कृषि एवं किसान
कल्याण मंत्रालय
MINISTRY OF
AGRICULTURE AND
FARMERS WELFARE
सत्यमेव जयते

भाकृअनुप
ICAR

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CAFRI

Promising Agroforestry Models for Chhattisgarh

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.

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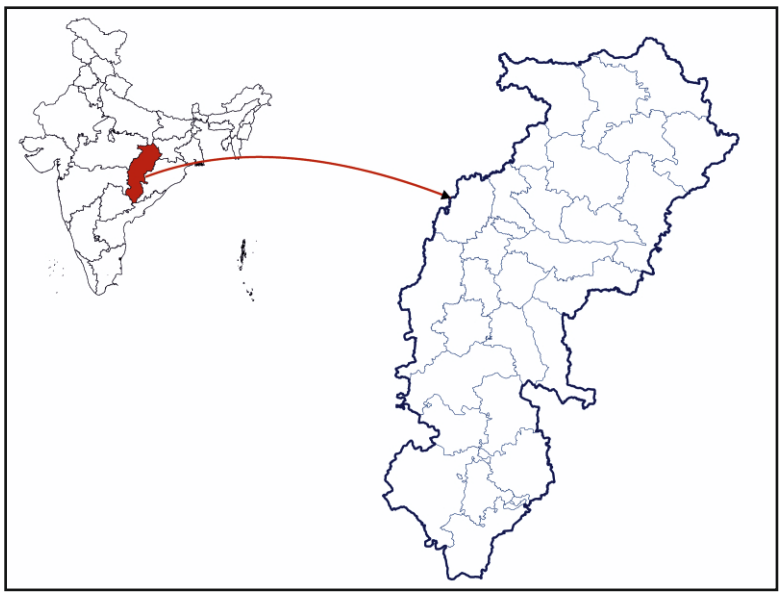
Promising Agroforestry Models for Chhattisgarh



Chhattisgarh is popularly known as *Dhan Ka Katora* (Bowl of Rice). Located in the heart of India, Chhattisgarh was carved out of Madhya Pradesh on 01 November, 2000 with its 16 Chhattisgarhi speaking districts. Most of the portion of the state is situated south of the Tropic of Cancer between 17°46'N to 24°5'N latitude and 80°15' E to 84°20' E longitude (Meshram *et al.*, 2017). The state is surrounded by seven states: Uttar Pradesh in the north, Madhya Pradesh in the northwest, Maharashtra in the southwest, Telangana and Andhra Pradesh in the south, Orissa in the southeast, and Jharkhand in the northeast. Raipur is the capital of the state. It is heavily forested state in the central India known for its waterfalls and temples. Chhattisgarh is the leading producer of iron, coal, tin, and dolomite. It is an important hub for the steel and electrical power production, producing nearly about 15% of the total steel produced in India. The state covers an area of 1,35,192km^2, which is 4.11% of the total geographical area of the country (ISFR, 2019).

Physiography

Physiographically, the state of Chhattisgarh can be divided into 3 distinct units namely; (1) Bastar plateau in southern part, (2) Chhattisgarh plain in central part, and (3) Northern hills in northern part (CGWB, 2022).

Bastar plateau in southern part

Bastar plateau covers Bastar, Kondagaon, Narayanpur, Kanker, Bijapur, Sukma and Dantewada districts located in the southern parts of the State. Except Indravati River plains, most of the area constitutes evergreen dense reserve forests and hilly tracts. The predominant land forms are high level plateaus, structural hills and valleys, pediments and pediplains. The altitude in the Bastar plateau ranges from 400 to 600m amsl. The Indravati River Plain covering central parts, and the Shabri River Plain covering southeastern parts have altitude ranging from 250 to 300m amsl (CGWB, 2022). This region is known for its varied and rich forests, diverse tribal population, and unique culture (SAPCC, 2013).

Chhattisgarh plain in central part

Chhattisgarh plain is extended over the central part of the State and covers parts of Bilaspur, Mungeli, Janjgir-Champa, Mahasamund, Dhamtari, Raipur, Balodabazar, Gariyaband Durg, Balod, Bemetara, Rajnandgaon and Kawardha districts. It forms the structural plains on Proterozoic rocks and matures Pediplain with remnants of few isolated hills and ridges in between flood plains of several tributaries of Mahanadi River system. This plain is characterized by a gently undulating and flat topography. The altitude varies from 750m amsl (northwestern parts) to area 284m amsl (southeastern parts) (CGWB, 2022). This plain is home of indigenous varieties of rice, and houses significant urban population of the state (SAPCC, 2013).

Northern hilly region

It covers from north to the north central part of the area and covers parts of Sarguja, Balrampur, Surajpur Koriya, Korba, Bilaspur, Jashpur and Raigarh districts. Northern hilly region is a part of Maikal and Hazaribagh hill ranges of central India. It forms structural plains of Gondwana rocks, pediment/pediplains, structural and denudational plateaus, structural and denudational hills and valleys. Governed largely by tribal customs, culture and traditions, people in Northern hilly region particularly in rural areas are largely dependent on agriculture and non-timber forest produce (NTFP) (SAPCC, 2013). This hilly region supports north flowing tributaries of the Son River and south flowing Hasdeo and other tributaries of the Mahanadi River. The Narmada, an important west-flowing River of central India, rises from Amarkantak in the central part of Northern hilly region (CGWB, 2022).

