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

भाकृअनुप
ICAR

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CAFRI

Promising Agroforestry Models for Rajasthan

ICAR-Central Agroforestry Research Institute

Jhansi-284003, Uttar Pradesh, India

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Citation

CAFRI (2024) Promising Agroforestry Models for Rajasthan. ICAR-Central Agroforestry Research Institute, Jhansi; 22p.

Contribution

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Acknowledgement

This document has been prepared for spreading awareness and training of stakeholders for agroforestry in different states and is supported by Govt. of India's *Rashtriya Krishi Vikas Yojana* and training grants from the State.

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Cover Page Design : Suresh Ramanan S. and A. Arunachalam

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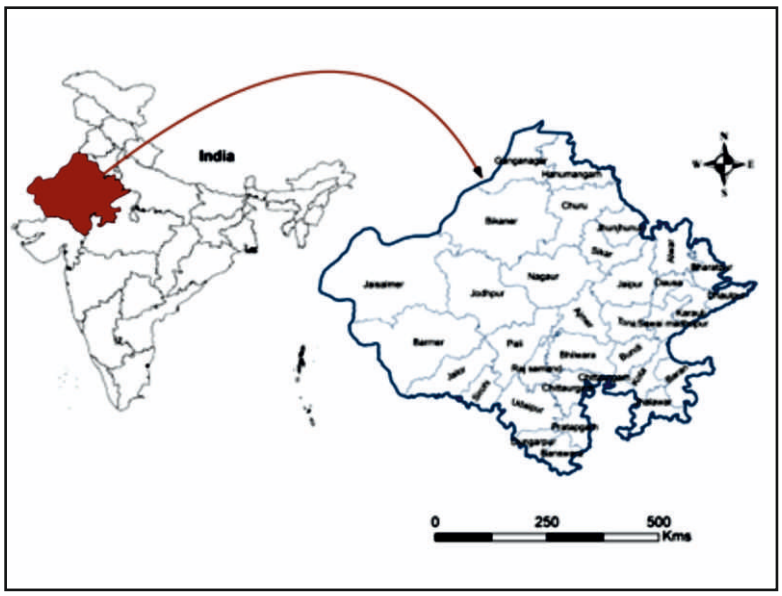
Promising Agroforestry Models for Rajasthan



Rajasthan, the largest state in India by area prior to Independence was known as Rajputana a region historically governed by the Rajput, a martial community. Its history stretches back to prehistoric times with a culture similar to that of the Indus Valley civilization around 3,000 to 1,000 BC. Notable historical states within Rajasthan included Mewar, Marwar, Jaipur, Bundi, Kota, Bharatpur and Alwar, with other regions being offshoots of these principal states. The process of unifying these scattered states began between 1948 and 1956 with the enactment of the States Reorganisation Act. Initially, the Matsya Union (1948) incorporated a few states and by 1949 major states such as Bikaner, Jaipur, Jodhpur and Jaisalmer had joined forming the United State of Greater Rajasthan. Eventually, in 1958 the current state of Rajasthan was officially established and incorporating Ajmer, the Abu Road Taluka, and Sunel Tappa. Rajasthan is bordered by Pakistan to the west and is surrounded by Punjab, Haryana, Uttar Pradesh and Madhya Pradesh to the north-east and south-east with Gujarat to the south-west. Rajasthan international border stretches 1,070 kilometers from Hindumal Kot to Shahgarh. The districts of Rajasthan that lie along this border include Sriganganagar (210 km), Bikaner (168 km), Jaisalmer (464 km) and Barmer (228 km). It is located between the parallels of 23° 03' to 30° 12' N latitude and 69° 30' 78° 17' E longitudes (Know India., 2024).

Physiography

Rajasthan physiography is divided into four main regions:

- The Western Plain
- The Aravalli Range
- The Eastern Plain
- The South-eastern Plains or Hadoti Plateau

The Western Plain

The western plain which spans a significant portion of Rajasthan includes districts such as Hanumangarh, Ganganagar, Bikaner, Jaisalmer, Barmer, Jalore, Sirohi, Pali, Jodhpur, Nagaur, Churu, Sikar and Jhunjhunu. This region prominent in the western part of the state encompasses the Thar Desert, known for its sandy, dry environment and scarce water resources. It divied into two area: the sandy arid plains, which are mostly barren and the semi-arid transitional plains which include more fertile places like as the Luni Basin and Shekhawati.

The Aravalli Range

The Aravalli Range extends roughly 692 kilometers southwestward, passing through the districts of Jaipur, Sikar, Khetri, Alwar, and Sawai Madhopur. This notable mountain range traverses Rajasthan diagonally from the northeast to the southwest, creating a division between the less fertile northwest and the more productive southeast. The range highest peak Guru Shikhar rises to 1,722 meters.

