



Social and Farm Forestry

ICAR e-Course

Social and Farm Forestry

ICAR e-Course
For
B.Sc (Agriculture) and B.Tech (Agriculture)



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All About Agriculture...

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Lec.1 ROLE OF FORESTS

Forests serve two roles viz., a) Productive role and B) Protective role

a) Productive role

1. Food
2. Fuel
3. Shelter
4. Clothing
5. Timber
6. Industrial wood
7. NTFP

b) Protective role

1. Climate amelioration
2. Soil and water Conservation
3. Wildlife habitats

a) Productive role

It is estimated that the forest products contribute about 1% of world gross domestic product (GDP). The annual turnover of timber and other wood products from forests is valued at more than US\$200 billion. The demand for commercial timber and other products is ever increasing, and expected to rise by 50% by 2010. Apart from that, non-timber products like rubber, cotton, medicinal products, food and so on represent significant economic value.

1. Food

a) Rhizome : *Amarphous campanulatum, Cyprus rotandus*

b) Root and aerial : *Dioscorea , Moringa oleifera Caryota urens, Bauhinia
variegata*

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c) Buds : *Dillenia pentagyna, Phoenix sp*

d) Sap, and latex, : *Borassus flabellifer, Cissus rapanda*

Bark

e) Stems : *Cycas pectinata, Dendrocalamus strictus*

f) Leaves : *Tamarindus indica, Moringa oleifera*

g) Flowers : *Ficus glomerata, Madhuca indica, Bambax ceiba, Tamarindus indica*

h) Fruits : *Aegle marmelos, Anacardium occidentale, Anona squamosa.*

Artocarpus heterophyllus, Borassus flabellifer, Capparis

decidua, Diospyros melanoxylon, Emblica officinalis, Ferronia

elephantum, Morus alba, Zizyphus spp

i) Seeds : *Anacardium occidentale , Juglans regia, Prunus amygdalus,*

Tamarindus indica, Dendrocalamus strictus

2. Fuel

Wood is used as fuel for thousands of years, until the advent of coal, oil, gas, electricity, etc. Wood constitutes as chief source of fuel. Even today more than half of the total world consumption of wood is for fuel-wood. Wood remains the major source of domestic fuel in India. Approximately 175 mm³ of wood is used as fuel in the country. It is estimated that by 2010, most of the 3 billion people who depend on it for their daily living will find it hard to obtain. Already, rural families spend precious hours in collecting firewood instead of other productive work, something that causes losses to the tune of US\$ 50 billion to the world economy.

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Eg., *Acacia spp*, *Casuarina equisetifolia*, *Prosopis*, *Neem*, *Leucaena leucocephala*, etc.,

3. Shelter

Wood is used for construction of buildings.

Eg., Palmyra, Teak, Jack, etc.,

4. Clothing

Rayon cloth eg., *Eucalyptus spp*

5. Timber

Timber is a major forest produce and is used extensively for various purposes. In India most of the wood produced is used for construction of houses, agricultural implements, bridges, sleepers etc., In India 12 mm³ of timber is produced from our forests. More than 1500 species of trees are commercially exploited for timber in different parts of India. It is used in timber-based industries such as plywood, saw milling, paper and pulp, and particle boards.

Many species like teak, sal, deodar, babul, sissoo, chirpine, adina, axlewood, rosewood, dipterocarpus, and etc. yield valuable timber.

6. Industrial wood

1) Forest provide raw material to large number of industries eg: paper and pulp, plywood and other boards, packing cases, matches, toys etc.,

Paper and pulp : Bamboos, *Eucalyptus*, *casuarina*

Plywood : Teak, Rose wood, *Terminalia* etc.,

Packing cases : *Pinus sp*, Silver oak, Fir,

Matchwood : *Ailanthus*, *Simaruba*, *Bombax*

Toys : Adina, Redsanders, rose wood

7. NTFP

i) Fibre and flosses

Fibres are obtained from bast tissue of certain woody plants, which are used for making ropes. Flosses are obtained from *Ceiba pentandra* and fibres are obtained from *Agave sisalana*, *Sterculia urens*

ii) Grasses and bamboos

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A large variety of grasses are found in the forests. About 30% of the 416 million livestock population graze in the forests. Among valuable grasses eg: Sabai (*Eulaliopsis binata*) is harvested annually 6.5 million tones and 80,000 tonnes of bamboo are harvested from forest every year.

iii) Essential oil

India produced about 1500 tonnes of essential oils during 1980, which was utilized in making soaps, detergents and chemicals eg. Eucalyptus, Bursera, Cymbopogan, *Santalum album* etc.,

iv) Oil seeds

Many tree species of *Madhuca indica*, *Pongamia pinnata*, *Shorea robusta*, *Azadirachta indica*, *Schleichera oleosa*, *Vateria indica* etc., produce oil-bearing seeds, which are commercially important. Presently these seeds are used in the soap industry. There is a potential production of about 1 million tonnes of oil every year from forests tree seeds.

v) Tans and dyes

Important tannins are extracted from myrobolan nuts, bark of wattles (*A.mearnsii*, *A.decurrrens*, *A.dealbata*) and *Cassia auriculata*, leaves of *Embelica officinalis* and *Anogeissus latifolia*, bark of *Cleistanthus collinus*, fruits of *Zizphus xylophora*, *Cassia fistula*, *Terminalia alata*, *T.arjuna* etc., katha and cutch are obtained from *Acacia catechu*.

vi) Gums and resins

Gums and resins are exuded by trees as a result of injury to the bark or wood. Gums –eg: *Sterculia urens*, *Anogeissus latifolia*, *Lannea coromandalica*, *Acacia nilotica*, *Ptercapus marsupium*, *Butea monosperma* etc.,

Resin is obtained from *Pinus roxburghii*

vii) Drugs, Spices and Insecticides

Important spices yielding drugs are *Rauvolfia serpentina*, *Hemidesmus indicus*, *Dioscorea spp*, *Atropa spp*, *Datura innoxia* etc,

Spices : Seeds of *Carum carvi*, barks of *Cinnomomum zeylanicum*, dried capsules of *Elletaria cardomomum*.

Insecticides : Pyrethrum and neem

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viii) Tendu and other leaves

Tendu leaves (bidi leaves) (*Diopyrus melanoxylon*) and leaves of baubhinia spp, *Butea spp*, plates, dona etc.,

ix) Lac and other products

Lac is a resinous secretion of insects which feed on forest trees eg ; *Butea monosperma*. Silkworm is feed on *Morus alba* or *Terminalia alata*. Honey is produced from forests.

x) Fodder and grazing

About 30% of 416 million livestock population depend up on forest grazing and leaf fodder supply. **Eg;** *Luecaena leucocephala*, *Albizia lebbeck*, *Hardwickia binata*

xi) Cane

Canes or rattans are the stems of a climber plant and are used for a large number of household items. It is used to make walking sticks, polo sticks, baskets, picture frames, screens, and mats.

b) Protective Role

1. Forests as Earth's air purifiers

Forests form an effective sink for the carbon dioxide produced as a result of animal respiration, burning of fossil fuels, volcanoes and other natural and human-induced phenomenon. And if that is not all, a by-product of photosynthesis is oxygen. Thus, the Amazon forests are the Earth's air purifiers, given the large amounts of carbon dioxide they absorb from the atmosphere.

Forests play a significant role in maintaining the CO₂ balance in the atmosphere without sufficient forest cover all the CO₂ released in the atmosphere will not be utilised, resulting in a higher per cent of CO₂ in the atmosphere.

According to scientists, this will result in warming of the world temperature; disturbance in the climate etc., The CO₂ percent in the atmosphere has already reached 0.042 per cent against the normal of 0.03%. If this increases continuously higher temperature and other disturbances on the earth may bring unimaginable miseries to mankind.

2. Climate amelioration

Forest increase local precipitation by about 5 to 10% due to their orographic and microclimatic effect and create conditions favourable for the condensation of clouds .Forest reduce temperature and increase humidity. It also reduces evaporation losses.

3. Soil and water conservation

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Forests maintain the productivity of the soil through adding a large quantity of organic matter and recycling of nutrients. The leaves are used as manure.

Tree crowns reduce the violence of rain and check splash erosion. Forests increase the infiltration and water holding capacity of the soil, resulting in much lower surface runoff. This inturn results in checking of soil erosion.

Forest checks floods. Forests intercept 15 to 30% of the caused due to siltation of river channels caused due to erosion. Forests and trees reduce wind velocity considerably. Reduction of wind velocity causes considerable reduction in wind erosion, checks shifting of sand dunes and halts the process of desertification. Forests by reducing erosion check the siltation of irrigation and hydel resources. Rapid siltation of various reservoirs in the country is the result of deforestation in the catchment areas of these reservoirs.

Forest protect us from physical, chemical and noise pollution, dust and other particulates and gaseous pollutants cause serious health problems. Forests protect as from these pollutants. Forest and trees provide shelter and wind break effect which is beneficial to agricultural crops, particularly in arid and semiarid areas and increase agricultural production.

4. Wildlife habitats

Tees act as a habitat for wildlife.

Lec.2 STATUS OF FORESTS IN INDIA

India is one of the 12 mega diversity countries having a vast variety of flora and fauna, commands 7% of world's biodiversity and supports 16 major forest types, varying from the alpine pastures in the Himalayas to temperate, sub-tropical forests, and mangroves in the coastal areas.

According to the State of Forest Report, published by the Forest Survey of India (FSI) in 1997, India has a recorded forest **area of 76.5 million hectare or 23.3%** of the total geographic area of the country. But the actual forest cover is **63.34 million ha (19.27% of the country's area)** of which **26.13 million ha are degraded**. There is another **5.72 million ha scrub** in addition to the reported forest cover of 63.34 million ha. Thus, in total, **31.85 million ha forests** in the country are degraded or open.

STATEWISE INDIA'S FOREST COVER

S. No.	State/Uts	Geographical Area (Km ²)	Total Forest area (Km ²)	% of forests area
1	Andhra Pradesh	275068	63814	23.20
2	Arunachal Pradesh	83743	51540	61.55
3	Assam	78438	30708	39.15
4	Bihar	173877	29226	16.81
5	Delhi	1483	85	5.73
6	Goa	3702	1424	38.47
7	Gujarat	196024	19393	9.89
8	Haryana	44212	1673	3.78
9	Himachal Pradesh	55673	35407	63.60
10	Jammu & Kashmir	222235	20182	9.08
11	Karnataka	191791	38724	20.19
12	Kerala	38863	11221	28.87
13	Madhya Pradesh	443446	154497	34.84
14	Maharashtra	307690	63842	20.75
15	Manipur	22327	15154	67.87
16	Meghalaya	22429	9496	42.34
17	Mizoram	21081	15935	75.59
18	Nagaland	16579	8629	52.05
19	Orissa	155707	57184	36.73
20	Punjab	50362	2901	5.76
21	Rajasthan	342239	31700	9.26
22	Sikkim	7096	2650	37.34
23	Tamil Nadu	130058	22628	17.40
24	Tripura	10486	6293	60.01
25	Uttar Pradesh	294411	51663	17.55
26	West Bengal	88752	11879	13.38
27	Andaman & Nicobar Island	8249	7171	86.93
28	Chandigarh	114	31	27.19
29	Dadra & Nagar Haveli	491	203	41.34
30	Daman & Diu	112	1	0.63
31	Lakshadweep	32	0	0.00
32	Pondicherry	493	0	0.00

Total	3287263	765253	23.28
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Comparison with other countries

The area of the world's forests, including natural forests and forest plantations, was estimated to be **3454 million hectares in 1995**, or about one-fourth of the land area of the Earth. About **55 percent of the world's forests** are located in **developing countries**, with the remaining **45 percent in developed countries** . The world's forests are almost equally divided between tropical/subtropical forests and temperate/boreal forests. Only about **3 percent of the world's forests** are forest plantations. The remaining **97 percent are natural or semi-natural forests**.

