

Module - II

2026
2020

The Science of Forest Cultivation

FORESTRY

Paper - 1

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Section - A

Indian Forest Service (Main) Exam



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FORESTRY

Module – 2



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SYLLABUS



Indian Forest Service (IFoS) [Paper 1 Section A]	Mangrove : ♦ Habitat and characteristics of mangrove ♦ Plantation – establishment, and rehabilitation of degraded mangrove formations. ♦ Silvicultural systems for mangrove; ♦ Protection of habitats against natural disasters. Cold Desert – Characteristics, identification and management of species. Silviculture Systems : ♦ Clear felling, Uniform shelter wood, Selection, Coppice and Conversion systems. ♦ Management of silviculture systems of temperate, subtropical, humid tropical, dry tropical and coastal tropical forests with special reference to plantation silviculture, choice of species, establishment and management of standards, enrichment methods, technical constraints, intensive mechanized methods, aerial seeding, and thinning. Silviculture of Trees : ♦ Traditional and recent advances in <u>tropical silvicultural research and practices</u>. ♦ Silviculture of some of the economically important species in India such as <i>Acacia catechu</i>, <i>Acacia nilotica</i>, <i>Acacia auriculiformis</i>, <i>Albizia lebbek</i>, <i>Albizia procera</i>, <i>Anthocephalus Cadamba</i>, <i>Anogeissus latifolia</i>, <i>Azadirachta indica</i>, Bamboo spp., <i>Butea monosperma</i>, <i>Cassia siamea</i>, <i>Casuarina equisetifolia</i>, <i>Cedrus deodara</i>, <i>Chukrasia tabularis</i>, <i>Dalbergia sissoo</i>, <i>Dipterocarpus spp.</i>, <i>Emblica officinalis</i>, <i>Eucalyptus spp.</i>, <i>Gmelina Arborea</i>, <i>Hardwickia binata</i>, <i>Lagerstroemia Lanceolata</i>, <i>Pinus roxburghii</i>, <i>Populus spp.</i>, <i>Pterocarpus marsupium</i>, <i>Prosopis juliflora</i>, <i>Santalum album</i>, <i>Semecarpus anacardium</i>, <i>Shorea robusta</i>, <i>Salmalia malabaricum</i>, <i>Tectona grandis</i>, <i>Terminalia tomentosa</i>, <i>Tamarindus indica</i>.
Indian Forest Service (IFoS) [Paper 1 Section B]	Agroforestry : ♦ Scope and necessity; role in the life of people and domestic animals and in integrated land use, planning especially related to (i) soil and water conservation; (ii) water recharge; (iii) nutrient availability to crops; (iv) nature and eco-system preservation including ecological balances through pest-predator relationships and (v) Providing opportunities for enhancing biodiversity, medicinal and other flora and fauna. ♦ Agroforestry systems under different Agro-ecological zones; Selection of species and role of multipurpose trees and Non-Timber Forest Products (NTFPs), techniques, food, fodder and fuel security. ♦ Research and Extension needs. Social / Urban Forestry – Objectives, scope and necessity; People's participation.
Other state PSC exams also have similar syllabi to the IFoS exam, such as the Uttar Pradesh PSC State Forest Service [Paper 1, Section A]; Odisha PSC State Forest Service (Main) Examination [Paper 1 Section A]; Jharkhand PSC State Forest Service (Main) Examination [Paper 1], Maharashtra PSC State Forest Service Examination [Unit – 1],	

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INDIAN FOREST SERVICE (IFoS) PYQs | 2010 – 2025

Mangroves & Cold desert

2025	- Write the Scientific names and uses of eight mangrove species [P1/1(c) 8 M]. - Describe the habitats and characteristics of mangroves. Discuss their ecological values [P1/3(b) 15 M]. - Write the major characteristics of cold deserts. Describe two cold deserts of India. [P1/4(a) 15 M].
2024	- Briefly summarize the Characteristic Features of cold arid forest vegetation. Discuss their mechanism of survival under extreme cold temperatures [P1/1(b) 8 M]. - Write in brief on the current scenario of the growth pattern of cold desert areas in India. Describe in detail, the Causes of Desertification in cold areas. Suggest suitable restoration plan [P1/2(b) 15 M]. - What is the Status of Mangrove Forests in India? How are they associated with the sustainability of coastal areas? Enumerate the list of challenges faced by mangroves [P1/4 (a) 15 M].
2023	- What are mangroves? Write their ecological implications [P1/1(c) 8 M]. - What are the sequences of operations followed in mangrove afforestation? Discuss in detail the Fishbone Technique of mangrove plantation [P1/3(b) 10 M]. - What is a cold desert? Describe the Distribution Pattern of cold desert species in India. How are cold desert areas afforested? [P1/4(a) 15 M].
2022	- What are the Major Threats to mangrove forests? [P1/1(b) 8 M]. - Describe the Characteristics of Cold Desert. How does choice of species play an important role in cold desert afforestation programme? How are cold desert areas afforested? [P1/2(b) 15 M]. - Is coastal Rehabilitation using mangrove species a success? Explain the plantation technique for degraded mangrove forest [P1/3(c) 10 M].
2021	- Why is it difficult to carryout Afforestation Programmes in cold deserts? [P1/1(a) 8 M]. - What is the Ecological Significance of cold deserts? How do plants adapt and survive under cold and harsh desert conditions? Provide a list of common native species of a cold desert [P1/2(a) 15 M]. - What are the Characteristics and Significance of mangrove forests? Discuss important species formation in mangrove forests [P1/3(b) 15 M].
2020	- Write the adaptive Characteristics of plant species of cold desert [Linked Q P1/1(d) 8 M]. - Describe the Reforestation Techniques of mangrove forests. Explain the following mangrove habitats : (i) Deltaic mangrove habitat, (ii) Coastal mangrove habitat [P1/2(b) 15 M]. - Describe the various causes of Degradation of mangrove forests. Discuss the factors responsible for mangrove species regeneration and growth. Write the scientific names of five woody shrubs/tree species of cold desert [P1/4(c) 15 M].
2019	- What are the Major Causes of Degradation of mangrove forest? Discuss in brief the methods of rehabilitation of degraded mangroves. [P1/3(c) 15 M]. - What are the Characteristic Features of cold deserts of the Himalayas? Write the scientific names of <i>any 5 tree species</i> of cold desert. [P1/2(b) 10 M].

2018	Define the Characteristics of mangrove forest [P1/1(d) 8 M].
2017	- Describe the unique Characteristics of mangrove forest vegetation. [P1/4(a) 10 M]. - Enlist 6 Genera of Mangroves. Name 2 state and 1 UT with the large area under mangrove forest. [P1/1(d) 8 M]. - Where are cold desert found in India? explain Site Characteristics of cold desert and stem suggested to overcome problems in their afforestation. [P1/3(a) 10 M]. - A soil can be wet, yet Physiologically Dry. How? What steps are suggested to correct the problem? [P1/3(a) 10 M].
2016	- Write in details the term Girdling and Pruning. Write the Scientific name of 5 trees / shrubs each for the cold desert and mangrove forest. [Linked Q P1/4 (a) 20 M]. - Write the Characteristics of cold desert. Discuss soil working and planting techniques for cold desert. [Linked Q P1/1(d) 8 M].
2015	- Discuss the Sustainable Management of mangrove forest in India [P1/1(e) 8 M]. - How is the accrual of Tangible and Intangible benefits of mangroves forest being affected by their degradation? [P1/2(d) 10 M]. - Give the scientific name of – (a) 5 species of mangrove forest, (b) Five tree/Shrub species of the cold desert [P1/3(c) 10 M]. - Comment upon the adaptation and Survival Strategies of the plant species endemic to the cold desert area of the western Himalaya. [P1/4(c) 10 M].
2014	- Discuss the Characteristics of mangrove forest with examples [P1/5(e) 8 M]. - Describe the following – (a), (b) Fish Bone Technique [P1/6(b) 2.5 M]. - Discuss the importance of Willow Cultivation in cold desert [P1/5(c) 8 M].
2013	- Explain the following mangrove habitat [P1/1(d) 8 M]. (a) Deltaic mangrove habitat (b) Coastal mangrove habit (both east & west) - Write about the species diversity and centre of origin of Willows (<i>Salix</i> species). Describe its various uses under short rotation forestry. [P1/5 (c) 8 M]. Willow is the life line in dry temperate region (Lahul-Spiti) but its large-scale drying is causing great concern. Give your viewpoints. [P2/8(c) 8 M].
2012	How are the mangrove forest managed in India? [P1/1 (c) 5 M].
2011	- Suggest measures to Rehabilitate degraded mangroves forest. [P1/1 (c) 10 M]. - Define a forest types, Discuss the different Forest Types found along tidal swamp forest with their species composition. Give a note on how <i>rhizophora racemosa</i> in mangroves is managed in mangrove forest of Sundarbans. [P1/3 (a) 3+12+5 = 20 M].
2010	- Comment on - Mangrove ecosystems have Physiologically Dry soil [P1/4 (a) ii 5 M]. - Give the Zonation of Land-Sea interface in a typical mangrove eco-system with its characteristics [P1/1 (d) 5 M]. - How and why should cold desert forest ecosystem be conserved? [P2/7(c) 10 M].

Silviculture Systems

2025	- Describe the felling pattern adopted under uniform system. [P1/1(b) 8 M]. - Describe the methods of regeneration followed under clear felling system with suitable examples. [P1/2(b) 15 M]. - Write the advantages of simple coppice system and coppice with standard system [P1/2(c)i 5]. - Differentiate between coppice of two rotations system and shelterwood coppice system. [P1/2(c)ii 5 M]. - Explain any two of the following : (i) Periodic blocks, (ii) Felling cycle, (iii) Felling series, (iv) Taungya [P1/4(c) 10 M].						
2024	- What is Conversion in silvicultural systems? Explain with two examples [P1/1(e) 8 M]. - Describe the following [P 1/2(a) 15 M]. <table border="0"> <tr> <td>(i) Regeneration felling</td><td>(iv) Secondary Felling</td></tr> <tr> <td>(ii) Felling Series</td><td>(v) Felling Cycle</td></tr> <tr> <td>(iii) Seedling Felling</td><td></td></tr> </table> - Give a detailed account of Indian Irregular Shelterwood System and its applications [P1/3(b) 15 M].	(i) Regeneration felling	(iv) Secondary Felling	(ii) Felling Series	(v) Felling Cycle	(iii) Seedling Felling	
(i) Regeneration felling	(iv) Secondary Felling						
(ii) Felling Series	(v) Felling Cycle						
(iii) Seedling Felling							
2023	- What are Accessory Systems? Describe the two-storeyed high forest system [P1/2(c) 10 M]. - Who developed the Andaman Canopy Lifting Shelterwood System? Describe the different operations being followed in the system. [P1/3(c) 15 M]. - What is Clear Felling System? Describe the pattern of felling and methods of obtaining regeneration under clear felling system. [P1/4(b) 10 M].						
2022	Improvement Felling is not considered as a silvicultural system. Why? [P1/1(a) 8 M]. - Differentiate between Coppice with Standards and Coppice with Reserves. Explain in detail the coppice with two rotations and pollard system [P1/2(a) 15 M]. - Explain the following – (a) Selection felling, (b) Regeneration felling, (c) Selective felling, (d) Enrichment planting [P1/2(c) 10 M].						
2021	‘An appropriate silviculture system promotes better regeneration of forest stand’ Comment. [P1/1(c) 8 M]. - Elucidate the pattern of felling and mode of regeneration adopted under Selection System of management [P1/2(c) 10 M]. - What are the conditions on which the Choice of a Particular Silvicultural System to be adopted for specific species in any locality depends? [P1/4(a) 15 M].						
2020	- Explaining the factors which affect the Length of Regeneration Period in a periodic block [P1/1(c) 8 M]. - Define Coppice with Standard system. What are the advantages and disadvantages? Differentiate it from Coppice with Two Rotation System. [P1/3(b) 15 M]. - Enumerate the objectives of Management of Canal Plantations. Explain the silviculture system to manage them. [P1/4(b) 15 M].						
2019	- Write the special characteristics of Indian Irregular Shelterwood System and differentiate it from Uniform System. [P1/2(a) 15 M]. “Felling height and felling intensity play a major role in the advantages sustainability of clumps of bamboo species” Comment. [P1/3(a) 10 M]. - Explain the Alternative Strip System and the clear strip system. Write the advantages and						

	disadvantages of clear-felling system. [P1/3(b) 15 M].
2018	- Enlist the Classification of Silvicultural Systems on the basis of mode of regeneration and pattern of felling. [P1/2(b) 15 M]. - What is Conversion? Discuss the need of conversion of one silvicultural system to another [P1/4(a) 15 M].
2017	Enlist the general rules governing the Felling of Bamboo in forests. What are the consequences of gregarious flowering of bamboo? What special measures would you take in the event of gregarious flowering? [P1/3(c) 15 M].
2016	- Define Clear Felling System. How is Saranda Sal (<i>Shorea robusta</i>) forest managed under clear felling followed by natural regeneration? [P1 / 1(e) 8 M]. - Describe the silvicultural system which may be introduced to manage a plantation forest of <i>Azadirachta indica</i> [P1 / 2(a) 20 M]. - Discuss in brief the Simple Coppice System. Write different types of Coppice System [20 M]. - Describe kinds and pattern of fellings followed in Shelterwood Uniform System. Explain Uniform System which is followed to manage (<i>Pinus roxburghii</i>) forests of Himachal Pradesh [P1/3(b) 20 M].
2015	- Describe the major factors which affect the Length of the Regeneration period in a Periodic Block [P1/1(b) 8 M]. - Comment upon the variations practised in the silvicultural system of <i>Shorea robusta</i> in the States of UP, Bihar, Odisha and West Bengal [P1/1(c) 8 M]. - How can a forest with shade bearer and light demander tree species be managed under Uniform Shelterwood System? [Linked Q P1/2(c) 10 M]. - Describe the silvicultural system which is introduced to manage <i>Shorea robusta</i> forest after the failure of Uniform System [P1/3(b) 10 M]. - How is <i>Tectona grandis</i> forest managed under Clear Felling followed by Artificial Regeneration? [P1/4(b) 10 M].
2014	- Discuss the Uniform System with artificial regeneration [P1/3(c) 10 M]. - Explain the forest conversion process of Coppice System to Uniform broad-leaved high forest by natural regeneration [P1/6(a) 20 M]. - Discuss Two Stories High Forest and explain its advantages [P1/7(b) 10 M].
2013	- Explain the factors which affect the Length of Regeneration Period in a Periodic Block. What is the effect of regeneration period on the form of crop? [P1/1(e) 8 M]. - How is allotment of areas made in Permanent and Floating Periodic Blocks? [P1/3(a) 10 M]. - Describe the method followed to introduce the Uniform Shelterwood System in a forest where <i>Cedrus deodara</i> is mixed with <i>Pinus wallichiana</i> [P1/3(b) 10 M]. - Write about the impact of Felling Height and Felling Intensity on the sustainability of bamboo's clump [P1/3(c) 10 M].
2012	- Successful regeneration in a forest depends upon silvicultural System [P1/1(d) 5 M]. - How will you classify a silvicultural system? Discuss important features of Uniform System with reference to <i>Pinus roxburghii</i> and give its merits and demerits [P1/2(a) 4+8+4 = 16 M]. - briefly describe the Clear-Felling Silvicultural System with particular reference to – (a) Nature of crop produced, (b) Felling system, (c) Tending, (d) Regeneration, (e) Advantages and disadvantages [P1/4(b) 10 M].