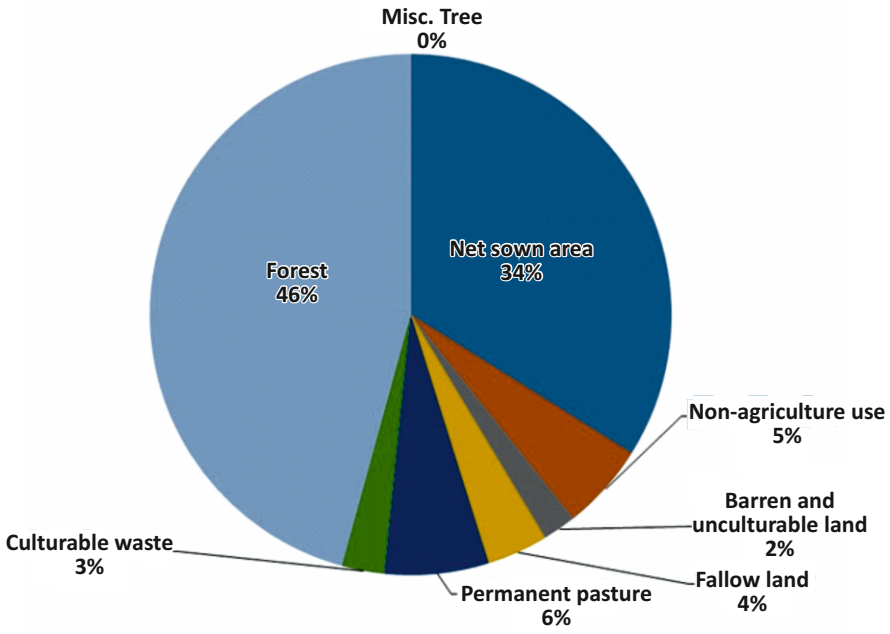
Climate

The state enjoys a tropical climate (hot and humid) due to its proximity to the Tropic of Cancer and dependence on the southwest monsoon for rainfall (Quamar and Bera, 2014). Climate of the state is characterized by three distinct seasons: (i) Winter (October to February), (ii) Summer (March to Middle June), and (iii) Monsoon (Middle June to September) (CGWB, 2022). The average annual rainfall in the state is nearly 1400mm, and about 80% is received during the monsoon season (Meshram *et al.*, 2017). The temperature varies between 30 and 47°C in summer and between 5 and 25°C during winter (SAPCC, 2013). Winters are pleasant in the state with less humidity and low temperatures.

Northern hill region has more severe and longer winter period as compared to the southern regions in Bastar plateau. Analysis of annual and seasonal rainfall in Chhattisgarh indicated that the maximum rainfall of 1847.30mm was in Koriya in 1934 and the minimum rainfall was 349.12mm in the year 1913 (Meshram *et al.*, 2017). Months of July and August are the wettest months of the year. Rainfall occurring in the month of October due to cyclonic activity in the Bay of Bengal is most crucial for the productivity of rice in the state.

Land use pattern

In Chhattisgarh, which covers 135190 km^2 total geographical area, the forest cover constitutes only 46.63% of the land. During 2018-19, the net sown area in Chhattisgarh was 46790 km^2, which accounts for 34.61% of the total geographical area. There was a slight increase of 0.558% in the net sown area compared to the previous year (2017-18).



Source: Land Use Statistics at a Glance(2021

Forests and tree resources

Chhattisgarh is a heavily forested area. The state has a total forest cover of 55716.60 km², which is 41.20% of its total geographical area (ISFR, 2021). The state's forest cover includes very dense forest (7068.21 km²), moderately dense forest (32278.59 km²), and open forest (16369.80 km²). Bijapur (Forest area: 6538.26 km^2) and Narayanpur (Forest cover: 81.61% of geographical area) have highest forest ocover in terms of total area and percentage of geographical area, respectively. Forest cover inside recorded forest area (RFA) is 42467 km^2 while forest cover outside RFA is 13250 km^2 (ISFR, 2021). Chhattisgarh's forest cover increased from 55610.57 km² in 2019 to 55716.60 km² in the 2021 assessment. As per the ISFR (2021), tree cover in the state is 5355 km^2. Trees outside forests (TOF) occupy 18605 km², which includes both forest cover outside RFA and tree cover. Dominant tree species in rural TOF of Chhattisgarh are *Shorea robusta* (23.33%), *Mangifera indica* (7.18%), *Butea monosperma* (6.49%), *Acacia arabica* (5.90%), and *Madhuca latifolia* (5.86%). In the urban regions dominant TOF species include *Mangifera indica* (14.67%), *Moringa* spp. (9.64%), *Azadirachta indica* (7.23%), *Tectona grandis* (6.00%), and *Psidium guajava* (5.30%).