The Eastern Plain

The region situated to the northeast, east and southeast of the Aravalli Range is referred to as the Eastern Plains of Rajasthan encompassing approximately 23.3% of the state. It spans across the districts of Tonk, Ajmer, Bhilwara, Chittorgarh and Bharatpur. This area comprises alluvial plains that are more conducive to agriculture compared to the western regions. It includes the Banas Basin and the Chappan Plains known for their relatively flat terrain and improved water resources.

The south-eastern plains or Hadoti Plateau

The southeastern plains or Hadoti Plateau cover approximately 9.6% of Rajasthan area extending across the districts of Bundi, Kota and Karauli. This region features the Hadoti Plateau characterized by its rugged landscapes and tablelands with elevations between 100 and 350 meters above sea level. Known for its varied topography and the area also hosts several seasonal rivers (Government of Rajasthan, 2024).

Climate

Rajasthan experiences four distinct seasons: Summer, Monsoon, Post-Monsoon and Winter.

Summer season lasts from April to June and is characterized by extremely high temperatures ranging from 32°C to 45°C with western regions sometimes reaching up to 48°C particularly in May and June. Nights in the desert areas can be cooler and dust storms locally known as "aandhi," are common during this period.

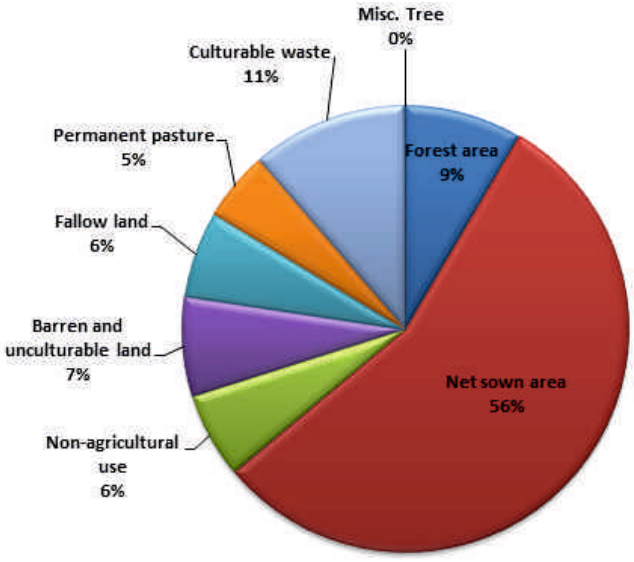
Monsoon occurring from late June to September brings a significant drop in temperature but an increase in humidity with temperatures typically between 35°C and 40°C. This season accounts for about 90% of the annual rainfall in Rajasthan.

Post-Monsoon extends from October to November with average maximum temperatures ranging from 33°C to 38°C and minimum temperatures between 18°C and 20°C. This period marks a transition from the humid conditions of the monsoon.

Winter season spanning from December to March features marked temperature variations, with January being the coldest month. Temperatures can drop to around 0°C in some areas such as Churu. This season sees slight precipitation in the northern and northeastern regions with relative humidity ranging from 50% to 60% in the mornings and dropping to 25% to 35% in the afternoons. Overall, the climate of Rajasthan is primarily hot and dry with significant seasonal variations that influence agricultural practices and daily life (Rajasthan Tourism, Government of India, 2024).

Land use pattern

In Rajasthan which spans a total geographical area of 34.29 mha, forest cover comprises only 8.10% of the land. In 2020-21, the net sown area was 17.94 mha making up 52.33% of the state total area. This represents a slight increase of 0.53% in the net sown area compared to the previous year.



***Source*:** Agricultural Statistics of Rajasthan (2023)

Forests and its resources

Rajasthan has four of India's sixteen primary forest types: Tropical thorn forests, Tropical dry deciduous forests, Central India subtropical hill forests and mixed miscellaneous woods (Forest Department, 2024). Rajasthan's forest area spans 16,654.96 km² representing 4.87% of its total geographical extent. This includes 78.15 km² of very dense forest, 4,368.65 km² of moderately dense forest and 12,208.16 km² of open forest. The district of Udaipur, which is home to many tribal communities, has the highest forest cover making up 23.49% of its land area (ISFR, 2021). Rajasthan covers 12,560 km² within the Recorded Forest Area (RFA) and an additional 4,095 km² outside of it. The state tree cover increases from 8,112 km² in 2019 to 8,733 km² in 2021. Trees outside forests (TOF) cover a total of 12,828 km² combining both forest and tree cover. In rural areas the top five TOF tree species are *Prosopis cineraria* (22.45%), *Prosopis juliflora* (10.13%), *Acacia arabica* (8.78%), *Azadirachta indica* (8.33%) and *Acacia tortilis* (7.40%). In urban areas, the predominant species are *Azadirachta indica* (23.42%), *Prosopis juliflora* (14.89%), *Acacia arabica* (7.95%), *Prosopis cineraria* (5.92%) and *Zizyphus mauritiana* (4.00%). The forests and TOF patches larger than one hectare in Rajasthan sequester 110.77 million tonnes of carbon, representing 1.54% of India's total carbon stock. Major Non-Timber Forest Produce (NTFP) species in Rajasthan include *Butea monosperma, Boswellia serrata, Diospyros melanoxylon, Wrightia arborea/Wrightia tomentosa* and *Aegle marmelos* (ISFR, 2021).