2011	- Define forest Conversion. Explain the adverse situations under which conversion is advisable. Write in brief the general techniques of forest conversion [P1/2(a) 2+4+4 = 10 M]. - Briefly describe the selection system with particular reference to the following - (i) Character of crop produced, (ii) Felling cycle, (iii) Tending, (iv) Regeneration, (v) Advantages and disadvantages [P1/2(c) 2 × 5 = 10 M].
2010	- Briefly discuss a silvicultural system in which equal or equi-productive areas of mature crops are successfully felled [P1/1(b) 5 M]. - Successful regeneration in a forest stand depends upon judicious choice of a silviculture system. Comment [P1/2(d) 10 M]. - Comment upon, “Conversion” is an accepted silvicultural system [P1/4(a) iv 5 M].

Important Tree Species

2025	- Discuss the silvicultural characters of <i>Acacia nilotica</i> and <i>Cedrus deodara</i>. [P1/1(d) 8 M]. - Give the phenological characters of <i>Tectona grandis</i> and <i>Albizia lebbek</i>. [P1/1(e) 8 M]. - Write the distribution and economic importance of <i>Dalbergia sissoo</i> and <i>Emblica officinalis</i>. [P1/3(c) 10 M]. - Describe the regeneration of the following tree species : (i) <i>Shorea robusta</i>, (ii) <i>Azadirachta indica</i>, (iii) <i>Hardwickia binata</i>. [P1/4(b) 15 M].
2024	- Elucidate the phenology, silvicultural characters and artificial regeneration of Bamboos [P1/1(a) 8]. - Write in detail the distribution and importance of <i>Prosopis juliflora</i> and <i>Emblica officinalis</i> [P1/1(d) 8 M]. - Write the economic importance of the following tree species [P1/3(a) 15 M]. (i) <i>Salmalia malabarica</i> (ii) <i>Acacia nilotica</i> (iii) <i>Lagerstroemia lanceolata</i> (iv) <i>Pterocarpus marsupium</i> (v) <i>Chukrasia tabularis</i> - Discuss the distribution and regeneration of <i>Cedrus deodara</i> and <i>Pinus roxburghii</i> [P1/4(c) 10 M].
2023	- The shoot portion of seedlings of some tree species like <i>Sal</i> and <i>Sandal</i>, under natural regeneration, keeps on drying year after year but the roots remain alive. Discuss [Linked Q P1/1(a) 8 M]. - Write the factors which affect the natural regeneration of <i>Sal (Shorea robusta)</i>. Discuss the procedure to obtain natural regeneration of moist <i>Sal</i> forests [Linked Q P1/2(b) 15 M]. - Write the economic importance of the following tree species [P1/3(a) 15 M]. (i) <i>Acacia catechu</i> (ii) <i>Casuarina equisetifolia</i> (iii) <i>Hardwickia binata</i> (iv) <i>Butea monosperma</i> (v) <i>Tamarindus indica</i>
2022	Explain the techniques for the upgradation and hardening of nursery seedlings of <i>Lagerstroemia lanceolata</i> [Linked Q P1/1(d) 8 M].
2021	Discuss the phenology, Silvicultural characters and regeneration methods of – (i) <i>Gmelina arborea</i>, (b) <i>Pinus roxburghii</i>. [P1/2(b) 15 M].

	Elucidate the distribution, Nursery techniques and economic importance of – (i) <i>Cedrus deodara</i>, (ii) <i>Acacia catechu</i>, (iii) <i>Casuarina equisetifolia</i>. [P1/4(b) 15 M].
2020	- Describe the methods of artificial regeneration of <i>Tamarindus indica</i> [Linked Q P1/1(e) 8 M]. - Give a brief account of the silvicultural characters and regeneration methods for the following species - (a) <i>Acacia catechu</i>, (b) <i>Populus deltoides</i> [P1/2(c) 15 M].
2019	- Write a brief account of the phenology, silvicultural characters and methods of regeneration of <i>Dalbergia sissoo</i> [P1/1(a) 8 M]. - Discuss in details silviculture of <i>Albizia lebbbeck</i> [P1/2(c) 15 M]. - Give a brief account of origin and natural distribution of the following - (a) <i>Adina cordifolia</i>, (b) <i>Cedrus deodara</i> and (c) <i>Santalum album</i> [P1/4(c) 15 M].
2018	- Discuss the physiology of <i>root parasitism</i> in Sandal Tree (8M). [P1/1(e) 8 M]. - Write the <i>phenology</i> of the following (5M) – (a) <i>Tectona grandis</i>, (b) <i>Melia dubia</i>, (c) <i>Shorea robusta</i>, (d) <i>Cedrus deodara</i> [P1/3(b)i 5 M]. - Can climate-change change the period of phenology? Share with examples [P1/3(b)ii 5 M]. - Give the <i>silvicultural characteristics</i> and <i>economic importance</i> of the following [P1/4(b) 10 M]. (a) <i>Azadirachta indica</i> (b) <i>Acacia catechu</i>
2017	- Describe the natural distribution of – (i) <i>Shorea robusta</i>, (ii) <i>Azadirachta indica</i> [P1/2(a) 10 M]. - Write silvicultural characters of – (i) <i>Casuarina equisetifolia</i>, (ii) <i>Abies pindrow</i> [P1/2(b) 10 M].
2016	Describe in brief the distribution, phenology, silvicultural characteristics, artificial regeneration and uses of the following species - (a) <i>Tectona grandis</i> (2) <i>Santalum albus</i> [P1/4(b) 20 M].
2015	- Explain how the knowledge about the silvicultural characteristics of a tree enables us to manage the species in a better way [P1/1(d) 10 M]. - Describe in brief the phenology, silvicultural characteristics and artificial regeneration of the following tree species – [P1/2(b) 10 M]. (a) <i>Pinus roxburghii</i>, (b) <i>Cedrus deodara</i>, (c) <i>Albizia lebbbeck</i> - Briefly Describe the silviculture characters and natural regeneration of the following – (a) <i>Dendrocalamus hamiltonii</i>, (b) <i>Acacia auriculiformis</i>, (c) <i>Dalbergia sissoo</i> [P1/3(d) 10 M].
2013	Write critical notes on – (ii) Importance of <i>Butea monosperma</i> [P2/8(b) ii 2.5 M].
2012	- Give distribution, phenology, method of regeneration and brief silvicultural management of two tree species belonging to each family below - (a) <i>Meliaceae</i> (b) <i>Papilionaceae</i>, grown in India [P1/2(b) 4 x 4 = 16 M]. - Discuss in brief the <i>silviculture</i> of the following species - (a) <i>Shorea robusta</i> (b) <i>Bamboo species</i> [P1/4(c) 2 x 4 = 8 M]. - Describe the economic importance of <i>Acacia nilotica</i>, <i>Terminalia belerica</i>, <i>Vitex negundo</i> and <i>Madhuca latifolia</i> in detail [P1/7(d) 10 M].
2011	- Describe the silvics of <i>Tectona grandis</i> under the following heads [P1/4(a) 5 x 4 = 20 M]. (a) Distribution and morphology, (b) Silvicultural characters, (c) Silvicultural system and management, (d) Utilization. - Describe the silvics of <i>Casuarina equisetifolia</i> under the following heads [P1/4(b) 5x4 = 20 M].

	(a) Ecology and distribution, (b) Propagation and management, (c) Functional uses, (d) Pests and disease.
2010	“Indian Sandalwood (<i>Santalum album</i>) is the most valuable wood in India. However, silvicultural production of this species is not satisfactory.” Discuss the above in relation to the phenology of <i>Santalum album</i> and the forest laws governing its cultivation and trade [P1/3(b) 20 M]. - Give climatic requirement, rotation age, spacing, tending operations and yield of the following forest species – (a) <i>Populus deltoides</i>, (b) <i>Casuarina equisetifolia</i> [P1/4(b) 10 M].

Agroforestry & Social Forestry

Agroforestry

2025	- Write the scientific names and uses of eight tree species suitable each for temperate and arid climate agroforestry plantations. [P1/5(a) 8 M]. - What are the characteristics of trees suitable for watershed management? [P1/5(b) 8 M]. - Write in brief the following : (i) Objectives of social forestry, (ii) Multipurpose trees and their characteristics. [P1/5(c) 8 M]. - Describe an agroforestry model suitable for hill farming system. How does it increase the productivity of degraded hills? [P1/6(a) 15 M]. - Enumerate the guiding principles to finalize the choice of tree species for afforestation of denuded areas where soil conservation measures are implemented. [P1/7(b) 15 M].
2024	- How is Shifting Cultivation related with tribal society? Is it a good practice or bad, under present situation? Justify your claim [P1/5(c) 8 M]. - What is agroforestry? Elucidate the scope, importance and Role of Agroforestry in climate amelioration [P1/7(a) 15 M].
2023	- Explain the Role of Windbreaks and Shelterbelts in Agroforestry. Name two tree species for each [P1/5(a) 8 M]. - Discuss the role of Agroforestry in the well-being of mankind. [P1/6(a) 15 M].
2022	- How does agroforestry help to achieve the <i>United Nations' Sustainable Development Goals</i>? [P1/5 (a) 8 M]. - What are the differences between Traditional Agroforestry and Ethno-Agroforestry? Explain in brief, below-ground and above-ground, tree-crop interactions in agroforestry systems [P1/6(a) 20 M]. - What are the constraints in the Value Chain under Industrial Agroforestry? [P1/6(b) 10 M].
2021	- How do agroforestry wood perennials protect the understorey crops? [P1/5(e) 8 M]. - How does agroforestry promote the Sustainable Livelihood of marginal farmers? [P1/6(c) 10 M]. - How does Crop Rotation and mixed farming improve soil productivity? [P1/8(b) 15 M].
2020	“Agroforestry system Conserves Soil and Moisture” Justify the statement [P1/5(b) 8 M]. - Write the Tangible and Intangible Benefits of agroforestry. [P1/5(d) 8 M]. “Taungya Cultivation is a type of traditional agroforestry system” Justify the statement [P1/6(b) 15]. - Write the scientific names of any five multipurpose tree species suitable for agroforestry system in (i) Arid and semi-arid and (ii) Sub-tropical Hills of India. [P1/7(c) 10 M]. - How does Shifting Cultivation support community livelihood and biodiversity conservation? [P2/5(a) 8 M].

2019	- Agroforestry is a better land-use system for Climate Change Mitigation and adaptability. Justify. [P1/5(a) 8 M]. - What are Multipurpose Tree Species (MPTs)? explain their role in social forestry [P1/7(c) 10 M].
2018	Write about the Diagnostic and Design Survey of agroforestry. Can it help the farmers in the integration of tree with crops to enhance the crop productivity in agroforestry system? Justify. [P1/6(a) 10 M].
2017	- Discuss the impact of agroforestry practices on the environment in general and on soil properties in particular, with a suitable example. [P1/5(e) 8 M]. - Differentiate between Windbreaks and Shelterbelts. Discuss in brief, their impact on the environment [P1/7(c) 10 M].
2016	- Discuss the role of agroforestry in nutrient cycling and soil conservation. How is saline soil reclaimed? [P1/7(c) 20 M]. - Provide scientific names of four potential NFTs each suitable for Tropical and Temperate conditions [P1/5(c) 8 M].
2015	- Discuss the needs and scope of agro-forestry for the benefits of people [P1/5(a) 8 M]. - Elaborate upon the social Objectives of agroforestry [P1/5(e) 8 M]. - Discuss why Land-Use System is often more appreciated in agroforestry than in pure agriculture [P1/6(a) 10 M]. - The adoption of agroforestry practices by the farming community is the result of increasing human and cattle populations. Discuss [P1/7(a) 10 M]. - Outline the role of Tree Architecture in agroforestry [P1/8(b) 10 M]. - Can you differentiate between the terms mixed plantations in forestry and mixed cropping in agriculture? Justify the differences between them [P2/1(a) 10 M].
2014	- Describe the Benefits and Constraints of agroforestry [P1/1(d) 8 M]. - Why are agroforestry systems becoming Popular in Himalayan Tarai regions, Western plains and Southern parts of India? Discuss your answer with reasons and tree-crop combinations adopted in these regions and parts of the country [P1/8(b) 20 M].
2013	- What are the unique requirements for tree improvement in agroforestry? [P1/5(a) 8 M]. - Elaborate upon the multipurpose tree species ideotype selection criteria [P1/5(c) 8 M]. - Describe tree-crop Allelopathy in agroforestry [P1/5(e) 8 M]. - What are the fundamental bases of Classification of agroforestry systems? [P1/7(b) 10 M].
2012	- Differentiate between the – (i) Agroforestry and Silviculture [P1/3(a) i 5 M]. - How Shelterbelt and Windbreaks are helpful in sand dune stabilization and desert control? [P1/5(a) 5 M]. - Describe the extent, method of cultivation and effects of Shifting Cultivation. Suggest some suitable alternatives to shifting cultivation [P1/5(d) 5 M]. - What do you know about recent progress in Agroforestry Research and development in our country for sustainable development? [P1/5(g) 5 M]. - what is D & D ? Who can make use of D & D and How? [P1/7(a) 10 M].
2011	While selecting the species for agroforestry, the below-ground and above ground interaction between the component species need to be considered. Discuss [P1/5(a) 10 M].