The total carbon stock of forests in the state including TOF patches larger than 1 ha, amounts to 496.44 million tonnes (1820.28 million tonnes of CO_2 equivalent) representing 6.89% of the country's total carbon stock. Major Non-Timber Forest Produce (NTFP) species in Chhattisgarh *Shorea robusta* (42.88%) *Oscimum* spp. (11.76%), *Buchanania lanzan* (8.69%), *Diospyros melanoxylon* (8.48%), and *Anogeisus latifolia* (7.67) (ISFR, 2021).

Forest types

S.No.	Type of Forest	Area (in sq.km)	% of the total mapped area
1.	Slightly teak moist forest	3619.06	6.44
2.	Southern moist mixed deciduous forest	8778.21	15.61
3.	Moist Peninsular high level sal	843.59	1.50
4.	Moist Peninsular low level sal	9350.91	16.63
5.	*Terminalia tomentosa* forest	11.92	0.02
6.	Dry bamboo brakes	0.76	0.00
7.	Dry teak forest	242.52	0.43
8.	Southern dry mixed deciduous forest	15315.84	27.24
9.	Dry Peninsular sal forest	8591.22	15.28
10.	Northern dry mixed deciduous forest	7388.21	13.14
11.	Dry deciduous scrub	627.82	1.12
12.	Dry bamboo barkes	840.04	1.50
	Sub Total	55610.10	98.91
13.	TOF/Plantation	609.99	1.09
	Total (Forest Cover & Scrub)	55220.09	100.00

Source: ISFR (2021)

Soil

The soil types are diverse in Chhattisgarh due to topographical variations. In the upper part of the state, the soils are usually shallow and young, with less developed features, and are frequently highly eroded (Sharma *et al.*, 2014). The soils of the Chhattisgarh Plain are principal natural resource, and are pivotal for agricultural population of the state. Based on the composition, formation, colour and character, the soils of Chhattisgarh are classified into five major gropus: (1) Red-yellow soil (Matasi); (2) Red-Dorsa Soil (3) Laterite soil (Bhattaa), (4) Black soil (Kanhar: clayey), and (5) Red-loamy soil (Tikra) (Sarwa and Vishwakarma (2019). The soils of Chhattisgarh are briefly described in the following table.

Red and Yellow loamy soil is the predominant soil type in Chhattisgarh. Red Yellow soil and Red-Dorsa (Clay-loam) soil are suitable for paddy cultivation. Red colour of soil is due to the ferrous oxide while yellow colour is due to ferric oxide. Red Yellow soil is rich in calcium content and is suitable for paddy cultivation. Red-Dorsa (Clay-loam) soils constitute large quantity of clay and have intermediate level of water retention and humidity. It is slightly red due to ferrous oxide. Paddy is the most suitable crop for Red-Dorsa (Clay-loam) soils.

Types of soil	Parent rock	Area	Distribution	Suitable crops
Red Yellow soil	Gondwana, Chhattisgarh Supergroup	50-60%	Sarguja, Koriya, Jashpur, Raigarh, Korba, Bilaspur, Durg, Raipur, Dhamtari, Mahasamund	Rice
Red-Dorsa soil	Achaean Granite	_	Dantewada, Konta Block	Rice
Laterite soil (Bhattaa)	Mixed	3-5%	Bagicha, Samri, Sitapur, Ambikapur, Kawardha, Chhui-Khadan, Saja, Bemetara, Jagdalpur Block	Pulses, Jowar, Kodo-Kutki, Oil seeds, Potato
Black soil (Kanhar: clayey)	Deccan Trap & Basalt	8-10%	Mungeli, Pandariya, Raipur, Rajim, Mahasamund, Kurud,	Rice, Wheat, Cotton, Gram, Suagrcane
Red-loamy Soil (Tikra)	Archaean Granite	20-25%	Bastar, Dantewara, Kanker, Durg, Rajnandgaon, Dhamtari	Kodo-Kutki, Jowar, Maize, Potato

Source: Sarwa and Vishwakarma (2019), CGWB (2022)

Black soil of the state is important for *Kharif* as well as Rabi crops including Rice, Wheat, Pulses and Sugarcane. The colour of black soil is due to the presence of titaniferous magnetite, derived from trap lava. Water retention capacity of Balck soil (Kanhar: clayey) is high, and is converted to sticky mass and after drying so many crack is formed (Sarwa and Vishwakarma (2019). Laterite soil (Bhattaa) is a coarse-textured, red sandy-gravelly soil, found on upland tops. This soil is deficient in humus, minerals and other nutrients, and is often suitable for Pulses, Jowar, Kodo-Kutki, Oil seeds, and Potato. Red loamy soil (locally called Tikra) is rich in iron content and also contains a large quantity of clay, sand and stone. The water retention capacity of Tikra is low. Kodo-Kutki, Jowar, Maize, and Potato are suitable crops for Red loamy soil.