Comparison with other countries

CHANGE IN FOREST AREA, 1990-2000				
Country/area	Total forest, 1990 ('000 ha)	Total forest, 2000 ('000 ha)	Forest cover change, 1990-2000	
			Change ('000 ha)	Change (%)
Algeria	1 879	2 145	27	1.3
Angola	70 998	69 756	-124	-0.2
Benin	3 349	2 650	-70	-2.3
Botswana	13 611	12 427	-118	-0.9
Burkina Faso	7 241	7 089	-15	-0.2
Burundi	241	94	-15	-9.0
Cameroon	26 076	23 858	-222	-0.9
Cape Verde	35	85	5	9.3
Central African Republic	23 207	22 907	-30	-0.1
Chad	13 509	12 692	-82	-0.6
Comoros	12	8	n.s.	-4.3
Congo	22 235	22 060	-17	-0.1
Côte d'Ivoire	9 766	7 117	-265	-3.1
Dem. Rep. of the Congo	140 531	135 207	-532	-0.4
Djibouti	6	6	n.s.	n.s.
Egypt	52	72	2	3.3

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Equatorial Guinea	1 858	1 752	-11	-0.6
Eritrea	1 639	1 585	-5	-0.3
Ethiopia	4 996	4 593	-40	-0.8
Gabon	21 927	21 826	-10	n.s.
Gambia	436	481	4	1.0
Ghana	7 535	6 335	-120	-1.7
Guinea	7 276	6 929	-35	-0.5
Guinea-Bissau	2 403	2 187	-22	-0.9
Kenya	18 027	17 096	-93	-0.5
Lesotho	14	14	n.s.	n.s.
Liberia	4 241	3 481	-76	-2.0
Libyan Arab Jamahiriya	311	358	5	1.4
Madagascar	12 901	11 727	-117	-0.9
Malawi	3 269	2 562	-71	-2.4
Mali	14 179	13 186	-99	-0.7
Mauritania	415	317	-10	-2.7
Mauritius	17	16	n.s.	-0.6
Morocco	3 037	3 025	-1	n.s.
Mozambique	31 238	30 601	-64	-0.2
Namibia	8 774	8 040	-73	-0.9
Niger	1 945	1 328	-62	-3.7
Nigeria	17 501	13 517	-398	-2.6
Réunion	76	71	-1	-0.8
Rwanda	457	307	-15	-3.9
Saint Helena	2	2	n.s.	n.s.
Sao Tome and Principe	27	27	n.s.	n.s.
Senegal	6 655	6 205	-45	-0.7
Seychelles	30	30	n.s.	n.s.
Sierra Leone	1 416	1 055	-36	-2.9
Somalia	8 284	7 515	-77	-1.0
South Africa	8 997	8 917	-8	-0.1
Sudan	71 216	61 627	-959	-1.4
Swaziland	464	522	6	1.2

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Togo	719	510	-21	-3.4
Tunisia	499	510	1	0.2
Uganda	5 103	4 190	-91	-2.0
United Republic of Tanzania	39 724	38 811	-91	-0.2
Western Sahara	152	152	n.s.	n.s.
Zambia	39 755	31 246	-851	-2.4
Zimbabwe	22 239	19 040	-320	-1.5
Total Africa	702 502	649 866	-5 262	-0.8
Afghanistan	1 351	1 351	n.s.	n.s.
Armenia	309	351	4	1.3
Azerbaijan	964	1 094	13	1.3
Bahrain	n.s.	n.s.	n.s.	14.9
Bangladesh	1 169	1 334	17	1.3
Bhutan	3 016	3 016	n.s.	n.s.
Brunei Darussalam	452	442	-1	-0.2
Cambodia	9 896	9 335	-56	-0.6
China	145 417	163 480	1 806	1.2
Cyprus	119	172	5	3.7
Dem People's Rep. of Korea	8 210	8 210	n.s.	n.s.
East Timor	541	507	-3	-0.6
Gaza Strip	-	-	-	-
Georgia	2 988	2 988	n.s.	n.s.
India	63 732	64 113	38	0.1
Indonesia	118 110	104 986	-1 312	-1.2
Iran, Islamic Rep.	7 299	7 299	n.s.	n.s.
Iraq	799	799	n.s.	n.s.
Israel	82	132	5	4.9
Japan	24 047	24 081	3	n.s.
Jordan	86	86	n.s.	n.s.
Kazakhstan	9 758	12 148	239	2.2
Kuwait	3	5	n.s.	3.5
Kyrgyzstan	775	1 003	23	2.6
Lao People's Dem. Rep	13 088	12 561	-53	-0.4

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Lebanon	37	36	n.s.	-0.4
Malaysia	21 661	19 292	-237	-1.2
Maldives	1	1	n.s.	n.s.
Mongolia	11 245	10 645	-60	-0.5
Myanmar	39 588	34 419	-517	-1.4
Nepal	4 683	3 900	-78	-1.8
Oman	1	1	n.s.	5.3
Pakistan	2 755	2 361	-39	-1.5
Philippines	6 676	5 789	-89	-1.4
Qatar	n.s.	1	n.s.	9.6
Republic of Korea	6 299	6 248	-5	-0.1
Saudi Arabia	1 504	1 504	n.s.	n.s.
Singapore	2	2	n.s.	n.s.
Sri Lanka	2 288	1 940	-35	-1.6
Syrian Arab Republic	461	461	n.s.	n.s.
Tajikistan	380	400	2	0.5
Thailand	15 886	14 762	-112	-0.7
Turkey	10 005	10 225	22	0.2
Turkmenistan	3 755	3 755	n.s.	n.s.
United Arab Emirates	243	321	8	2.8
Uzbekistan	1 923	1 969	5	0.2
Viet Nam	9 303	9 819	52	0.5
West Bank	-	-	-	-
Yemen	541	449	-9	-1.9
Total Asia	551 448	547 793	-364	-0.1
Albania	1 069	991	-8	-0.8
Andorra	-	-	-	-
Austria	3 809	3 886	8	0.2
Belarus	6 840	9 402	256	3.2
Belgium and Luxembourg	741	728	-1	-0.2
Bosnia and Herzegovina	2 273	2 273	n.s.	n.s.
Bulgaria	3 486	3 690	20	0.6
Croatia	1 763	1 783	2	0.1

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Czech Republic	2 627	2 632	1	n.s.
Denmark	445	455	1	0.2
Estonia	1 935	2 060	13	0.6
Finland	21 855	21 935	8	n.s.
France	14 725	15 341	62	0.4
Germany	10 740	10 740	n.s.	n.s.
Greece	3 299	3 599	30	0.9
Hungary	1 768	1 840	7	0.4
Iceland	25	31	1	2.2
Ireland	489	659	17	3.0
Italy	9 708	10 003	30	0.3
Latvia	2 796	2 923	13	0.4
Liechtenstein	6	7	n.s.	1.2
Lithuania	1 946	1 994	5	0.2
Malta	n.s.	n.s.	n.s.	n.s.
Netherlands	365	375	1	0.3
Norway	8 558	8 868	31	0.4
Poland	8 872	9 047	18	0.2
Portugal	3 096	3 666	57	1.7
Republic of Moldova	318	325	1	0.2
Romania	6 301	6 448	15	0.2
Russian Federation	850 039	851 392	135	n.s.
San Marino	-	-	-	-
Slovakia	1 997	2 177	18	0.9
Slovenia	1 085	1 107	2	0.2
Spain	13 510	14 370	86	0.6
Sweden	27 128	27 134	1	n.s.
Switzerland	1 156	1 199	4	0.4
The FYR of Macedonia	906	906	n.s.	n.s.
Ukraine	9 274	9 584	31	0.3
United Kingdom	2 624	2 794	17	0.6
Yugoslavia	2 901	2 887	-1	-0.1
Total Europe	1 030 475	1 039 251	881	0.1
Antigua and Barbuda	9	9	n.s.	n.s.

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Bahamas	842	842	n.s.	n.s.
Barbados	2	2	n.s.	n.s.
Belize	1 704	1 348	-36	-2.3
Bermuda	-	-	-	-
British Virgin Islands	3	3	n.s.	n.s.
Canada	244 571	244 571	n.s.	n.s.
Cayman Islands	13	13	n.s.	n.s.
Costa Rica	2 126	1 968	-16	-0.8
Cuba	2 071	2 348	28	1.3
Dominica	50	46	n.s.	-0.7
Dominican Republic	1 376	1 376	n.s.	n.s.
El Salvador	193	121	-7	-4.6
Greenland	-	-	-	-
Grenada	5	5	n.s.	0.9
Guadeloupe	67	82	2	2.1
Guatemala	3 387	2 850	-54	-1.7
Haiti	158	88	-7	-5.7
Honduras	5 972	5 383	-59	-1.0
Jamaica	379	325	-5	-1.5
Martinique	47	47	n.s.	n.s.
Mexico	61 511	55 205	-631	-1.1
Montserrat	3	3	n.s.	n.s.
Netherlands Antilles	1	1	n.s.	n.s.
Nicaragua	4 450	3 278	-117	-3.0
Panama	3 395	2 876	-52	-1.6
Puerto Rico	234	229	-1	-0.2
Saint Kitts and Nevis	4	4	n.s.	-0.6
Saint Lucia	14	9	-1	-4.9
Saint Pierre and Miquelon	-	-	-	-
Saint Vincent and Grenadines	7	6	n.s.	-1.4
Trinidad and Tobago	281	259	-2	-0.8
United States	222 113	225 993	388	0.2
United States Virgin Islands	14	14	n.s.	n.s.

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Total North and Central America	555 002	549 304	-570	-0.1
American Samoa	12	12	n.s.	n.s.
Australia	157 359	154 539	-282	-0.2
Cook Islands	22	22	n.s.	n.s.
Fiji	832	815	-2	-0.2
French Polynesia	105	105	n.s.	n.s.
Guam	21	21	n.s.	n.s.
Kiribati	28	28	n.s.	n.s.
Marshall Islands	n.s.	n.s.	n.s.	n.s.
Micronesia	24	15	-1	-4.5
Nauru	n.s.	n.s.	n.s.	n.s.
New Caledonia	372	372	n.s.	n.s.
New Zealand	7 556	7 946	39	0.5
Nile	6	6	n.s.	n.s.
Northern Mariana Islands	14	14	n.s.	n.s.
Palau	35	35	n.s.	n.s.
Papua New Guinea	31 730	30 601	-113	-0.4
Samoa	130	105	-3	-2.1
Solomon Islands	2 580	2 536	-4	-0.2
Tonga	4	4	n.s.	n.s.
Vanuatu	441	447	1	0.1
Total Oceania	201 271	197 623	-365	-0.2
Argentina	37 499	34 648	-285	-0.8
Bolivia	54 679	53 068	-161	-0.3
Brazil	566 998	543 905	-2 309	-0.4
Chile	15 739	15 536	-20	-0.1
Colombia	51 506	49 601	-190	-0.4
Ecuador	11 929	10 557	-137	-1.2
Falkland Islands	-	-	-	-
French Guiana	7 926	7 926	n.s.	n.s.
Guyana	17 365	16 879	-49	-0.3
Paraguay	24 602	23 372	-123	-0.5
Peru	67 903	65 215	-269	-0.4

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Suriname	14 113	14 113	n.s.	n.s.
Uruguay	791	1 292	50	5.0
Venezuela	51 681	49 506	-218	-0.4
Total South America	922 731	885 618	-3 711	-0.4
TOTAL WORLD	3 963 429	3 869 455	-9 391	-0.2

NATIONAL FOREST POLICY, 1988

BACKGROUND AND NEED

The first National Forest Policy of Independent India was promulgated in 1952. However, since then many new developments had taken place and concepts of forest management changed. It was in view of the following perspectives, the need of a new forest policy was felt.