	- Write short notes on – (i) Aquaforestry, (iii) Water Use efficiency, (iv) Home Gardens [P1/6(a) 2 ½ × 3 = 7.5 M]. - Explain the various components of a Hydrological Model for an agroforestry system [P1/6(b) 10 M]. - Compare Nutrient Cycling in a natural forest, an agroforestry system and an agriculture field. Discuss how it helps to sustain soil fertility [Linked Q P1/7(a) 10 M].
2010	<i>Acacia Catechu</i> and <i>Prosopis juliflora</i> have emerged as important species for marginal lands. Discuss briefly [P1/1(h) 5 M]. - Differentiate between the following – (i) Shelter Belts and Wind Breaks [P1/3(a) 4 M]. - What is integrated land use management? Give a plan of integrated land use management for 10 ha. of land in tropics and sub-tropics parts of India [P1/6(b)ii 10 M]. - Comment on the needs of Research in Agroforestry in India [P1/7(b)ii 5 M]. - Write short notes on - Diagnosis and Design in Agroforestry [P1/5(c) 5 M].

Social Forestry

2025	Write in brief the following : (i) Objectives of social forestry, (ii) ____ [P1/5(c) 8 M].
2024	What do you mean by Urban Forestry? Discuss the choice of species for environmental conservation in these areas. [P1/5(a) 8 M].
2022	Discuss the key problems to expand tree cover in urban areas. Explain the role of urban trees in abating soil pollutants [P1/8(a) 15 M].
2021	- Discuss the problem of commons in social forestry. Suggest some effective strategies to overcome these problems [P1/6(b) 15 M]. - What factors are considered important while choosing a species under Avenue Plantation? [P1/1(b) 8 M].
2019	Briefly describe the Aim, Objectives and Scope of urban forestry in India. [P1/5(b) 8 M].
2018	What is Farm Forestry? Write about the objectives, difficulties and financial return from the farm forestry [P1/8(c) 10 M].
2017	Explain the scope and aims of Urban forestry. Discuss the need of urban forestry in the improvement of city environment [P1/6(b) 20 M].
2016	Briefly discuss aims, objectives and scope of social forestry. Why is people's participation must in social forestry? [P1/8(b) 10 M].
2012	How social forestry differs from other types of forestry? [P1/1(f) 5 M].
2011	Management challenges in the urban forestry are unique as compared to other social forestry programs. Discuss [P1/6(c) 10 M].
2010	- Write Short notes on – (a) Management of urban forestry [P1/5(a) 5 M]. - Discuss the following – (iv) Drawback of social forestry programs in India [P1/6(a) iv 5 M].

This module also covers questions from **Gujarat** PSC ACF/RFO (Main) 2024 (held on 28/01/2026), **Jharkhand** PSC RFO (Main) 2024 (held on 24/01/2026), **UKPSC** ACF/RFO/Logging Officer (Mains) 2025 (held on 26/11/2025), **Maharashtra** PSC ACF/RFO (Main) 2024 (held on 14/05/2025), and **Kerala** PSC RFO (Main) 2022 (held on 05/05/2025).

MANGROVES

Mangroves form the coastal and estuarine *wetland ecosystems* in the tropical and subtropical regions of the world. This unique *intertidal ecosystem* acts as a safeguard to the coastlines from the disasters of cyclones, tsunamis, and storm surges. They are one of the most productive and biologically complex ecosystems on earth, providing critical *ecosystem services* including coastal protection, carbon sequestration, fisheries support, and biodiversity conservation.

► Mangroves are a diverse group of *salt-tolerant (Helophytic) evergreen plant communities* found in the *tropical* and *subtropical coastal* and *intertidal zone* of the world, occurring mainly between *latitudes 24°N and 32°S*.

1.1 HABITAT

Mangroves inhabit the *intertidal zone* of coastal and estuarine mudflats, where unique environmental conditions create a highly specialised habitat

- Diurnal **tidal inundation** of marine water, making the soil loose, very wet, salty, and low in oxygen (*anaerobic*) = *Redox reaction sequence*.
- The soil **lacks available minerals** like nitrogen (N), phosphorus (P), potassium (K), iron (Fe), and sulfur (S) due to *leaching* and anaerobic conditions.
- Area experiences **strong winds** from *cyclones and tsunamis*.
- The temperature ranges from **25-35°C**, and there is **1000 to 3000 mm of rainfall** annually.
- **Rich biodiversity** because of the edge effect (ecotone between terrestrial and marine ecosystems).
- **Salt spray**

1.2 DISTRIBUTION

Mangrove distribution is primarily controlled by three factors : ① *Temperature* — Determines latitudinal limits, ② *Tidal regime* — Determines species zonation; ③ *Salinity* — Salt excluder/excreter strategy determines species composition.

Chapter Outline

- 1.1 Habitat
- 1.2 Distribution
- 1.3 Characteristics of mangroves forest
 - ✿ Salt regulation mechanism
 - ✿ Pneumatophores.
 - ✿ Vivipary
- 1.4 Zonation of vegetation
- 1.5 Mangroves forest classification
 - ✿ Littoral / Tidal
 - ✿ Deltaic / Coastal
- 1.6 Importance of Mangroves
- 1.7 Threats to Mangroves
- 1.8 Mangroves conservation
 - ✿ Why afforestation failed?
 - ✿ How manage sustainably
- 1.9 In News
- 1.10 Exercise

IFoS 2024 : What is the *Status of Mangrove Forests* in India? ____ [15 M].

IFoS 2017 : Enlist 6 genera of mangroves. Name 2 state and 1 UT with the large area under mangrove forest [8 M].

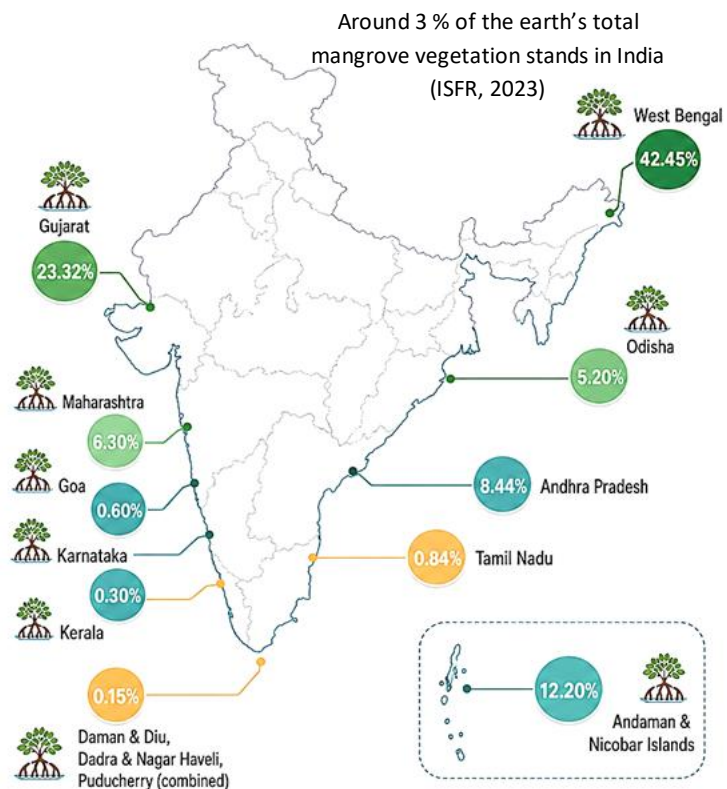
[Also, in OPSC Civil (Main) 2018, 2019].

INDIA

Approximately **4992 km²**, which is 0.15% of the country's total geographical area and about **3% of global** mangrove cover. **Very Dense mangrove** comprises 1464 sq. km ($\approx 29.4\%$) of the total mangrove cover, **Moderately Dense mangrove** is 1500 km² (30%), while **Open mangroves** constitute an area of 2028 km² ($\approx 40.6\%$). There has been a net **decrease** of 7.43 km² in the country's mangrove cover compared to the 2021 assessment. There is a prominent decrease of 36 km² in Gujarat [ISFR, 2023].

STATE/UTS-WISE

West Bengal = 2114 km² (42.5 % of total in India) > Gujarat = 1163 km² (23.3 %) > A & N = 608 km² (12.5 %).



✎ **South 24 Parganas** district of **West Bengal** alone accounts for **41.75 % Mangrove cover** of the country.

✎ Bhitarkanika (Odisha) = India's 'Mangrove Genetic Paradise'

Why does the **eastern coast** of India support a **more extensive mangrove** cover than the western coast, despite being more prone to **cyclones, storm surges** and **tsunamis**? Explain.

India holds approximately 5,000 km² of mangrove cover, of which **57% lies on the east coast**, 30% on the west coast, and 12.5% on the Andaman & Nicobar Islands. In terms of biodiversity, the east coast supports **40 species**, Andaman & Nicobar **38 species**, while the west coast has only **27 species**. This asymmetry persists despite the east coast being far more cyclone-prone — a paradox explained by the following factors :

- **Coastal Geomorphology — Emergence vs. Submergence** : The east coast is an **emergent coast**, characterized by gradual **shallow slopes**, a **wide nutrient-rich continental shelf**, **flat river deltas**, and **lagoons**. **Year-round river silt** deposition creates **nutrient-rich mudflats** ideal for mangrove colonization. The west coast, by contrast, is a **submergent coast** — down-faulted terrain with a narrow, steep, rocky shoreline and rift-valley rivers that form no deltas, no mudflats, and consequently support no significant mangrove growth.
- **Salinity and Brackish Water Zones** : The Bay of Bengal maintains **optimal brackish salinity (10–25 ppt)** due to massive freshwater river discharge — the lowest surface salinity of any tropical ocean. The Arabian Sea, with higher evaporation and fewer river inputs, remains **hypersaline (35–36.5 ppt)**, restricting west-coast mangroves to stunted, salt-tolerant species such as **Avicennia marina**.
- **Cyclones as Ecosystem Engineers** : Cyclones are not merely destructive — for mangroves they act as **fertilizers and dispersal agents**. Storm surges deposit phosphorus-rich mineral sediment at 6–14 times the normal annual rate, boosting soil nutrients and tree productivity. Cyclone currents also disperse **viviparous propagules** (buoyant mangrove seeds) into new territories, enabling colonization. Post-cyclone forest recovery typically occurs within **5–10 years** — well within cyclone return intervals — making disturbance ecologically beneficial over the long term.
- **Wave Energy, Tidal Dynamics, and Sediment Retention** : The **Bay of Bengal** has **lower wave energy** than the Arabian Sea, allowing fine sediment to accumulate and propagules to establish. The **Arabian Sea's high wave energy**, driven by strong southwest monsoon winds, continuously erodes shorelines and prevents sediment deposition — a critical

- **Nursery-Raised Seedling Transplantation** : Propagules are germinated in beds, raised to 30-60 cm height in poly-bags or specialised mangrove tubes (perforated HDPE sleeves that allow aeration), then out-planted at 1-2 m spacing after site preparation. Higher establishment cost is offset by 15-20 percentage-point higher survival relative to direct sowing. Essential for species with **recalcitrant** or **cryptoviviparous** propagules (*Bruguiera*, *Ceriops*, *Xylocarpus*).
- **Raised-Bed / Mound Plantation** : On poorly drained, over-saline or waterlogged soils, planting mounds (30-50 cm high) are raised to improve rhizosphere aeration and leach salts. Used extensively in Gujarat's Gulf of Kachchh and parts of the Kerala backwaters.
- **Fish-Bone (Herringbone) Channel Plantation** : A **central feeder canal** is excavated in the **direction of the prevailing tides**, with lateral **branches canals fan out** at $\approx 30^\circ$ angles, producing the eponymous **fish skeleton** pattern. High tide flushes the channel network, leaches accumulated salts and distributes propagules; seedlings are planted on the embankments.

Advantages of this method

- It prevents soil erosion by allowing the easy entry and exit of marine water and by distributing tidal forces more evenly.
- Water reaches every part of the area during high tide.

