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ALL INDIA RANK 1, IBPS RRB AGRICULTURAL OFFICER (SCALE II)



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Forestry: Definition, Types, and Classifications

Definition of Forestry: Forestry encompasses the theoretical and practical aspects of creating, conserving, managing forests, and utilizing their resources. This field involves all activities related to the management and conservation of forests, including the harvesting, marketing, and use of forest products and services. It focuses on both the management of existing forests and the creation of new ones.

Classification Based on Functions (National Forest Policy, 1952):

1. **Protection Forests:** Managed primarily for their protective functions to stabilize terrain and soil.
2. **National Forests:** Designated for the conservation of national heritage and biodiversity.
3. **Village Forests:** Managed to meet the needs of local communities.
4. **Tree Lands:** Areas outside conventional forests dedicated to tree planting.

National Commission of Agriculture (1976) Classification:

1. **Protection Forests:** Focus on forest protection to prevent soil erosion, landslides, and other ecological imbalances.
2. **Production Forests:** Managed for the maximum production of timber, fuelwood, and other forest products. Subcategories include:
 - **Commercial Forestry:** Aimed at maximizing forest product output as a business venture.
 - **Industrial Forestry:** Targets the production of raw materials for industrial use.
 - **Mixed Quality Forests:** Forests with varied species and quality.
 - **Valuable Forests:** Forests containing high-value species.
 - **Inaccessible Forests:** Forests in remote areas not easily reachable for exploitation.
3. **Social Forests:** Aimed at fulfilling the requirements of rural and urban populations. This includes:
 - **Community Forestry:** Management on non-forest lands for local benefit.
 - **Farm Forestry:** Integration of forestry practices on village lands and farms.
 - **Extension Forestry:** Involves tree planting on community lands, along roads, canals, and railways.
 - **Agro-Forestry:** Combines crop and forest plant/animal production on the same land, adhering to sustainable and culturally compatible practices.
 - **Recreational Forestry:** Develops and maintains forests for recreational and scenic value.

Main Groups of Forestry:

Basic Forestry: Covers fundamental theories, practices of forest constitution, management, and product utilization.

Key branches include:

- **Silviculture:** The cultivation and management of forest trees.
- **Forest Mensuration:** Measurement of forest produce and tree dimensions.
- **Silvicultural Systems:** Methods for forest crop management, harvesting, and renewal.
- **Forest Management:** Application of scientific, technical, and economic principles to forest management.
- **Forest Utilization:** Branch focused on forest harvesting and product utilization.
- **Forest Law:** Legal framework governing forest conservation, management, and wildlife protection.
- **Forest Policy:** Social and economic objectives underpinning forest management and development.

Applied Forestry: Encompasses specialized subjects that enhance the core practices of forestry, with a significant emphasis on silviculture for comprehensive forest crop management.

Geographical Overview of India:

- Total area: 3,280,500 square kilometers (328.8 million hectares).
- Forest coverage: 750,500 square kilometers (75.06 million hectares).
- Agricultural land: Approximately 46.4% of the total area.

National Forest Policy (1952):

- Objective: To maintain one-third of India's total land under forest for ecological balance.
- Special focus on hilly areas: Aim for 60% coverage with trees.
- Recent decades: 2 million hectares of forest have been allocated for non-forest activities such as agro-industry, power, irrigation projects, and housing.

Forest Conservation Act (1980):

- Purpose: To prevent the conversion of reserved forests to other categories and restrict the use of forest land for non-forest purposes.

Utilization of Forest Area:

- In use: 45.6 million hectares (60%).
- Potentially exploitable: 14.8 million hectares (20%).

- Unexploited areas: Primarily in Himalayan states, North Eastern regions, and Andaman and Nicobar Islands.

Energy Consumption Sources in India:

- Coal: 16.5%.
- Oil: 10%.
- Electricity: 15.7%.
- Wood: 37.6%.
- Cow dung: 8.7%.
- Vegetation waste: 11.5%.

Definitions and Terms in Forestry:

- **Forestry:** The science and practice of forest creation, conservation, management, and resource utilization.
- **Silviculture:** Focuses on the establishment, development, care, and reproduction of forest crops.
- **Pollarding:** Cutting branches to induce new shoot growth, practiced on certain tree species for protection from browsing animals.
- **Lopping:** Trimming branches or stems to encourage new shoots, used in various industries including the bidi industry.
- **Pruning:** Removing branches to improve timber quality.
- **Taungya System:** A method combining agriculture with forestry, originated in Burma for teak replanting.
- **Coppice:** Producing new shoots by cutting plants or seedlings near ground level.
- **Seed Orchards:** Plantations aimed at producing seeds from genetically superior trees.
- **Seed Production Areas or Seed Stands:** Designated for high-quality seed production from superior trees, involving the removal of inferior trees and establishment of seed orchards with controlled pollination. Types include clonal (grafted superior clones) and seedling (from superior tree seeds).
- **Pricking Out:** The process of relocating seedlings from their initial beds to other nursery beds or boxes after a year for further growth.
- **Wind Breaks:** Plantations designed to protect against strong winds, typically consisting of a few rows of trees or shrubs spaced between 0.5 to 2.5 meters apart.
- **Shelter Belts:** Large areas planted with trees, shrubs, and grasses in rows perpendicular to prevailing wind directions to deflect air currents, reduce wind velocity, and provide protection from hot winds.
- **Tending:** General care provided to forest crops at any stage of their life, including weeding, cleaning, thinning, and improvement cutting, but excluding regeneration activities.

- **Felling:** The act of cutting down trees, either individually or in small groups, throughout the forest.
- **Afforestation:** The creation of forests on land that has not been forested for a significant period through artificial means.
- **Reforestation:** The restoration of forest cover on land that previously had forest vegetation but was cleared, using artificial methods.
- **Age Crop:** The age of a forest stand determined by the average diameter of its trees.
- **Age Classification:** Sorting a forest based on the age of its trees or allocating sections of the forest into different age categories.
- **Alpine Zone:** High-altitude areas with severe winters, heavy snowfall, a mean annual temperature around 45°F, and a mean January temperature below 30°F, typically above 10,000 feet in the Himalayas.
- **Basal Area:** The cross-sectional area of a tree trunk at breast height, or the total area of all tree trunks per unit area of forest.
- **Bole:** The main trunk of a tree.
- **Breast Height:** The standard height for measuring tree dimensions, set at 4 feet 6 inches (1.37 meters) in India and 4 feet 3 inches (1.30 meters) in the UK and most Commonwealth countries.
- **Coupe:** A designated area for logging, part of a series and often numbered with Roman numerals.
- **Crown:** The top part of a tree where the branches grow out from the main trunk.
- **Dendrology:** The study of identifying and classifying tree species.
- **Reserved Forests:** Land designated under the Indian Forest Act or other laws for conservation and restricted use.
- **Protected Forests:** Areas with a degree of protection under the Indian Forest Act, with limited human activity allowed.
- **Unclassed Forest:** Government-owned forest land not designated as reserved, village, or protected forest.
- **Log:** A tree trunk or large branch that has been cut down and trimmed.
- **Logging:** The process of cutting down trees, removing branches, and transporting timber out of the forest.
- **Pole:** A young tree that has lost its lower branches and is in a stage of rapid height growth.
- **Raft:** A collection of logs, timbers, or bamboos tied together for transport by water.
- **Scrub:** Areas of poor growth, mainly small or stunted trees and shrubs.
- **Stand:** A group of trees or plants that are similar in type, age, and condition, forming a distinct unit within a forest.

- **Succession:** The natural process by which one type of plant community gradually replaces another, leading towards a stable climax community.