The emphasis was gradually shifting from production forestry to conversion and protection of the forest resources. The needs and attributes of the general masses with regard to forests and forestry had undergone a massive change

1. Many new forest based industries were being set up and it was apparent that their raw material requirements could not be met from the natural forests, without upsetting the ecological balance.
2. Social community and farm forestry had gained increasing importance in the seventies and eighties
3. There was a need to address the rights and concessions of the people and recognize the symbiotic relationship between forests and tribals
4. Provisions needed to be incorporated in the forest policy for ecological security, biodiversity conservation and compensatory afforestation.

The National Forest Policy of 1988 was issued on 7th December 1988 by the Secretary, Ministry of Environment and Forests to the Government of India.

1. PREAMBLE

In Resolution No. 13/52/f, dated the 12th May, 1952, the Government of India in the erstwhile Ministry of Food and Agriculture enunciated a Forest Policy to be followed in the management of State Forests in the country. However, over the years, forests in the country have suffered serious depletion. This is attributable to relentless pressures arising from ever-increasing demand for fuel wood, fodder and timber; inadequacy of protection measures; diversion of forests lands to non-forest uses without ensuring compensatory afforestation and essential environmental safeguards; and the tendency to look upon forests as revenue earning resource. The need to review the situation and to evolve, for the future, new strategy of forest conservation has become imperative. Conservation includes preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment. It has thus become necessary to review and revise the National Forest Policy.

2. BASIC OBJECTIVES

The basic objectives that should govern the National Forest Policy are the following:

1. Maintenance of environmental stability through preservation and, where necessary, restoration of the ecological balance that has been adversely disturbed by serious depletion of the forests of the country.
2. Conserving the natural heritage of the country by preserving the remaining natural forests with the vast variety of flora and fauna, which represent the remarkable biological diversity and genetic resources of the country.
3. Checking soil erosion and denudation in the catchment areas of rivers, lakes, reservoirs in the interest of soil and water conservation, for mitigating food and droughts and for the retardation of siltation of reservoirs.
4. Checking the extension of sand dunes in the desert areas of Rajasthan and along the coastal tracts.

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5. Increasingly substantially the forests/tree cover in the country through massive afforestation and social forestry programmes, especially on all denuded, degraded and unproductive lands.
6. Meeting the requirements of fuelwood, fodder, minor forest produce and small timber of the rural and tribal population.
7. Increasing the productivity of forests to meet essential national needs.
8. Encouraging efficient utilisation of forests produce and maximising substitution of wood.
9. Creating a massive people's movement with the involvement of women, for achieving these objectives and to minimise pressure on existing forests.

The principal aim of Forest Policy must be to ensure environment stability and maintenance of ecological balance including atmospheric equilibrium which are vital for sustenance of all life forms, human, animal and plant. The derivation of direct economic benefit must be subordinated to this principal aim.

3. ESSENTIAL OF FOREST MANAGEMENT

- 1) Existing forests and forest lands should be fully protected and their productivity be improved. Forest and vegetal cover should be increased rapidly on hill slopes, in catchment areas of rivers, lakes and reservoirs and ocean shores and on semi-arid, arid and desert tracts.
- 2) Diversion of good and productive agriculture lands to forestry should be discouraged in view of the need for increased food production.
- 3) For the conservation of total biological diversity, the network of national parks, sanctuaries biosphere reserves and other protected areas should be strengthened and extended adequately.
- 4) Provision of sufficient fodder, fuel and pasture, specially in areas adjoining forest, is necessary in order to prevent depletion of forests beyond the sustainable limit. Since fuel wood

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continues to be the predominant source of energy in rural areas, the programme of afforestation augmenting fuelwood production to meet the requirement of the rural people.

5) Minor Forest Produce provides sustenance to tribal population and to other communities residing, in and around the forests. Such produce should be protected, improved and their production enhanced with due regard to generation of employment and income.

4. STRATEGY

i) Area Under Forests

The national goal should be to have a minimum of one-third of the total land area of the country under forest or tree cover. In the hills and in mountainous regions, the aim should be to maintain two-third of the area under such cover in order to prevent erosion and land degradation and to ensure the stability of the fragile eco-system.

ii) Afforestation, social forestry and Farm forestry

A massive needs-based and time bound programme of afforestation and tree planting, with particular emphasis on fuelwood and fodder development, on all degraded and denuded lands in the country, whether forest or non-forest land, is a national imperative.

It is necessary to encourage the planting of trees alongside of roads, railway lines, rivers and streams and canals, and on other unutilized lands under State/corporate, institutional or private ownership. Green belts should be raised in urban/industrial areas as well as in arid tracts. Such a programme will help to check erosion and desertification as well as improve the micro-climate.

Village and community lands, including those on foreshores and environs of tanks, not required for other productive uses, should be taken up for the development of tree crops and fodder resources. Technical assistance and other inputs necessary for initiating such programmes should be provided by the Government. The revenues generated through such programmes should belong to the panchayats where the lands are vested in them; in all other cases, such revenues should be shared with the local communities in order to provide an incentive to them. The vesting, in individual, particularly from the weaker sections (such as landless labour, small and

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marginal farmers, scheduled castes, tribals, women) of certain ownership rights over trees, could be considered, subject to appropriate regulations; beneficiaries would be entitled to usufruct and would in turn be responsible for their security and maintenance.

Land laws should be so modified wherever necessary so as to facilitate and motivate individuals and institutions to undertake tree-farming and grow fodder plants, grasses and legumes on their own land. Wherever possible, degraded lands should be made available for this purpose either on lease or on the basis of a tree-patta scheme. Such leasing of the land ceiling laws. Steps necessary to encourage them to do so must be taken. Appropriate regulations should govern the felling of trees on private holding.

iii) MANAGEMENT OF STATE FORESTS

Schemes and projects which interfere with forests that clothe steep slopes, catchments of rivers, lakes and reservoirs, geologically unstable terrain and such other ecological sensitive areas should be severely restricted. Tropical rain/moist forests, particularly in the areas like Arunachal Pradesh, Kerala, Andaman and Nicobar Islands, should be totally safeguarded.

No forest should be permitted to be worked without the Government having approved the management plan, which should be in a prescribed format and in keeping with the National Forest Policy. The Central Government should issue necessary guidelines to the State Governments in this regard and monitor compliance.

In order to meet the growing needs for essential goods and services which the forests provide, it is necessary to enhance forest cover and productivity of the forests through the application of scientific and technical inputs. Production forestry programmes, while aiming at enhancing the forest cover in the country, and meeting national needs, should also be oriented to narrowing, by the turn of the turn of the century, the increasing gap between demand and supply of fuelwood. No such programme, however should entail clear-felling of adequately stocked natural forests. Nor should exotic species be introduced, through public or private sources, unless long-term scientific trials undertaken by specialists in ecology, forestry and agriculture have established that they are suitable and have no adverse impact on native vegetation and environment.

iv) RIGHTS AND CONCESSIONS

The rights and concessions, including grazing, should always remain related to the carrying capacity of forests. The capacity itself should be optimised by increased investment, silvicultural research and development of the area. Stall-feeding of cattle should be encouraged. The requirements of the community, which determined, should be met by development of social forestry outside the reserved forests.

The holders of customary rights and concessions in forest areas should be motivated to identify themselves with the protection and development of identify themselves with the protection and development of forests from which they derive benefits. The rights and concessions from forests should primarily be for the bonafide use of the communities living within and around forest areas, specially the tribals.

The life of tribals and other poor living within and near forests revolves around forests. The rights and concessions enjoyed by them should be fully protected. Their domestic requirements of fuelwood, fodder, minor forest produce and construction timber should be the first should be made available through conveniently located depots at reasonable prices.

Similar consideration should be given to scheduled castes and other poor living near forests. However, the area, which consideration should cover would be determined by the carrying capacity of the forests.

Wood is in short supply. The long-term solution for meeting the existing gap lied in increasing the productivity of forests, nut to relieve the existing pressure on forests for the demands of railway sleepers, construction industry (particularly in the public sector), furniture and panelling, mine-pit props, paper and paper board etc. substitution of wood needs to be taken recourse to. Similarly, on the front of domestic energy, fuelwood needs to the substituted as far as practicable with alternate sources like biogas, LPG and solar energy. Fuel-efficient be popularised in rural areas.

v) DIVERSION OF FOREST LANDS FOR NON-FOREST PURPOSES

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Forest land or land with tree cover should not be treated merely as a resources readily available to be utilised for various projects and programmes, not as a national asset which requires to be properly safeguarded for providing sustained benefits to the entire community. Diversion of forestland for any non-forest purpose should be subject to the most careful examinations by specialists from the standpoint of social and environmental costs and benefits. Construction of dams and reservoirs, mining and industrial development and expansion of agriculture trees and forests. Projects which involve such diversion should at least provide in their investment budget, funds for regeneration/compensatory afforestation.

Beneficiaries who are allowed for mining and quarrying in forest land and in land covered by trees should be required to repair and re-vegetate the area in accordance with established forestry practices. No mining lease should be granted to any party, private or public, without a proper mine management plan appraised from the environmental angle and enforced by adequate machinery.

vi) Wildlife Conservation - Forest Management should take special care of the needs of wildlife conservation, and forest management plans should include prescriptions for this purpose. It is specially essential to provide for "corridors" linking the protected areas in order to maintain genetic continuity between artificially separated sub-sections if migrants wildlife.

vii) Tribal People and Forests - Having regard to symbiotic relationship between the tribal people and forests, a primary task of all agencies responsible for forest management, including the forest development corporations should be to associate the tribal people closely in the protection, regeneration and development of forests as well as to provide gainful employment to people living in and around the forest. While safeguarding the customary rights and interests of such people forestry programmes should pay special attention to the following:-

1. One of the major causes for degradation of forest is illegal cutting and removal by contractors and their labour. In order to put an end to this practice, contractors should be replaced by institutions such as tribal co-operatives, labour co-operatives, government corporations, etc. as early as possible;

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2. Protection, regeneration and optimum collection of minor forest produce along with institutional arrangements for the marketing of such produce;
3. Development of forest villages on par with revenue villages;
4. Family oriented schemes of improving the status of the tribal beneficiaries; and
5. Undertaking integrated area development programmes to meet the needs of the tribal economy in and around the forest areas, including the provision of alternative sources of domestic energy on a subsidised basis, to reduce pressure on the existing forest areas.

viii) Shifting Cultivation - Shifting cultivation is affecting the environment and productivity of land adversely. Alternative avenues of income, suitably harmonised with the right land use practices, should be devised to discourage shifting cultivation. Efforts should be made to contain such cultivation within the area already affected, by propagating improved agriculture practices. Area already damaged by such cultivation should be rehabilitated through social forestry and energy plantations.

ix) Damage to Forests from Encroachments, Fires and Grazing

Encroachment on forests lands has been on the increase. This trend has to be arrested and effective action taken to prevent its continuance. There should be no regularization of existing encroachments.

The incidence of forest fires in the country is high. Standing trees and fodder are destroyed on a large scale and natural generation annihilated by such fires. Special precautions should be taken during the fire season Improved and modern management practices should be adopted to deal with forest fires.