Forest types

S.No	Type of Forest	Area (in sq. km)	% of the total mapped area
1.	Very dry teak forest	1052.53	4.92
2.	Dry teak forest	45.03	0.22
3.	Northern dry mixed deciduous forest	8294.34	38.78
4.	Dry deciduous scrub	2335.13	10.92
5.	Dry savannah forest	2.87	0.01
6.	*Anogeissus pendula* forest	3162.27	14.78
7.	*Anogeissus pendula* scrub	523.55	2.45
8.	*Boswellia* forest	151.04	0.71
9.	*Butea* forest	54.34	0.25
10.	*Aegle* forest	1.69	0.01
11.	*Phoenix* savannah	2.03	0.01
12.	Dry tropical riverain forest	49.86	0.23
13.	*Khair-sissu* forest	304.35	1.42
14.	Desert thorn forest	813.43	3.80
15.	Ravine thorn forest	329.48	1.54
16.	*Ziziphus* scrub	164.31	0.77
17.	Tropical *Euphorbia* scrub	2.92	0.01
18.	*Euphorbia* scrub	133.47	0.62
19.	*Acacia Senegal* forest	46.44	0.22
20.	Desert dune scrub	969.52	4.53
21.	TOF/Plantation	2950.95	13.80
	Total (Forest Cover & Scrub)	**21389.55**	**100.00**

Source: ISFR (2021)

Soil resources

Rajasthan, a state with limited surface water resources, holds only 1.16% of India's total surface water, equating to 21.71 billion cubic meters (BCM), with 16.05 BCM being economically usable. The state has developed the capacity to store 11.29 BCM, about 70% of its usable water. It also contains 1.72% of India's groundwater, translating to 11.36 BCM. Despite allocations of 17.88 BCM from inter-state agreements, actual availability is uncertain due to political factors. While theoretically, water use could increase by 30%, a more realistic assessment suggests an additional 21% of water is economically usable. The rivers in Rajasthan, except the perennial Chambal, are seasonal, influenced by the region's rugged topography and low stream density. The Aravalli Range acts as the main water divide, with Luni being the only river flowing west and others draining internally into desert sands. Major catchments include the Chambal and its tributaries, the Yamuna-Ganga system, and rivers like Barah and Sahibi. Salt lakes such as Sambhar and Didwana also exist in the desert region.

Water Resources of Rajasthan

S.No	River Basin	Basin area (Km^2)	Available Yield (in Million Cubic Meter)	Storage Created (in Million Cubic Meter)
1.	Banas	46902	5,097.26	3639.76
2.	Banganga	9949	754.83	412.26
3.	Chambal	31229	8,702.14	2906.77
4.	Gambhiri	4934	700.89	231.56
5.	Luni	69580	2,269.92	1136.66
6.	Mahi	16598	3,720.25	2726.59
7.	Parvati	1891	427.18	157.28
8.	Ruparail	2550	641.38	101.64
9.	Sabi	4615	348.09	113.65
10.	Sabarmati	4118	732.52	212.09
11.	Shekhawati	9691	562.85	89.72
12.	Sukli	994	137.61	48.00
13.	West Banas	1835	222.14	80
14.	Other Nallah of Jalore	1775	51.42	6
15.	Outside Basin	135603	990.60	9

Source: Kumar (2020)

Agriculture

Agriculture is central to Rajasthan's economy with the state being predominantly agricultural and pastoral. Key crops include wheat, barley, pulses, sugarcane and oilseeds while cotton and tobacco are significant cash crops. Rajasthan is a major producer of edible oils and ranks as the second-largest oilseed producer in India. Agriculture contributes 22.5% to the state's economy yet it faces challenges such as water scarcity, poor soil fertility, small land holdings, frequent droughts and inadequate post-harvest management. In the 2021-22 crop year, out of a total cropped area of 274.42 lakh hectares, 56.86% was devoted to food grain crops, including cereals (91.45 lakh hectares) and pulses (64.57 lakh hectares). Factors like monsoon behavior, rainfall, irrigation, soil fertility and climate conditions are critical in shaping the agricultural landscape of Rajasthan. Production of major crops in the State during 2021- 22 is presented in the given table.