Forest cover, canopy density, RFA, TOF and tree cover:

| Term | Definition | Characteristics |
|-----------------------------------|---|--|
| Forest Cover | Area covered by forest canopy on the ground, irrespective of legal status, with canopy density >10% and area >1 ha. | Includes all tree patches with a canopy density of more than 10% and an area of 1 ha or more. |
| Canopy Density | Proportion of an area in the field/ground covered by the crown of trees. | Used to measure the density of the forest canopy. |
| Recorded Forest Area (RFA) | All geographic areas recorded as forest in government records. | Includes Reserved Forests (RF) and Protected Forests (PF) under the Indian Forest Act, 1927, and other areas recorded as forests under State Acts or local laws. |
| TOF (Trees Outside Forest) | Trees found outside the recorded forest areas. | Refers to all trees growing outside RFA, irrespective of patch size, which could also be larger than 1 ha. |
| Tree Cover | Patches of trees occurring outside RFA with size less than 1 ha, including scattered trees. | Considered a subset of TOF. Includes all patches of trees outside RFA that are less than 1 ha in size. |

Type of forest cover:

| Type of Forest Cover | Definition | Relative Composition in India (%) | Characteristics |
|--------------------------------|---|-----------------------------------|---|
| Very Dense Forest | Lands with tree canopy density of 70% and above. | 3.04 | Highest level of canopy density, usually rich in biodiversity and biomass. |
| Moderately Dense Forest | Lands with tree canopy density of 40% and more but less than 70%. | 9.33 | Moderate level of canopy density, often transitional zones between very dense and open forests. |
| Open Forest | Lands with tree canopy density of 10% and more but less than 40%. | 9.34 | Lower canopy density, often found at forest edges or in areas with less rainfall. |
| Scrub Forest | Lands with canopy density less than 10%. | 1.42 | Lowest level of canopy density, often found in arid regions or as a result of deforestation. |
| Non-forest | Lands not included in any of the above classes (includes water). | 76.87 | Includes all other land types like agricultural land, urban areas, and bodies of water. |

Definitions of silviculture:

1. **Tourney and Karstien:** Silviculture involves the establishment, development, care, and reproduction of timber stands.
2. **Indian Forest and Forest Products Terminology (1957):** Silviculture combines art and science in the cultivation of forest crops.
3. **Society of American Foresters (1983):** Described as both science and art, silviculture is dedicated to the cultivation of forest crops, emphasizing the establishment, composition, constitution, and growth based on silviculture knowledge.
4. **Rao (1987):** Focuses on the theoretical and practical aspects of raising forest crops, including methods of cultivation, growth, and aftercare until final harvest.

Importance of Silviculture:

- Essential for managing forests to enhance wildlife, timber, forage production, and recreational and watershed values.

Objectives of Silviculture:

1. Control Crop Composition for Economic Value:

- Natural conditions produce diverse species; silviculture prioritizes economically valuable ones by removing inferior species and supporting desirable ones.

2. Manage Stand Density for Maximum Volume:

- Adjusts tree density to optimize wood production, using thinning methods to prevent overcrowding or underutilization of space.

3. Afforestation of Depleted Areas:

- Targets reforestation in areas affected by natural or human activities, applying silvicultural knowledge for effective seed collection, nursery techniques, and plantation methods.

4. Quality Timber Production:

- Addresses the challenge of producing quality timber in unmanaged forests by controlling factors like insects, fungi, fire, wind, and grazing through silvicultural practices.

5. Regulate Rotation Period:

- Silviculture helps adjust the density of forest stands to achieve desired sizes more quickly, potentially reducing the rotation period for crop harvesting.

Facilitation of Forest Management and Use:

6. Enhanced Forest Management:

- Managed forests allow for optimized growth and distribution, enabling efficient and economic utilization of produce. Forests can be organized by age classes and species composition for simplified management.

7. Creation and Introduction of Man-Made Forests and Exotics:

- **Man-Made Forests and Exotics:** Silviculture enables the creation of man-made forests, either by replanting with native species or introducing exotic ones. Techniques include identifying suitable exotics based on location, conducting trials, and perfecting nursery and plantation methods.

8. Site Protection and Intangible Benefits:

- The goal is to maximize site protection for sustained intangible benefits, such as climate moderation, precipitation increase, soil erosion reduction, flood control, soil and water conservation, and wildlife habitat provision. Preference is given to species that enhance site protection and offer continuous intangible returns.

Functions & Types of Forests in India:

- **Productive:** Supply timber, fuel, charcoal, beedi leaves, wax, resins, fruits, tanning materials, manure leaves, grass, bamboo, gums, lac, etc.
- **Protective:** Protect watersheds and river/stream catchments against erosion.
- **Aesthetic:** Enhance appearance and provide a scenic landscape.
- **Recreational:** Offer picnic spots, hiking, trekking, wildlife and bird watching opportunities.
- **Scientific:** Facilitate ecological studies.
- **Ameliorative:** Improve climate and reduce pollution.
- **Hygienic:** Enhance the environment, reduce noise, purify air, and produce oxygen.
- **Industrial Development:** Provide raw materials for industries like paper, rayon grade pulp, saw mills, plywood, and hardboard.

Classification of Forests Based on Various Criteria:

Based on Age:

1. Even-Aged Forests:

- Consist of trees of approximately the same age.
- True even-aged forests are typically man-made.
- Naturally regenerated forests may have some age variation, with up to 25% difference allowed.

2. Uneven-Aged Forests:

- Trees vary widely in age.

Based on Regeneration:

1. High Forest:

- Regeneration from seed.

2. Coppice Forest:

- Regeneration through coppice or vegetative parts of the tree.

3. Natural Forest:

- Regeneration occurs naturally.

4. Man-Made Forest:

- Regeneration is achieved artificially.

Based on Composition:

1. Pure Forests:

- Composed almost entirely of one species.

2. Mixed Forests:

- Composed of two or more species intermingled.

Based on Management:

1. Protection Forests:

- Managed for climate amelioration, soil erosion control, and other protective functions.

2. Production Forests:

- Managed primarily for produce.

3. Social Forests:

- Produce utilized by the neighbouring society.

Based on Ownership:

1. Government Forests:

- Owned by government entities.
 - Reserved Forests: Complete protection under the Indian Forests Act, 1927.
 - Protected Forests: Limited degree of protection.
 - Village Forests: Assigned to village communities.

2. Private Forests:

- Owned by individuals, juridical persons, or partnerships.

3. Corporations, Panchayats, Societies, and Other Agencies:

- Owned by various entities outside of government or private ownership.

Based on Growing Stock:

1. Normal Forest:

- Ideal in terms of growing stock, age class distribution, and increment.

2. Abnormal Forest:

- Deviates from the norm in growing stock, age class distribution, and increment.

Structure of Forest:

- Forest Floor Layer: Blanketed with decaying matter, home to recycling organisms.
- Herb Layer: Dominated by herbaceous plants, adapted to low light conditions.
- Shrub Layer: Characterized by woody vegetation growing close to the ground.

- **Understory Layer:** Contains immature and small trees under the main canopy.
- **Canopy Layer:** Comprises the crowns of most of the forest's trees, forming a thick layer.
- **Emergent Layer:** Features trees whose crowns emerge above the rest of the canopy, receiving most sunlight.

Types of Forests in India:

India's forests can be broadly classified into five categories based on the average annual rainfall they receive. These categories encompass a diverse range of forest types, each with its unique climatic conditions, flora, and geographical distribution.

1. Tropical Evergreen Forests

- **Moist Evergreen Forests:**
 - **Location:** Southern India along the Western Ghats, Andaman and Nicobar Islands, and the northeastern region.
 - **Climate:** Warm and humid with annual precipitation over 200 cm and a mean annual temperature above 22°C.
 - **Common Trees:** Jackfruit, betel nut palm, jamun, mango, and hollock.
- **Semi-Evergreen Forests:**
 - **Location:** Less rainy parts of Western Ghats, Andaman and Nicobar Islands, and the Eastern Himalayas.
 - **Flora:** A mix of moist evergreen and moist deciduous trees including white cedar, hollock, and kail.
- **Dry Evergreen:**
 - **Location:** Along the coasts of Andhra Pradesh and Karnataka.
 - **Climate:** Prolonged hot and dry season with a cold winter.
 - **Common Trees:** Pomegranate, olive, and oleander.

2. Tropical Deciduous Forests (Monsoon Forests)

- **Moist Deciduous Forests:**
 - **Location:** Northeastern states along the foothills of the Himalayas, eastern slopes of the Western Ghats, and Odisha.
 - **Rainfall:** Regions with 100-200 cm of rainfall.
 - **Common Trees:** Teak, Sal, shisham, hurra, mahua, amla, semul, Kusum, and sandalwood.
- **Dry Deciduous Forests:**
 - **Location:** Throughout northern India, excluding the northeast.
 - **Rainfall:** Areas receiving 70-100 cm of rainfall.
 - **Common Trees:** Tendu, palas, amaltas, bel, khair, axlewood.

3. Thorn Forests

- **Characteristics:** Found in areas with less than 50 cm of annual rainfall.