Grazing in forest areas should be regulated with the involvement of the community. Special conservation areas, young plantations and regeneration areas should be fully protected. Grazing and browsing in forests areas need to be controlled. Adequate grazing fees should be

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levied to discourage people in forests areas from maintaining large herds of non-essential livestock.

x) Forest-based Industries - The main considerations governing the establishment of forest-based industries and supply of raw material to them be as follows:

- As far as possible, a forests-based industry should raise the raw material needed for meeting its own requirements, preferably by establishment of a direct relationship between the factory and the individuals who can grow the raw material by supporting the individuals with inputs including credit, constant technical advice and finally harvesting and transport services.
- No forest-based enterprise, except that at the village or cottage level, should be permitted in the future unless it has been first cleared after a careful scrutiny with regard to assured availability of raw material. In any case, the fuel, fodder and timber requirements of the local population should not be sacrificed for this purpose.
- Forest-based industries must not only provide employment to local people on priority but also involve them fully in raising trees and raw-material.
- Natural forests serve as a gene pool resources and help to maintain ecological balance. Such forests will not, therefore, be made available to industries for undertaking plantation and for any other activities.
- **Farmers**, particularly small and marginal farmers, would be encouraged to grow, on marginal/degraded lands available with them, wood species required for industries. These may also be grown along with fuel and fodder species on community lands not required for pasture purposes, and by forest department/corporations on degraded forests, not earmarked for natural generation.
- The practice of supply of forests produce to industry at concessional prices should cease. Industry should be encouraged to use alternative raw materials. Import of wood and wood products should be liberalised.
- The above considerations will, however, be subject to the current policy relating to land ceiling and land-laws.

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xi) Forest Extension - Forests conservation programme cannot succeed without the willing support and co-operation of the people. It is essential, therefore, to inculcate in the people, a direct interest in forests, their development and conservation, and to make them conscious of the value of trees, wildlife and nature in general. This can be achieved through the involvement of educational institutions, right from the primary stage. Farmers and interested people should be provided opportunities through institutions like Krishi Vigyan Kendras, Trainers' Training/centres to learn agrisilvicultural and silvicultural techniques to ensure optimum use of their land and water resources. Short term extension courses and lectures should be organised in order to educate farmers. For this purpose, it is essential that suitable programmes are propagated through mass media, audio-visual aids and the extension machinery.

xii) Forestry Education - Forestry should be recognised both as a scientific discipline as well as a profession. Agriculture universities and institutions dedicated to the development of forestry education should formulate curricula and courses for imparting academic education and promoting postgraduate research and professional excellence, keeping in view the manpower needs of the country. Academic and professional qualifications in forestry should be kept in view for recruitment to the Indian Forest Service and the State Forest Service. Specialised and orientation courses for developing better management skills by in service training need to be encouraged, taking into account the latest development in forestry and related disciplines.

xiii) Forestry Research - With the increasing recognition of the importance of forests for environmental health, energy and employment, emphasis must be laid on scientific of the research base as well as new priorities for action. Some broad priority areas of research and development needing special attention are:-

- i) Increasing the productivity of wood and other forest produce per unit of area per unit time by the application of modern scientific and technological methods.
- ii) Revegetation of barren/margin/waste/mined lands and watershed areas.

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- iii) Effective conservation and management of existing forests resources (mainly natural forests eco-system).
- iv) Research related to social forestry for rural/tribal development.
- v) Development of substitutes to replace wood and wood products.
- vi) Research related to wildlife and management of national parks and sanctuaries.

xiv) Personnel Management - Government policies in personnel management for professional foresters and forest scientist should aim at enhancing their professional competence and status and attracting and retaining qualified and motivated personnel, keeping in view particularly the arduous nature of duties they have to perform, often in remote and inhospitable places.

xv) Forest Survey and Data Base - Inadequacy of data regarding forests resources is a matter of concern because this creates a false sense of complacency. Priority needs to be accorded to completing the survey of forest resources in the country on scientific lines and to updating information. For this purpose, periodical collection, collation and publication of reliable data on relevant aspects of forests to modern technology and equipment.

xvi) Legal Support and Infrastructure Development - Appropriate legislation should be undertaken, supported by adequate infrastructure, at the Centre and State levels in order to implement the Policy effectively.

xvii) Financial Support for Forestry - The objectives of this revised Policy cannot be achieved without the investment of financial and other resources on a substantial scale. Such investment is indeed fully justified considering the contribution of forests in maintaining essential ecological processes and life-support systems and in preserving genetic diversity. Forests should not be looked upon as source of revenue. Forests are renewable natural resources. They are a national asset to be protected and enhanced for the well being of the people and the Nation.

Lec 3. Agroforestry - definition, different terminologies - components- distinction between agroforestry and social forestry- benefits and constraints of agroforestry

Concept of Agroforestry

Agroforestry is a collective name for land-use systems involving trees combined with crops and/or animals on the same unit of land. It combines i) production of multiple outputs with protection of resource base;ii) places emphasis on the use of multiple indigenous trees and shrubs;iii) particularly suitable for low-input conditions and fragile environments ;iv) It involves the interplay of socio-cultural values more than in most other land-use systems; and v)It is structurally and functionally more complex than monoculture.

Definition

Agroforestry is any 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 at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area.

or

Agroforestry is a collective name for a land-use system and technology whereby woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. In an agroforestry system there are both ecological and economical interactions between the various components.

Difference between Social forestry and Agroforestry

Social forestry is defined as “Forestry outside the conventional forests which primarily aims at providing continuous flow of goods and services for the benefit of people. This definition implies that the production of forest goods for the needs of the local people is Social forestry. Thus, social forestry aims at growing forests of the choice of the local population.

Shah (1985) stated that Conceptually Social forestry deals with poor people to produce goods such as fuel, fodder etc. to meet the needs of the local community particularly underprivileged section.

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Agroforestry is termed as any 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 at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area.

Different terminologies for describing tree cultivation in non forest areas

1. Farm Forestry

Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land

Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations.

2. Extension Forestry

Extension forestry is the practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth .

It includes the following.

i) Mixed forestry

Mixed forestry is the practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons

ii) Shelterbelts

Shelterbelt is defined as a belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc.

iii) Linear Strip plantations

These are the plantations of fast growing species on linear strips of land

3. Rehabilitation of Degraded forests

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The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio economic needs of the communities living in and around such areas.

4. Recreation Forestry

Recreation forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as **Aesthetic forestry** which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.

Benefits of agroforestry

i) Environmental benefits

- i) Reduction of pressure on forest
- (ii) More efficient recycling of nutrients by deep-rooted trees on the site
- (iii) Better protection of ecological systems
- iv) Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes
- v) Improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading
- vi) Increment in soil nutrients through addition and decomposition of litter-fall.
- (vii) Improvement of soil structure through the constant addition of organic matter from decomposed litter.

ii) Economic benefits

- (i) Increment in an outputs of food, fuel wood , fodder,fertiliser and timber;
- ii) Reduction in incidence of total crop failure ,which is common to single-cropping or monoculture systems
- iii) Increase in levels of farm income due to improved and sustained productivity

iii) Social benefits

- (i) Improvement in rural living standards from sustained employment and higher income

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- ii) Improvement in nutrition and health due to increased quality and diversity of food outputs
- iii) Stabilisation and improvement of communities through elimination of the need to shift sites of farm activities.

Constraints in agroforestry

The following are the major constraints in agroforestry

1. Depression in crop yields due to interference effects caused by the tree
2. Delayed liquidation of planting investments due to long gestation period
3. Increased damage to crops due to birds which the tree attract
4. Increased damage to crops due to pests for which the tree serve as alternate hosts
5. Allelopathy

1. Interference effects

In an agroforestry system, trees being the dominant partners, will compete with the herbaceous substratum for resource pools of light, water and nutrients. When the immediate supply of a single necessary factor falls below the combined demands of the plant, then the competition begins. The competition is also referred as Allelopathy.

a) Competition for Light

Many tree crops are inefficient in interception of radiant energy in their early years since full canopy formation in trees may take many years. Under such circumstances, solar radiation falling on bare soil is wasted and promote only weed growth. Intercropping of ground cover crops with the trees in their early years will therefore help in better utilization of the resource. Reduction in crop yield from second year of tree growth under agroforestry systems has been reported.

The shade effects caused by full canopy of a 13 year old untopped *Acacia tortilis* was considerable. Compared to open field, the total and net radiation beneath the tree canopy were only 24% and 16% respectively.

Under limitation of light, there is an inevitable depression in the intersown crop yields. Establishment and growth of *Cenchrus ciliaris* was poor under 13 year old untopped *Acacia tortilis*. Forage yield of introduced ground cover of grasses under

A. tortilis plantation was also found to decline within two years of pollarding due to shading caused by newly sprouted shoots

b) Competition for moisture

One of the primary promises of agroforestry, especially of mixed systems rests on the assumption that trees being deep rooted abstract water from the deeper regions and therefore do not compete in the upper stratum to which the herbaceous component is restricted. The increased yield of arable crops and range grasses under *Prosopis juliflora* was due to the deep taproot of the tree. The predominant occurrence of lateral roots in the top 30cm soil has also been reported in Eucalyptus and it extracted moisture mostly from the upper soil layer. Thus trees do compete with arables in the top 30cm soil profile.

In intercropping experiment, depletion of soil moisture was considerable in bamboo.

The other characteristics which have been associated for competition are high root density, high root-shoot ratio high root length per unit soil volume. etc.

c) Competition for nutrients

A higher concentration of the fine tree roots in the soil layer upto 50cm suggests that trees also obtain most of the nutrient requirements from the soil layer upto 50cm. The lower concentration of the fine roots below 50cm soil depth suggests that the nutrient absorption from deeper soil layers may be small. The main function of the roots reaching greater depths appears to be water uptake, particularly during periods of water stress. The proportional abundance of fine roots of agricultural crops, grasses and trees suggests that there is a keen competition for nutrients between the crops and trees when grown in mixture.

Some trees are said to be great transpire of moisture. Particularly Eucalyptus. But studies carried out regarding water consumption by different species indicate that the value of water consumption per unit of biomass produced is lower in *Eucalyptus tereticornis* and *Albizia lebbek* compared to *Acacia auriculiformis*, *dalbergia sissoo* and *pongamia pinnata* though per plant consumption of water is highest in Eucalyptus spp.

When the trees are grown together with agricultural crops either as intercrop or on bunds, their adverse effects are visible on the agricultural crops in the vicinity of the trees. The adverse effects on the growth and yield of agricultural crops are due to the competition for light, moisture and nutrients. The nature and quantum of these adverse effects depend upon i) the age and size of the trees, ii) nature of the tree species iii) nature of the agricultural crops, iv) availability of water, nutrients, light, etc. The impact of the adverse effects is greatest in the close vicinity of the trees and diminishes as the distances increases Such effects were observed in different crops with a combination of different tree species. The effects of *Eucalyptus tereticornis*, *Populus deltoides*, *Dalbergia sissoo* and *Acacia nilotica* grown on field bunds were studied under

different conditions on wheat, paddy, jowar, potato and it was found that *P. deltooides* caused the least damage to the crops of the rabi season but damage by the other species was higher.

i) Environmental aspects

- (i) Possible competition of trees with food crops for space, sunlight, moisture and nutrients which may reduce food crop yields
- (ii) Damage to food crops during tree harvest operations
- (iii) Potential of trees to serve as hosts to insect pests that are harmful to food crops
- (iv) Allelopathic effect of trees on agricultural crops

ii) Socioeconomic aspects

- (i) Requirement for more labour inputs, which may cause scarcity at times in other farm activities
- (ii) Competition between food and tree crops, which could cause aggregate yields to be lower than those of a single crop
- (iii) Longer period required for trees to grow to maturity and acquire an economic value
- (iv) Resistance by farmers to displace food crops with trees especially where land is scarce

2. Allelopathy

Muller (1969) emphasized that allelopathy, the direct or indirect effect of one plant upon another through the production of chemical inhibitors that are released into the environment, should also be recognized as another factor in analyzing mechanisms of plant interactions.