Major crops in Rajasthan

Crops	Production (in thousand tonnes)
Rice	478.507
Jowar	535.706
Bajra	4313.777
Maize	1984.572
Small Millets	1.920
Wheat	11112.289
Barley	711.000
Tur	6.722
Gram	2684.329
Groundnut	1705.960
Sesamum	77.041
Castorseed	192.146
Soyabean	925.847
Rape & Mustard	7162.638
Linseed	14.012
Taramira	199.162
Cotton (Lint)	421.931
Sunhemp	0.179
Sugarcane	321.992
Dry Chilies	13.378
Ginger	0.334
Turmeric	1.234
Coriander	64.110
Cuminseed	230.957
Ajwain	6.588
Garlic	592.644
Sauf (Fennel)	22.832
Methi	113.049
Potato	197.859
Onion	1398.849
Sweet Potato	15.274
Singhada	0.204
Tobacco	0.290
Guarseed	1003.457
Mehandi	28.836
Total	**36539.625**

Source: Agricultural Statistics of Rajasthan (2023)

Schemes of Rajasthan

The Rajasthan government has implemented a number of initiatives aimed at increasing agricultural output and promoting environmental sustainability. Major scheme include the National Food Security

Mission (NFSM), which aims to increase food availability the *Rashtriya Krishi Vikas Yojana* (RKVY), which promotes flexible agricultural growth and the National Horticulture Mission which encourages horticulture. In addition, the *Nagar Van Yojana* aims to maintain biodiversity by increasing green cover. Collectively, these activities aim to assure food security promote agricultural expansion and preserve the state's natural balance. According to the 20th livestock census, livestock population of Rajasthan is 71.4 million (Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, 2019).

S.No.	Scheme	Objective
1.	Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)	The scheme aims to provide livelihood security to households in rural areas by guaranteeing at least 100 days of wage employment per financial year to every household willing to undertake unskilled manual work. This program is designed to enhance employment opportunities and ensure income stability for rural households, thereby contributing to their overall well-being and reducing poverty.
2.	Credit for Poultry	In this poultry production scheme, farmers are provided with loans ranging from ₹ 139 to ₹ 309 per bird for various aspects of their operations, including egg production, broiler farming, and the construction of poultry shelters. This financial support aims to assist farmers in expanding and improving their poultry businesses, ultimately contributing to the growth of the sector.
3.	Credit for Fisheries	Farmers with access to water sources can receive loans between ₹ 23,500 and ₹ 2,50,000 to support pond development and various fisheries-related activities. This financial assistance aims to enhance their aquaculture practices and promote sustainable fish farming initiatives.
4.	*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.
5.	*Paramparagat Krishi VikasYojna* (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.
6.	National Horticulture Mission (NHM)	The National Horticulture Mission (NHM) is a centrally sponsored scheme launched during the 10th Five Year Plan (2005-06 and 2006-07), providing full assistance to State missions. Its main objective is to achieve comprehensive development of horticulture through an "end to end" approach, covering everything from

		planting material production to marketing and export after value addition. NHM aims to double the output and productivity of key horticultural crops and improve the quality of produce.
7.	National Mission for Sustainable Agriculture (NMSA), Sub Mission on Agroforestry (SMAF)	The initiative is designed to promote and enhance tree plantation systematically, ensuring access to high-quality plant materials like seeds, seedlings, clones, and improved varieties. It aims to encourage diverse agroforestry practices suited to different agro ecological regions and land use patterns, while also providing extension services and capacity-building support to the agroforestry sector. The funding structure consists of 60% central government contribution and 40% state government contribution.
8.	Credit for Piggery Development	Farmers can obtain loans ranging from ₹ 22,600 to ₹ 65,900 for activities related to pig farming. They have the opportunity to establish a unit of 3+1 to 10+1 on their own land, enabling them to engage in piggery operations effectively.
9.	Credit for *Resham Keet Palan*	Farmers can access loans between ₹ 18,220 and ₹ 23,885 to develop silk worm units on plots ranging from 0.25 acre to 0.50 acre. This financial support is aimed at promoting sericulture and enhancing their silk production capabilities.
10.	Credit for Honey Bee Farming	Farmers can receive a loan of ₹ 23,250 to establish 10 box units for beekeeping. This financial assistance is designed to support honey bee farming and encourage the growth of apiculture practices.
11.	Credit for Green Fodder Production	Farmers are given loan of ₹ 10,000/ acre for green fodder production.
12.	*Saghan Kapaas Vikas Karya*	The scheme aims to provide technical and financial support to cotton farmers in the state with the goal of enhancing the quantity, productivity, and quality of cotton production. This assistance helps farmers adopt improved practices and technologies leading to better yields and quality of the cotton crop.
13.	Intensification of Forest Management	The condition and quality of current forests can be enhanced, providing protection against various threats and factors contributing to degradation. This improvement is essential for preserving forest ecosystems and ensuring their sustainability.
14.	*Luv Kush Vatika*	To encourage ecotourism in the state, two *Luv Kush Vatikas* will be established in each district. These *vatikas* will offer various recreational activities, including walking paths, water features, bird watching areas, informative signage, benches, and other amenities for visitors. A total budget of ?18.58 crore has been allocated for the year 2023-24.