- **Common Trees:** Babul, Acacia, Kokko, Khair, Khajuri, Ber, Neem, Khejri, Palas.

4. Montane Forests

- **Montane Wet Temperate Forests:**

- **Location:** Eastern Nepal to Arunachal Pradesh (north) and parts of Nilgiris Hills, higher reaches of Kerala (south).
- **Rainfall:** Minimum of 200 cm.
- **Flora:** Northern forests are denser with species like rhododendrons, champa, eucalyptus; southern forests have replaced original trees with fast-growing varieties.

- **Montane Subtropical Forests:**

- **Location:** Northwestern Himalayas excluding Ladakh and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh.
- **Climate:** Rainfall of 100-200 cm with temperatures between 15°C to 22°C.
- **Common Trees:** Chir (Pine), Oak, Jamun, and Rhododendron.

5. Alpine and Subalpine Forests

- **Flora:** Juniper, rhododendron, willow, black currant in the west; red fir, black juniper, birch, and larch in the east.

6. Mangroves

- **Spread:** Over 6,740 sq. km in India, making up 7% of the world's mangrove forests.
- **Location:** At the confluence of rivers and seas, notably the Sundarbans in the Ganges delta, the largest tidal forest globally.
- **Function:** Stabilize shorelines and protect coastal areas from erosion.

Important forest tree species:

| Sr. No | Botanical Name | Common Name | Use or Utilities |
|--------|---------------------------------|--------------------|--|
| 1 | Acacia catechu | Khair | Fodder, fuel, poles, soil conservation and katha |
| 2 | Acacia nilotica | Babul | Fodder, soil conservation; agricultural implements, bark as medicine, tannin products and fuel |
| 3 | Azadirachta indica | Neem | Planks, tooth brush and medicine (Bark, leaves gum) |
| 4 | Bombax ceiba, Bombax malbaricam | Simal (Kate sawar) | Match Sticks, packing cases, play wood, soil |

| | | | |
|----|--|-----------------|--|
| | | | conservation, roots used as medicines |
| 5 | Dalbergia sissoo | Sissoo | Fodder, Timber, fuel, soil conservation |
| 6 | Dalbergia latifolia | Rose Wood | Fodder, Timber, fuel |
| 7 | Melia azadirachta | Bakan/ Limbara | Avenue tree, fodder, timber |
| 8 | Tectona grandis | sag / Teak Wood | Structures and industrial timber, furniture, fuel, tannin, ornamental and medicinal use, KING OF TIMBEER |
| 9 | Terminalia tomentosa | Asan / Ain | Industrial timber, tannin, gum, medicinal, tassar |
| 10 | Terminalia arjuna | Arjun | Industrial timber, small poles, fodder, timber, ornamental, tassar |
| 11 | Acacia auriculiformis | Australin Babul | Denuded places, tannin, fuel |
| 12 | Acacia chundra | Lal khair | Timber, pole, fuel, tannin and soil conservation |
| 13 | Aegle marmelos | Bel | Tooth brush, fruits, medicine (Bark, gum) |
| 14 | Albizia chinensis | Kala sires | Timber, pole, fuel, tannin and soil conservation |
| 15 | Albizia procera | Safed Siris | Timber, medicine, fuel |
| 16 | Arto carpusus | Jack Fruit | Fruit and timber |
| 17 | Anthocephalus chinensis/Neolamarckia cadamba | Kadamb | Fodder, pulp wood, ornamental |
| 18 | Emblica officinalis | Amla | Fruit, fuel, ornamental, medicinal |

| | | | |
|----|-----------------------------|-----------|--|
| 19 | <i>Madhuka latifolia</i> | Mahua | Liquor oil seed, timber, edible flower |
| 20 | <i>Mangifera Indica</i> | Mango | Fruit, timber, medicine. |
| 21 | <i>Tamarindus indica</i> | Imli | Fruit, fuel, medicinal, timber, leaves, flowers, fodder, poles |
| 22 | <i>Ziziphus jujuba</i> | Ber | Fruit, fodder, poles, lac |
| 23 | <i>Syzygium cumini</i> | Jamun | Fruit, fodder, poles, timber, fuel, medicinal (flowers fruits) |
| 24 | <i>Moringa oleifera</i> | Drumstick | Fruit, fodder, hand paper |
| 25 | <i>Sesbania grandiflora</i> | Hadga | Flowers, fence poles, tannin fodder, fuel, pulp |
| 26 | <i>Saraca indica</i> | Ashok | Ornamental, medicinal |
| 27 | <i>Santalum album</i> | Sandal | Industrial timber, oil, ornamental, medicinal |
| 28 | <i>Mores alba</i> | Mulberry | Fodder, fruit, sport goods, silk industries |
| 29 | <i>Pongamia pinnata</i> | Karanja | Leaves used for green manuring branches used as tooth brush seeds for oil, used for soil conservation. |
| 30 | <i>Bauhinia variegata</i> | Kanchan | Fodder, food, timber, leaves and flowers are used as vegetables, medicine |
| 31 | <i>Bathinia racemosa</i> | Jhangora | Medicinal plant, ornamental |
| 32 | <i>Barchinia chinensis</i> | Kanchan | Medicinal and fuel, ornamental |
| 33 | <i>Michelia chamapaca</i> | Chaffa | Pole, industrial timber, fuel, ornamental, soil conservation, medicinal |

| | | | |
|----|----------------------------------|-------------------|---|
| | | | flowers are more valuable for perfume |
| 34 | <i>Populus deltoids</i> | Poplar | Pulp wood, fodder, packing cases, soil conservation, fuel match box and splints |
| 35 | <i>Pithecellobium dulcis</i> | Vilayati Chinch | Fuel, hedge, soil conservation |
| 36 | <i>Prosopis chinensis</i> | Kabuli kikar | Fodder, fuel. soil conservation |
| 37 | <i>Casuarina equisetifolia</i> | Khadsarni or suru | Fuel, timber, good for plantation in coastal area, charco |
| 38 | <i>Cupressus cashmiriana</i> | Cypress | Industrial timber, poles, soil conservation sandy area |
| 39 | <i>Eucalyptus camatndulensis</i> | Eucalyptus | Gum, oil, tannin, soil conservation, industrial timber, paper, pulp |
| 40 | <i>Eucalyptus globules</i> | Blue Gum | Pulp wood, fuel, timber |
| 41 | <i>Eucalyptus teriticornis</i> | Mysore Gum | Fuel and pulp wood |
| 42 | <i>Ficus religiosa</i> | Pipal | Avenue trees, fuel, fodder |
| 43 | <i>Ficus bengalensis</i> | Wad | Avenue trees, fodder, fuel, fruits, soil conservation, timber for packing cases |
| 44 | <i>Ficus glomerata</i> | Gular / Umbar | Avenue trees, fodder, fuel |
| 45 | <i>Delonix regia</i> | Gulmohar | Ornamental, avenue trees |

Important N fixing tree species:

| Common No. | Common Name | Botanical Name | Family | Characteristics |
|------------|-------------|-------------------------|----------|---|
| 1 | Shisham | <i>Dalbergia sissoo</i> | Fabaceae | Deciduous tree, grows up to 25m; compound leaves; small, fragrant flowers; used for timber. |

| No. | Common Name | Botanical Name | Family | Characteristics |
|-----|--------------------|-----------------------|-------------|--|
| 2 | Subabul | Leucaena leucocephala | Fabaceae | Fast-growing, small tree; white, fluffy flowers; mimosa-like leaves; used for fodder and firewood. |
| 3 | Indian Mesquite | Prosopis cineraria | Fabaceae | Drought-resistant; deep root system; small leaves; used for fodder, fuel, and timber. |
| 4 | Khejri | Prosopis cineraria | Fabaceae | Highly valued in desert regions; provides fodder, fuelwood, and is considered sacred. |
| 5 | Banyan | Ficus benghalensis | Moraceae | Large, shade-providing tree; aerial prop roots; significant cultural and religious value. |
| 6 | Arhar (Pigeon Pea) | Cajanus cajan | Fabaceae | Shrub; produces edible seeds; used in traditional Indian cooking; improves soil fertility. |
| 7 | Neem | Azadirachta indica | Meliaceae | Evergreen tree; compound leaves; used for its medicinal properties and for timber. |
| 8 | Indian Beech | Pongamia pinnata | Fabaceae | Medium-sized tree; pink-white flowers; seed oil used for biodiesel; salt-tolerant. |
| 9 | Acacia | Acacia nilotica | Fabaceae | Thorny; spherical yellow flowers; used for gum arabic, timber, and medicinal purposes. |
| 10 | Siris | Albizia lebbek | Fabaceae | Large tree; large, spreading crown; fragrant white flowers; used for timber and medicinal uses. |
| 11 | Gmelina | Gmelina arborea | Lamiaceae | Fast-growing, deciduous tree; light demander; used for plywood, paper, and medicinal purposes. |
| 12 | Sesbania | Sesbania grandiflora | Fabaceae | Small tree or shrub; large white flowers; leaves and flowers used as vegetables in local cuisine. |
| 13 | Moringa | Moringa oleifera | Moringaceae | Fast-growing, drought-resistant tree; edible leaves and pods; used in traditional medicine. |
| 14 | Indian Coral Tree | Erythrina variegata | Fabaceae | Deciduous tree with spiny trunk; bright red flowers; used as an ornamental and for medicinal uses. |