In Odisha's **Bhitarkanika**

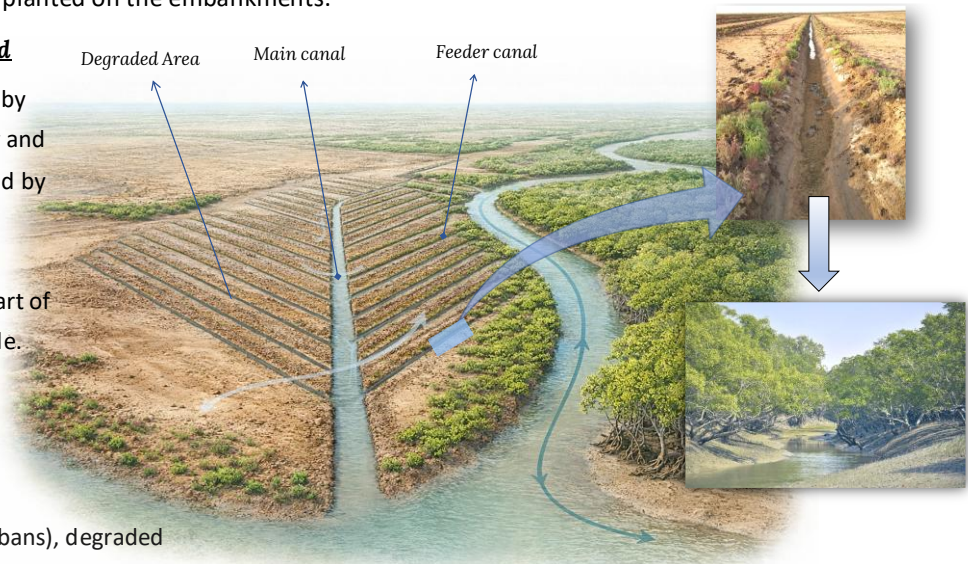
National Park (India's

second-largest mangrove

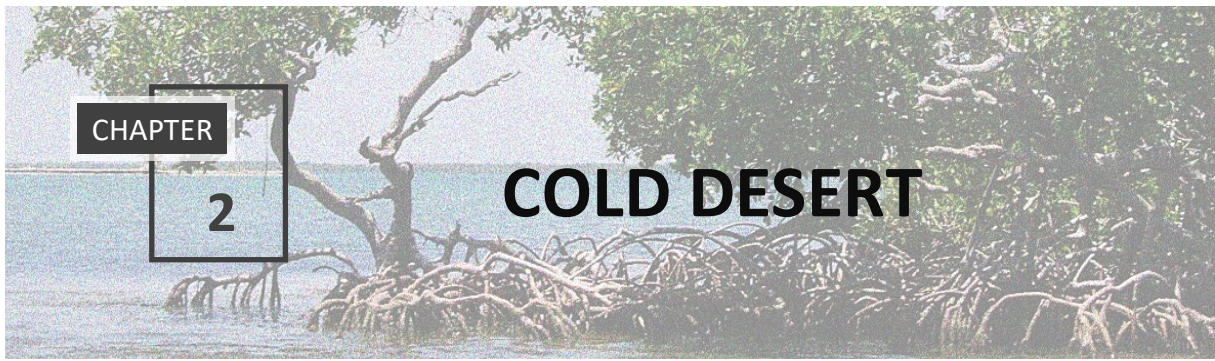
formation after the Sundarbans), degraded

salt flats invaded by *Prosopis juliflora* were reclaimed by first removing the invasive, then constructing fish-bone channels, and finally planting $\approx 20,000$ saplings across ≈ 100 ha of *Avicennia marina*, *Avicennia officinalis* and *Excoecaria agallocha*. The same technique has been successfully deployed in the Krishna-Godavari delta (Andhra Pradesh) and Pichavaram (Tamil Nadu).

- **Snake Method (Restoration through Sinuous Meandering Canals)** : A **hydrological restoration technique** in which artificially excavated canals are designed in a sinuous, meandering form to replicate the behaviour of natural tidal creeks in mangrove ecosystems. Since mangrove distribution is primarily regulated by tidal hydroperiod, salinity regime, sediment dynamics, and micro-relief, straight-line drainage channels often fail to recreate the ecological conditions required for long-term restoration. In contrast, meandering canals reduce flow energy, encourage sediment settling, generate elevation heterogeneity, and facilitate natural species zonation. Thus, the snake method is considered ecologically superior in sites where restoration depends on re-establishing near-natural tidal hydrology.



- **Aerial Seeding** : Propagules of *Avicennia alba* and *Avicennia officinalis* are dispersed by **aircraft** or



Cold desert — also known as the **temperate desert** — is a **high-altitude rain-shadow arid zone** ecosystems, where **Extreme cold**, **Aridity**, **rugged barren topography**, **desiccating Katabatic winds** and **stunted vegetation** together produce a **physiologically dry habitat**. Although moisture may be present in frozen form, it remains unavailable to plants for much of the year. As a result, vegetation is **sparse**, **xerophytic**, and highly adapted to low temperature and water stress.

- Compressed altitudinal zonation.
- Cryoturbation.
- The narrow pioneer–climax sequence.

Here, the climate and soil are hostile to plant growth, and the land is largely barren except for isolated, scattered, and often overgrazed shrubs and cushion herbs.

Strategic importance ?

cold deserts are **water towers of Asia** — source catchments for the Indus, Sutlej, Beas, rivers — host critical **biodiversity** (Snow leopard, Chiru), carry significant **blue-carbon equivalents** in alpine peat and permafrost, and occupy India's most sensitive **border security zone** along the LAC with China.

2.1 DISTRIBUTION

India's cold deserts span ≈3% of the country's geographical area across the **Trans-Himalayan** zone and **Inner Dry Valleys**.

Distribution is controlled by three factors :

- ① **Altitude** — determines the lower thermal limit,
- ② **Rain-shadow geometry** — determines aridity.
- ③ **Wind regime** — determines soil denudation and desiccation stress.

TWO PHYSIOGRAPHIC DIVISIONS

- **Trans-Himalayan zone** : Part of the **Tibetan plateau**, lying beyond the Great Himalayan range. Includes the **Leh-Ladakh region**, **Lahaul-Spiti**, and **Pin Valley** of Himachal Pradesh. Extremely arid (< 100 mm rainfall).
- **Inner Dry Valleys** : smaller valleys nested **within** the main Himalayan range, situated in the rain-shadow of the outer ridges.

Chapter Outline

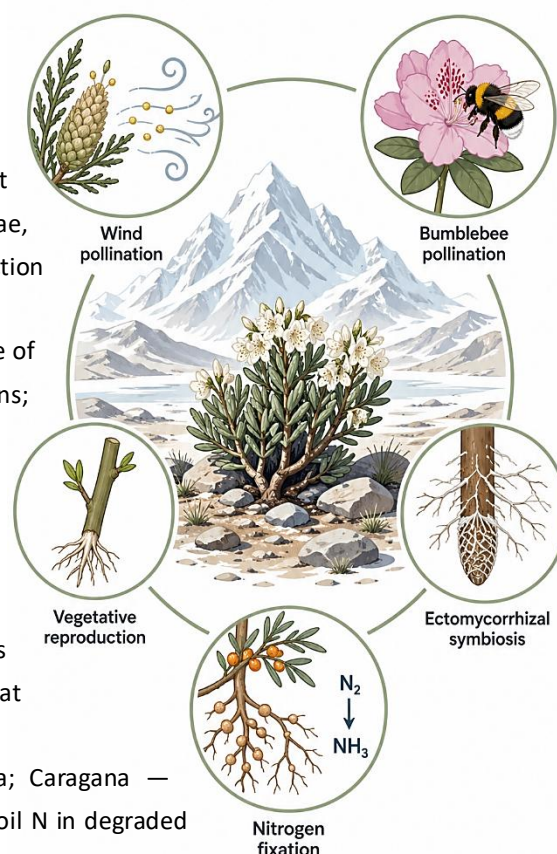
- 2.1** Distribution
- 2.2** Habitat characteristics
- 2.3** Classification of cold desert
- 2.4** Flora of cold desert
 - ✿ Chilgoza pine
- 2.5** Adaptation strategies
- 2.6** Threats
 - ✿ Current scenario
- 2.7** Need for conservation
- 2.8** Conservation measures
 - ✿ Soil working
- 2.9** Willow cultivation
 - ✿ Why Afforestation difficult?
- 2.10** Exercise

- the plant enters a quasi-desiccated anhydrobiotic state, minimising ice-damage risk.
- C₂ dominance : CAM/C₄ are absent because temperature-driven photorespiration is minimal at low temperatures; C₃ is thermodynamically adequate.
- Compressed phenology — bud-break to seed-set in **90–120 days** above 4,500 m; **<90 days** above 5,500 m. Most perennials are *bud-preformers* (buds differentiated previous summer).
- Seed dormancy & Cold-stratification : seeds require 60–120 days of moist chilling before germination — synchronises germination with safe spring conditions.

ECOLOGICAL ADAPTATIONS

Strategy : abiotic pollination + vegetative dominance + microbial symbioses

- Wind pollination (anemophily) dominant : insect activity is curtailed by cold; Juniperus, Ephedra, Hippophae, Betula, and all grasses rely on wind. Pollen production massive to offset dispersal losses.
- Entomophily restricted to bumblebees (Bombus) — one of the few pollinators robust enough for cold conditions; critical for alpine Rhododendron.
- Vegetative reproduction dominant : rhizomes, stolons, layering — Salix and Populus strike readily from cuttings (80–95% success), which is why they are Indian cold-desert afforestation workhorses.
- Ectomycorrhizal associations : Betula utilis, Pinus gerardiana, Juniperus partner with ECM fungi that enhance P and micronutrient uptake from skeletal soils.
- Nitrogen-fixation : Hippophae — Frankia actinorhiza; Caragana — Rhizobium symbiosis. These two pioneer genera build soil N in degraded sites.



PREVIOUS YEAR QUESTION

IFoS 2024 : Briefly summarize the Characteristic Features of cold arid forest vegetation. Discuss their mechanism of survival under extreme cold temperatures [8 M].

IFoS 2021 : What is the ecological significance of cold deserts? How do plants adapt and survive under cold and harsh desert conditions? Provide a list of common native species. [15 M]

IFoS 2020 : Write the adaptive characteristics of plant species of cold desert. [8 M]

IFoS 2015 : Comment upon the adaptation and survival strategies of plant species endemic to the cold desert area of the western Himalaya. [10 M]

IFoS 2017 : A soil can be wet yet physiologically dry — how? Suggest corrective silvicultural measures [10 M]. [Cold desert core]

IFoS 2010 : Beneficial role of ecto-mycorrhizal fungi in forest nurseries [10 M]. [Critical for Pinus gerardiana, Betula utilis]

2.6 THREATS TO COLD DESERT ECOSYSTEM

Cold deserts — already **ecologically marginal** — are buckling under compounded pressures from **anthropogenic use**, accelerating **climate change**, and episodic **natural hazards**.

ANTHROPOGENIC THREATS

SILVICULTURE SYSTEM

Paper – 1 | Section – A



EDITION : 2026

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SILVICULTURE SYSTEM

INTRODUCTION

Silviculture

Silviculture is the *art and science of cultivating forest crops*. It deals with the natural laws governing the growth and development of trees and forests, the influence of *environmental factors* upon them, and the techniques of *regenerating them — naturally or artificially* — and *tending* them through their life.

Silvicultural System ?

Forests in India are not all the same. They differ in the *kinds of trees* they have, the *climate*, the *soil*, the *terrain*, and the *biotic pressure*. Because of these differences, one single method of *growing, managing, Tending* and *Harvesting* cannot work everywhere. If we use the same method in every forest, the crop may fail.

So, foresters have made different methods to manage different types of forests, based on local conditions. Each such method is called a **Management System** or a **Silvicultural System**.

To study these methods, compare them, and talk about them easily, we need to give them proper names. Like the clear felling system, where we harvest the mature crop in single operation (in one go), or the shelterwood system, where we grow a younger crop under the shelter of the older ones before harvesting them — this protects young seedlings from frost, sun, and soil erosion, especially on sensitive or sloping sites.

- **Definition :** a **silvicultural system** is a method of the *silvicultural procedure worked out in accordance with accepted sets of silvicultural principles*, by which the crops constituting forests are *tended, harvested and replaced by new crops of distinctive forms* [BCFT].

or

- Silviculture system is a *planned silvicultural treatment* which is applied to a forest crop, throughout its life, so that it assumes a distinctive form. It begins with regeneration fellings, includes a method of regeneration, and continues through tending until the next felling cycle.

✎ A silvicultural system is a process of tending, harvesting, and replacing with new crops.

1.2 ESSENTIAL CHARACTERISTICS

Every silvicultural system, whatever its name, embodies four essential characters.

- **Method of Regeneration :** It may be obtained by *Seed* (self-sown or sown artificially), by *Coppice*, or by other *Vegetative Methods* (root suckers, layering, pollards). *Mode of regeneration is the primary axis of classification* in the Indian system — it splits all systems into **High Forest** (seedling origin) and **Coppice** (vegetative origin).

 *Define* silvicultural system. Discuss its *essential characteristics* and explain the *basis* on which silvicultural systems are *classified* in India.

[Synthesis question, repeatedly asked in IFoS (Main) 2018; HPPSC Civil (Main) 2014, 17; MHPSC ACF (Main) 2012].

To overcome all these difficulties together, foresters introduced a very practical arrangement — They divided the entire forest area (under production) into a few number of *equal productive* or *equal-size (equi-extensive)* plots, called — *annual coupes*, equal to the number of years of the rotation.

Now every year, harvesting and regeneration work is carried out in one coupe. This single change solved many problems in one go:

- Labourers got continuous work throughout the year, every year, which made it possible to keep them as a permanent and trained workforce.
 - The local timber market started getting a regular annual timber supply.
 - And most importantly, it secured a steady and reliable annual supply of timber (*Sustained Yield*) = something badly needed for the rapidly expanding European economy of that era.
- The **Clear-felling** system is a *silvicultural system* in which *equal* or *equi-productive areas* of a mature crop are *successively clear-felled in one operation* and regenerated, most frequently artificially but sometimes naturally.
- **Annual coupe**^{***} : Suppose the rotation length is *n* years. To harvest the forest in a planned way, the total area under the system is divided into *n* equal parts. Each year, one such part is clear-felled. This area, felled in a single year, is called the *annual coupe*. Annual coupes are usually numbered using Roman numerals — I, II, III, and so on — to show the order in which they will be harvested.