15.	*Nagar Van Yojana*	The *Nagar Van* scheme, initiated by the Ministry of Environment, Forest and Climate Change aims to establish 200 Nagar Vans across India over the next five years. Its goal is to enhance awareness and promote plant biodiversity by creating green spaces and improving the aesthetic environment in urban areas. In this sequence, the work of developing 14 *Nagar Van* is currently in progress in the State.

Sources: NIRDPR, (2015); DES, (2024)

Biodiversity

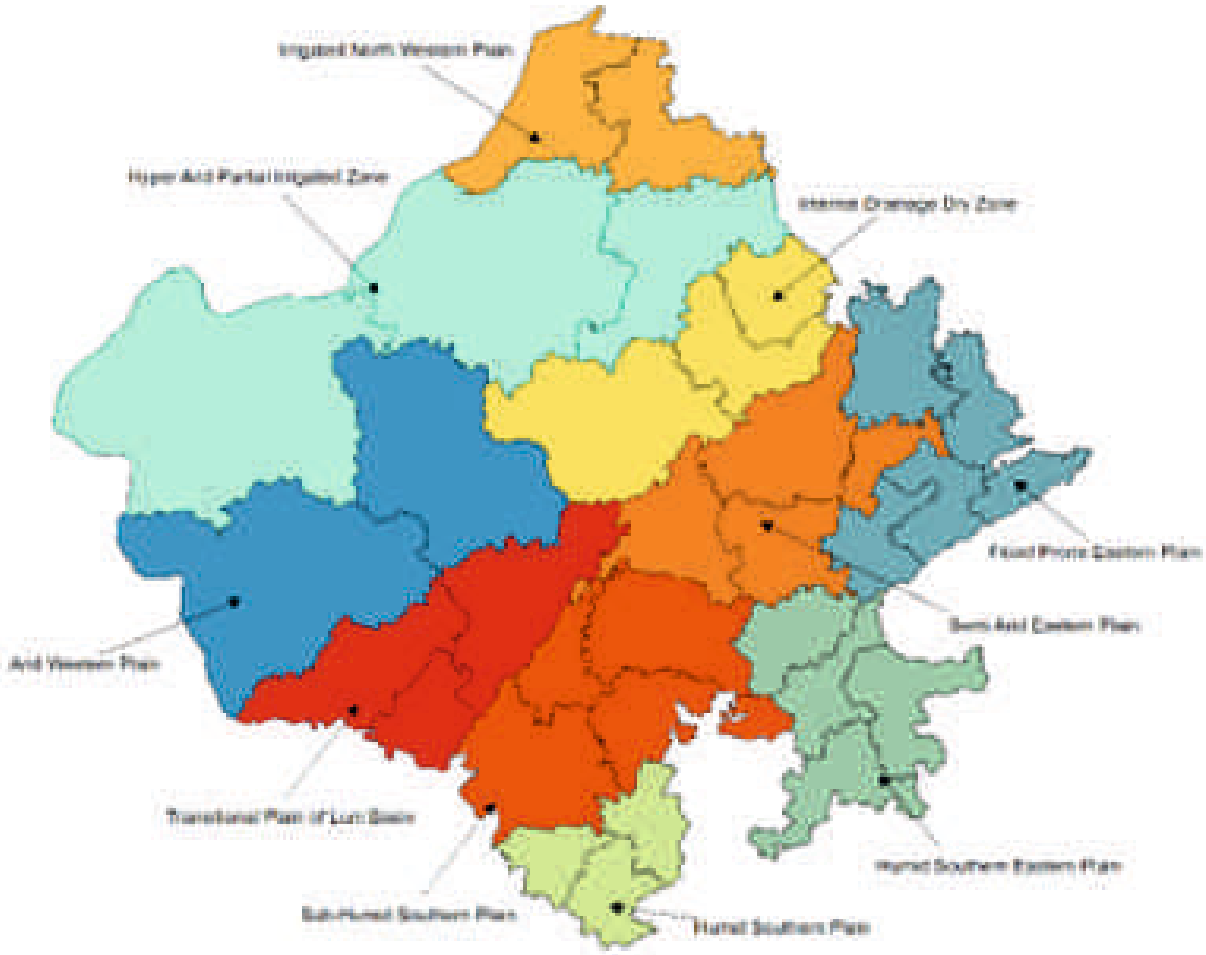
Rajasthan has extensive arid terrains supports a rich and varied array of flora and fauna. The main natural vegetation is known as Northern Desert Thorn Forest which appears in scattered small clusters throughout the state. These patches of vegetation become denser and larger as one travels from the western to the eastern regions aligning with the increase in rainfall. The Northwestern thorn scrub forests create a band around the Thar Desert situated between the desert and the Aravalli Range. The Aravalli Range and the southeastern part of the state feature dry deciduous forests including tropical dry broadleaf species such as Teak and *Acacia*. The southernmost Vagad region near the Gujarat border is the most forested and receives the most rainfall with Mount Abu being a notable exception. To the north of Vagad is the Mewar region, which includes cities like Udaipur and Chittaurgarh while the Hadoti region lies to the southeast bordering Madhya Pradesh. North of Hadoti and Mewar is the Dhundhar region. Each of these regions hosts unique plant and animal species, contributing to Rajasthan's overall biodiversity. The state's protected areas, which include 5 national parks and 26 wildlife sanctuaries, as well as 36 conservation reserves, 5 tiger reserves, and 5 zoo farms, play an important role *in situ* biodiversity conservation (Forest department of Rajasthan, 2024).

