4,02,750</b>	<b>45,437</b>	<b>2932</b>	<b>0.72</b>	<b>6.45</b>

Source: UPSBB (2024)

### Animal Diversity of Uttar Pradesh

The faunal diversity of Uttar Pradesh includes 41 species of free-living protozoa, 140 species of phytophagous nematodes, 1445 species of insects, 15 species of ixodid ticks (Acari), 47 species of freshwater Mollusca and 699 species of vertebrates (UPSBB, 2024). Animal diversity of Uttar Pradesh represents 2.76% of our country's faunal species.

Groups of Animal Kingdom	No. of species in the World	No. of species in India	No. of species in Uttar Pradesh	% of species in U.P. with respect to World	% of species in U.P. with respect to India
Protozoa (Free-living + Parasite)	31,250	3,500	41	0.13	1.17
Nematoda (all)	30,028	2,902	140	0.46	4.82
Mollusca	66,535	5,169	47	0.07	0.90
Arthropoda(Insecta)	10,20,007	63,423	1,445	0.14	2.27
Arthropoda (Arachnida)	73,451	5,850	15	0.02	0.25
Pices	32,120	3,022	152	0.47	5.02
Amphibia	6,771	342	25	0.36	7.30
Reptilia	9,230	526	77	0.83	14.63
Aves	9,026	1,233	358	3.96	29.03
Mammalia	5,416	423	87	1.60	20.56
<b>Total</b>	<b>12,83,834</b>	<b>86,390</b>	<b>2,387</b>	<b>0.18</b>	<b>2.76</b>

Source: UPSBB (2024)

### Agro-climatic zones

Uttar Pradesh state can be divided into 9 agro-climatic zones based on the rainfall pattern, soil types, texture, depth and physico-chemical properties, elevation and topography, and major crops and vegetation. Nine agro-climatic zones of Uttar Pradesh include the Bhabhar and Tarai zone, Western plain zone, Mid-western plain zone, South western semi-arid zone, Central plain zone, Bundelkhand zone, Northeastern plain zone, Eastern plain zone, and Vindhyan zone.

Agroclimatic zones	Districts covered
Bhabar and tarai zone	Saharanpur, Muzaffarnagar, Bijnour, Moradabad, Rampur, Bareilly, Shamli, Pilibhit, Shahjahanpur, Khiri, Bahraich, and Shravasti
Western plain zone	Saharanpur, Muzaffarnagar, Meerut, Shamli, Bhagpat, Ghaziabad, Hapur, Gautam Buddha Nagar, and Bulandshahar
Mid-western plain zone	Bareilly, Badaun, Pilibhit, Moradabad, Sambhal, Gautam Buddha Nagar, Rampur, and Bijnour
South western semi-arid zone	Agra, Firozabad, Aligarh, Hathras, Mathura, Mainpuri, Etah, and Kasganj
Central plain zone	Shahjahanpur, Kanpur nagar, Kanpur dehat, Etawah, Auraiya, Farrukhabad, Kannauj, Lucknow, Unnao, Raebareli, Hardoi, Kheri, Sitapur, Fatehpur, Prayagraj and Kaushmbi
Bundelkhand zone	Lalitpur, Jhansi, Jalaun, Hamirpur, Mahoba, Banda and Chitrakoot
North eastern plain zone	Gorakhpur, Maharajganj, Deoria, Kushinagar, Basti, SantKabir Nagar, Siddharthnagar, Gonda, Baharaich, Balrampur and Shrawasti
Eastern plain zone	Azamgarh, Mau, Ballia, Pratapgarh, Faizabad, Ambedkar Nagar, Barabanki, Sultanpur, Varanasi, Chandauli, Jaunpur, Ghazipur and Sant Ravidas Nagar
Vindhyan zone	Prayagraj, SantRavidas Nagar, Mirzapur and Sonbhadra

Source: Misra et al. (2017)



Agroclimatic zones of Uttar Pradesh (Source: RS & GIS lab, ICAR-CAFR)



## Demography

According to the 2011 Indian Census, Uttar Pradesh has a total population of 199.81 million people, with 104.48 million men and 95.33 million women. This accounts for 16.51% of the nation's total population of 1210.19 million. Uttar Pradesh's population density is 666 per km<sup>2</sup>, which exceeds the national average of 382 per km<sup>2</sup>. The state's literacy rate is 67.70%, and the sex ratio is 918 which is lower than the national average of 943 (Government of India, 2011).