| Common No. | Name | Botanical Name | Family | Characteristics |
|------------|---------------------|-------------------------|---------------|---|
| 15 | Silver Oak | Grevillea robusta | Proteaceae | Fast-growing; used for timber, shade, and ornamental purposes; not a true oak. |
| 16 | Black Locust | Robinia pseudoacacia | Fabaceae | Fast-growing; invasive in some areas; used for erosion control, ornamental, and timber. |
| 17 | Casuarina | Casuarina equisetifolia | Casuarinaceae | Evergreen; needle-like foliage; used for firewood, timber, and soil conservation. |
| 18 | Jatropha | Jatropha curcas | Euphorbiaceae | Drought-resistant; produces seeds with oil used for biodiesel; used in afforestation projects. |
| 19 | Drumstick Tree | Moringa oleifera | Moringaceae | Fast-growing; produces edible pods and leaves; used in traditional medicine and water purification. |
| 20 | Flame of the Forest | Butea monosperma | Fabaceae | Deciduous tree; bright orange flowers; used in traditional medicine and dye production. |

Important diseases of trees in India, their causes, and symptoms:

| Disease Name | Causes | Symptoms |
|-----------------------------|--|--|
| Red Rust of Eucalyptus | Fungus (Cephaleuros virescens) | Reddish powdery appearance on leaves leading to defoliation and stunted growth |
| Heart Rot | Various Fungi (e.g., Ganoderma, Fomes) | Decay in the heartwood of trees, leading to hollow trunks and weakened structure |
| Wilting of Sissoo | Fungus (Fusarium solani) | Yellowing of leaves, wilting, and eventual death of the tree |
| Spike Disease of Sandalwood | Mycoplasma-like organisms | Leaf chlorosis, wilt, dieback, and eventual death of the tree |
| Dutch Elm Disease | Fungus (Ophiostoma ulmi) | Wilting, yellowing of leaves, branch dieback, and ultimately tree death |

National Forest Policy, 1988 - Overview in Points:

Preamble

1. **Origination:** Follow-up to the 1952 Forest Policy due to depletion of forests from various pressures.

2. **Need for Revision:** Urgent need for a new strategy focusing on conservation, including preservation, maintenance, sustainable utilization, restoration, and enhancement of the natural environment.

Salient Features

1. **Environmental Stability:** Preserve and restore ecological balance.
2. **Conservation of Natural Heritage:** Preserve natural forests and biodiversity.
3. **Soil and Water Conservation:** Check soil erosion and denudation in catchment areas.
4. **Desertification Control:** Prevent extension of sand-dunes in desert and coastal areas.
5. **Increase Forest Cover:** Through afforestation and social forestry on degraded lands.
6. **Meeting Rural and Tribal Needs:** Fulfil fuelwood, fodder, minor forest produce, and timber needs.
7. **Enhancing Forest Productivity:** To meet national needs.
8. **Efficient Utilization and Substitution of Forest Produce:** Maximize substitution of wood.
9. **People's Movement:** Involve communities, especially women, to minimize pressure on forests.
10. **Primary Aim:** Environmental stability and ecological balance over direct economic benefits.

Essentials of Forest Management

1. **Protection and Productivity Improvement:** Of existing forests and lands.
2. **Avoid Agricultural Land Conversion:** Due to the need for increased food production.
3. **Conservation of Biodiversity:** Strengthen and extend protected areas network.
4. **Provision of Fodder, Fuel, and Pasture:** Especially near forests to reduce depletion.
5. **Enhancement of Minor Forest Produce:** For tribal sustenance and employment.

Strategy

1. **National Forest Coverage Goal:** Minimum one-third of total land under forest/tree cover.
2. **Afforestation and Social Forestry Initiatives:** Time-bound programme for fuelwood and fodder development on degraded lands.
3. **Tree Planting Alongside Roads and Canals:** To improve micro-climate and check erosion.
4. **Community Land Use for Tree Crops:** With government technical assistance and revenue sharing.
5. **Legal and Incentive Measures for Tree Farming:** Modification of land laws and provision of leases or tree-pattas.

Management of State Forests

1. **Restriction on Projects in Sensitive Areas:** To protect ecological stability.
2. **Mandatory Management Plans for Forest Working:** Approved by the government and in line with National Forest Policy.

3. **Scientific Enhancement of Forest Cover and Productivity:** Without clear-felling of natural forests or introducing harmful exotics.
4. **Rights and Concessions:** To be related to the carrying capacity and optimized through increased investment.
5. **Tribal and Rural Communities:** Protection of their rights and involvement in forest development.

Special Considerations

1. **Forest Based Industries:** Must be self-sufficient in raw materials and prioritize local employment.
2. **Wildlife Conservation:** Special care in forest management plans and provision for wildlife corridors.
3. **Tribal People Engagement:** In protection, regeneration, and development of forests.
4. **Control of Shifting Cultivation and Encroachments:** With rehabilitation of damaged areas.
5. **Regulation of Forest Fires and Grazing:** With modern management practices.

Additional Strategies

1. **Forest Extension and Education:** To build public support and knowledge about forestry.
2. **Forestry Research:** Prioritizing productivity, conservation, and alternative income avenues.
3. **Personnel Management:** Enhancing competence and motivation of forestry staff.
4. **Forest Survey and Data Base:** Completion and updating of forest resource surveys.
5. **Legal and Infrastructure Development:** For effective policy implementation.
6. **Financial Support for Forestry:** Investment in forests as a national asset, not as a revenue source.

Natural Regeneration of Forest:

1. **From Seed:**
 - **Seed Production:** Involves the maturation of ovules into seeds containing embryos, influenced by species, tree age, site conditions, weather, seasonality, pest/disease attacks, and predation.
 - **Seed Dissemination:** Essential for species survival, involving seed transport away from the parent plant via wind, water, animals, or explosive mechanisms to reduce competition and increase survival chances.
 - **Seed Germination:** Relies on factors like seed coat permeability, moisture, oxygen, embryo nature (dormancy), temperature, soil moisture, soil oxygen, and light. Additional influences include tree age, flowering phase, seed health, coppice origin, seed size, germination rate, dissemination type, soil nutrition, and pest/disease presence.
 - **Seedling Establishment:** The critical phase for integrating germinated seedlings into the forest ecosystem, influenced by climate (light, moisture,

rainfall, temperature, frost) and edaphic factors (soil nutrients, aeration, texture, structure).

2. By Coppice and Root Suckers:

- **Coppice Regeneration:** Involves shoot growth from adventitious buds on stumps, categorized into seedling coppice, stool coppice, root collar shoots, and pollard shoots. Coppice shoots are shorter-lived than those from dormant buds.
- **Natural Regeneration by Root Suckers:** Shoots emerging from roots, either naturally or through artificial stimulation.

Artificial Regeneration of Forests:

Preliminary Considerations for Artificial Regeneration:

Alarming Deforestation Rate: Approximately 1.5 million hectares annually.