Group of organisms	Number of species in Rajasthan
Angiosperm	2034
Gymnosperm	01
Liverworts & Hornworts	37
Mosses	42
Ferns	60
Orchids	14
Terrestrial	08
Epiphytic	06
Fish	114
Amphibians	14
Reptiles	67
Mammals	87
Birds	510

Source: Rajasthan State Biodiversity Board (2024)

Agro-climatic zones

The Rajasthan state is divided into 10 distinct agro-climatic zones based on soil type, topography, crops and rainfall. These are the zones: Arid western plains, Irrigated north western plain, Hyper arid Partial irrigated zone, Internal drainage dry zone, Transitional plain of Luni basin, Semi-arid eastern plains, Flood prone Eastern plain, Sub humid southern plains, Humid southern plains and Humid south Eastern plain.



Source: RS & GIS Lab, ICAR-CAFRI

Agro-Climatic Zones of Rajasthan

S.No.	Name of the Zones	Total Area (million ha)	Annual Rainfall (mm)	District covered	Crops grown
1.	Arid western plains	4.74	200-370	Barmer & part of Jodhpur	Pearlmillet, Mothbean, Sesame, Wheat, Mustard and Cumin
2.	Irrigated north western plain	2.10	100-350	Sriganganagar, Hanumangarh	Cotton, Clusterbean, Wheat, Mustard and Gram
3.	Hyper arid Partial irrigated zone	7.70	100-350	Bikaner, Jaisalmer, Churu	Pearlmillet, Mothbean Clusterbean, Wheat, Mustard and Gram
4.	Internal drainage dry zone	3.69	300-500	Nagaur, Sikar, Jhunjhunu, Part of Churu	Pearlmillet, Clusterbean, Pulses, Mustard and Gram

5.	Transitional plain of Luni basin	3.00	300-500	Jalore, Pali, Part of Sirohi, Jodhpur	Pearlmillet, Clusterbean, Sesame, Wheat and Mustard
6.	Semi-arid eastern plains	2.96	500-700	Jaipur, Ajmer, Dausa, Tonk	Pearlmillet, Clusterbean, Sorghum, Wheat, Mustard and Gram
7.	Flood prone eastern plain	2.77	500-700	Alwar, Dholpur, Bharatpur, Karoli, Sawai Madhopur	Pearlmillet, Clusterbean, Groundnut, Wheat, Barley, Mustard and Gram
8.	Sub humid southern plains	3.36	500-900	Bhilwara, Sirohi, Udaipur, Chittorgarh	Maize, Pulses, Sorghum, Wheat and Gram
9.	Humid southern plains	1.72	500-1100	Dungarpur, Udaipur, Banswara, Chittorgarh	Maize, Paddy, Sorghum, Blackgram, Wheat and Gram
10.	Humid south eastern plain	2.70	650-1000	Kota, Jhalawar, Bundi, Baran	Sorghum, Soyabean, Wheat and Mustard

Source: Government of Rajasthan (2024)

Demography

According to the 2011 Indian Census, Rajasthan had a population of 68.55 million showing a growth rate of 21.2% over 56.5 million from 2001. As of 2011, out of the total population, males number 35.55 million and females are 33 million and a sex ratio of 928 females for every 1,000 males. The major working portion is 45.57% cultivators, 17.53% agricultural labourers and 2.41% in household industries. About religious demography Hindus account for 88.49 %, Muslims 9.07 %, Sikhs 1.27% and Jains 0.91%. The overall literacy rate in Rajasthan was 67.06%, while for males it was 80.51% and for females 52.66%. Although the overall literacy rate of the state is below the national average of 74.04% and the female literacy rate is particularly low and the Rajasthan has done considerably well in recent years to increase its literacy rate. The population density of the state is 200 people km^2 (Government of Rajasthan, 2024).