The species interaction due to chemical influences is also designated as **Allelochemistry, Phytochemical ecology or Ecological biochemistry** and **Allelobiology**.

Most of the chemical substances involved in allelopathic reactions are secondary compounds. Though the toxic metabolites are distributed in other plant parts also, leaves are the potent source of allelochemicals. Summer materials are more toxic than those of rainy and winter season. Toxins released from plant litter are the primary causes of allelopathy.

3. Damage due to Birds

It is generally believed that planting of trees in the farm will attract the birds and thereby enhance the risk of damage for agricultural crops.

4. Trees as a alternate hosts to Agricultural crops

Some trees act as alternate hosts for insect pests. For instance, the jowar hopper migrates to neem tree after harvest of crop and returns to the crop after completing its life cycle on the woody perennial.

Silvicultural options for minimizing the negative interactions

1. Manipulation of Densities and Arrangement of Trees

The negative effects of trees can be minimized by increasing the spacing between the trees. The studies carried out in the semi arid regions of India showed that as the distance between the hedgerows of *Luecaena luecocephala* increased, the percent reduction in crop yield decreased. The reduction in the yield of sorghum, cowpea and castor was relatively less in wider spacing (7.2m) compared to narrow spacing (3.6m).

Tree orientation is also important to reduce the negative effect of trees on crops. Planting in east–West direction may reduce the shading effect of trees on the crops.

2. Manipulation of Tree crown and roots

The negative effects of trees can be further reduced by pruning of tree crown and roots. In alley cropping system, pruning of trees and applying the biomass to the soil will reduce the trees competitive ability and increase the growth yield of the associated intercrops by providing green manure and by allowing more light to the intercrops.

In situations of severe root competition for moisture and nutrients, root pruning operation or trenching may eliminate or reduce the negative effect trees on the intercrops.

3. Choice of Agricultural crops

There is a great need to identify the suitable agricultural crops which can grow well under trees with limited solar energy available.

Example:

1. Vegetables : Ginger, turmeric, potato, cucurbit
2. Agricultural crops : Oats, maize, soybean, groundnut
3. Grasses : Cenchrus spp, panicum,

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Through skillful management practices any or all of these constraints can be controlled. For example, once it is known that trees compete with food crops and may reduce food yields, it is easy to adopt some or all of the following strategies:

- (i) Select legume trees that have small or light crowns so that sufficient sunlight will reach the food crops for photosynthesis;
- (ii) Select tree species that are deep-rooted so that they will absorb moisture and nutrients from the deeper subsoil while the food crops receive their share from the surface layer of the soil;
- (iii) Space the trees farther apart to reduce their competitive effects on the food crops.

Certainly agroforestry has considerable potential, not as the only way to improve agricultural production, but as one important way to enhance and maintain overall productivity of the small upland farm, the agricultural unit that is becoming more prevalent in many parts of the world.

Lec4. Classification of Agroforestry systems

Nair (1987) has classified the agroforestry systems based on the following four criteria.

1. Structural Basis
2. Functional basis
3. Socio economic Basis
4. Ecological basis

1. STRUCTURAL BASIS

- a) Nature of Components
- b) Arrangements of Components

a) Nature of Components

1. Agricultural systems
2. Silvopastoral systems
3. Agrosilvopastoral systems
4. Other systems

1. Agricultural systems

- i. Improved fallow species in shifting cultivation
- ii. The taungia system
- iii. Multispecies tree gardens
- iv. Alley cropping
- v. Multipurpose trees and shrubs on farmlands
- vi. Crop combinations with plantation crops
- vii. Agroforestry fuel wood plantations
- viii. Shelter belt s
- ix. Wind breaks
- x. Soil conservation hedges

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2. Silvopastoral systems

- i) Protein bank
- ii) Live fence of fodder trees and hedges
- iii) Trees and shrubs on pastures

3. Agrosivopastoral systems

- i) Home gardens
- ii) woody perennials for browse, mulch, green manure, soil conservation

4. Other systems

- i) Apiculture with trees
- ii) Aquaforestry
- iii) Multipurpose wood lots

b) Arrangement of components

- 1. Spatial arrangement
- 2. Temporal arrangement

2. FUNCTIONAL BASIS

- i) Productive functions
- ii) Protective functions

i) Productive functions

Food

Fodder

Fuel wood

Cloths

Shelter

NTFPs

Protective functions

Wind breaks

Shelterbelts

Soil conservation

Soil improvement

Shade

3. SOCIO ECONOMIC CLASSIFICATION

- i) Commercial systems
- ii) Intermediate systems
- iii) Subsistence systems

4. ECOLOGICAL CLASSIFICATION

- i. Humid / sub humid
- ii. Semiarid / arid
- iii. Highlands

Lec.5 AGRISILVICULTURAL SYSTEMS- SUB SYSTEMS

AGRISILVICULTURAL SYSTEM involves the conscious and deliberate use of land for the concurrent production of agricultural crops including tree crops.

Based on the nature of the components this system can be grouped into various forms.

- (i) Improved fallow species in shifting cultivation
- (ii) The Taungya system
- (iii) Multispecies tree gardens
- (iv) Alley cropping (Hedgerow intercropping)
- (v) Multipurpose trees and shrubs on farmlands
- (vi) Crop combinations with plantation crops
- (vii) Agroforestry fuelwood production
- (viii) Shelterbelts
- (ix) Windbreaks
- (x) Soil Conservation hedges

i)Improved Fallow Species in Shifting Cultivation

Fallows are cropland left without crops for periods ranging from one season to several years. The objective of improved fallow species in shifting cultivation is to recover depleted soil nutrients. Once the soil has recovered, crops are reintroduced for one or more seasons.

Shifting cultivation is a pattern of land use and a system of production of crops under which plots of land are cleared ,cultivated for a short period for raising one, two or three crops, after which the land is allowed to rest longer than the period of cultivation. However, during the period of rest the land reverts to some modified form of its original cover

This system is practised extensively in the north-eastern hill region comprising the states of Assam, Meghalaya, Manipur, Nagaland and Tripura and the two Union territories of Arunachal Pradesh and Mizoram and to some extent Andhra Pradesh, Bihar, Madhya Pradesh, Orissa and Karnataka states. It is called '**jhum**' in the north-eastern hill region and '**podu**' in AP and Orissa states and considered most destructive for forest areas.

The main feature of the improved fallow system of agroforestry is that trees and shrubs are not grown with crops on the same plot at the same time. The fallow periods vary from region

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to region but are presently becoming shorter due to an increasingly acute land shortage. The best species for the fallow system should induce good nitrogen fixation in the soil.

Species: While the main function of the fallow is to maintain or restore soil fertility and reduce erosion, some plants can be introduced primarily for their economic value. Species choice should not be exclusively confined to '**soil improvers**'; plants with marketable products should also be considered. Plants included in improved fallows should be compatible with future crops, free of any negative physical or chemical effects on the soil and not in competition with the crops to be planted later on the same site.

Establishment: Improved fallows can be established in a variety of ways and at various stages of the fallow. Methods might include:

- ✓ Direct seeding of clean tilled, harvested plots;
- ✓ Selective cutting of bush, followed by enrichment planting with tall seedlings;
- ✓ Introducing tall seedlings and cuttings into poor-quality fallows on degraded land;
- ✓ Planting tree seedlings in closely spaced, deep planting holes or furrows within blocks of cleared cropland.

The exact techniques vary with the previous land use, value of the fallow vegetation condition of the land and expected duration of the fallow.

(ii) Taungya System:

The taungya (taung = hill, ya = cultivation) is a Burmese word coined in Burma in 1850s. The taungya system was introduced into India by Brandis in 1890 and the first taungya plantations were raised in 1896 in North Bengal. It is practised in the states of Kerala, West Bengal and Uttar Pradesh and to a lesser extent in Tamil Nadu, Andhra Pradesh, Orissa, Karnataka and the north-eastern hill region. In southern India, the system is called '**kumri**'. It is practised in areas with an assured annual rainfall of over 1200-1500 mm.

This is a modified form of shifting cultivation in which the labour is permitted to raise crops in an area but only side by side with the forest species planted by it. This labour is responsible for the upkeep of a plantation. The practice consists of land preparation, tree planting, growing agricultural crops for 1-3 years, until shade becomes too dense, and then moving on to repeat the cycle in a different area. In some cases crops may be grown one year before the trees are planted. A large variety of crops and trees, depending on the soil and climatic conditions.

Crops and trees grown in Tamil Nadu

a) Trees

Tectona grandis

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Bamboo

Santalum album

Tamarindus indica

Acacia nilotica

Acacia mearnsii

Ceiba pentandra

Cashew, Rubber

b) Crops

Millet, pulses, groundnut, cotton

Types of Taungya systems

Taungya systems are of three types:

(a) Departmental Taungya : Under this, agricultural crops and plantation are raised by the forest department by employing a number of labourers on daily wages. The main aim of raising crops along with the plantation is to keep down weed growth.

(b) Leased Taungya: The plantation land is given on lease to the person who offers the highest money for raising crops for a specified number of years and ensures care of tree plantation.

(c) Village Taungya: This is the most successful of the three taungya systems. In this, crops are raised by the people who have settled down in a village inside the forest for this purpose. Usually each family has about 0.8 to 1.7 ha of land to raise trees and cultivate crops for 3 to 4 years.

Advantages offered by the taungya system are:

- (i) Artificial regeneration of the forest is obtained cheaply
- (ii) Problems of unemployment are solved
- (iii) Helps towards maximum utilisation of the site
- (iv) Low cost method of forest plantation establishment
- (v) In every case highly remunerative to the forest departments
- (vi) Provision of food crops from forest land
- (vii) Weed, climber growth etc. is eliminated.

Disadvantages of the taungya system

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- (i) Loss of soil fertility and exposure of soil
- (ii) Danger of epidemics
- (iii) Legal problems created
- (iv) Susceptibility of land to accelerated erosion increases
- (v) It is a form of exploitation of human labour.

The taungya farmers are given the following concessions as a part and parcel of success of the system

- (i) Free grazing for animals;
- (i) Free timber for house construction and agricultural implements
- (ii) Schooling facilities for children
- (iii) Monetary loan at nominal interest
- (iv) Water supply through excavation of wells and construction of ponds.

iii) Multispecies Tree Gardens:

In this system of agroforestry, various kinds of tree species are grown mixed. The major function of this system is production of food, fodder and wood products for home consumption and sale for cash. Major woody species involved in this system are: *Acacia catechu*, *Areca catechu*, *Phoenix dactylifera*, *Artocarpus* spp., *Cocos nucifera*, *Mangifera indica*, *Syzygium aromaticum* etc

(iv) Alley Cropping (Hedgerow Intercropping):

Alley cropping, also known as hedgerow intercropping, involves managing rows of closely planted (within row) woody plants with annual crops planted in alleys in between hedges. The woody plants are cut regularly and leaves and twigs are used as mulch on the cropped alleys in order to reduce evaporation from the soil surface, suppress weeds and/or add nutrients and organic matter to the top soil. Where nitrogen is required for crop production, nitrogen-fixing plants are the main components of the hedgerows.