Basic Steps in Artificial Regeneration:

1. Choice of Species:

- **Purpose Specification:** Define the objective of tree cultivation.
- **Climatic Considerations:** Select species based on climate and microclimate.
- **Soil Requirements:** Choose species suitable for specific soil types, e.g., wet soils (Salix, Populus), water-logged soils (Eucalyptus robusta, E. saligna), sandy loam (Albizia procera, Acacia nilotica, Dalbergia sissoo).
- **Market Considerations:** Factor in market demand and facilities.
- **Growth Rate:** Prefer fast-growing species for quicker results.
- **Exotic Species:** Consider non-native species adaptable to local conditions.
- **Establishment Base:** Evaluate the ease of species establishment.
- **Management Objectives:** Align species choice with management goals.
- **Site Conditions:** Assess physical and biological site factors.
- **Successional Stages:** Understand vegetation development towards climax.
- **Cost Considerations:** Account for the financial aspects of cultivation.
- **Seed/Propagation Material Availability:** Ensure a reliable seed source.

2. Choice of Method:

- **Sowing vs. Planting:** Determine the most suitable approach.

Sowing Advantages:

- Cost-effective and straightforward.
- Direct method without root disturbance.
- Quick execution with minimal complications.
- Possible direct field application without nursery requirement.

Planting Advantages:

- Higher success rate with controlled seed usage.
- Reduced weeding costs and less seedling damage.

Disadvantages of Planting:

- Nursery requirement.
- Potential root disturbance.
- Time-consuming and skill-dependent.
- Higher costs.

3. Site Selection:

- Consider ground cover, topography, soil type, erosion risks, area size, and accessibility.
- Prepare the site to ensure a suitable environment for species establishment.

4. Manpower and Equipment Needs:

- Skillful execution and appropriate equipment are crucial.

5. External Constraints:

- Legal responsibilities, smoke management, proximity to sensitive areas, and local community attitudes.

6. Spatial Arrangement (Spacing):

- Critical for optimal growth and development.

Artificial Regeneration by Vegetative Method:

Materials Beyond Seeds:

- Utilize bare root seedlings, containerized seedlings, cuttings, layering, rhizomes, suckers, offsets, bulbs, and corms.

Propagation by Cuttings:

- Types include stem cuttings (hardwood, softwood) and root cuttings, suitable for species with easy rooting like Shisam and Sandalwood.

Stumps Use:

- For species like Teak and Shisam, ensuring minimal stem and root portion for effective transport and planting.

Root Suckers:

- Employed for species like Pomegranate and Shisam, focusing on conservation of superior genotypes and commercial plantation suitability.

Vegetative Propagation Advantages:

- Conserves superior genotypes.
- Suitable for commercial plantations with specific traits (short-lived, non-timber focused).

Tending Operations in Silviculture:

Tending operations in silviculture are essential for the establishment, growth, and development of forest crops up to the point of harvesting. These operations aim to create a conducive environment for the healthy growth of trees. The primary tending operations include:

1. Weeding:

- **Objective:** To remove unwanted vegetation competing with the forest crop for nutrients, water, and light.
- **Methods:**
 - **Mechanical:** Physical removal of weeds using tools and machinery.
 - **Biological:** Utilizing living organisms to control weed populations.
 - **Chemical:** Applying herbicides to suppress or kill weeds.

2. Cleaning:

- **Definition:** The removal of undesirable trees of the same age as the crop trees, particularly in the sapling stage, to prevent competition and promote the growth of desired trees.
- **Benefit:** Ensures optimal crop composition, especially in mixed-species stands.
- **Methods:** Similar to weeding, involving mechanical, biological, and chemical techniques.

3. Thinning:

- **Purpose:** To enhance the growth and form of remaining trees by removing some trees from an immature stand without permanently opening the canopy.
- **Application:** Conducted from the sapling stage until the beginning of the regeneration period, primarily in pure or relatively even-aged stands.

4. Improvement Felling:

- **Objective:** To remove defective, diseased, or poorly formed trees to improve the overall quality and value of the forest stand.

5. Pruning:

- **Purpose:** To remove lower branches from trees to improve timber quality by reducing knots and promoting straight, clear boles.

6. Climber Cutting:

- **Definition:** The removal of climbing plants and vines that may strangle or compete with trees for light and nutrients.

Important timber woods, their characteristics and defects:

| Timber Wood Type | Characteristics | Common Uses | Defects |
|------------------|---|------------------------------------|-------------------------|
| Teak | Durable, water-resistant, easy to work with | Furniture, boat building, flooring | Knots, shakes, wane |
| Oak | Strong, durable, good workability | Furniture, flooring, cabinetry | Checks, splits, warping |

| Timber Wood Type | Characteristics | Common Uses | Defects |
|-------------------------|---|--|--|
| Pine | Soft, lightweight, easy to work with | Framing, furniture, paneling | Knots, pitch pockets, resin canals |
| Maple | Hard, fine-grained, smooth finish | Flooring, furniture, musical instruments | Bird pecks, mineral streaks, gum spots |
| Cedar | Lightweight, aromatic, natural insect repellent | Outdoor furniture, decking, fencing | Knots, splits, wane |
| Birch | Strong, fine-grained, pale color | Furniture, cabinetry, veneer | Knots, pitch pockets, discoloration |
| Cherry | Fine-grained, reddish-brown, ages well | Fine furniture, cabinetry, veneer | Gum pockets, pitch pockets, splits |
| Mahogany | Durable, easy to work, reddish-brown | High-end furniture, boat building, cabinetry | Pinholes, splits, shakes |
| Spruce | Lightweight, straight-grained, soft | Construction, musical instruments | Knots, resin canals, shakes |
| Fir | Strong, straight-grained, light color | Construction, plywood, furniture | Knots, pitch pockets, checks |

Important Timber Defects:

| Wood Defect | Detailed Description |
|--------------------|---|
| Knots | Hard, cylindrical regions in wood where a branch once grew. Vary in size, may impact appearance and strength. Natural features formed during the tree's growth. |
| Shakes | Separations along the wood grain. Can occur radially or tangentially. May impact structural integrity. Caused by drying stresses or wood deterioration. |
| Wane | Bark or lack of wood along the edge or corner. Occurs when the wood doesn't entirely cover the cross-section, affecting dimensional stability and appearance. |
| Checks | Splits along the wood grain, usually at the ends. Result from drying or stresses. Some are normal, excessive checking may reduce strength. |
| Splits | Separations of wood fiber running parallel to the grain. Can result from drying stresses, mechanical damage, or natural characteristics of the wood species. May compromise structural integrity. |
| Warping | Distortion in the shape of the wood, including cupping, bowing, and twisting. Result of uneven drying, changes in humidity, or improper storage. |

| Wood Defect | Detailed Description |
|------------------------|--|
| Bird Pecks | Small holes or indentations caused by birds feeding on insects or drilling for larvae. May not impact structural integrity but can affect visual appeal. |
| Mineral Streaks | Discolorations caused by minerals in the wood. Varies in color and intensity. Does not necessarily impact strength but can affect appearance. |
| Gum Spots | Spots of hardened sap in the wood. Sticky or resinous. More common in certain softwood species. May affect finish and workability. |
| Pitch Pockets | Small openings filled with resin. Occurs when resin accumulates during wood growth. May not compromise strength but can affect appearance and workability. |
| Resin Canals | Tubes within the wood filled with resin. Natural part of certain wood species. Can affect appearance and workability. |
| Pinholes | Small holes caused by wood-boring insects. Evidence of insect activity. May not always impact structural integrity but can affect visual appeal. |

Various implements used in forestry with their functions:

| Tool | Function |
|------------------------|---|
| Chainsaw | Cutting down trees, trimming branches |
| Crosscut Saw | Cutting down trees, especially in areas where chainsaws are not allowed |
| Machete | Clearing brush and undergrowth |
| Pruning Shears | Trimming small branches and twigs |
| Pole Saw | Pruning high branches |
| Wedge and Maul | Splitting logs into smaller pieces |
| Cant Hook | Rolling and moving logs |
| Log Peavey | Similar to Cant Hook but with a spiked end for better grip |
| Clinometer | Measuring the height of trees, slope, topographic relief, and preliminary surveying |
| Increment Borer | Extracting cores from trees to determine age and health |
| Brush Grubber | Removing small trees and shrubs by the roots |
| Fire Rake | Clearing leaves and debris to prevent forest fires |
| Pulaski Axe | Multi-purpose tool for chopping wood and digging soil |
| Diameter Tape (D-tape) | Measuring tree's diameter, usually at breast or chest height |
| Callipers | Measuring tree and log diameters with high precision |

| Tool | Function |
|--------------------------------|---|
| Haga altimeter | A portable instrument used for measuring tree height from a distance without using any trigonometric formulae |
| Logger Tape | Measuring land dimensions of felled timber |
| Angle Gauge | Selecting or tallying trees in variable area plot sampling |
| Prism | Deflecting the tree trunk image when viewed, used in sampling |
| Surveyor Chain | Horizontal land measurement, length of 66 feet, divided into 100 "links" |
| Biltmore Stick (Cruiser Stick) | Measuring trees and logs based on the principle of similar triangles |
| Billhook | Used for cutting smaller woody material such as shrubs and branches |