Administrative profile

Jaipur is the capital of Rajasthan. The state is divided into 33 districts, and it has a long history of working with major planning authorities at both the district and city levels. Recently in September 2024, the districts were reorganised and Rajasthan has 50 districts now. Rajasthan has 5 Corporations, 30 Municipal councils, 33 Zila Parishads, 149 Municipal Boards, 244 Tehsils, 248 Blocks, 44795 Revenue Villages, 11305 Gram Panchayats, 25 Lok Sabha Constituencies and 200 Assembly Constituencies. The name of 33 Administrative Districts are as follows: Ajmer, Alwar, Anupgarh, Balotra, Banswara, Baran Barmer, Beawar, Bharatpur, Bhilwara, Bikaner, Bundi, Chittorgarh, Churu, Dausa, Deedwana-Kuchaman, Deeg, Dholpur, Dudu, Dungarpur, Ganganagar, Gangapur City, Hanumangarh, Jaipur, Jaipur (Rural), Jaisalmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Jodhpur (Rural), Karauli, Kekri, Khairthal-Tijara, Kota, Kotputli-Behror, Nagaur, Neem Ka Thana, Pali, Phalodi, Pratapgarh, Rajsamand, Salumber, Sanchore, Sawai Madhopur, Shahpura, Sikar, Sirohi, Tonk and Udaipur (Government of Rajasthan, 2024).

State symbols

Rajasthan state symbols include the Indian Gazelle locally called Chinkara (*Gazella bennettii*) as its state animal, while the Arabian camel (*Camelus dromedarius*), locally known as Oont is recognized as a State Heritage Animal. The Great Indian Bustard (*Ardeotis nigriceps*) locally referred to as Godavan in Rajasthan and Hookna in Hindi is designated as the state bird. The Marwar teak or desert teak (*Tecomella undulata*) is the state flower and the Khejri (*Prosopis cineraria*) serves as the state tree and Sangiri the pods of the Khejri tree is known as the state fruit. Hindi is the official language of Rajasthan and the most commonly spoken language, used by 90.97% of the population according to the 2001 census. It is followed by Bhili (4.60%), Punjabi (2.01%), and Urdu (1.17%). In the state's educational system, the three-language formula includes: Hindi as the First language, English as the Second language, and a choice among Urdu, Sindhi, Punjabi, Sanskrit, or Gujarati as the Third language (Ministry of I&B, Government of India, 2024).

Promising Agroforestry Models for Rajasthan

S.No.	Agroforestry	Tree component	Crop component	Economic returns/ Benefit Cost Ratio (BCR)
1.	Agri-silviculture system	*Dalbergia sissoo*	Cowpea *var*. RC 19, FS 68, Clusterbean *var*. RGC 936, RGC 197, Moth bean *var*. RMO 40, Jadia, Mungbean *var*. RMG 62, K 851, Pearl millet *var*. MH 179, HHB 67	The maximum gross return was recorded in Clusterbean *var.* RGC 936 (Rs. 7578 ha) followed by Pearlmillet *var.* MH 179 (Rs. 6350 ha) and Mungbean *var.* K 851 (Rs. 5675 ha)
2.	Agri-silviculture system	*Acacia nilotica*	Cowpea *var*. RC 19, FS 68, Clusterbean *var*. RGC 936, RGC 197, Moth bean *var*. RMO 40, Jadia, Mungbean *var*. RMG 62, K 851, Pearl millet *var*. MH 179, HHB 67	The maximum gross return was recorded in Mungbean *var*. K 851 (Rs. 17292 ha) followed by Mungbean *var.* RMG 62 (Rs. 15000 ha) and Clusterbean *var.* RGC 197 (Rs. 14325 ha)
3.	Agri-silviculture system	*Acacia nilotica*	Pearl millet *var*. HHB 67, MH 169, Moth bean *var*. RMO 40, FMM 96, Mungbean *var*. RMG 62, K 851, Clusterbean *var*. RGC 936, RGC 197, Cowpea *var*. FS 68, RC 19	The higher grain yield attain by the Cowpea *var*. RC 19 (1438 kg/ha) followed by Pearl millet *var*. HHB 67 (1021 kg/ha) intercropped with *Acacia nilotica*
4.	Silvipastoral system	*Dichrostachys cinerea* (Nutans)	*Cenchrus ciliaris*	The higher yield of Biomass is recorded in Nutans (1 m row distance) (42.29 kg/ha) followed by Grass (10 m row distance) (16.45 kg/ha)