The primary purpose of alley cropping is to maintain or increase crop yields by improvement of the soil and microclimate and weed control. Farmers may also obtain tree products from the hedgerows, including fuelwood, building poles, food, medicine and fodder and on sloping land, the hedgerows and prunings may help to control erosion. Alley cropping usually works best in places where people feel a need to intensify crop production but face soil fertility

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problems. This situation is often characteristic of crowded, densely populated areas, but may also occur wherever some farmers wish or forced to increase production on a plot of limited size.

Design: Woody plants are introduced as hedgerows in farm fields to maximise the positive and minimise the negative effects of trees on crop management and yields. Without doubt, trees compete with farm crops for soil nutrients, soil moisture and light. However, the right kind of trees at the right spacing, with proper management, may actually produce a net increase in yields from croplands. Trees may also provide new products such as fuelwood, fodder or food, in addition to the annual crops.

The position and spacing of hedgerow and crop plants in an alley-cropping system depend on plant species, climate, slope, soil conditions and the space required for the movement of people and tillage equipment. Ideally, hedgerows should be positioned in an east-west direction so that plants on both sides receive full sunlight during the day. The spacing used in fields is usually 4 to 8 metres between rows and 25 cm to 2 metres between trees within rows. The closer spacing is generally used in humid areas and the wider spacing in subhumid or semi-arid regions.

The position and spacing of hedgerows may also be affected by slope and the placement and design of soil and water conservation structures when these are combined with alley cropping. On sloping land hedgerows should always be placed on the contour. If this means that they do not have the desirable east-west orientation, then they may need regular thinning to prevent excessive shading of adjacent crops.

Species for hedgerow intercropping: Alley cropping usually includes leguminous trees to improve soil fertility through nitrogen fixation; hence an ideal alley-cropping tree or shrub species should have following characteristics

- ✓ It should have a sparse, small crown to permit sunlight penetration or should resprout rapidly after pruning, coppicing, pollarding or lopping.
- ✓ It should form a deep taproot system with few lateral root branches near the surface so as not to compete with crop roots.
- ✓ It should have shallow lateral roots that are easily 'pruned' by ploughing along the hedgerow, without serious damage to the plants.
- ✓ The leaf litter or some portion of it, should decompose at a rate that makes nutrients available when they are needed in the cropping cycle.

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- ✓ Ideally, trees and shrubs used for alley cropping should fix nitrogen and should also produce wood, food, fodder, medicine or other products used by farmers or other local community.
- ✓ The species selected should grow well under the specific limitations of the site such as saline or acid soils, drought, flooding, heavy winds, insect pests or other hazards.
Eg. Cassia siamea, Leucaena leucocephala, Gliricidia sepium, Callianda calothyrsus and Sesbania sesban are commonly used tree species for alley cropping.

v) Multipurpose Trees and Shrubs on Farmlands:

In this system, various multipurpose tree species are scattered haphazardly or according to some systematic patterns on bunds, terraces or plot/field boundaries. The major components of this system are multipurpose trees and other fruit trees and common agricultural crops. The primary role of this system is production of various tree products and the protective function is fencing, social values and plot demarcation. Examples of multipurpose trees employed in agro forestry are: *Leucaena leucocephala, Acacia albida, Cassia siamea, Casuarina equisetifolia, Azadirachta indica, Acacia senegal, Cocos nucifera* etc.

(vi) Crop Combinations with Plantation Crops:

Perennial trees and shrub crops, such as coffee, tea, coconut and cocoa, are combined into intercropping systems in numerous ways, including:

- (a) Integrated multistorey (mixed dense) mixture of plantation crops;
- b) Mixture of plantation crops in alternate or other regular arrangement
- (c) Shade trees for plantation crops, shade trees scattered; and
- (d) Intercropping with agricultural crops.

(vii) Agroforestry Fuel wood Production:

In this system, various multipurpose fuelwood/firewood species are interplanted on or around agricultural lands. The primary productive role of this system is to produce firewood; the protective role is to act as fencing, shelter-belts and boundary demarcation. Tree species commonly used as fuelwood are: *Acacia nilotica, Albizia lebbek, Cassia siamea, Casuarina equisetifolia, Dalbergia sissoo, Prosopis juliflora, Eucalyptus tereticornis* etc.

Lec. 6 SOME SUB SYSTEMS OF AGRISILVICULTURAL SYSTEM

(viii) Shelter-belt:

These are belts/blocks consisting of several rows of trees established at right angles to the prevailing wind. The purposes are:

- a) to deflect air currents,
- b) to reduce the velocity of prevailing winds,
- c) to provide general protection to the leeward areas against the effects of wind erosion,
- d) to protect the leeward areas from the desiccating effects of hot wind,
- e) to provide food, fodder, timber etc.

The following are the main characteristics of shelter-belts:

i)Shape and composition: Shelter-belts have a typical triangular shape. This can usually be brought about by raising tall trees in the centre.

ii)Density and width: A certain degree of penetration by winds is planned as by raising a solid wall, the protection decreases very fast on the leeward side. Shelter-belts up to 50 m width are considered ideal under Indian conditions.

iii)Height and spacing: The ratio of height and width should be roughly 1:10. However, this figure may vary with local conditions.

iv)Orientation: Orientation of shelter-belts depends on the direction and velocity of the prevailing winds. Shelter-belts may be raised in quadrangles if the wind direction tends to change very often.

v)Length: Length is an important consideration as far as shelterbelts are concerned. The minimum length of a shelter-belt should be about 25 times its height,

vi)Choice of species: The following species are recommended:

Grasses: *Saccharum spontaneum*, *S. munja*, *Panicum antidotale*,
Cenchrus sp.

Shrubs: *Calotropis procera*, *Clerodendron phlomoides*, *Cassia auriculata*, *Dodonaea viscosa*

Trees: *Acacia arabica*, *A. leucopholea*, *Dalbergia sissoo*, *Lannea coromandelica*,
Eucalyptus spp., *Tamarix, articulata*, *Parkinsonia aculeata*, *Prosopis juliflora*, *Prosopis*
Spicigera, *Casuarinaequisetifolia*.

ix) Wind-break:

Wind-breaks are strips of trees and/or shrubs planted to protect fields, homes, canals or other areas from wind and blowing soil or sand.

The important reasons for which wind-breaks are planted include:

- ✓ to protect livestock from cold winds
- ✓ to protect crops and pastures from hot, drying winds
- ✓ to reduce/prevent soil erosion
- ✓ to provide habitat for wildlife
- ✓ to reduce evaporation from farmlands
- ✓ to improve the microclimate for growing crops and to shelter people and livestock,
- ✓ to retard grass fire
- ✓ for fencing and boundary demarcation

When properly designed and maintained, windbreaks reduce the speed of the wind and thus its ability to carry and deposit soil and sand. They also improve growing conditions by decreasing water evaporation from soil and plants and can be used to reduce evaporation from water surfaces, such as irrigation ponds, canals or streams. In addition, wind-breaks can provide wide range of useful products, from poles and fuelwood to fruit, fodder, fibre and mulch.

i) Permeability: A wind-break works by filtering and breaking the force of the wind. For most purposes, permeable wind-breaks which allow some wind to pass through are the most suitable. The slight movement of air through the wind-breaks forms a cushion of slow-moving air on both upwind and downwind sides. This deflects the main volume of wind upwards and prevents it from descending for some distance. Thus, the wind velocity in the protected area may be reduced to between 25 and 75 per cent of the wind speed.

Dense wind-breaks produce a small area of still air in a narrow strip behind the trees, but further downwind there may be considerable turbulence. However, dense wind-breaks may be desirable when a high level of protection is needed for small areas such as around homesteads and work areas or for vulnerable livestock such as newborn lambs, calves etc.

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The desired permeability can be obtained by carefully selecting tree shrub species. Species such as *Eucalyptus* and *Casuarina* will form el wind-breaks but most native species are more permeable.

ii)Orientation: For best results, plant wind-breaks at right angles to winds from which protection is needed. Wind-breaks planted north-south are a good compromises as they provide protection from winds coming from the western quarter. They also give better shading of adjacent crops and pastures than wind-breaks planted east-west.

iii)Height: The wind-break height determines the size of the sheltered area. The taller the wind-break, the greater the area it protects. On level ground a windbreak will reduce the speed of wind for about 25 times the tree height on down windside. Maximum reduction of wind speed is in the area 5 to 15 times the tree height away from the wind break. On the upwind side some protection is gained up to a distance of 5 times the tree height away from the windbreak. Thus a wind break 20 m tall will give some protection from 100 m on the upwind side to 500 m on the downwind side.

iv)Length: Wind breaks are most effective when they stretch without major gaps for distances exceeding 12 times the mature height of the trees.

v)Number of rows: A single row wind break should be used only where land is so valuable that only a small amount of space can be spared for tree planting. If a single row wind break is to be planted, tree species that retain their foliage to the ground and give a fairly dense growth should be selected. ***Eucalyptus* are generally unsuitable as single-row wind-breaks** because of their habit of losing their lower limbs. The main disadvantage of a single row is that if one tree is lost, gap is created, which reduces the efficiency of the entire wind break. **Wind breaks of three to five rows are more effective** for most farm situations and are less affected by gaps caused by mission trees. Tall growing species should be planted in the centre rows and small bushy species in the outside rows

vi)Tree spacing: Distance between trees varies with the relative importance of the protective versus productive purposes of the wind break. Where the products of wind breaks have a high priority, then land-users may favour greater number of shorter strips and a higher proportion of small trees and shrubs which provide products such as fodder and fuelwood. If the by product is timber, the height of wind breaks and the intervals between them can be increased. When the interest is to protect valuable crops, the wind breaks should be as tall and as far apart as possible

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to obtain the more protection. In dry areas, individual plants should be widely spaced so that they do not compete with each other for the available soil moisture.

vii)Gaps: Gaps are required for gates and tracks, but because of the funneling effect through gaps, wind velocity in these areas can be substantially increased. In multi row wind breaks this can be eliminated by angling the gap at about 45 degrees to the prevailing wind direction. Alternatively, a few plant, trees or shrubs can be used on either side of the gate or track to broaden the gap and reduce the funneling effect. Other solutions are to plant five or six trees at an angle to the main belt as a wing or to plant a second short row to cover the gaps .

viii)Species: In general, trees with narrow, vertical growth are ideal for wind breaks to minimise the land removed from crop production. Some fast-growing species should be used to establish the desired effect as rapidly as possible. Some of the tree species used for wind-breaks are *Eucalyptus*, *Cassia*, *Prosopis*, *Leucaena*, *Casuarina*, *Acacia*, *Grevillea*, *Syzygium*, *Dalbergia* etc.

(x) Soil Conservation Hedges: Trees can be planted on physical soil conservation works (grass strips, bunds, risers and terraces) wherein they play two roles: **ie.**, to stabilise the structure and to make productive use of the land they occupy. Stabilisation is through the root system. In some of sloping landscapes of the country, the risers or terraces are densely planted with trees, with multiple use being made of them for fruit, fodder and fuel wood . **In this system the major groups of components are:** multipurpose and trees and common agricultural species. The primary role of multipurpose trees and agricultural species is soil conservation and provision of various tree products. The following tree species are used for soil conservation: *Grevillea robusta*, *Acacia catechu*, *Pinus roxburghii*, *Acacia modesta*, *Prosopis juliflora*, *Alnus nepalensis*, *Leucaena leucocephala* etc.

Lec.7 SILVIPASTURE SYSTEM

The production of woody plants combined with pasture is referred to Silviculture system. The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuelwood, fruit or to improve the soil.