When the site is *uniform* (that is, all parts of the forest grow equally well), the area is divided into coupes of equal size. Such coupes are called *equi-extensive* coupes. When the site is *heterogeneous* (some parts are fertile and some are poor), equal-sized coupes will not give equal yield every year. In such cases, the forest is divided into *equi-productive* coupes — coupes that produce roughly the same quantity of wood each year.

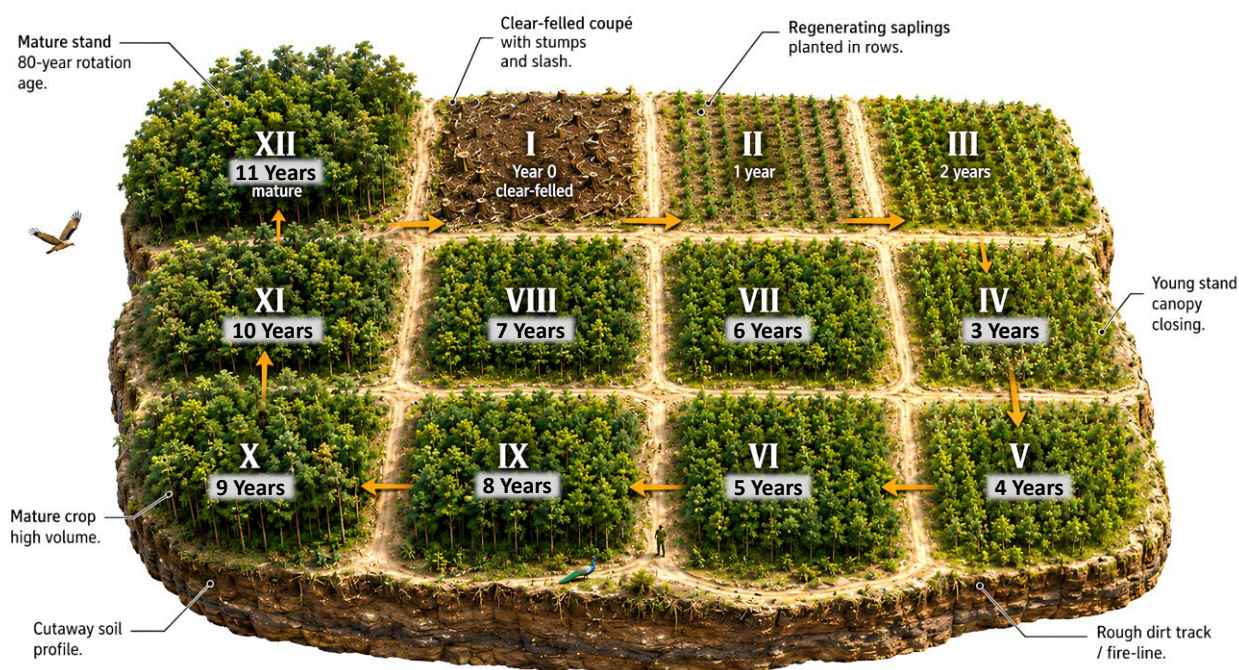


Figure 2.1 : A clear-felling system showing a production area divided into 12 *equi-extensive annual coupes*. ♦ **Coupe I** : Freshly harvested, soil preparation is underway and regeneration activities are about to begin. ♦ **Coupe II** : harvested one year ago, with regeneration carried out at that time; one-year-old seedlings are now visible. ♦ **Coupe III** (adjacent plot) : Two-year-old saplings, ♦ **Coupe XI** : the crop is nearly mature and is scheduled for harvesting next year. *below-ground root competition* and *biodiversity characteristic* at each stage are also illustrated.

SELECTION SYSTEM

The only system that gives an all-aged forest. The intellectual home of **Continuous Cover Forestry**. The system best suited to Himalayan slopes, river catchments, and tropical evergreens – where canopy continuity is non-negotiable

Unlike *clear-felling* and *shelterwood* systems, where regeneration fellings are concentrated and confined to a particular part of the forest at a given time, and often create larger canopy openings, which may expose the soil, reduce site productivity, disturb microclimatic conditions, and degrade wildlife habitats. Natural forests, however, rarely function in such an even-aged or uniform manner. In virgin Himalayan deodar forests, Western Ghats evergreen forests, or Bastar Sal forests, trees of different ages, sizes, and crown classes occur together in a complex vertical and horizontal structure. When a mature tree dies or is removed, advance regeneration or a suppressed sapling beneath it gradually occupies the vacant growing space. This continuous, in-situ process of replacement and renewal is the ecological principle that the Selection System seeks to imitate.

Single Tree selection system

Group selection system



The Selection System is a Silvicultural System in which scattered mature trees, generally those having diameter above the prescribed exploitable diameter or felling diameter, are selected throughout the forest area and removed individually or in small groups. The resultant crop is so *uneven-aged* that *trees of all ages are found mixed together over every part of the area*.

- Therefore, the crop is referred to as “**Selection Forest**” or “**all-Aged Forest**”
- Felling and regeneration works = Distributed over the whole area.
- Form of crop : Uneven-aged + Mixed on every unit of area.
- Regeneration period : throughout the life of the crop = Fellings, regeneration and thinnings happen simultaneously, continuously.

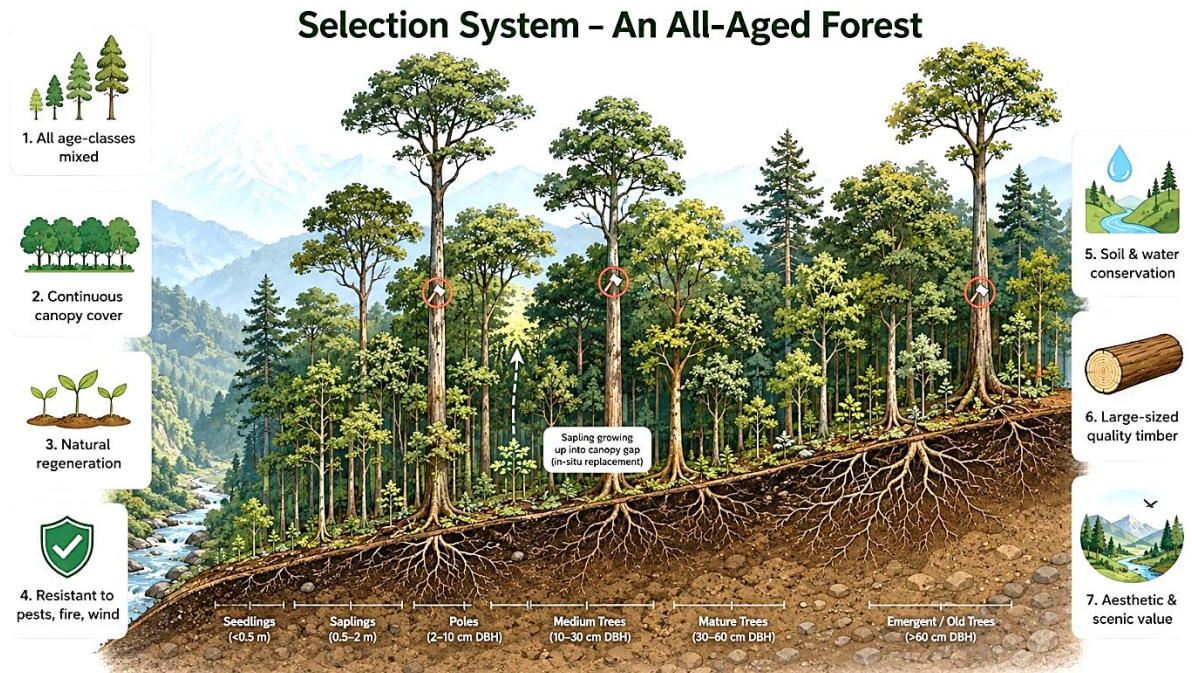
► PATTERN OF FELLING

Scattered mature single trees (having DBH above the exploitable diameter) are selected all over the whole area and removed.

- Dead, dying, diseased, malformed, defective, or unsound trees.
- Trees of undesirable or low-value species, where their removal helps improve species composition.
- Immature trees, only where their removal is required as a judicious thinning operation to regulate stand density and improve the distribution of size classes.

However, the selection system is not merely the selective extraction of commercially valuable trees. It is a regulated silvicultural system aimed at *maintaining an uneven-aged forest structure*, where all age or

size classes are represented in a **balanced proportion** on every unit area. Its objective is to **secure continuous regeneration**, **sustained yield**, and **stable growing stock**.



The **modern (European) trend** is to **ignore exploitable diameter** altogether and base felling on normal diameter-class distribution: where a class is in excess, fell from it; where deficit, restrict fellings to defective trees only.

► FELLING CYCLE

In India, areas worked under the Selection System are usually **too large to go over annually**. So, the area is divided into coupes, and fellings are confined to **one coupe each year**. Once all coupes are done, the cycle resumes from the first.

Felling Cycle : The time that elapses between successive main fellings on the same area.

- **MODE OF REGENERATION** : Mainly **natural** — coming up in the gaps created by fellings. Where natural fails, **artificial regeneration** supplements (works well for shade-tolerant species under closed canopy).
- **NATURE OF CROP** : **Absolutely un-even-aged** with all age-classes mixed together on each unit area. **multi-storey canopy** → site factors used to the maximum (full vertical and horizontal occupation).
- **TENDING OPERATION** : Weeding, cleaning, climber cutting etc.

Single Tree selection system	Group selection system
-------------------------------------	-------------------------------



The Selection System in which trees are selected and felled in small patches or groups, instead of as scattered single trees. Tending and regeneration mode are unchanged.

- Best suited for : **light-demanders** → whose seedlings need larger gaps than Single-Tree Selection allows.
- Group size : varies with light requirement, aspect, slope, surrounding tree height, soil condition.
- Differs from Bavarian Femelschlag : groups are not enlarged centrifugally → they remain irregular.

COPPICE SYSTEM

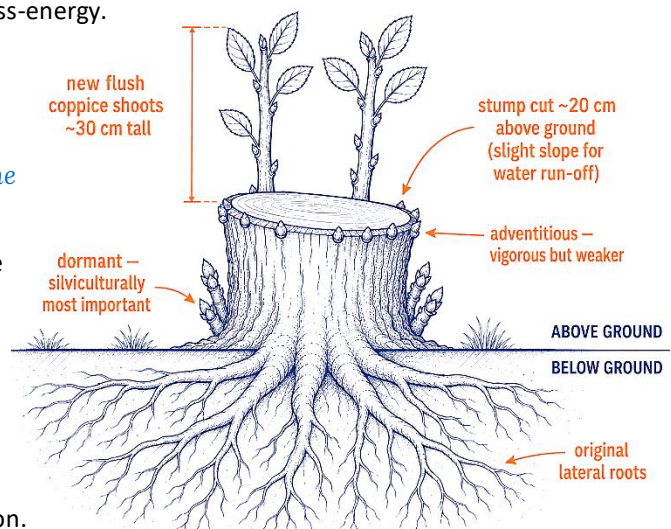
All silvicultural systems studied so far — *Clear-felling, Shelterwood, Selection* — depend on regeneration from seed, and are collectively termed *High Forest Systems*. The *Coppice Systems*, in contrast, depend on the *vegetative regenerative power of stools* — the *adventitious* and *dormant buds* situated round the periphery of the cambial layer of the stump throw out new shoots after the parent stem is cut. As *only certain species coppice*, and as coppicing *power weakens with age*, these systems are necessarily worked on a *short rotation*.

Definition : A silvicultural system in which the new crop originates mainly from **stool coppice**, and where the rotation of the coppice is **short**. Wood produced is small-sized but quick — ideal for fuel, poles, pulpwood, basket-and-mat work, cricket-bat clefts, fibre, fodder, biomass-energy.

BIOLOGICAL BASIS : THE TWO KINDS OF SHOOTS

Coppice shoots arise from two kinds of buds :

- **Dormant** : *pre-existing buds* situated on the *side of the stool*, generally *at or near ground level/root collar*. Shoots from these buds are more firmly attached to the stool and are silviculturally the most important.
- **Adventitious buds** : *Newly formed buds* arising from the *cambial/callus tissue* around the *periphery of the cut surface*. These may produce an early flush of shoots, but such shoots are usually less firmly attached and are therefore less preferred for coppice regeneration.



Some species also regenerate by *root suckers*, for example *D. sisoo*. Sucker production may be stimulated by cutting, damage or wounding of roots.

TYPES : Based on the pattern of felling

- The *Simple Coppice System* **
- *Coppice of two rotation system* : Modification of Simple Coppice for some large-sized timber.
- The Shelterwood Coppice System
- The *Coppice-with-Standards System* **
- The *Coppice-with-Reserves System* **
- The Coppice Selection System
- The *Pollard System* **

6.1 SIMPLE COPPICE SYSTEM

a silvicultural system based on **stool coppice**, in which the old crop is *clear-felled completely* with no reservation for shelterwood, and the new crop grows naturally through stool coppice.

CONVERSION

Sometimes, we required to change from one silvicultural system to another as per necessitated by market demand, soil and climatic condition. This is usually referred to as conversion.

► **Definition** : *A change from one silvicultural system or one set of species to another.*

7.1 KINDS OF CONVERSION

- **Change in crop composition** (Species) : Replacing an indigenous mix with a fast-growing / valuable / climate-adapted species.
Example : *Tropical pines* and teak in Bastar (CG); *Cryptomeria japonica* in Darjeeling hills (WB); *Eucalyptus hybrid* and *Populus deltoides* in UP, Punjab, Haryana.
- **Change in silvicultural system** : Driven by failure of the existing system, advance of regeneration knowledge, market shift or policy.
Example : Selection-cum-Improvement → Uniform → Indian Irregular Shelterwood for Sal.