Water resources of Chhattisgarh

The state is drained by several rivers originating from Peninsular India. Major river basins of Chhattisgarh include (1) Mahanadi, (2) Godavari, (3) Ganga, (4) Bramhani, and (5) Narmada River Basin (Sarwa and Vishwakarma, 2019; CGWB, 2022). Mahanadi River Basin (75858 km^2) is the largest river basin of the state. The Mahanadi River is called as the “Lifeline of Chhattisgarh”. The Mahanadi River is the largest river of the state and is the key source of water for irrigation and domestic use. The surplus electricity production in the state is largely due to pulsating river Mahanadi which also ripples life in the southern coast of Odisha (Sarwa and Vishwakarma, 2019). Major river basins of Chhattisgarh are described in the following table.

Basin name	Main river	Major tribuatries and subtribuatries	Area of basin (km^2)
Mahanadi Basin	Mahanadi River (origin: Dhamtari, Chhattisgarh)	Ib, Hasdeo, Jonk, Seonath, Tel, Pairi River and Mand	75858

Godavari Basin	Godavari River (origin: Trimbakeshwar, Nashik, Maharashtra)	Indravati, Kotri, Narangi, Sabari	38694
Ganga Basin	Ganga River (origin: GangotriGalcier, Uttarakhand)	Son, Rihand, and Kanhar	18407
Bramhani Basin	Bramhani River (origin: Ranchi, Jharkhand)	Sankh	1394
Narmada Basin	Narmada River (origin:Maikala range, Amarkantak, Madhya Pradesh)	Narmada	744

Source: Sarwa and Vishwakarma (2019), CGWB (2022)

The estimated utilizable water resource in Chhattisgarh icnludes: (a) Surface Water: 41,720 MCM; and (b) Ground Water: 11,960 MCM (Sarwa and Vishwakarma, 2019).

Agriculture

The rainfed agriculture is the major source of livelihood for the large tribal population in the state. Rice, wheat, maize, jowar, groundnut, and gram are the main agricultural crops in Chhattisgarh State (Sharma *et al.*, 2014; Meshram *et al.*, 2017). Horticulture is a significant extension of agriculture industry in Chhattisgarh and medicinal herbs, flowers and aromatic plants are key component of horticulture in the state (Sharma *et al.*, 2014). During 2020-21, total area, production and yield of food grain in the state was 4.80 million ha, 8.23 million tonnes, and 1712 kg/ha, respectively (Agricultural Statistics at a Glance, 2022). During 2020-21, total milk, meat, and egg production in the state were1747000 tonnes, 47000 tonnes, 19788 lakh numbers, respectively. Chhattisgarh produced 80.044 tonnes of wool during 2020-21, while fish production was recorded 5.77 lakh tonnes during 2020-21. Area and production of major *Kharif* crops for year 2019 in the state are given as follows.

Crops	**Area (ha)**	**Production (tonnes)**
Rice	4040910	8002200
Jowar	60940	20250
Maize	130440	406840
Total cereals	4232290	8429290
Arhar	35810	22510
Moong	3580	1500
Urd	74290	24310
Kulthi and other pulses	26000	10150
Total Pulses	139680	58470
Groundnut	20000	30420
Til	14020	5800
Ramtil	36320	6890
Soyabean	75120	83010
Sunflower	50	40
Total Oilseeds	145510	126160

Source: Directorate Agriculture (2024)

Chhattisgarh ranks 4th in terms of total rice production area in the country. According to National Programme for Organic Production (NPOP) certification, the area of organic farming in Chhattisgarh is 18856 ha (Agricultural Statistics at a Glance, 2022). Horticulture is gaining popularity in Chhattisgarh owing to the high value of horticulture produces than agriculture crops. Area, production, and productivity of horticultural crops in Chhattisgarh is given in the following table.

S.No.	Crops	Year (2022-23)		
		Area (000 ha)	Production (000 MT)	Productivity (MT/ha)
1.	Fruits	223.868	2473.34	11.05
2.	Vegetables	498.953	6892.501	13.81
3.	Flowers	13.638	167.336	12.27
4.	Plantation crops	31.980	1045.504	32.69
5.	Spices	67.702	453.604	6.70
6.	Aromatic plants	2.116	23.400	11.06
7.	Medicinal plants	4.492	22.773	5.07
	Total	842.748	11245.793	13.34

Source: Chhattisgarh State Centre (2024)

Schemes of Chhattisgarh

The government of India and State Government have implemented several schemes for the welfare of farmers and tree plantation in Chhattisgarh such as Paramparagat Krishi Vikas Yojna (PKVY), Rastriya Krishi Vikas Yojna (RKVY), *Nagar Van Yojana (NVY), Mukhyamantri Vriksha Sampada Yojana* and *Chiraag Yojna*. According to the 19th Livestock census 2012, total livestock population in the state is 15.04 million (ISFR, 2019).