Instrument used for different purposes:

- Instrument used to measure upper stem diameter for determination of volume: **Ruler and wheeler penta prism, speagle relaskop, dendrometer.**
- Instrument used to measure height of tree based on similar triangle principle: **Christen's hypsometer, smythie's hypsometer.**
- Instrument used to measure height of tree based on trigonometric principle: **Abney's level, brandis hypsometer, haga altimeter, ravi multimeter, ravi altimeter, Clinometer/silva ranger compass, electronic clinometer, vertex laser hypsometer.**

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Some common formulas used for volume estimation of standing trees:

1. Volume of a Tree Using Diameter at Breast Height (DBH) and Height

The most basic formula for estimating the volume V of a tree involves its Diameter at Breast Height (DBH) and total height (H). One commonly used formula is:

$$V = \frac{\pi}{4} \times DBH^2 \times H$$

where:

- V is the volume in cubic units,
- DBH is the diameter of the tree at breast height (1.3 meters above the ground) in the same linear units as H ,
- H is the height of the tree.

2. Huber's Formula

Huber's formula is a simple method that estimates the volume of a tree using the cross-sectional area at breast height and the total height of the tree:

$$V = A \times H$$

where:

- A is the cross-sectional area at breast height ($\frac{\pi}{4} \times DBH^2$),
- H is the total height of the tree.

3. Newton's Formula

Newton's formula estimates the volume of a tree by averaging the areas at the base, middle, and top of the tree and multiplying by the height:

$$V = \frac{A_{base} + 4A_{mid} + A_{top}}{6} \times H$$

where:

- A_{base} , A_{mid} , and A_{top} are the cross-sectional areas at the base, middle, and top of the tree,
- H is the height of the tree.

4. Smalian's Formula

Smalian's formula is used for trees with irregular shapes. It calculates volume by averaging the cross-sectional areas at the ends and multiplying by the length:

$$V = \frac{A_1 + A_2}{2} \times L$$

where:

- A_1 and A_2 are the cross-sectional areas at the ends of the log,
- L is the length of the log.

5. Paraboloid Formula

The paraboloid formula estimates the volume of a tree assuming the shape of a paraboloid:

$$V = \frac{2}{3}\pi r^2 H$$

where:

- r is the radius at the base of the tree,
- H is the height of the tree.

6. Cone Formula

The cone formula assumes the tree is a perfect cone:

$$V = \frac{1}{3}\pi r^2 H$$

where:

- r is the radius at the base of the tree,
- H is the height of the tree.

7. Cylinder Formula

The cylinder formula assumes the tree is a perfect cylinder:

$$V = \pi r^2 H$$

Types of Forest Mensuration Measurements:

| Measurement Type | Description | Tools Used |
|---------------------------------|---|--------------------------------|
| Tree Height | Measures the height of individual trees | Clinometer, Hypsometer |
| DBH (Diameter at Breast Height) | Measures the diameter of the tree at breast height (1.3m from the ground) | Diameter tape, Calipers |
| Crown Diameter | Measures the width of the tree's crown | Measuring tape, Rangefinder |
| Basal Area | Measures the cross-sectional area of a tree at breast height | Basal area gauge, Prism |
| Tree Volume | Estimates the volume of wood in a tree | Volume tables, Form factor |
| Stand Density | Measures the number of trees per unit area | Quadrat method, Point sampling |

Common Formulas in Forest Mensuration:

| Formula Name | Formula | Description |
|--------------|--|--|
| Tree Height | $H = D \times \tan(\theta)$ | H is height, D is distance to tree, θ is angle to top of tree |
| Basal Area | $BA = \pi \times \left(\frac{DBH}{2}\right)^2$ | BA is basal area, DBH is diameter at breast height |
| Tree Volume | $V = BA \times H \times F$ | V is volume, BA is basal area, H is height, F is form factor |

Standard rules for diameter or girth measurement in forest mensuration:

| Method/Rules | Diameter/Girth Measured At | Tools Used | Purpose |
|---------------------------------|----------------------------|-------------------------|--|
| DBH (Diameter at Breast Height) | 1.3m or 4.5ft above ground | Diameter tape, Calipers | General inventory, growth studies |
| Merchantable Height | Up to first major branch | Diameter tape, Calipers | Timber valuation |
| Variable Radius Plot | 1.3m or 4.5ft above ground | Angle gauge, Prism | Forest inventory, especially for variable area plot sampling |
| Coppice Stool Measurement | Ground level | Diameter tape | For coppiced trees, to assess regrowth potential |
| Sapling Measurement | 0.3m or 1ft above ground | Calipers | For young trees, to assess potential for inclusion in timber inventory |
| Irregular Form | Multiple points | Diameter tape, Calipers | For trees with irregular forms, to get an average diameter |

Common Defects and Their Impact on Mensuration:

| Defect Type | Impact on Measurement |
|-------------|---|
| Forks | Complicates height and volume calculations |
| Hollows | Reduces actual usable volume |
| Knots | May affect diameter measurements and timber quality |
| Decay | Reduces actual usable volume and quality |

Important acts related to forestry in India:

| Act Name | Year of Enactment | Key Provisions |
|---|-------------------|---|
| Indian Forest Act | 1927 | Governs the management of forests and wildlife resources. Defines Reserved, Protected, and Village Forests. |
| Wildlife Protection Act | 1972 | Provides for the protection of wild animals, birds, and plants. |
| Forest (Conservation) Act | 1980 | Regulates the diversion of forest lands for non-forest purposes. |
| Environment (Protection) Act | 1986 | Provides for the protection and improvement of the environment. |
| Biological Diversity Act | 2002 | Provides for the conservation of biological diversity and sustainable use of its components. |
| Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act | 2006 | Recognizes the rights of forest-dwelling communities over land and other resources. |
| National Green Tribunal Act | 2010 | Establishes a National Green Tribunal for effective and expeditious disposal of environment-related cases. |
| Compensatory Afforestation Fund Act | 2016 | Establishes funds for compensatory afforestation and conservation. |

Important forest related institutions in India:

| Institution Name | Location |
|---|--------------------------|
| Forest Research Institute (FRI) | Dehradun, Uttarakhand |
| Indian Council of Forestry Research and Education (ICFRE) | Dehradun, Uttarakhand |
| Wildlife Institute of India (WII) | Dehradun, Uttarakhand |
| Indira Gandhi National Forest Academy (IGNFA) | Dehradun, Uttarakhand |
| Tropical Forest Research Institute (TFRI) | Jabalpur, Madhya Pradesh |
| Arid Forest Research Institute (AFRI) | Jodhpur, Rajasthan |
| Himalayan Forest Research Institute (HFRI) | Shimla, Himachal Pradesh |
| Institute of Forest Genetics and Tree Breeding (IFGTB) | Coimbatore, Tamil Nadu |
| Institute of Forest Productivity (IFP) | Ranchi, Jharkhand |
| Centre for Social Forestry and Eco-Rehabilitation (CSFER) | Allahabad, Uttar Pradesh |

| Institution Name | Location |
|--|------------------------|
| National Institute of Forest Management (NIFM) | Bhopal, Madhya Pradesh |

Introduction to Agroforestry

Agroforestry Overview:

- Agroforestry, a key component of social forestry, integrates the cultivation of trees, crops, and sometimes livestock on the same land parcel. This sustainable land management system enhances land yield through simultaneous or sequential cultivation of agricultural and forest crops, including trees and animals. It incorporates management practices aligned with local cultural norms, facilitating the coexistence of agriculture and forestry to significantly boost overall land productivity.

Current Forest and Land Use Statistics in India:

- Total land area: 329 million hectares.
- Agricultural land: 143 million hectares (47%).
- Forested land: 75 million hectares (22.7%).
- Barren land: 21 million hectares.
- Non-agricultural land: 18 million hectares.
- Illegally occupied land: 24 million hectares.
- Population: 1 billion.
- Cattle population: 400 million.