7.2 NEEDS = YIE

- *Increasing yield from forests* : To meet rising demand of fuelwood, fodder and timber = Forces restocking with valuable, fast-growing species.
- *Industrial demand* : Pulp-paper, plywood, match, particle-board, biomass-energy and rayon industries demand specific species → conversion to Eucalyptus, Casuarina, Populus, Subabul, Acacia mearnsii plantations on captive/farm forests.
- *Advantages of a particular system* : When a system offers higher yield, simpler working, concentration of work and easier improvement of growing stock, it is adopted.
- *Failure/Loss of the Existing system* : When the prescribed system fails to regenerate the crop, it must be abandoned. Examples : Uniform System for sal in Haldwani / Ramnagar (UP) — abandoned for Indian Irregular Shelterwood System.
- *Advancement in Silvicultural knowledge with time* : Where regeneration of a species (natural or artificial) has been perfected, more intensive systems become feasible — driving conversions to Uniform / clear-felling-with-taungya / clear-felling-with-artificial regeneration.
- *Development of communication system and market demand* : Improved roads + assured demand for smaller-dimension timber make concentrated-regeneration systems economically viable, driving the shift from selection-based working to Uniform / Coppice systems.

7.3 IS CONVERSION A SILVICULTURAL SYSTEM? THE GREAT DEBATE

► **YES, it is (as per some believers)**

- Trevor (1925) : Coined the term *Conversion System* & formally recognised these methods as a class of silvicultural treatment in their own right.
- British Commonwealth Forest Terminology (BCFT) has accepted the term *Conversion System* and has defined it as a method of silvicultural procedure designed to change forest crops from one

MANAGEMENT OF BAMBOO FOREST + AVENUE + CANALS

Bamboo is an important **Minor Forest Produce (MFP)** and occupies a significant place in India's forest-based economy and rural livelihood system. Owing to its versatility, rapid growth and wide utility, it is often described as the **Common Man's Timber**. It is extensively used in house construction, scaffolding, fencing, agricultural implements, basketry, handicrafts, mat-making and rural cottage industries. Bamboo also provides an important long-fibred cellulosic raw material for the paper and pulp industry. In recent years, its potential has further expanded in areas such as *engineered bamboo products*, *biomass energy* and *bio-ethanol* production.

India hosts >130 bamboo species. Among them, *Dendrocalamus strictus*, commonly known as **Lathi bans** or **solid bamboo**, is one of the most important and widely distributed species, especially in drier parts of India. Another commercially significant species is *Bambusa bambos* syn. *Bambusa arundinacea*, commonly known as **spiny bamboo**.

BIOLOGY OF THE BAMBOO CLUMP

Botanically, bamboo belongs to the family **Poaceae (Gramineae)**. It is a perennial, woody grass with a distinctive underground rhizome system. From the seedling base, a scaly underground stem or **rhizome** develops. Initially, the rhizome grows vertically downwards for a short distance and then curves upwards to produce a small aerial shoot or **culm**. Full-sized culms generally appear after **4–12 years**, depending upon the species and locality. Each new culm usually attains its full height and diameter during the monsoon season, after which it does not increase in girth.

In *clump-forming bamboos*, rhizome development generally proceeds from the centre towards the periphery. As a result, new culms are produced annually on the outer margin of the clump, while older culms remain towards the interior. This age-wise spatial arrangement is important in scientific bamboo management, as mature culms can be selectively harvested without damaging the younger growing stock.

On the basis of rhizome architecture, bamboos may be broadly classified into two major types:

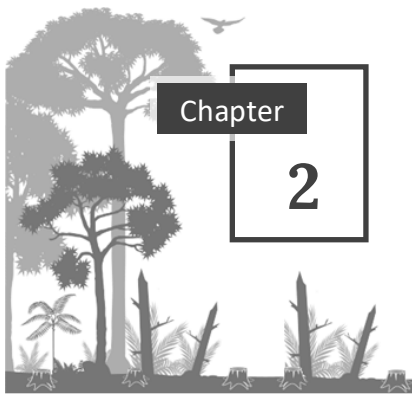
1. **Sympodial or Pachymorph Type** : In this type, the rhizomes are short, thick and bulbous, and the culms arise close to one another, forming compact clumps. This is the typical clump-forming habit seen in many commercially important Indian bamboos such as *Dendrocalamus strictus* and *Bambusa bambos*. Most traditionally worked bamboo species in India belong to this category. Since culms are crowded within a clump, proper felling, cleaning and thinning are essential to avoid congestion and maintain productivity.
2. **Monopodial or Leptomorph Type** : In this type, the rhizomes are long, slender and laterally running. They spread horizontally for some distance before producing aerial culms. Therefore, culms are more widely spaced and the growth form resembles a *bamboo grove* rather than a compact clump. This rhizome type is seen in species such as *Melocanna baccifera* and *Phyllostachys* spp. It is more common in parts of North-East India. Such bamboos require a different management approach because their regeneration and spread depend on extensive underground rhizome growth.



There are 32 species listed in our IFoS syllabus, and in addition to these, we also need to discuss 4 or 5 more species to cover this section properly. However, we all have significantly less time to prepare for them one by one in a traditional, structured way, especially after the preliminary examination. Furthermore, if we do not study them properly, it can cause terrible confusion, with information about one species merging with another. To avoid this, we need to study all of them in groups by using some common characteristics.

1.1 A BASIC FRAMEWORK FOR THE STUDY OF EACH SPECIES

- ▶ **Scientific name**
- ▶ **Common name**
- ▶ **Family**
- ▶ **Distribution**
 - Distribution map [A map should be draw where you can]
 - Enlist all the locality factors that a species requires for its proper growth and development with some factual details, like -
 - Climatic factors**, *i.e.*, Rainfall (above 2000 mm rainfall), temperature, light demander, etc.
 - Edaphic factors**, *i.e.*, Soil type, well-aerated or poor water table, specific condition if any.
 - Topographic factors**, *i.e.*, Gentle slopes, altitude, etc.
 - Biotic factors**, *i.e.*, Forest types and associated species, wildlife, etc.
- ▶ **Phenology**
 - General description of the tree
 - Leaf fall & reappear season
 - Flowering season
 - Fruiting season
 - Seed collection, Good seed year
- ▶ **Silvicultural characters**
 - Coppicing, pollarding, root sucker's property.
 - Properties like light demander/shade bearer, Drought hardy/ Frost resistant, etc.
 - Biotic factors like damages caused by wild animals, Insect – pests and Parasitism (if any).
- ▶ **Natural regeneration**
 - **Seeds** :
 - **Vegetative** : Rhizome, Coppice, Propagule (Mangroves)



PENINSULAR TREE SPECIES



There is no any such classification that divides our trees into North Indian, South Indian, Himalayan Indian, etc. We are here creating this arbitrary to make the species easier to understand, remember, and reproduce in the main exam. Species that primarily grow in the peninsular region are :

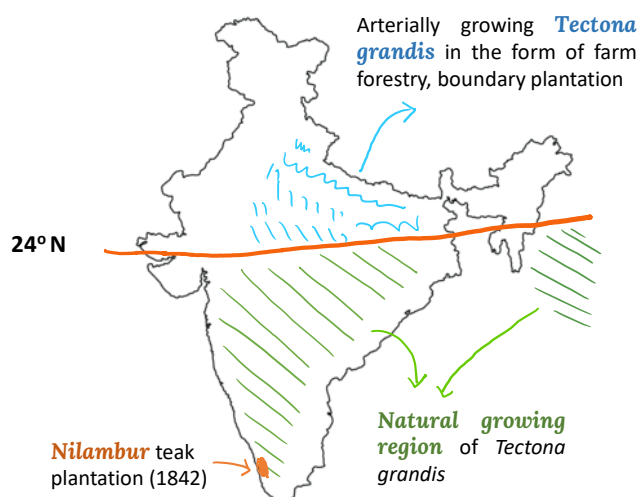
- *Tectona grandis* (Teak) & *Gmelina arborea* (Gamhari, Safed teak)
- *Albizia lebbek* (Kala Siris) & *Albizia procera* (Safed siris)
- *Santalum album*
- *Lagerstroemia Lanceolata*
- *Bombax Ceiba Syn. Salmalia malabaricum*
- *Butea monosperma*
- *Semecarpus anacardium*
- *Pterocarpus marsupium*

2.1 *Tectona grandis* (Teak)

- ▶ **Vernacular / Local Name** : Sagwan (Hindi), Sagaun (Kannada), Singuru (Oriya), Tekkumaram (Tamil)
- ▶ **Family** : Verbenaceae.
- ▶ **DISTRIBUTION** : Teak is a *Large, deciduous, and light-demanding* tree that naturally grows *below 24° North latitude* on the Indian peninsula and in Myanmar, where a warm tropical climate with *100–500 cm of rainfall* and temperatures ranging from *10°C to 40°C* provides the perfect growing conditions. Therefore, most of our teak forests are located in *Madhya Pradesh, Maharashtra, Karnataka, etc.*, where the tropical conditions are suitable for their strong light-demanding nature.

As market demand and popularity have increased, *block and boundary plantations* have become common in the North Indian plains. Teak trees can attain a *height of 40 meters* and a *girth of more than 1.5 meters*.

- Climate : Thrives best in a *fairly moist, warm tropical climate*.
- Altitude : Generally grows *below 800 meters*, but it may perform well up to 1200 meters in the Western Ghats.
- Geology & soil : Teak grows on a wide



2.5 *Santalum album* (Sandalwood)

- **Common / Vernacular Name** : Indian Sandalwood, Chandan (Sanskrit, Hindi, Marathi), Srigandha (Kannada), Sandanam (Tamil)

- **Family** : Santalaceae

- **Distribution** : Sandalwood trees are primarily found in *tropical moist & dry deciduous* and *moist semi-deciduous* forests in the southern peninsular region of India, up to 1500 meters altitudes. The main sandalwood-producing regions are the southern part of Karnataka and the northern part of Tamil Nadu.

Non-traditional sandalwood-growing areas include Andhra Pradesh, Assam, Gujarat, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Telangana, and Uttar Pradesh.

- **Rainfall** : 600 to 1200 mm
- **Temperature** range 25 to 35° C
- **Altitude** : 500 to 1000 m
- **Topography** : undulating topography, gentle to moderate slopes
- **Geology and soil** : grow mainly over *red soil* and moist, fertile alluvial soil lies along the banks of rivers and streams. Sandalwood is *not able to tolerate conditions of salinity* and *waterlogging*.

- **PHENOLOGY** : A small to medium-sized, *Evergreen*, *light-demanding*, *partially root parasite tree* found in a large group.

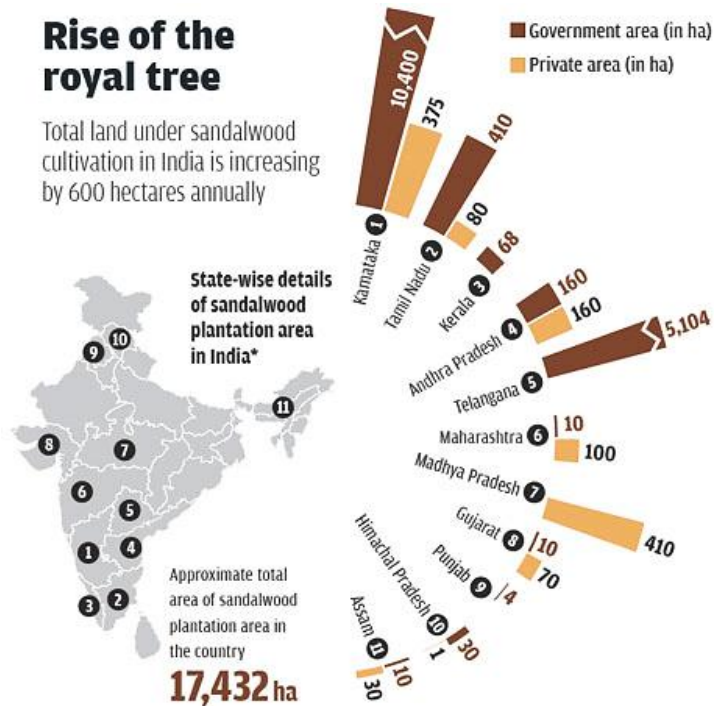
- **Leaf fall** : Sandalwood is more or less evergreen in character. Hence there is no specific period of leaf fall. It occurs all around the year.
- **Leaf renewal** : A new flush of leaves appears at the onset of the monsoon season and another just after the monsoons.
- **Flowering** : Twice in a year, *May-June* and *November-December*; It may be earlier in hotter localities. In Some varieties, it extends from *mid-Feb* to *March-End*.
- **Fruiting** : June and December

► SILVICULTURAL CHARACTERS

- **Light** : at the initial stage, it required shade but later required overhead light.
- **Frost** : Conditions of frost do not occur in the natural habitat of sandalwood, hence susceptible to it.
- **Coppicing power** : Fairly high coppicing power
- **Root suckers** : freely produced when roots are exposed or when cut.
- Extremely *fire tender species*, even a small fire may cause irreparable damage.