This system is classified in to three categories

- i) Protein bank
- ii) Livefence of fodder trees and hedges
- iii) Trees and shrubs on pasture

i) Protein bank

In this Silvicultural system, various multipurpose trees(protein rich trees) are planted on or around farmlands and range lands for cut and carry fodder production to meet the feed requirement of livestock during the fodder deficit period in winter

Example: *Acacia nilotica, Albizia lebbek, Azadirachta indica, Leucaena leucocephala, Gliricidia sepium, Sesbania grandiflora*

ii) Livefence of fodder trees and hedges

In this system, various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences.

Example: *Gliricidia sepium, Sesbania grandiflora, Erythrina sp, Acacia sp.*

iii) Trees and shrubs on pasture

In this system, various tree and shrub species are scattered irregularly or arranged according to some systemic pattern to supplement forage production.

Example: *Acacia nilotica, Acacia leucophloea, Tamarindus indica, Azadirachta indica.*

Lec.8 AGRISILVOPASTURAL SYSTEMS AND OTHER SYSTEMS

The production of woody perennial combined with annuals and pastures is referred Agrisilvopastural system.

This system is grouped into two categories.

- i) Home gardens
- ii) Woody hedgerows for browse, mulch, green manure, soil conservation

i) Home gardens

This system is found extensively in high rainfall areas in tropical South and South east Asia. This practice finds expression in the states of Kerala and Tamil Nadu with humid tropical climates and where coconut is the main crop. Many species of trees, bushes , vegetables and other herbaceous plants are grown in dense and in random or spatial and temporal arrangements. Most home gardens also support a variety of animals. Fodder grass and legumes are also grown to meet the fodder requirement of cattle. In India, every homestead has around 0.20 to 0.50 ha land for personal production.

Home gardens represent land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and livestock within the compounds of individual houses. The whole tree- crop- animal units are being intensively managed by family labour. Home gardens can also be called as **Multitier system** or **Multitier cropping**

Home gardens are highly productive, sustainable and very practicable. Food production is primary function of most home gardens.

Structure of Home Gardens: Home gardens are characterized by high species diversity and usually 3-4 vertical canopy strata. The layered configuration and compatible species admixture are the most conspicuous characteristics of all home gardens. Generally all home gardens consist of a herbaceous layer near the ground, a tree layer at the upper levels and an intermediate layer. The lower layer can be partitioned in to two, the lowermost being at less than 1.0m in height, dominated by different vegetables and the second layer of 1.0 -3.0/m height comprising food crops such as banana, papaya and so on. The upper tree layer can also be divided into two, consisting of emergent , full grown timber and fruit trees occupying the upper most layer of

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25m height and medium size trees of 10-20m occupying the next lower layer. The intermediate layer of 5-10m height is dominated by various fruit trees.

Choice of species:

a) **Woody species** : *Anacardium occidentale*, *Artocarpus heterophyllus*, *Citrus sp*,

Psidium guajava, *Mangifera indica*, *Azadirachta indica*,

Cocos nucifera,

b) **Herbaceous species**: Bhendi, Onion, cabbage, Pumpkin, Sweet potato, Banana,

Beans, etc.

ii) Woody Hedgerows:

In this system various woody hedges , especially fast growing and coppicing fodder shrubs and trees are planted for the purpose of browse, mulch, green manure soil conservation etc. The following species viz., *Erythrina sp*, *Leucaena leucocephala* , *Sesbania grandiflora* are generally used.

OTHER SYSTEMS

- i) **Apiculture with trees**: In this system various honey (nector) producing trees frequently visited by honeybees are planted on the boundary of the agricultural field.
- ii) **Aquaforestry**: In this system various trees and shrubs preferred by fish are planted on the boundary and around fish ponds. Tree leaves are used as forage for fish. The main role of this system is fish production and bund stabilization around fish ponds
- iii) **Mixed wood lots**: In this system special location specific multipurpose trees (MPTs) are grown mixed or separately planted for various purposes such as wood, fodder, soil conservation , soil reclamation etc.

Lec.9 AGROFORESTRY DIAGNOSIS AND DESIGN

Definition

Agroforestry D & D is a family of procedures for the diagnosis of land management problems and potentials and the design of agroforestry solutions. The ICRAF has developed an approach to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects.

Key Features of D & D

- i) **Flexibility:** D & D is a flexible discovery of procedure, which can be adopted to fit the needs and resources of different users
- ii) **Speed:** D & D has been designed with the option of a 'rapid appraisal' application at the planning stage of a project with In-depth follow-up during project Implementation.
- iii) **Repetition:** D & D is an open-ended learning process. Since initial designs can almost always be improved. The D & D process need not end until further Improvements are no longer necessary.

Basic logic of AF Diagnosis and Design

Basic question	Key factors to consider
<p>Prediagnostic stage Which land-use system?</p> <p>How does the system work?</p>	<p>Distinctive combinations of resource technology and land-user objectives.</p> <p>Production objectives and strategy subsystems and components.</p>
<p>Diagnostic stage How well does the system work?</p>	<p>Problems in meeting objectives, causal factors, constraints, and intervention points.</p>
<p><i>Design and evaluation stage</i> How can the system be improved?</p>	<p>Specifications for problem-solving or performance-enhancing interventions.</p>
<p><i>Planning stage</i> How can the Improved technology be developed and disseminated?</p>	<p>D & D needs, extension needs.</p>

<i>Implementation stage</i> How can the plan of action be adjusted to new information?	Feedback from research trials, independent farmer innovations etc.

Procedures of AF Diagnosis and Design

The procedures of AF D & D are usually done of two types:

- 1) 'Macro' D & D and 2) 'Micro D & D '

i) MACRO D & D

An agroforestry research programme normally begins with a macro D & D exercise covering an entire ecological zone with I n a country. This consists of a rapid appraisal, based primarily on secondary information complemented by a few selected surveys in the field.

by a few selected surveys in the field.

Macro D & D includes on assessment of existing land use system constraints, agricultural policies and institutional arrangement, current agroforestry practices and the potential for improving productivity and sustainability through agroforestry interventions. The study zone is a broad region chosen for its importance at the national level. Its selection is usually based on the following factors.

- Contribution to food production and the national economy;
- Population area
- Urgency of problems or importance of unexploited potential
- Level of agricultural development and land use intensification

Typically, the D & D team comprises 5 to 10 specialists from biophysical and socioeconomic fields including soil science, agronomy, horticulture, animal science, forestry, agricultural economics and rural sociology or anthropology. All team members should have experience in both research and extension work. To ensure that the results of the D & D exercise are taken fully into account, the scientists who carry out the D & D should participate at least in the design and analysis and, better still, also in the implementation of the ensuing research programme.

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Macro D&D is usually completed in about three months. This includes two to three days to plan the study and orient the team , two to three weeks to review and synthesis the secondary information , two to three weeks to conduct the field work , and four to sis weeks to analyse the information and prepare the report.

Macro D & D includes a detailed review of past and present agroforestryresearch and development programmes. The fieldwork component of a macro D & D normally consists of a visual appraisal of the study zone with the team sometimes traveling many kilometers in a few days in order to identify the extent pattern and problems of existing land-use systems.Team members interview researchers and extension workers and may conduct a few informal interviews with local land-users.

Macro D & D is usually followed up by a national or regional workshop to analyse the common problems and potentials of land-use systems in the zone to identify agroforestry technologies with potential relevance for the zone as a whole, to identify specific land-use systems as the focus for future research and development efforts and to establish preliminary research requirements.

ii) MICROD & D

A central aspect of macro D & D is the delineation of land-use systems within the chosen ecological zone, leading to the selection of target systems for more detailed analysis by micro D & Ds. A land-use system is defined as a distinctive combination of crops, livestock, trees and other production components.

The primary focus of analysis is the management unit that makes decisions and shares resources, objectives, labour and products. Analysis of a land-use system comprises all the characteristics that affect its management and performance. These characteristics include the following:

- Location: Administrative and political divisions
- Environmental characteristics:
- Socio-economic characteristics
- Land-use:
- Resources/supporting service

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-Development activities and policies.

An important aspect of micro D & D is an analysis of the needs, objectives, and constraints of land-users. This step is based on interviews and field surveys.

One major aspect of micro D & D is the analysis of existing knowledge and agroforestry practices. What trees or shrubs are being used with what management procedures, with what objectives and obtaining what yields? Such analysis helps in defining strategies for working with target land-users.

The main objective during the initial D & D exercise is to assess how well the existing system is performing and meeting the needs of the land-users. Any performance gap can be evaluated by comparing present resources and outputs (what the farmers are actually producing) with biophysical potentials (for instance the yields obtained from on-station or on-farm experiments). This assessment must distinguish between problems that can be alleviated and those that cannot. The emphasis is on the problems that can be addressed by agroforestry.

Potential interventions are identified and evaluated in terms of their capacity to relieve the identified constraints. In the first instance, all interventions are considered, not just those related to agroforestry. For example, low soil fertility could be addressed by applying chemical fertilizers or manure or providing mulch from multipurpose trees or other plants. Each alternative is evaluated in terms of its technical potential and its feasibility in terms of resources and capabilities of the land users.

As with macro D & D, the research team for a micro D & D comprises 5 to 10 biophysical and social scientists. Again the exercise is usually completed in about three months. However, for the micro D & D, the fieldwork component entails more contact with farmers, often including a formal survey of 50 to 100 individuals with a semi structured questionnaire. In addition, the team may need to allocate considerable time to reviewing ongoing research and extension work in the selected land-use system.

Promising agroforestry technologies may be sketched on the basis of results from micro D & D, but a full evaluation requires information about technology performance under the specific conditions of the land-use system. If a technology is well known and some farmers have already adapted it successfully, then it can be recommended for further extension.

On the other hand, if the technology is new to the area and not well known or if it

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represents a major departure from the farmers' 'current practices, a research programme must be designed to test the components and management factors and make sure that the technology is well adapted to the target land-use system.

Criteria of Good Agroforestry Design

A good agroforestry design should fulfill the following criteria:

i) Productivity: There are many different ways to improve productivity with agroforestry viz., increased output of tree products, improved yields of associated crops, reduction of cropping system inputs, increased labour efficiency, diversification of production, satisfaction of basic needs and other measures of economic efficiency or achievement of biological potential.

ii) Sustainability: By seeking improvements in the sustainability of production systems, agroforestry can achieve its conservation goals while appealing directly to the motivation of low income farmers , who may not always be interested in conservation for its own sake

iii) Adoptability: No matter how technically elegant or environmentally sound an agroforestry design may be, nothing practical is achieved unless it is adopted by its intended users. This means that the technology has to fit the social as well as environmental characteristics of the land-use system for which it is designed.