Challenges and Objectives:

- With half of India's forests denuded to varying degrees due to human activity, and the country's rapidly growing population and livestock numbers demanding substantial resources, there's a critical need for afforestation and tree planting with widespread community involvement. Achieving a forest cover of 30-33% of the total geographical area is internationally recommended for environmental and ecosystem balance.

Agroforestry as a Solution:

- Recognizing the inadequacy of the existing 75 million hectares of forest cover to maintain environmental health, a national policy resolution in 1952 aimed to increase forest cover by 35 million hectares to achieve 33% forest coverage. Despite the wisdom of this decision, implementation has faltered.
- Agroforestry has emerged as a crucial land use system, recognized in the planning of India's seventh five-year plan, with recommendations for its inclusion in the agricultural curriculum of state universities.

Classification of Agro-forestry Systems

1. Structural Basis:

A. Nature of Components:

- **Agrisilvicultural Systems:**
 - Integration of agricultural crops with tree crops in the spaces between trees.
 - Agricultural crops can be grown under protective irrigated conditions for up to two years and under rainfed conditions for up to four years.
 - Beyond the specified period, it becomes uneconomical to grow grain crops, though fodder, shade-loving, and shallow-rooted crops remain viable.
 - Wider spacing is adopted to facilitate cultural operations and ensure sufficient sunlight for the intercrop, enhancing tree crop performance compared to monoculture.
- **Silvopastoral Systems:**
 - Combines woody plant production with pasture, serving dual purposes such as fodder production for livestock or growth for timber, fuelwood, fruit, and soil improvement.
 - Classified into:
 - **Protein Bank:** Multipurpose, protein-rich trees are planted for fodder production to support livestock during fodder-deficit winters.
 - **Live Fence of Fodder Trees and Hedges:** Utilizes various fodder trees and hedges as live fences for property protection.
 - **Trees and Shrubs on Pasture:** Incorporates tree and shrub species within pastures to enhance forage production.
- **Agrosilvopastoral Systems:**
 - Merges the production of woody perennials with annuals and pastures, categorized into:
 - **Home Gardens:** Dense mixtures of trees, bushes, vegetables, and herbaceous plants, often supporting animal life and fodder production.
 - **Woody Hedgerows:** Fast-growing, coppicing fodder shrubs and trees planted for browse, mulch, green manure, and soil conservation.
- **Other Systems:**
 - **Apiculture with Trees:** Involves planting nectar-producing trees to support honeybee activity.
 - **Aquaforestry:** Trees preferred by fish are planted around fish ponds for feed and bund stabilization.
 - **Mixed Wood Lots:** Location-specific Multi-Purpose Trees (MPTs) are grown for wood, fodder, soil conservation, etc.

B. Arrangement of Components:

- **Spatial Arrangement:** Can result in either dense mixed stands (like home gardens) or sparse stands (trees in pastures).
- **Temporal Arrangement:** Ranges from short cropping cycles to longer fallow periods with strategic planting of woody species.

2. Functional Basis:

- **Productive Functions:** Include food, fodder, fuelwood, cloth, shelter, and Non-Timber Forest Products (NTFPs).
- **Protective Functions:** Encompass windbreaks, shelterbelts, soil conservation, and soil improvement.

3. Socio-Economic Classification:

- **Commercial Agroforestry Systems:** Focused on large-scale production for commercial output.
- **Intermediate Agroforestry Systems:** Balance between commercial and subsistence production.
- **Subsistence Agroforestry Systems:** Primarily meet the basic needs of the owner's family.

4. Ecological Classification:

- **Humid/Subhumid Lowlands:** Home gardens, trees on rangelands, improved fallow, and woodlots.
- **Semiarid/Arid Lands:** Silvopastoral systems, windbreaks, and shelterbelts.
- **Tropical Highlands:** Plantation crops integration, woody perennials for soil conservation.

Benefits of Agroforestry System:

- **Environmental Benefits:** Reduced pressure on natural forests, nutrient recycling, ecological protection, reduced soil erosion, microclimate improvement, and soil structure enhancement.
- **Economic Benefits:** Increased output of food, fuelwood, fodder, and timber; reduced risk of crop failure; and higher farm income levels.
- **Social Benefits:** Improved living standards, nutrition, health, and community stabilization.

Common Types of Agro-Forestry:

- **Agri-silviculture:** Trees with food and fodder crops.
- **Silvi-pasture:** Tree species with improved pasture.
- **Agri-Horti System:** Interspaced agricultural crops and fruit trees.
- **Agri-silvipasture:** Combination of agri-silviculture and silvi-pasture.
- **Agri-Horti-Silviculture:** Fruit trees with crops and MPTs.
- **Homestead Agroforestry:** Trees planted around habitations for daily needs.
- **Horti-pastoral System:** Horticultural crops with pastures.
- **Agri-Horti-Pastoral System:** Marginal lands utilized for fruit crops, forest trees, and food grains.
- **Apiculture with Trees:** Honey-producing trees for beekeeping.
- **Aqua Forestry:** Trees around fish ponds for feed and stabilization.
- **Multipurpose Wood Lots:** Specific MPTs grown for various purposes.

Social Forestry vs. Agroforestry:

Social Forestry Explained: Social Forestry refers to the practice of managing and growing forests outside traditional forest areas, specifically tailored to fulfill the needs of the local community. It emphasizes the production of forest goods to meet the demands of local people, focusing on cultivating forests according to the preferences of the local population.

Agroforestry Defined: Agroforestry, on the other hand, combines agricultural and forestry technologies to create more integrated, diverse, productive, profitable, healthy, and sustainable land-use systems. It involves the strategic use of land for the simultaneous cultivation of trees and agricultural crops, aiming to achieve beneficial interactions.

Key Concepts in Tree Cultivation Outside Traditional Forest Areas

1. Farm Forestry: Farm Forestry promotes commercial tree cultivation by farmers on their own lands. As defined by the National Commission on Agriculture (1976), it integrates forestry practices within and around farm or village lands, harmonizing them with other agricultural operations.

2. Extension Forestry: Extension Forestry targets areas lacking in tree growth and vegetation outside traditional forest zones, with the goal of expanding tree-covered areas. It encompasses:

- **Mixed Forestry:** Involves raising fodder grass, scattered fodder trees, fruit trees, and fuelwood trees on wastelands, panchayat lands, and village commons.
- **Shelterbelts:** Strips of trees or shrubs maintained to provide protection from wind, sun, and snow drift.
- **Linear Strip Plantations:** Plantations of fast-growing species planted in linear strips of land.

3. Rehabilitation of Degraded Forests: Focuses on the ecological restoration and socio-economic upliftment of communities surrounding degraded forest areas, necessitating prompt and effective restoration practices.

4. Recreation Forestry: Also known as Aesthetic Forestry, this practice revolves around cultivating flowering trees and shrubs to create recreational spaces for urban and rural populations. It aims at developing or maintaining forests with high scenic value, enhancing the aesthetic and recreational appeal of the landscape.

Shifting cultivation:

Shifting cultivation, also known as slash-and-burn agriculture, is a traditional agricultural practice found in various parts of the world but predominantly practiced in the northeastern hill regions of India. This method involves clearing forested land, burning the felled vegetation, and using the ash-enriched soil for farming activities for a few years until the soil's fertility declines. Subsequently, the land is left fallow to naturally regenerate while the cultivator moves to a new plot, repeating the process.

- **Geographical Spread:** It's prevalent in Assam, Meghalaya, Manipur, Nagaland, Tripura, and to some extent in Arunachal Pradesh, Mizoram, Andhra Pradesh, Bihar, Madhya Pradesh, Odisha, and Karnataka.
- **Local Nomenclature:** Referred to as "Jhum" in the northeastern regions and "Podu" in Andhra Pradesh and Odisha.

- **Environmental Impact:** Criticized for its destructive impact on forests, leading to deforestation, soil erosion, and loss of biodiversity.

Improved Fallow System in Agroforestry:

To counteract the soil depletion inherent in shifting cultivation, the improved fallow system integrates specific plant species known for their soil-enriching properties into the fallow period.

- **Objective:** The primary goal is to enhance soil fertility through nitrogen-fixing plants or species that add organic matter to the soil, preparing it for future agricultural use.
- **Implementation:** Methods include direct seeding of fallow species after crop harvest and selective enrichment planting, where high-quality fallow species are introduced to degraded lands.