## Administrative profile

The British combined Agra and Oudh into one province and called it the United Provinces of Agra and Oudh. The name was shortened to the United Provinces in 1935. On 24 January 1950, the United Provinces was renamed as Uttar Pradesh. The state is divided into 75 districts and 18 administrative divisions. Sub-divisions of the state are Aligarh, Agra, Azamgarh, Ayodhya, Basti, Bareilly, Chitrakoot, Deopatan, Gorakhpur, Jhansi, Kannauj, Lucknow, Meerut, Mirzapur, Moradabad, Prayagraj, Varanasi, and Saharanpur division. Uttar Pradesh comprises 351 Tehsils, 915 Towns, 826 Development blocks, 835 NyayPanchayats, 58189 Gram Panchayats, and 106774 villages. The names of 75 districts are as follows: Agra, Ambedkar Nagar, Amethi, Amroha, Auraiya, Ayodhya, Azamgarh, Baghpat, Bahraich, Ballia, Balrampur, Banda, Barabanki, Bareilly, Basti, Bhadohi, Bijnor, Budaun, Bulandshahar, Chandauli, Chitrakoot, Deoria, Etah, Etawah, Farrukhabad, Fatehpur, Firozabad, Gautam Buddha Nagar, Ghaziabad, Ghazipur, Gonda, Gorakhpur, Hamirpur, Hapur, Hardoi, Hathras, Jalaun, Jaunpur, Jhansi, Kannauj, Kanpur Dehat, Kanpur Nagar, Kasganj, Kaushambi, Kushi Nagar, LakhimpurKheri, Lalitpur, Lucknow, Maharajganj, Mahoba, Mainpuri, Mathura, Mau, Meerut, Mirzapur, Moradabad, Muzaffar Nagar, Pilibhit, Pratapgarh, Prayagraj, Raebareli, Rampur, Saharanpur, Sambhal, SantKabir Nagar, Shahjahanpur, Shamli, Shravasti, Siddharth Nagar, Sitapur, Sonbhadra, Sultanpur, Unnao, and Varanasi (<https://up.gov.in/en/page/districts>).

## State symbols

Uttar Pradesh state animals and birds include Swamp deer/Barasingha (*Rucervus duvaucelii*) and Sarus Crane (*Grus antigone*). The state flower is Palash(*Butea monosperma*), and the state tree is Sita Ashoka (*Saraca asoca*). Mango (*Mangifera indica*) is the state fruit of Uttar Pradesh. Chital/Feather back (*Chitala chitala*) is the state fish of Uttar Pradesh. Hindi is the most widely spoken language in the state.

## Promising Agroforestry Models for Uttar Pradesh

S.No.	Agroforestry models	Tree component	Crop component	Economic returns/ Benefit Cost Ratio (BCR)
1.	Agri-silvicultural system	<i>Casuarina equisetifolia</i> and <i>Dalbergia sissoo</i>	Paddy and Mustard	In the Agri-silvi cultural system under <i>Casuarina</i> system paddy grain yield was found maximum (1.83 t/ha) for Sarjoo-52 followed by NDR-359 (1.78t/ha) and under the <i>Dalbergia</i> Sarjoo-52 (1.73 t/ha) obtained higher yield followed by NDR-359 (1.57 t/ha). In the Agri-silvi cultural system under <i>Casuarina</i> and <i>Dalbergia</i> the higher mustard yield was in NDR-8501 (1.24 t/ha) (1.41 t/ha) followed by Kranti (1.08 t/ha) (1.23 t/ha)