S.No.	Schemes	Objectives
1.	*Paramparagat Krishi Vikas Yojna* (PKVY)	*Paramparagat Krishi Vikas Yojna* (PKVY) is a scheme under National Mission for Sustainable Agriculture (NMSA). It aims at development of sustainable models of organic farming through integrating traditional and modern science to ensure long term soil fertility, resource conservation and address climate change.
2.	National Mission on Agricultural Extension and Technology (NMAET)	NMAET aims to restructure & strengthen agricultural extension to enable delivery of appropriate technology and improved agronomic practices to the farmers. National Mission on Agricultural Extension and Technology (NMAET) consists of 4 Sub Missions: (i) Sub Mission on Agricultural Extension (SMAE) (ii) Sub-Mission on Seed and Planting Material (SMSP) (iii)Sub Mission on Agricultural Mechanization (SMAM) (iv)Sub Mission on Plant Protection and Plant Quarantine (SMPP).
3.	*Rastriya Krishi Vikas Yojna* (RKVY)	*Rashtriya Krishi Vikas Yojana* was initiated in 2007 as an umbrella scheme for ensuring holistic development of agriculture and allied sectors by allowing states to choose their own agriculture and allied sector development activities as per the district/state agriculture plan.
4.	*Nagar Van Yojana (NVY)*	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. Under NVY for Chhattisgarh, a fund of 830.77 lakh was released during 2021-22. Further, seven projects covering 294.63 ha area was approved between 2020-21 to 2023-24.

5.	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. GIM is significant for increasing the forest/tree cover and to improve the quality of existing forest.
6.	*Mukhyamantri Vriksha Sampada Yojana*	The *Mukhyamantri Vriksha Sampada Yojana* is a scheme launched by the government of Chhattisgarh, India, on World Forestry Day 2023. The programme aims to encourage commercial tree plantation in rural areas, increase farmer incomes, and promote sustainable development. The scheme targets to plant 15 crore trees on 180000 acres over 5 years, targeting 36000 acres per year. Under this scheme, government provides 100% subsidy to the beneficiariesenaged in commercial tree plantation on 5 acres and 50 % subsidy to the beneficiaries planting trees on more than 5 acres of land.
7.	*Krishak Unnati Yojna*	Recently, Government of Chhattisgarh launched the '*Krishak Unnati Yojna*' to provide input assistance to farmers, mainly paddy cultivators and released ₹13,320 crore to 24.72 lakh farmers under this scheme.
8.	*Ekeekrut Baagwani Vikas Yojana*	*Ekeekrut Baagwani Vikas Yojana* (Mission for Integrated Development of Horticulture-MIDH) is a Centrally Sponsored Scheme for the holistic growth of the horticulture sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. Under this scheme, Government of India (GOI) contributes 60%, of total outlay for developmental programmes in 40% share is contributed by Chhattisgarh Government. Budget outlay of 205 crore rupees has been provided by state government for MIDH.
9.	*Chiraag Yojna*	*Chiraag Yojna* aims to boost farmer's income in tribal dominated development blocks in 14 districts of Chhattisgarh. Budeget outlay of 200 Crore rupees has been allotted to *Chiraag Yojna* for 2024-25.
10.	State Mission on Millets	To State Mission on Millets implement this mission, an MoU was signed between the Indian Institute of Millet Research (IIMR), Hyderabad and collectors of 14 Chhattisgarh districts under the “Millet Mission”. The Millet Mission aims to provide the farmers the right price for small cereal crops and to support them through input assistance, procurement arrangements and processing.

Biodiversity

India is known for its rich diversity of flora and fauna and is one of the mega-diverse countries of the world, harbouring nearly 7-8% of the recorded species of the world (CBD, 2024) and representing 4 of the 36 globally identified biodiversity hotspots (Himalayas, Indo-Burma, Western Ghats, and Sundaland). Chhattisgarh is endowed with rich diversity of plant and animal species. In Chhattisgarh State 7.8 million

Indigenous and tribal communities obtain their livelihood from forests and biological resources (CSBB, 2022). Chhattisgarh is possibly last home of genetically un-swamped and critically endangered wild Buffalo (*Bubalus bubalis*) and Bastar myna (*Gracula religiosa*).

The state has three National Parks (Guru Ghasidas, Indravati, and Kanger Valley National Parkand 11 Wildlife Sanctuaries (Achanakmar, Badalkhol, Barnawapara, Bhairamgarh, Bhoramdev, Sarangarh-Gomardha, Pamed Wild Buffalo, Semarsot, Sitanadi, Tamor Pingla, and Udanti Wild Buffalo Wildlife Sanctuary); two Elephant Reserves (Badalkhol-Tamorpingla, and Lemru Elephant Reserve); three Tiger Reserves (Achanakmar Tiger Reserve, Indravati Tiger Reserve, and Udanti-Sitanadi Tiger Reserve); one Biosphere Reserve (Achanakamar-Amarkantak Biosphere Reserve) (WII, 2024).

Periodic and extensive collection made in erstwhile Madhya Pradesh from 1964 and onwords 27,000 plant specimens of different plant species have been collected. Till now 1685 species belonging to 785 genera and 147 families have been identified and kept preserved in the herbarium (CBSAP, 2003). Ten dominant families of Chhattisgarh are Fabaceae, Poaceae, Cyperaceae, Asteraceae, Euphorbiaceae, Acanthanceae, Convolvulaceae, Malvaceae, Scrophulariaceae, and Rubiaceae. A total of 645 medicinal plant species have been identified from Chhattisgarh state.