Rise of the royal tree

Total land under sandalwood cultivation in India is increasing by 600 hectares annually





SPECIES OF SEMI-ARID TROPICS

Species that are predominant in the Indo-Gangatic planes are –

- ☐ *Acacia nilotica*
- ☐ *Acacia catechu*
- ☐ *Azadirachta indica*
- ☐ *Prosopis juliflora*

4.1 *Acacia nilotica* (Syn. *Vachellia nilotica*)

- ▶ **Common / Local Name** : Babool, Gum Arabic tree, Desi babool
- ▶ **FAMILY** : Mimosaceae (Leguminosae).
- ▶ **DISTRIBUTION** : hardy to handle damages created by cracking's in black cotton soil, drought, and moderate frost, so, widely distributed over the North Indian plains, Rajasthan, MP, MH, etc.
 - **Climate** : Tropical dry deciduous and subtropical dry deciduous conditions.
 - **Rainfall** : 25 to 160 cm.
 - **Temperature** : 18 to 45°C
 - **Geology & Soil** : Alkaline to neutral, deep black, and fertile alluvial soil.
- ▶ **PHENOLOGY** : A *medium-size deciduous* tree with a *brood-shaped crown* and *thorny branches*. It attains a height of 20-25 m but may remain a shrub in poor growing conditions.
 - Leaf fall : April – May
 - Leaf renewal : May – June
 - Flowering : January to March
 - Fruiting : ripen in April – May
 - *Thorny branches*.
- ▶ **SILVICULTURAL CHARACTERISTICS**
 - Drought hardy.
 - Frost resistant
 - Light demanded
 - Poor coppice
 - Root suckers ✓
- ▶ **NATURAL REGENERATION** : by seed + Coppice
- ▶ **ARTIFICIAL REGENERATION** : By direct seed sowing (Soaking in cold water for 48 hours at room temperature, or keeping the seeds in a moist cow dung heap for 2 to 3 days to remove seed coat dormancy).

- ▶ **ARTIFICIAL REGENERATION** : largely propagated by artificial means = by **Cutting**. Cuttings are generally prepared by 2-year-old seedlings during winter month when the plant is leafless and planted with **Spacing of 4 × 4 meters**.
- Rotation** : in fertile soils and sufficient irrigation is about 6 years. In less intensively managed plantations, the rotation age is 8 to 10 years.
- ▶ **UTILIZATION** : Wood is suitable for making plywood, fillings for ply-boards, matchsticks, paper, packing cases, spoons, toothpicks, ice cream sticks, etc.

EXERCISE

IFoS 2020 : Give a brief account of the silvicultural characters and regeneration methods for the following species - (a) __ (b) *Populus deltoides* (15 m).

IFoS 2010 : Give climatic requirement, rotation age, spacing, tending operations and yield of the following forest species – (a) *Populus deltoides*, (b) *Casuarina equisetifolia*.

- ✿ Explain the phenology, silviculture characters and regeneration of *Populus deltoides* and *Cedrus deodara* [Himachal PSC RFO (Main) 2017]

5.3 *Casuarina equisetifolia* (Beefwood)

- ▶ **FAMILY** : *Casuarinaceae*
- ▶ **DISTRIBUTION** : Casuarinas is an **exotic plant** (Australia- Indonesia) and is Artificially used for - (a) coastal afforestation (Sand dune fixation) and (b) for Scenic beauty in urban gardens as a hedge. It gives the best performance in Tropical areas under 30°C - 35°C temperature and 100 to 300 cm rainfall.
- ▶ **PHENOLOGY** : *casuarinas* is an **evergreen tree** and resemble like conifers (its needles look like them), and grown in the gregarious habit.
 - Flowers are unisexual, and **flowering comes twice in a year** – 1st in **March – April** (Before monsoon), and 2nd one is **August – September** (end of monsoon).
 - Fruit ripens in June & December month respectively.
 - Extremely sensitive to drought.

▶ SILVICULTURAL

CHARACTERISTICS : It is a strong **light demander**, **medium size** (10-15 m height), wind firm, **evergreen tree** with **conical shape crown** and having extensive deep root system.

- it requires well-drained sandy soil and is not able to grow in heavy soil
- Frost hardy species

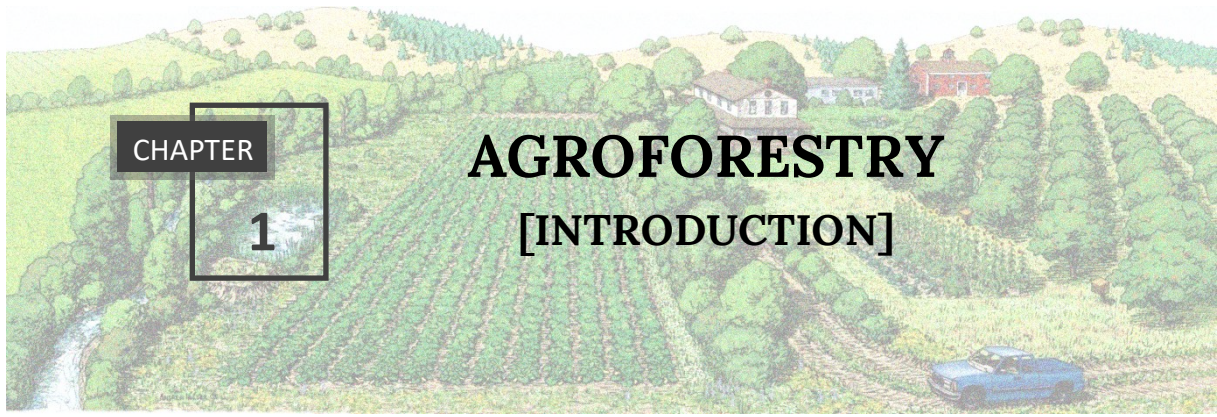


⤴ Casuarina growing over the coastal sand dunes



Casuarina growing as a hedge in a garden ⤵





Agroforestry is a **sustainable land-use system** that integrates **trees, crops**, and/or **livestock** on the **same unit of land** in a **complementary** and **interactive** manner. It enhances **productivity, sustainability**, and **resilience** of rural landscapes.

Historically, the concept is rooted in **ancient Indian farming tradition**, where farmers planted trees along field boundaries and used them for **timber, fuelwood**, and **fodder**. Modern agroforestry merges these traditional practices with **scientific land management approaches**.

- Agroforestry systems are **ecologically & functionally more complex than monocultures**, as they integrate multiple plant strata such as trees, shrubs, and crops.
- The integration of trees offers **economic security** and **alternative investment opportunities** to farmers by serving as a **natural insurance mechanism**—even if agricultural crops fail due to drought or pests, trees continue to generate income through timber, fruits, or fuelwood.
- Rooted in indigenous traditions and socio-cultural practices.

KEY DEFINITIONS

Agroforestry is a **sustainable land-use system** that **maintains** or **increases total yields** by combining **food crops (annuals)** with **tree crops (perennials)** and/or **livestock** on the **same unit of land**, either **alternately** or **simultaneously** (at the same time), using **management practices** that are compatible with the **local socio-cultural, economic, and ecological conditions** of the area.

- **Bene et al.** (1977) : Agroforestry is a land-use system **integrating trees, crops**, and **animals** in a manner that is **scientifically sound, ecologically desirable**, and **socially acceptable**.
- **P.K.R. Nair** (1979) : Agroforestry is a **sustainable land-management system** which **increases the overall production** yield by combining **agricultural crops** (annuals) with **tree crops** (perennials) **and/or livestock simultaneously** or **sequentially** on the **same land unit**, using management practices that are **compatible with the local social, economic, and ecological conditions**.

KEY ATTRIBUTES OF AGROFORESTRY

- **Productivity** : Maintains or increases overall yield and soil productivity.
- **Sustainability** : Conserves and enhances the production potential of resources. **Cornerstone of agroforestry*****
- **Adaptability** : The term “adopt” in this context refers to **acceptance**, not *modification* or *change*. It implies that any **improved** or **newly introduced agroforestry technology** should be **compatible with local farming practices, traditions**, and **socio-economic conditions**, ensuring easy adoption by farmers.

IMPORTANCE AND SCOPE IN INDIA

CHAPTER

2

CLASSIFICATION OF AGROFORESTRY

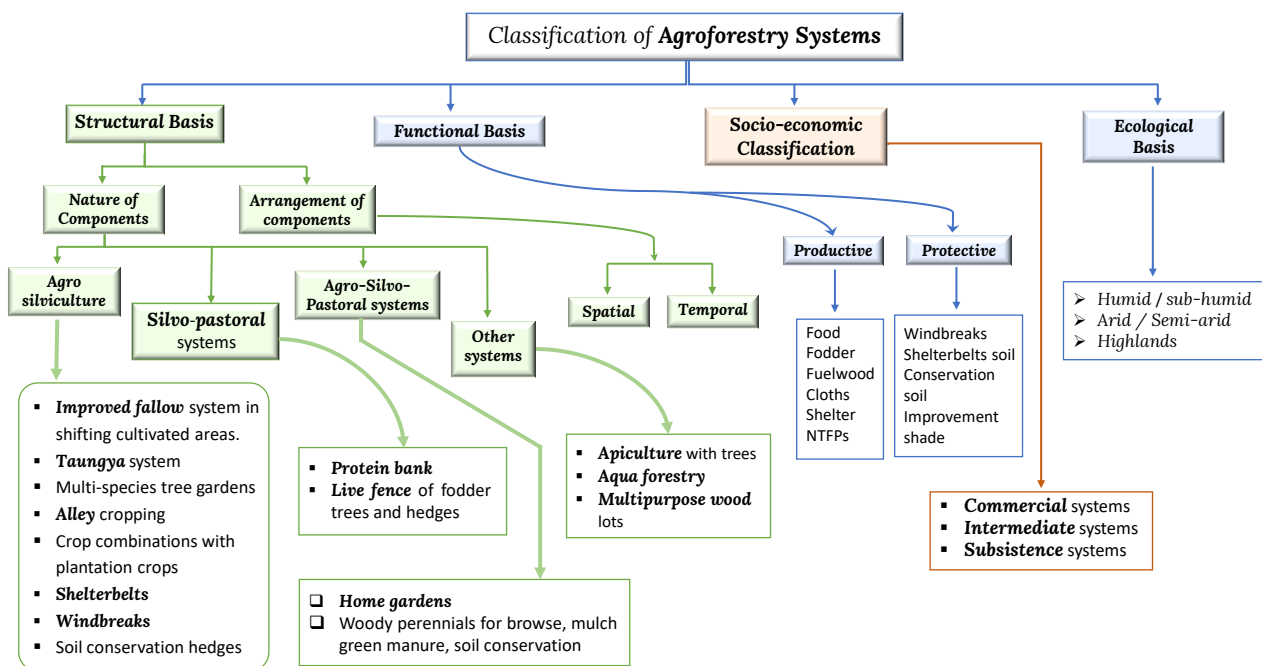
Agroforestry systems can be classified based on **Structure**, **Functions**, **Socio-Economic** settings, **Ecological** conditions, and **Vegetation** appearance. Two major scientists proposed widely accepted classification systems :

➤ **PKR Nair (1987)** : Classified agroforestry on **4 bases** :

- **Structural** basis,
- **Functional** basis,
- **Socio-economic** basis, and
- **Ecological** basis,

➤ **Tejwani (1994)** : Added a 5th category — **Physiognomic basis**, making classification more comprehensive.

These classifications help understand **tree-crop-livestock** arrangements, **resource flow**, and **productivity interactions**.



➤ **Physiognomic Classification** : Based on **appearance** and **ecological adaptations** of vegetation – Xeromorphic, Mesomorphic, Hydromorphic, etc.

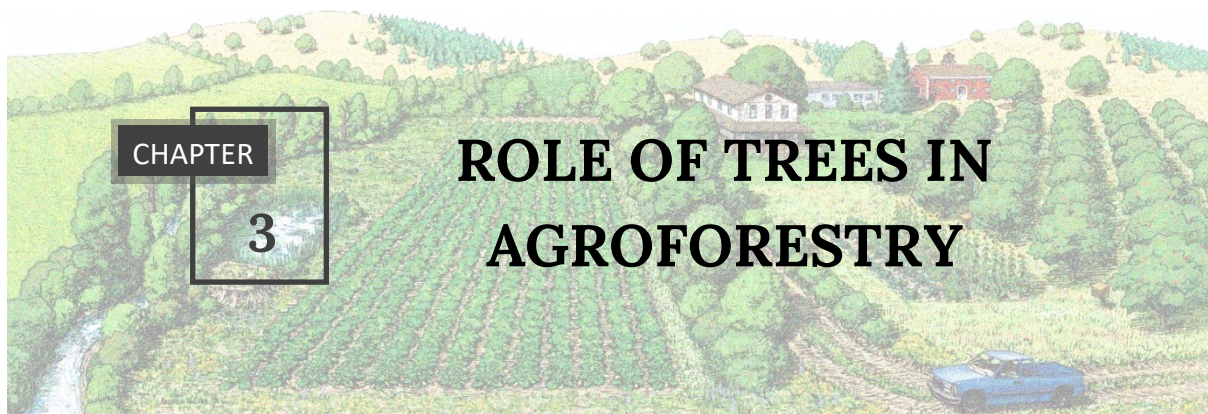
2.1 | STRUCTURAL CLASSIFICATION

2.1.1 | NATURE OF COMPONENT

Agroforestry systems under this include : ♦ **Agri-silviculture** – Crops + Trees, ♦ **Silvi-pasture** – Trees + Pasture/Animals, ♦ **Agri-silvi-pasture** – Trees + Crops + Livestock, ♦ **Other systems** – Silviculture, Aqua-forestry, etc.

IFoS 2013 : What are the fundamental bases of the **classification of agroforestry** systems? [10 M].