2.	Agri-silvi-horti system	<i>Casuarina equisetifolia</i> and <i>Psidium guajava</i>	Turmeric ( <i>Curcuma longa</i> )	The higher yield of Guava fruits and Turmeric with similar treatments in T <sub>3</sub> (50% NPK + 50% FYM) was 7.32 t/ha and 4.78 t/ha, respectively followed by 6.97 t/ha and 4.21 t/ha in T <sub>4</sub> (25% NPK + 75% FYM).
3.	Agri-silvi-pastoral system	<i>Dalbergia sissoo</i>	<i>Pennisetum purpureum</i> , <i>Brachiara mutica</i> and <i>Panicum maximum</i>	The higher yield of herbage was obtained in the <i>Dalbergia sissoo</i> + <i>Pennisetum purpureum</i> (48.14 t/ha) followed by <i>D sissoo</i> + <i>B. mutica</i> (34.53 t/ha)
4.	<i>Eucalyptus</i> -based Agri-silvicultural system	<i>Eucalyptus</i>	Moong, Mustard, Urd, Wheat, Cowpea and Berseem	The higher grain yield of Moong was obtained in T1- Moong-Wheat (0.52 t/ha) as compared to T2- Moong-Mustard (0.37 t/ha).
5.	Poplar-based Agri-silvicultural system	<i>Populus deltoides</i>	Pearl millet, Sorghum Cowpea, Wheat, Potato, Mustard, Oats, Barseem, Sugarcane, Turmeric and Ginger	Net returns from 5-year-old poplar-based agroforestry is Rs. 1,95,000 ha <sup>-1</sup> yr <sup>-1</sup>
6.	<i>Melia</i> -based Agroforestry Model	<i>Melia dubia</i>	Blackgram, Cowpea, Greengram, Okra, Groundnut, Sorghum, Vegetables, Wheat, Ginger and Turmeric	<i>Melia dubia</i> gives Rs. 10,25,000 ha <sup>-1</sup> after 5 years (Handa <i>et al.</i> , 2020)
7.	Teak-based Agroforestry Model	<i>Tectona grandis</i>	Black gram, Soybean, Red gram Sesame, Sorghum, Cowpea and Linseed	Economic returns obtained include Rs. 60,000 ha <sup>-1</sup> at first 50% thinning upon 7 years; Rs. 2,28,900 ha <sup>-1</sup> at second (25%) thinning upon 12 years and Rs. 19,44,000 ha <sup>-1</sup> at final harvesting upon 20-25 years (Handa <i>et al.</i> , 2020)
8.	Ardu-based Agroforestry Model	<i>Ailanthus excelsa</i>	Pulses Sorghum, Bajra, Cluster bean, Wheat, Mustard, Barley, <i>Cenchrus ciliaris</i> , and <i>Panicum antidotale</i>	Net returns of Rs. 38, 800 ha <sup>-1</sup> yr <sup>-1</sup> is obtained in block plantation from the degraded land at 13-15 years of rotation (Handa <i>et al.</i> , 2020)

9.	Bamboo-based Agroforestry Model	Bamboo spp.	Wheat, mustard, pulses ginger and turmeric	Net income of Rs. 95,000 to 2,00,000 ha <sup>-1</sup> yr <sup>-1</sup> is obtained after 4 years under irrigated conditions (Handa <i>et al.</i> , 2020)
10.	Aonla-based Agri-horticultural System	<i>Phyllanthus emblica</i>	Green gram, black gram sesame, Mustard and chickpea	After 7 years of the Aonla-based agri-horticulture system (Aonla+ green gram/black gram), the BCR of the system was 1.84. BCR increased to 3.28 at the age of 13 years of the system (Handa <i>et al.</i> , 2019)
11.	Kadamb-based Agri-silvi-horticultural System	<i>Anthocephalus cadamba</i>	Rice, Mustard, Lentil, Cabbage, Cauliflower, Pointed gourd, Bottle gourd and fodder	The overall net economic return is Rs. 1,50,000 to Rs. 1,80,000 ha <sup>-1</sup> year <sup>-1</sup> in the initial years and Rs. 2,25,000 to Rs. 3,50,000 ha <sup>-1</sup> with the complete establishment of the system (Handa <i>et al.</i> , 2019).