5.	Agri-silviculture system	*Prosopis cineraria*	Pearl millet *var.* HHB 67, MH 169, Moth bean *var.* RMO 40, RMO435, Mungbean *var.* G 8, K 851 Clusterbean *var.* RGC 936, RGC 197 Cowpea *var.* RC 101, RC 19	The higher gross return was recorded in Clusterbean *var*. RGC-197 and RGC- 936 (Rs. 23833 ha and Rs. 20640 ha) followed by Pearl millet HHB-67 (Rs. 19500 ha)
6.	Agri-silviculture system	*Hardwickia binata*	Pearl millet *var.* HHB 67, MH 169, Moth bean *var.* RMO 40, RMO435, Mungbean *var.* G 8, K 851, Clusterbean *var.* RGC 936, RGC 197 Cowpea *var.* RC 101, RC 19	The higher gross return was recorded in Clusterbean *var*. RGC-197 and RGC- 936 (Rs. 25313 ha and Rs. 22375 ha) followed by Pearl millet HHB-67 (Rs. 20677 ha)
7.	Silvipastoral system	*Prosopis cineraria*	Pearl millet *var.* HHB 67, MH 169, Cowpea *var.* RC 101, RC 19, Clusterbean *var.* RGC 936, RGC 197	The higher green fodder yield was recorded in the Clusterbean *var.* RGC-197 and 936 (16406 kg/ha and 15469 kg/ha) followed by Pearl millet *var*. MH 169 and HHB 67 (15313 kg/ha and 13984 kg/ha)
8.	Silvipastoral system	*Prosopis cineraria, Tecomella undulata, Hardwickia binata, Azadirachta indica, Clorophospermum mopane* and *Acacia tortilis*	*Cenchrus ciliaris*	The maximum green fodder yield of *C.ciliaris* recorded in sole crops (265 q/ha) is followed by *Cenchrus* with *Prosopis* (250 q/ha) and *Tecomella* (219 q/ha)

Agroforestry Systems for Rajasthan

Babul (*Acacia nilotica*) based agroforestry model

Scientific name: *Acacia nilotica*

Suitable intercrops: Pearl millet, Maize, Sorghum, Groundnut, Black gram and Green gram

Economic returns: *Acacia nilotica* over sole herbaceous crop vary from Rs. 6,250 to Rs. 7,700 per hectare. This agroforestry system provides both economic and ecological benefits.

Source: ICFRE- Arid Forest Research Institute (2016)

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: Soybean, Pulses, Wheat, Mustard and Barley and Perennial (Napier hybrid grass)

Tree productivity: Timber yield of 100 m^3 ha^{-1} and biomass of 210 t^{-1} 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).

Khejri (*Prosopis cineraria)* based agri-silvicultural system

Scientific name: *Prosopis cineraria*

Suitable intercrops: Pearl millet

Fuelwood productivity: Fuelwood yield from Khejri ranged from 20.50 to 21.02 kg tree

Economic returns: The Khejri-based model with a B:C ratio of 2.02, significantly benefits farmers by enhancing profitability and sustainability.

Source: Kaushik *et al*. (2020)

Ailanthus based agri-silvicultural system

Scientific name: *Ailanthus excelsa* Roxb.

Suitable Spacing: 5 x 5 m under rainfed conditions and as a block and boundary plantation the spacing should be 3 x 3 m

Suitable intercrops: Green gram, cluster bean and cowpea

Tree productivity: Timber volume: 944.2 cubic feet/ha; Fuel wood: 10834 kg/ha

Economic returns: The highest net return from Ardu intercropping with green gram was Rs. 76,024/ha, surpassing both sole cropping and other agri-silvi systems. However, the benefit-cost ratio (B:C ratio) from sole Ardu was greater at 8.53 compared to the Ardu + green gram system.

Source: Handa *et al.* (2020).

Anjan (*Hardwickia binata*) based agroforesty model

Scientific name: *Hardwickia binata*

Suitable intercrops: Green gram

Economic returns: Age of tree 7-8 years old *H. binata* yields 1.0-1.5 kg of dry fodder and 1.0-2.0 kg of fuel wood per tree.

Source: ICFRE-Arid Forest Research Institute (2016)

Bakain (*Melia azedarach)* based agri-silvicultural system

Scientific name: *Melia azedarach*

Suitable intercrops: Foxtail millet

Economic returns: The net return from the model is Rs. 50,000 per hectare (tree age 3-4 years).

Source: 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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