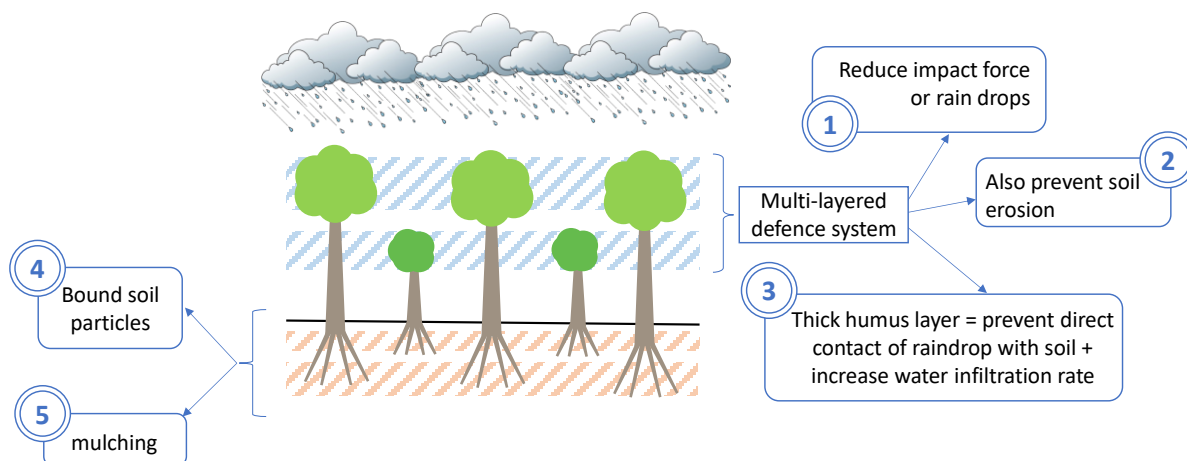
✍ Write short notes : **classification of agroforestry** systems [Mizoram PSC 2017]



Trees form an *integral component* of agroforestry systems and contribute significantly to *ecological stability*, *agricultural sustainability*, and *livelihood diversification*. Their presence modifies the microclimate across *vertical (canopy-soil profile)* and *horizontal (field-landscape)* dimensions, thereby improving soil health, regulating microclimate, supporting biodiversity, and enhancing ecosystem resilience.

3.1 | ROLE IN SOIL AND WATER CONSERVATION

Agroforestry integrates *trees* with *crops/livestock* systems, creating a *multi-layered vegetation structure* that plays a critical role in soil & water conservation, especially in *erosion-prone*, *dryland*, and *hilly watershed* landscapes.

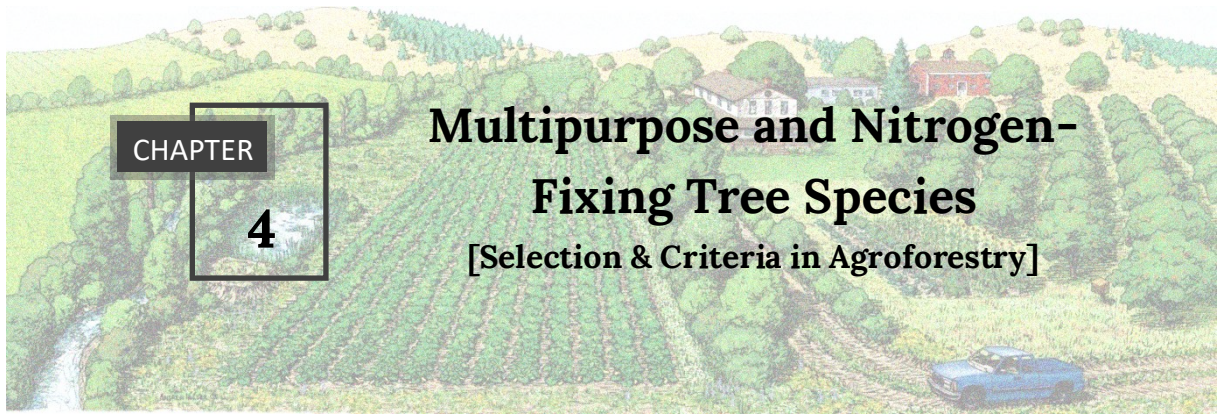


- **Multi-tiered canopies** (upper, middle, lower foliage) reduce *kinetic energy* of rainfall. Prevents soil particle detachment, *splash erosion*, and *crust formation*. Acts as the *first line of defence* against soil degradation.
- Hedgerows act as **windbreaks**, lowering wind speed on the leeward side = Reduces **wind erosion**, **desiccation**, and protection of food crops.
- Continuous deposition of litter forms **natural mulch** = Enhances **soil aggregation**, reduces **compaction**, and increases *infiltration* (↑ Porosity) = Improves *soil water-holding capacity*, reduce *run-off*, and evaporation loss.
- Deep roots : enhance **vertical water percolation** + **Reinforcing soil** = Act as bio-drainage systems in waterlogged areas + Supports groundwater recharge and base flow.

3.2 | ROLE OF TREES IN NUTRIENT RECYCLING / PRODUCTIVITY

Trees significantly enhance soil fertility and overall productivity by **improving nutrient cycling**. Their key functions include :-

- **Recovery of Leached Nutrients** : Deep and extensive root systems absorb nutrients (e.g., nitrates) that have moved below crop root zones and return them to the topsoil through litter and root decay.



CHAPTER

4

Multipurpose and Nitrogen-Fixing Tree Species

[Selection & Criteria in Agroforestry]

4.1 | CHOICE OF SPECIES / SELECTION CRITERIA

The success of an agroforestry system largely depends on the appropriate selection of tree species. Ideal tree species must possess desirable biological, ecological, and socio-economic characteristics to ensure **productivity**, **compatibility**, and **sustainability**.

Key Characteristics –

▷ Growth Behaviour and Establishment

- **Fast growing*** : Species should establish quickly, grow rapidly, attain harvestable size early, and require minimal maintenance—supporting short rotation cycles.
- **Short juvenile period (Early Maturity)** : Reduces gestation lag and improves farmer adoption and profitability.
- **Ease of propagation and regeneration** : Species capable of reproducing through seeds, vegetative propagation, or root suckers and showing high survival rates are desirable.

▷ Production Compatibility

- **Low competition with food crops** (Complementarity) : Selected species should not compete with associated food crops for *light, water, nutrients, or space*.
- **Compatible root architecture** : **Deep taproots*** system or **sparse lateral*** roots system minimize underground competition and allow crops to utilize topsoil resources efficiently.
- **Complementary Canopy architecture*** : A small and straight crown with light-filtered (dappled) shade or a deciduous habit (seasonal leaf fall) is preferred, especially for intercropping systems.

▷ Soil Health and Ecosystem Services

- **Nitrogen-fixing* capability** : Preference should be given to leguminous species (NFTs) to enhance soil fertility and nutrient cycling = Adaptable to grow on difficult sites.
- **Non-toxic & non-allelopathic*** : Species should not release harmful compounds (e.g., Mimosine) or allergens detrimental to crops, livestock, or human health (e.g., poplar-related allergy cases in J&K).
- **High litter quality & biomass return (Nutrient Cycling Potential)** : Leaf litter should be nutrient-rich, fast degrading, and capable of improving soil structure and organic matter.

▷ Management Suitability

- **High coppicing* ability** : Tree species should regenerate vigorously post-harvesting and support multiple cutting cycles [Ensuring continuous biomass supply].
- **Amenability to pruning and pollarding (Silvicultural Responsiveness)** : Allows canopy manipulation to maintain crop–tree balance and enhance biomass production.
- **Thornless*** habit : Safer for farm operations and livestock handling.

▷ Stress Resistance & Adaptability

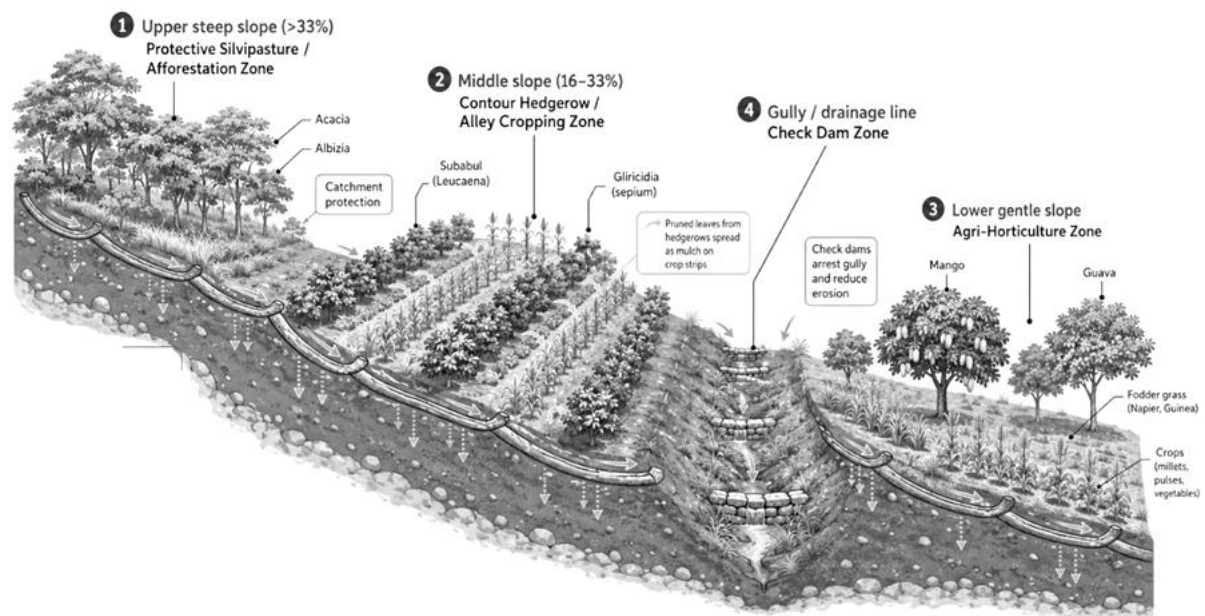
SALT Model for Degraded Hills

For degraded hill rehabilitation, the most suitable model is a contour-based, slope-zoned multi-tier agroforestry system, similar to Sloping Agricultural Land Technology — SALT.

In this approach, the hill slope is treated as the main planning unit:

- Upper steep slopes are kept under protective forestry or silvipasture.
- Middle slopes are managed through contour hedgerow intercropping or alley cropping.
- Lower gentle slopes are used for agri-horticulture or horti-pastoral systems.

Fast-growing nitrogen-fixing shrubs such as *Leucaena*, *Gliricidia*, *Flemingia*, *Sesbania* or *Tephrosia* may be planted along contours. Their periodic lopping supplies mulch and green manure, while their roots and hedge structure reduce runoff and soil erosion.



IFoS 2014 : Why are agroforestry systems becoming *Popular in Himalayan Tarai* regions, Western plains and Southern parts of India? Discuss your answer with reasons and tree-crop combinations adopted in these regions and parts of the country [20 M].

IFoS 2009 : Describe the *traditional agroforestry system* practiced in *North-eastern India*.

5.3 | SHADE TREES IN TEA / COFFEE PLANTATIONS

Tea (*Camellia sinensis*) cultivation thrives in *warm, humid tropical* climates with an optimum temperature range of *13–30°C* and *2000–3000 mm* of well-distributed annual rainfall. To simulate natural forest-like growing conditions, Indian tea estates traditionally integrate shade trees, particularly *leguminous species*, into plantation design.

Species	Common Name	Region/Use
<i>Albizia chinensis</i> ***	Silk Tree	Assam, Dooars, Darjeeling
<i>Albizia odoratissima</i> ***	Black Siris	Barak valley (Assam), North Bengal
<i>Albizia lebbeck</i> ***	Black Siris	Cachar area, Assam.
<i>Grevillea robusta</i> ***	Silver Oak	Nilgiris and parts of Darjeeling
<i>Acacia lenticularis</i>	Indian Acacia	Terai and Eastern Himalayas

AGROFORESTRY POLICY

Agroforestry—an integrated approach **combining trees, crops, and livestock**—plays a vital role in meeting India's growing demand for timber, fodder, fuelwood, and environmental services. However, until 2014, India lacked a dedicated national policy to coordinate the diverse programs under agriculture, forestry, and rural development.

Recognizing this gap, the Government of India formulated the **National Agroforestry Policy (NAP) 2014**, the first of its kind in the world, to promote tree-based farming in a systematic, farmer-friendly, and environmentally sustainable manner.

In one line

During the **3rd World Congress on Agroforestry^{***}** held from **10–14^{***} February 2014^{***}** in **New Delhi^{***}**, the then President of India, Shri **Pranab Mukherjee^{***}**, announced India's National Agroforestry Policy 2014 — which was also the **1^{st^{***}} such policy in the world**.

Later, **Nepal^{***}** became the **2nd country** to launch a national agroforestry policy.

Need for a National Agroforestry Policy

Earlier agroforestry and social-forestry efforts achieved limited success because of several inter-related constraints :

- **Absence of Dedicated Policy and Institutional Mechanism** : No unified framework existed to coordinate different schemes and ensure inter-sectoral convergence.
- **Weak Integration of Farming Systems** : Past programs often emphasized **exotic species** and neglected integration with crops and livestock.
- **Restrictive Regulations** : Complicated permissions under **forest laws and court orders** (e.g., Supreme Court, NGT) discouraged felling and marketing of trees grown on private lands.
- **Inadequate Research and Extension** : **Limited R & D, poor dissemination of technologies**, and weak capacity-building among farmers and field officers.

- **Lack of Finance and Insurance** : Farmers had little access to **institutional credit or risk coverage** for tree-based systems.
- **Poor Market Access and Industry Linkages** : Absence of efficient **value chains** kept industry operations at sub-optimal levels.
- Integration of our forest **policy targets and goals** through agroforestry practices for enhancing productivity and ecological stability.

MAJOR POLICY GOALS

The policy seeks to **mainstream agroforestry** into the national rural-development and environmental agenda through the following broad goals:

- Setting up a **National Agroforestry Mission** and an **Agroforestry Board** to implement the National Policy by bring coordination and synergy among diverse programs under agriculture, forestry, environment, and rural sectors.
- Improving the **Productivity, Employment, Income, and Livelihood Opportunities** – Particularly for small and marginal farmers through agroforestry systems.
- **Meeting the Ever-Increasing Demand** for timber, food, fuel, fodder, fertilizer, fibre, and other agroforestry products.
- **Conserve Natural Resources and Protect the Environment** – Enhance ecological stability, mitigate climate change, and increase tree / forest cover outside recorded forests.

BASIC OBJECTIVES

- **Encourage and expand tree plantation** in a complementarity and integrated manner with crops and livestock to improve productivity, employment, income, and livelihoods of rural households, especially the smallholder farmers.

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