Taungya System:

The Taungya system represents a synergistic approach to agroforestry, where agricultural crops are grown alongside forest plantations, allowing for dual land use that benefits both the environment and local communities.

- **Origin and Practice:** Introduced in India by Dr. Brandis in 1890, with the first Taungya plantation established in North Bengal in 1896. It's practiced across various Indian states, including Kerala, West Bengal, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Odisha, and the northeastern hill regions.
- **System Variants:** Includes Departmental Taungya, where agricultural and plantation crops are raised by the forest department; Leased Taungya, involving leasing forest land for agriculture; and Village Taungya, which is considered the most successful variant involving local communities in crop cultivation and tree planting.

Wind Breaks and Shelter Belts:

Windbreaks and shelter belts are strategic plantings of trees and shrubs designed to reduce wind speed and mitigate its effects on crops, soil, and livestock.

- **Design and Composition:** Typically involves multiple rows of trees and shrubs of varying heights, strategically placed to block or reduce wind speed. The selection of species is crucial, with preference for fast-growing, dense-crowned trees that provide additional benefits such as fruit, fodder, and timber.
- **Benefits:** Include reduction of soil erosion, enhancement of microclimate conditions, improvement in water retention, support for biodiversity, and provision of economic resources to farmers.
- **Implementation:** Effective windbreaks require careful planning regarding the choice of species, spacing, and arrangement to ensure maximum protection and benefits. Cooperative efforts are encouraged to extend benefits across community lands.

Shelterbelt Composition:

1. **Grasses:** Varieties such as *Cenchrus barbatus* and *Saccharum spontaneum* are utilized for their soil binding properties and erosion control capabilities.

2. **Shrubs:** Species including *Calotropis procera* and *Jatropha curcas* are selected for their drought resistance and utility in providing mid-level coverage and contributing to biodiversity.
3. **Small Trees:** *Acacia jacquemontii* and *Salvadora oleoides* are chosen for their adaptability to semi-arid conditions and their role in enhancing the microhabitat.
4. **Trees:** Larger tree species like *Acacia arabica* and *Azadirachta indica* are integral for creating a substantial barrier against wind, offering significant ecological benefits and resources like timber and medicinal extracts.

Implementation Techniques:

- Seeds are initially sown in polythene bags to ensure healthy sapling development, facilitating easier transplantation.
- Site-specific nurseries are recommended for effective sapling acclimatization and management.
- Consistent watering during the initial one to two years post-planting is critical to establish the plants.
- Protective fencing is essential to safeguard young plants from grazing by livestock.

Wind Breaks:

- Wind breaks consist of 2-3 rows of trees or shrubs, spaced 0.5m to 2.5m apart, encircling gardens, farms, or fields to guard against strong winds.

Soil Conservation Hedges:

- Comprise multipurpose/fruit trees and common agricultural species.
- Mainly for soil conservation and yielding various tree products.
- Key species include *Grevillea robusta*, *Acacia catechu*, and *Leucaena leucocephala*.

Horti-Silviculture:

- Integrates horticultural trees with timber trees for simultaneous fruit and timber production.
- Timber trees on orchard bunds serve as windbreaks.

Horti-Silvopastoral:

- Combines improved leguminous grasses in orchards for livestock forage.
- Trees on orchard bunds act as windbreaks and provide multiple products.

Silvi-Pastoral System (Trees + Pasture/Animals):

- Focuses on producing woody plants alongside pasture for fodder or other uses.
- Categories include protein banks, live fodder fences, and trees/shrubs on pasture land.

A. Protein Bank:

- **Purpose:** Protein banks utilize multipurpose, protein-rich trees around farmlands and rangelands to provide cut-and-carry fodder for livestock, especially during winter's fodder deficit.

- **Benefits:** Trees in protein banks are selected for their high protein content, aiding in meeting nutritional needs of livestock during lean periods.
- **Common Tree Species:** Key species include *Grewia optiva*, *Bauhinia variegata*, *Morus alba*, *Artocarpus* spp., *Anogeissus latifolia*, *Cordia dichotoma*, *Dalbergia sissoo*, *Eutralobium saman*, and *Zizyphus jujube*, selected for their ability to thrive in the targeted environment and their nutritional value.
- **B. Live Fence of Fodder Trees and Hedges:**
 - **Function:** Live fences of fodder trees and hedges serve dual purposes of providing fodder and acting as a barrier to protect property from stray animals and other biotic influences.
 - **Implementation:** These barriers are created by planting fodder trees and shrubs in a way that forms a living fence around the property, offering a sustainable and eco-friendly solution.
 - **Species Used:** The assortment includes *Sesbania grandiflora*, *Gliricidia sepium*, *Erythrina abyssinica*, *Euphorbia* spp., and *Acacia* spp., chosen for their robustness, growth habit, and fodder value.
- **C. Trees and Shrubs on Pasture Land:**
 - **Concept:** This approach integrates tree and shrub species within pasture lands, either irregularly scattered or systematically arranged, to enhance the pasture's biodiversity and productivity.
 - **Objective:** The primary goal is to enrich the pasture ecosystem, providing additional fodder sources and improving the soil and microclimate for the benefit of both livestock and pasture grasses.
 - **Arrangement and Management:** Careful planning is essential to ensure that the selected tree and shrub species complement the existing pasture system without competing for resources, thereby maximizing the benefits of this integrated approach.

Agrisilvopastoral/Agrosilvopastoral System (Crops + Trees + Grasses/Animals):

- Includes home gardens and woody hedges for browsing, mulching, green manuring, and soil conservation.
- Home gardens mix trees, crops, and animals in spatial/temporal sequences, often found in high rainfall areas of South and Southeast Asia.

Other Specified Systems:

- **Apiculture with Trees:** Focuses on nectar and pollen-rich trees for honey production.
- **Aqua-forestry:** Common in coastal regions for integrating fish/prawn cultivation with tree growth on pond bunds.
- **Multipurpose Wood Lots:** Grow specific multipurpose trees for wood, fodder, soil protection, etc.

Shelterbelt Benefits:

- Regulate temperature, increase humidity, reduce evapo-transpiration, and enhance soil moisture.

- Decrease wind velocity and erosion, boosting agricultural and horticultural crop yields.
- Provide protection to infrastructure and promote environmental conservation.

Agroforestry Systems Based on Component Arrangement:

- Spatial arrangement can vary from dense mixed stands (e.g., home gardens) to sparse (e.g., trees in pastures).
- Temporal arrangement includes coincident, concomitant, overlapping, separate, and interpolated systems.

Functional Basis of Agroforestry Systems:

- Classified by productive (e.g., food, fodder, fuelwood) and protective (e.g., windbreaks, soil conservation) functions.

Ecological and Socio-Economic Classifications:

- Based on ecological conditions (tropical, sub-tropical, temperate, sub-alpine, alpine) and socio-economic factors (subsistence, commercial, intermediate systems).

India State of Forest Report (ISFR), 2021 - Key Points

- Biennial survey assessing forest and tree resources.
- First published in 1987, with the 2021 report marking the 17th publication.
- Prepared by the Forest Survey of India (FSI).

Major Findings of ISFR, 2021

- Increase in forest and tree cover by 2,261 sq. km since ISFR-2019.
- Total forest and tree cover is 80.9 million hectares, 24.62% of India's geographical area.
- Top three states with increased forest cover: Andhra Pradesh, Telangana, and Odisha.
- Madhya Pradesh has the largest forest cover by area; Mizoram has the highest percentage of forest cover relative to its geographical area.
- Seventeen states/UTs have over 33% of their geographical area under forest cover.
- Five states/UTs have over 75% forest cover: Lakshadweep, Mizoram, Andaman & Nicobar Islands, Arunachal Pradesh, and Meghalaya.
- Mangrove cover increased by 17 sq. km since ISFR-2019, totalling 4,992 sq. km.
- Odisha, Maharashtra, and Karnataka showed the most significant increase in mangrove cover.
- Total carbon stock increased by 79.4 million tonnes compared to ISFR-2019, with an annual increase of 39.7 million tonnes.
- Bamboo forests expanded significantly from 13,882 million culms in 2019 to 53,336 million culms in 2021.
- 35.46% of India's forest cover is prone to forest fires.
- Climate change is expected to negatively impact 45-64% of Indian forests by 2030.

- Forest cover in tiger reserve areas analysed for the first time, showing a net decrease of 22.62 sq. km over the last decade, with 20 reserves showing an increase in forest cover.

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