Habit	Number of species	Percentage
Herbs	325	50.38
Shrubs	121	18.75
Trees	144	22.30
Climbers	55	8.52

Source: CBSAP (2003)

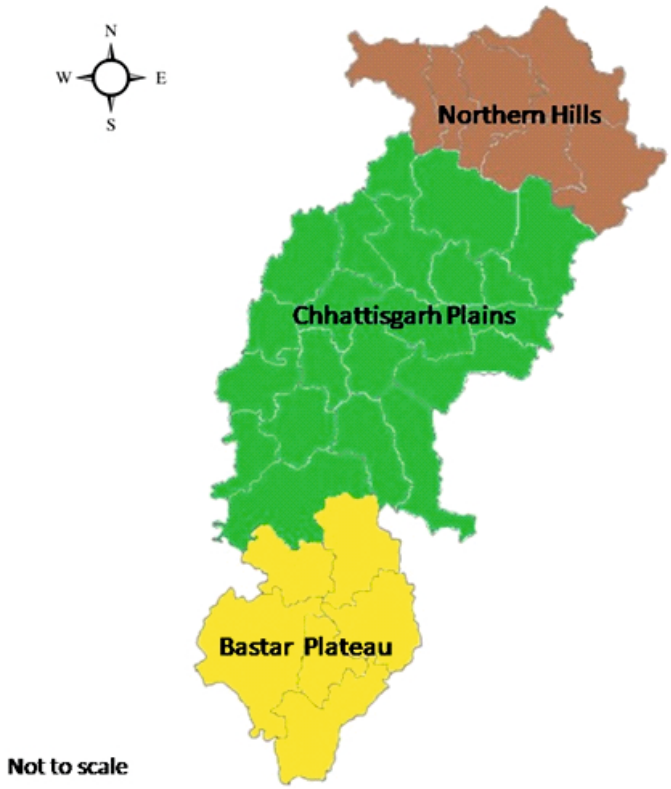
Biogeographically, the Chhattisgarh is under Deccan Bioregion comprising of the representative fauna of Central India like the Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Gaur (*Bos gaurus*), Sambhar (*Cervus unicolor*), Chital (*Axis axis*), Nilgai (*Boselaphus tragocamelus*) and Wild Boar *(Sus scrofa*). The State is a proud possessor of rare wildlife like the Wild Buffalo (*Bubalus bubalis*) and Hill Myna (*Gracula religiosa*), which have been declared as rare and endangered (CBSAP, 2003).

Agro-climatic zones

Chhattisgarh can be divided into three agro-climatic zones: Chhattisgarh Plains, Northern Hills and Bastar Plateau showing the significant variations in temperature and humidity with rainfall varying from 1000 to 1600 mm (ISFR, 2019; Pandey *et al.*, 2021).

Agro-climatic zones	Districts covered	Total geographical area (lakh ha)	Net sown area (lakh ha)
Chhattisgarh Plains	Raipur, Gariaband, Balodabazar, Mahasamund, Dhamtari, Durg, Balod, Bemetara, Rajnandgaon, Kabirdham, Bilaspur, Mungeli, Korba, Janjgeer, Raigarh & a part of Kanker Districts (Narharpur & Kanker Block)	68.49	32.95
Northern Hills	Jagdalpur, Narayanpur, Beejapur, Kondagaon, Dantewada, Sukma and the remaining part of Kanker Districts	39.05	6.40
Bastar Plateau	Sarguja, Surajpur, Balrampur, Koria, Jashpur & Dharamjaigarh Tehsil of Raigarh Districts	28.47	8.35

Source: SAPCC (2013)



Demography

The state has a total population of 25.55 million (25545198) with 12.83 million male and 12.71 female (DCHB, 2011). This accounts for 2.11% of the nation's total population of 1210.19 million. Rural and urban population of the state is 19. 60and 5.93 million, respectively. The total population growth of the state was 22.61% during 2001 to 2011. Significant number (7.82 million as per Census 2011) of tribal people house the state of Chhattisgarh. The average population density (Persons per km^2) in the State is 189 per km^2, which is much lower than the national average of 382 per km^2 (ISFR, 2019). The state's literacy rate is 70.28%, and the sex ratio (Number of females per 1000 males) is 991 which is lower than the national average of 943 (DCHB, 2011).