# **Agroforestry Systems for Uttar Pradesh**





## Poplar-based Agroforestry Model



**Scientific Name:** *Populous deltoides*

**Suitable Spacing:** 5m x 4m, 8m x 2.5 m, 10m x 2m for agroforestry and 2-4m for boundary plantation.

**Suitable Intercrops:** *Kharif* (Pearl millet, sorghum and cowpea); *Rabi* (Wheat, potato, mustard, oats, and barseem); and *Annuals* (Sugarcane, turmeric and ginger)

**Tree Productivity:** 150 t ha<sup>-1</sup> commercial biomass

**Economic Returns:** Net returns from 5-year-old poplar-based agroforestry is Rs. 1,95,000 ha<sup>-1</sup> yr<sup>-1</sup> (Handa *et al.*, 2020)



## ***Eucalyptus*-based Agroforestry model**



**Scientific Name:** *Eucalyptus tereticornis*

**Suitable Spacing:** 3m x 3m or 4m x 4m for block and 2-5m for boundary plantation

**Suitable Intercrops:** *Kharif* (Pearl millet, cowpea, sorghum and soybean); *Rabi* (Wheat, potato, barley, oats and berseem); *Annuals* (Turmeric and ginger); and Fruits (Mango)

**Tree Productivity:** 260 t ha<sup>-1</sup> under agroforestry and 50-80 t ha<sup>-1</sup> in boundary

**Economics Returns:** Net income Rs. 95,000 to 1,26,072 ha<sup>-1</sup> yr<sup>-1</sup> under irrigated conditions (Handa *et al.*, 2020)

## ***Melia*-based Agroforestry Model**



**Scientific Name:** *Melia dubia*

**Suitable Spacing:** 5m × 5m, 6m × 6m, 8m × 2m for agroforestry and 3m × 3m, 2.5m × 2.5m for block and 3-4m for boundary plantation

**Suitable Intercrops:** *Kharif* (Black gram, cowpea, greengram, okra and groundnut); *Rabi* (Sorghum, vegetables and wheat); and *Perennial* (Ginger and turmeric)

**Tree Productivity:** 148 t ha<sup>-1</sup> commercial biomass

**Economics:** *Melia* gives Rs. 10,25,000 ha<sup>-1</sup> after 5 years (Handa *et al.*, 2020)



## Teak-based Agroforestry Model



**Scientific Name:** *Tectona grandis*

**Suitable Spacing:** 8m x 2m, 12m x 2m for agroforestry, 2m x 2m for block, and 2-5m for boundary plantation

**Suitable Intercrops:** *Kharif* (Black gram, soybean, red gram and sesame) and *Rabi* (Sorghum, cowpea, and linseed)

**Tree Productivity:** First thinning (50%) in the 7<sup>th</sup> year (300 poles/ha), second thinning (25%) in the 12<sup>th</sup> year (small timber 7.65 m<sup>3</sup> ha<sup>-1</sup>), and final harvesting (timber 77m<sup>3</sup> ha<sup>-1</sup>) at 20-25 years.

**Economics:** Rs. 60,000 ha<sup>-1</sup> at first 50% thinning upon 7 years; Rs. 2,28,900 ha<sup>-1</sup> at second (25%) thinning upon 12 years and Rs. 19,44,000 ha<sup>-1</sup> at final harvesting upon 20-25 years (Handa *et al.*, 2020)

## Shisham-based Agroforestry Model



**Scientific Name:** *Dalbergia sissoo*

**Suitable Spacing:** 6m × 4m, 8m × 4m for agroforestry, and 4-5m between trees for boundary

**Suitable Intercrops:** *Kharif* (Paddy, soybean and pulses); *Rabi* (Wheat, mustard and barley); and *Perennial* (Napier hybrid grass)

**Tree Productivity:** Timber yield of 100 m<sup>3</sup> ha<sup>-1</sup> and biomass of 210 t<sup>-1</sup> ha<sup>-1</sup>

**Economics:** Net income of Paddy-wheat & Napier hybrid under Shisham increases from Rs. 7,500 to Rs. 11,000 yr<sup>-1</sup> after 7 years and Rs. 1,35,000 to Rs. 50,000 yr<sup>-1</sup> after 11 years under irrigated conditions. A single mature tree can be priced at Rs. 4,000 - 8,000 (Handa *et al.*, 2020)



## Ardu-based Agroforestry Model



**Scientific Name:** *Ailanthus excelsa*

**Suitable Spacing:** 3m×3m, 5m×5m for block; 10m×5m under agroforestry and paired-row (zig-zag pattern) or 3m apart on field boundary

**Suitable Intercrops:** *Kharif* (Pulses and legumes, sorghum, bajra and cluster bean); *Rabi* (Wheat, mustard and barley); and *Grasses* (*Cenchrus ciliaris* and *Panicum antidotale*).

**Tree Productivity:** 100-120 t ha<sup>-1</sup> of timber; 5-6 t ha<sup>-1</sup> yr<sup>-1</sup> of fodder (200-300 kg tree<sup>-1</sup>); 5-7t ha<sup>-1</sup> yr<sup>-1</sup> of fuelwood

**Economics:** Net returns of Rs. 38, 800 ha<sup>-1</sup> yr<sup>-1</sup> in block plantation from the degraded land at 13-15 years of rotation (Handa *et al.*, 2020)

## Bamboo-based Agroforestry Model



**Scientific Name:** *Bambusa balcoa*, *B. bambos*, *B. tulda*, *B. nutans*, *Dendrocalamus hamiltonii*, *D. strictus* and *D. stocksii*

**Suitable Spacing:** 10m × 8m or 12m × 10m in agroforestry and 3-4m between clumps on boundary

**Suitable Intercrops:** Wheat, mustard, pulses etc. during the establishment phase with normal yield and shade-loving crops *i.e.* ginger and turmeric from the second year onwards

**Productivity:** 500-750 culms ha<sup>-1</sup> yr<sup>-1</sup>

**Economics:** Net income of Rs. 95,000 to 2,00,000 ha<sup>-1</sup> yr<sup>-1</sup> after 4 years under irrigated conditions (Handa *et al.*, 2020)



## ***Casuarina*-based Agroforestry Model**



**Scientific Name:** *Casuarina equisetifolia*

**Suitable Spacing:** 1.5m × 1.5m; 2m × 2m for block plantation; 4m × 2m; 6m × 2m for agroforestry; paired row (2m × 1m) for windbreak

**Suitable Intercrops:** *Kharif* (Groundnut, pulses and sesame); and *Rabi* (Vegetables)

**Tree Productivity:** Biomass-120-150 t ha<sup>-1</sup> under irrigated & 70-100 t ha<sup>-1</sup> in rainfed; Timber yield-15-25 m<sup>3</sup> ha<sup>-1</sup> from windbreak; Charcoal yield-10-15 t ha<sup>-1</sup> yr<sup>-1</sup>

**Economics:** Net returns of Rs. 88,827 ha<sup>-1</sup> yr<sup>-1</sup> with groundnut within a short rotation period of 3-4 years. The average net income from plantations is Rs. 2,27,000 ha<sup>-1</sup> under 6-7 years rotation period (Handa *et al.*, 2020)

## Aonla-based Agroforestry Model



**Scientific Name:** *Phyllanthus emblica*

**Suitable Spacing:** 6 m x 6 m or 8 m x 8 m

**Suitable Intercrops:** *Kharif* (Green gram, black gram and sesame); *Rabi* (Mustard, wheat, barley and chickpea)

**Yield:** 400 to 500 kg/ha fruits after 4 years of plantation. At the age of 10 years, *Phyllanthus emblica* can yield up to 120 kg of fruits per plant

**Economics:** After 7 years of the Aonla-based agri-horticulture system (Aonla+ green gram/black gram), the B:C ratio of the system was 1.84. However, it increased to 3.28 at the age of 13 years of the system (Handa *et al.*, 2019)



## Kadamb-based Agroforestry Model



**Scientific Name:** *Anthocephalus cadamba*

**Suitable Spacing:** 3m x 3 m

**Suitable Intercrops:** Rice, mustard, lentil, cabbage, cauliflower, pointed gourd, bottle gourd and fodder

**Yield:** *A. cadamba* is a fast-growing tree in fruit-based agroforestry systems with annual increments of more than 3.0m in height and 3.5cm in diameter. A mean annual diameter increment of 3.0 cm is common.

**Economics:** The overall net economic return is Rs. 1,50,000 to Rs. 1,80,000 ha<sup>-1</sup>year<sup>-1</sup> in the initial years and Rs. 2,25,000 to Rs. 3,50,000 ha<sup>-1</sup> with the complete establishment of the system (Handa *et al.*, 2021)

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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.

***Promoting Agroforestry based Business Opportunities and Creating an Ecosystem for Entrepreneurship***



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