Administrative profile

The state is divided into 33 districts. These districts are categorized into 5 administrative divisions of Bilaspur, Bastar, Durg, Surguja, and Raipur. The Chhattisgarh districts are governed by a District Magistrate (DM) from the office of the Indian Administrative Service. Thirty three districts of Chhattisgarh along with their administrative divisions are as follows: Durg division (Balod, Bemetara, Durg, Kabirdham, Khairagarh-Chhuikhadan-Gandai, Mohla-Manpur-Ambagarh Chowki, and Rajnandgaon); Bastar division (Bastar, Bijapur, Dantewada, Kanker, Kondagaon, Narayanpur, and Sukma); Bilaspur division (Bilaspur, Gaurella-Pendra-Marwahi, Janjgir-Champa, Korba, Mungeli, Raigarh, Sakti, and Sarangarh-Bilaigarh); Raipur division (Baloda Bazar, Dhamtari, Gariaband, Mahasamund, and Raipur); and Sarguja division (Balrampur, Koriya, Jashpur, Manendragarh-Chirmiri-Bharatpur, and Surajpur, and Surguja). According to Census of India (2011), total number of villages in Chhattisgarh are 20126 (inhabited: 19567; Deserted: 559) (DCHB, 2011). Number of towns in the state are 182 (Census town: 14 and statutory town: 168).

State symbols

Wild buffalo (*Bubalus arnee*) is the state animal of Chhattisgarh. The state bird is the pahari myna (hill myna) (*Gracula religiosa*). Sal (*Shorea robusta*) is the state tree of Chhattisgarh. The widely spoken languages in the state are Hindi and Chhattisgarhi.

Promising Agroforestry Models for Chhattisgarh

S.No.	Agroforestry models	Tree component	Crop component	Economic returns/ Benefit Cost Ratio (BCR)
1.	Mangium-based Agroforestry Model	*Acacia mangium*	Pineapple, mango, ginger, turmeric and arrowroot	Net return of a 12-year old *Acacia mangium* agroforestry with sesame, arrowroot and pineapple is Rs. 1, 93,104 ha^{-1}
	Acacia mangium based multitier agroforestry system	*Acacia mangium*	*Ocimum basilicum*	Highest herbage yield (kg/ha) of *Ocimum basilicum* under Mangium agroforestry system during first and second harvest was 3735.83 and 2307.5, respectively (Bhagat and Prajapati, 2021)
2.	Kapok-based Agroforestry Model	*Ceiba pentandra*	Rainfed crops mainly pulses	Net profit of Rs. 37,800 to 4,01,700 ha^{-1} from the fifth year up to 25 years old plantation at 6m × 6m spacing (Handa *et al.*, 2020)
			Wheat	Maximum grain yield of wheat was found in 4m x 8m spacing (29.51 q ha^{-1}) and minimum in 4m x 4m (23.58 q ha^{-1}) (Singh *et al.*, 2004)
3.	Teak-based Agroforestry Model	*Tectona grandis*	Black gram, Soybean, Red gram Sesame Sorghum, Cowpea, and Linseed	Rs. 60,000 ha^{-1} at first 50% thinning upon 7 years; Rs. 2,28,900 ha^{-1} at second (25%) thinning upon 12 years and Rs. 19,44,000 ha^{-1} at final harvesting upon 20-25 years (Handa *et al.*, 2020)
4.	Gamhar-based Agroforestry Model	*Gmelina arborea*	Legumes, maize, rice, vegetable crops and mustard	Net income Rs. 30,000 to 50,000 ha^{-1} yr^{-1} with crops after 12- 15 years of rotation (Handa *et al.*, 2020)
			Mung urd cowpea soybean wheat linseed mustard, and chickpea	After 5 years biomass in agrisilviculture system was 14.1 Mg ha^{-1} (Swamy and Puri, 2005)
5.	Shisham-based Agroforestry Model	*Dalbergia sissoo*	Paddy, Soybean,Pulses, Wheat, Mustard, Barley and Napier hybrid grass	Net income of Paddy-wheat & Napier hybrid under Shisham increases from Rs. 7500 to Rs. 11,000 yr^{-1} after 7 years and Rs. 1 35,000 to Rs. 50,000 yr^{-1} after 11 years under irrigated conditions (Handa *et al*., 2020)
6.	*Melia*-based Agroforestry Model	*Melia dubia*	Black gram, Cowpea, Greengram, Okra, Groundnut, Sorghum, Vegetables, Wheat, Ginger and Turmeric	*Melia* gives Rs. 10,25,000 ha^{-1} after 5 years (Handa *et al.*, 2020)

7.	*Eucalyptus*-based Agroforestry model	*Eucalyptus tereticornis*	Pearl millet, cowpea, sorghum, soybean, wheat, potato, barley, oats, berseem, turmeric, and ginger	Net income Rs. 95,000 to 1,26,072 ha^{-1} yr^{-1} under irrigated conditions (Handa *et al.*, 2020)
			Colocasia esculenta	The fresh yield of Arbi obtained from *Eucalyptus*-based agroforestry with use of fertilizer is 118.66 qha^{-1} and without fertilizer 103.12 qha^{-1} which reduced, by 12.06 % with statistically significant variation (Yadav *et al.*, 2023)
			Paddy	Eucalyptus tree gives extra income to the farmers after harvesting the tree crop and rate of wood ranges around Rs. 6000-8000 per tons (Sinha and Prajapati, 2022)
8.	Bamboo-based Agroforestry Model	Bamboo spp.	Wheat, mustard, pulses, ginger and turmeric	Net income of Rs. 95,000 to 2,00,000 ha^{-1} yr^{-1} after 4 years under irrigated conditions (Handa *et al.*, 2020)
		Bambusa balcooa and *Bambusa vulgaris*	*Coriandrum sativum*	The intercropping of coriander under bamboo plants provided the farmer with a good economic return up to Rs. 200000 ha^{-1} yr^{-1} (Swarnkar *et al.*, 2023)
		Dendrocalamus strictus	*Zingiber officinale*	The yield of fresh ginger under wider spacing Bamboo plantation was 18.46 q ha^{-1} in agroforestry system as compare to open field in 22.12 q ha^{-1} (Lal and Naugraiya, 2019)
9.	Mango-based agroforestry system	*Mangifera indica*	*Zingiber officinales, Piper Nigrum,* and *Cinnamomum tamala*	Net returns in mango-based agroforestry system can be obtained between 8921 Rs. ha^{-1} yr^{-1} to Rs. 127907 ha^{-1} yr^{-1} (Awasthi *et al.*, 2005)
			Paddy	Rice grain yield under Mango-based agroforestry system was between 25.1±9.9 to 44.3±7.9 qha^{-1} (Anchal and Naugraiya, 2020)
10.	Peach-based agroforestry system	*Prunus persica*	*Solanum tuberosum*	Peach + Potato intercropping ha spotential to provide BCR ranging between 4.00 and 4.64 (Painkra *et al.*, 2023)

11.	*Acacia nilotica*-based traditional Aroforestry system	*Acacia nilotica*	Paddy	Economic analysis reveals that at the age of 20-25 years, the farmers get on an average around Rs 2000 for each tree and Rs 50,000 to Rs 1.5 lakh from one hectare depending upon its stocking rate, which not only compensates the yield loss but also pro vides extra income (Bargali *et al*., 2009)
12.	Coffee-based agroforestry system	Silver oak	Coffee	Biomass production (Mg ha^{-1}) in Coffee + Silver oak based Agroforestry ranges between 20.23 to 230.43 (above ground) and 5.06 to 57.61 (below ground) (Singh *et al.*, 2021)
13.	Karanj-based agroforestry system	*Pongamia pinnata*	*Curcuma longa*	The highest gross returns (Rs 303600) and net returns per ha (Rs. 159862.5) were registered in T7 treatment with 100% FYM (Painkra *et al.*, 2020)

Agroforestry Models for Chhattisgarh

Mangium-*based* Agroforestry Model

Scientific name: *Acacia mangium*

Suitable spacing: 3m×3m for block plantation and 2-3m between trees on field bund.

Suitable intercrops: Pineapple, mango, ginger, turmeric and arrowroot are commonly grown

Tree productivity: *Timber*: 20-25 m^3 ha^{-1} yr^{-1} (even higher in humid regions up to 30-35 m^3 ha^{-1} yr^{-1}); *Firewood*: 100 t ha^{-1} after 10 years

Economic returns: Net return of a 12-year old *Acacia mangium* agroforestry with sesame, arrowroot and pineapple is Rs. 1, 93,104 ha^{-1} yr^{-1} (Handa *et al.*, 2020)

Teak-*based* Agroforestry Model

Scientific name: *Tectona grandis*

Suitable spacing: 8mx2m, 12mx2m for agroforestry, 2mx2m for block, and 2-5m for boundary plantation

Suitable intercrops: *Kharif* (Black gram, Soybean, Red gram and Sesame) and *Rabi (S*orghum, Cowpea, and Linseed)

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

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

Gamhar-*based* Agroforestry Model

Scientific name: *Gmelina arborea*

Suitable spacing: 8m×2.5m, 6m×3m, 4m×3m for timber; 1.2m×1.2m, 1.8m×1.8m for pulp and small poles

Suitable intercrops: Legumes, maize, rice, vegetable crops and mustard

Tree productivity: 20-22 m^3 ha^{-1} of timber and 200 t ha^{-1} of total biomass after 12-15 years

Economics: Net income Rs. 30,000 to 50,000 ha^{-1} yr^{-1} with crops after 12- 15 years of rotation (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^3 ha^{-1} and biomass of 210 t ha^{-1}

Economics: Net income of Paddy-wheat &Napier hybrid under Shisham increases from Rs. 7500 to Rs. 11,000 yr^{-1} after 7 years and Rs. 1 35,000 to Rs. 50,000 yr^{-1} after 11 years under irrigated conditions. A single mature tree can be priced at Rs. 4000-8000 (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^{-1} commercial biomass

Economics: Rs. 10,25,000 ha^{-1} after 5 years (Handa *et al*., 2020)

Eucalyptus-based Agroforestry model

Scientific name: *Eucalyptus tereticornis*

Suitable spacing: 3mx3m or 4mx 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^{-1} under agroforestry and 50-80 t ha^{-1} in boundary

Economics returns: Net income Rs. 95,000 to 1,26,072 ha^{-1} yr^{-1} under irrigated conditions (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^{-1} yr^{-1}

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

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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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