Lec.10 Agroforestry Systems for seven agroclimatic zones of Tamil Nadu

I. Suitable agroforestry practices for northeastern zone of Tamil Nadu

1. **Districts** : Chennai, Kanchipuram, Thiruvallur, Cudallore, Vellore, Thiruvannamalai, Vilupuram
2. **Annual Rainfal** : 1054 mm
3. **Soil Types** : Red loam, red sandy loam, black clayey and black clay loam to limited extent, saline alluvial in sea coast
4. **Major Crops** : Groundnut, sesame, rice, bajra, ragi and sugarcane
5. **Dominant tree species** : Casuarina equisetifolia, Thespesia populnea, Pongamia pinnata, Lannea coromondalica, Anacardium occidentale
6. **Major agroforestry practices** :
 - a) Monoculture of *Casuarina equisetifolia*
 - b) Intercropping of groundnut, sesame and pulses with *C. equisetifolia*
 - c) Band planting of *Thespesia populnea* and *Lannea coromandalica*
 - d) Monoculture of *Acacia auriculiformis*
 - e) Intercropping groundnut, pulses and minor millets with *Anacardium occidentale*

II. Suitable agroforestry practices for northwestern zone of Tamil Nadu

- 1. Districts** : Dharmapuri, Krishnagiri, Salem and Namakkal
- 2. Annual Rainfal** : 825 mm in 47 rainy days
- 3. Soil Types** : Red to brown, loamy soils
- 4. Major Crops** : Groundnut, tapioca, sugarcane and vegetables, ragi, sesame, horsegram and castor
- 5. Dominant tree species** : *Delonix elata*, *Pongamia pinnata*, *Ailanthus excelsa*, *Albizia amara* and *Tamarindus indica*
- 6. Major agroforestry practices** :
 - a) Bund planting of *Pongamia pinnata* (Dharmapuri), *Delonix elata* and *Albizia amara* (Salem)
 - b) Intercropping tapioca with *Eucalyptus tereticornis*
 - c) Monoculture of *E. tereticornis*

III. Suitable agroforestry practices for cauvery delta zone of Tamil Nadu

- 1. Districts** : Tiruchirapalli (part of district), Perambalur (part of district), Pudukottai (part of district), Thanjavur, Nagapattinam and Thiruvarur
- 2. Annual Rainfal** : 900 – 1000 mm
- 3. Soil Types** : Alluvial in the old delta and red loam with pockets of laterite in the new delta
- 4. Major Crops** : Paddy, sugarcane, banana, pulses
- 5. Dominant tree species** : *Thespesia populnea*, *Bamboo*, *Acacia nilotica*, *Prosopis juliflora*, *Ailanthus excelsa*, *Casuarina equisetifolia*, *Eucalyptus tereticornis*
- 6. Major agroforestry practices** :
 - a) Bund planting of *Acacia nilotica* and *Bambusa bambos* (Thanjavur)
 - b) Intercropping groundnut and coriander with *B. bambos*
 - c) Boundary planting of *Tectona grandis* and *Dalbergia sissoo* along water courses and canals
 - d) Live fence of *Lannea coromandalica* (Nagapattinam)
 - e) Woodlots of *Terminalia arjuna*

IV. Suitable agroforestry practices for western zone of Tamil Nadu

- 1. Districts** : Erode, Coimbatore, Karur, Dindigul and Theni
- 2. Annual Rainfal** : 638 mm in 45 rainy days
- 3. Soil Types** : Thin red with a block of black soil
- 4. Major Crops** : Rice, sugarcane, cotton, sorghum, ragi, turmeric, banana, groundnut, Bengal gram, tobacco
- 5. Dominant tree species** : Hardwickia binata, Holoptelia integrifolia, Ailanthus excelsa, Acacia leucophloea, Acacia ferruginea, Santalum album
- 6. Major agroforestry practices** :
 - a) Bund planting of *Albizia lebbeck*, *Ailanthus excelsa*, *Hardwickia binata*
 - b) Intercropping tapioca, groundnut, sesame with *E. tereticornis*
 - c) Woodlots of *Ceiba pentandra*
 - d) Silvipasture consists of *Acacia leucophloea* with fodder sorghum, *Cenchrus* spp.
 - e) Fuel plantation of *Prosopis juliflora*

V. Suitable agroforestry practices for southern zone of Tamil Nadu

- 1. Districts** : Ramanathapuram, Tirunelveli, Madurai, Pudukottai (part), Sivagangai, Virudhunagar and Thoothukudi
- 2. Annual Rainfal** : 776 mm in 43 rainy days
- 3. Soil Types** : Black clayey (mid zone), saline coastal alluvium or river alluvium (eastern region), red sandy soil (north eastern side), deep red soil (western region)
- 4. Major Crops** : Bajra, cotton, jowar, fodder jowar, minor millets, groundnut, senna, chilli and vegetables
- 5. Dominant tree species** : Acacia planifrons, Ceiba pentandra, Bassia latifolia, Prosopis juliflora, Tamarindus indica, Eucalyptus tereticornis, Azadirachta indica
- 6. Major agroforestry practices** :
 - a) Woodlots of tamarind and neem
 - b) Silviculture consists of *Leucaena leucocephala*
 - c) Intercropping cereals or pulses with kapok
 - d) Monoculture of *Eucalyptus tereticornis*, *Acacia nilotica*, *A. leucophloea* and *Prosopis juliflora*

VI. Suitable agroforestry practices for high rainfall zone of Tamil Nadu

- 1. Districts** : Kanyakumari
- 2. Annual Rainfal** : 1500 mm in 64 rainy days
- 3. Soil Types** : Deep loam, saline coastal alluvium (south eastern belt)
- 4. Major Crops** : Rice, tapioca, coconut, peper, clove, nutmag, cardamom and coffee
- 5. Dominant tree species** : *Rubber, tamarind, Calophyllum inophyllum and Albizia falcataria*
- 6. Major agroforestry practices** :
 - a) Home garden
 - b) Intercropping food crops, spices and pastures with coconut
 - c) Bund planting of *Albizia falcataria*
 - d) Intercropping food crops with *Calophyllum inophyllum, Bassia latifolia* and *Pongamia pinnata*

VII. Suitable agroforestry practices for hilly zone of Tamil Nadu

1. **Districts** : Nilgiris, Shevroys, Elagiri javadhu, Kolli, Anamalai, Palni and Podhigai Hill ranges
2. **Annual Rainfal** : 1000 mm to 5000 mm
3. **Soil Types** : Laterite
4. **Major Crops** : Tea, coffee, cabbage, cauliflower
5. **Dominant tree species** : *Grevillea robusta*, *Eucalyptus globulus*, *temperate* Acacias, *Terminalias*
6. **Major agroforestry practices** :
 - a) Intercropping potato, beans with *Eucalyptus globulus*
 - b) *Grevillea robusta* and *Erythrina indica* as shade trees in tea and coffee gardens

**Lec.11 ROLE OF TREES IN SOIL FERTILITY
ECONOMICS OF AGROFORESTRY**

ROLE OF TREES IN SOIL FERTILITY

Soil is one of the most important natural resources to suffer as a result of tree cutting. If it is not protected, its productivity declines and it may become difficult to sustain the human and animal population even at its present level. Therefore, protection of this resource is important and an understanding of how this resource is influenced in an agroforestry system is necessary.

Tree Root Patterns

It is generally assumed that trees have deep and spreading roots and hence are capable of exploiting more soil volume and taking up nutrients and water from deeper layer not usually contacted by herbaceous crops. This process of taking up nutrients from deeper soil profiles and eventually depositing at least some portion of them on the surface layers through litter-fall and other mechanisms is referred to as '**nutrient pumping**' by trees. It is well known that the development of plants depends on site characters and environmental factors. Many woody species have the largest number of roots and the majority of the fine roots are located in the uppermost fertile portion of the soil profile. Some tree species are shallow rooted. *Prosopis chilensis* has a shallow and spreading root system whereas *P. juliflora*, is known to have a very deep root system.

Role of trees in soil fertility

a) Organic matter and nutrient addition to the soil

Tree species contain large quantities of 'living' biomass .About 20 to 25 per cent of the total living biomass of the trees is in roots and there is a constant addition of organic matter to the soil through dead and decaying roots. The major addition of organic matter and other nutrients to the soil from the trees standing on it is through **litter fall** ie., dead and falling leaves, twigs, branches, fruits etc.

b) Dinitrogen fixation by trees

There is a possibility for improvement of the fertility status of agricultural lands' through additional amounts of nitrogen added to the soil by the tree legume component. **Mimosoideae** and **Fabaceae** are well known to fix nitrogen. Therefore, among the various avenues of addition of nitrogen to a soil through natural and biological means, the most significant one brought

about by the presence of trees on agricultural lands could be nitrogen fixation by leguminous trees. For example, *Leucaena leucocephala* grown for forage for 9 months yields about 12,600 kg forage, 3,600 kg protein and 575 kg nitrogen per ha.

c) Nutrient cycling

The nutrient cycling model consists of the soil-plant system that is partitioned into several compartments. The crown surface forms the boundary of the system where input of bioelements occurs through precipitation. The soil surface is the entry point for inputs into the soil compartment, occurring through fertilizers, rainfall and stem flow. The surface layer may be considered the zone of intensive root activity, with the subsoil constituting the extensive root activity zone. The lower end of the extensive root layer is the boundary of the ecosystem to the hydrosphere and lithosphere. Bioelements transported beyond this layer are lost from the ecosystem and appear as output from the system.

ECONOMIC ANALYSIS OF AGROFORESTRY SYSTEM

A) Analysis at different times

1. Ex ante economic analysis
2. Ex post economic analysis

Ex ante economic analysis

The main aim of Ex ante economic analysis of a potential agroforestry system is to give the various interested parties some idea of whether a system that is technically feasible is economically viable and if so, whether it has a chance of meeting specified objectives. It may also help to prioritize the various technology options available and/ or guide scientists to formulate or propose other technologies.

Ex post economic analysis

The main aim of the ex post economic analysis of an agroforestry system that is already on the ground is to determine whether a such system should be readjusted so as to better meet the objectives. Such an analysis would also indicate the areas for adjustments.

B) Analysis from different view points

1. Private economic analysis
2. Public economic analysis

Private economic analysis

Private economic analysis is referred to as **Financial analysis**. In private economic analysis, the objectives of the individual or group are taken into account. This is reflected in the inputs and outputs to be considered as well as the values given to them. Common objectives for individuals are to obtain higher levels of income and leisure time as well as the avoidance of risk that results from widely fluctuating income and consumption.

Public economic analysis

Public economic analysis referred to as **Economic analysis** and that it takes into consideration costs and benefits outside the farm or area where the system is present.

C) Evaluation criteria (Tools used to economic analysis)

a) Benefit Cost Ratio

b) Net Present Value

c) Internal Rate of Return

a) Benefit Cost Ratio:

B:C ratio = Total discounted Benefits/Total discounted Costs

$$B:C \text{ ratio} = \left[\sum^n (B_t) / (1+r)^t \right] / \left[\sum^n (C_t) / (1+r)^t \right]$$

Where 'B' are the benefits accruing in year 't'

'C' are the costs accruing in year 't'

'r' is the selected discount rate

The BCR should be greater than one for agroforestry, then only it can be considered worthy

b) Net Present Value :

The net present value of AF system is obtained by present worth of costs from the present worth of benefits. The NPV should be positive.

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$$NPV = \sum (B_t - C_t) (1+r)^t$$

Where 'B' is the benefit in a year 't'

'C' is the costs in a year 't'

'r' is the selected discount rate

c) Internal Rate of Return:

IRR calculates the maximum rate of interest that a project can repay on loans while still recovering all investment and operating costs. The IRR determines the earning power of the money invested in a particular venture.

$$IRR = \text{Lower discount Rate} + \frac{\text{Diff. between the present worth of incremental net benefit stream at the lower discount rate and the present worth of incremental Net benefit stream of both discount rates}}{\text{Sum of the Present worth of incremental Net benefit stream of both discount rates}}$$

Types of Economic Analysis

- 1. Labour input analysis:** showing the flow of labour inputs required for the introduction and maintenance of an agroforestry technology .
- 2. Material input analysis:** showing the flow of material inputs required for the introduction and maintenance of an agroforestry system
- 3. Cash flow analysis :** showing the flow of cash expenditures and receipts results from the introduction and maintenance of an agroforestry technology. Such an analysis should include loans and repayments when applicable.

- 4. Discounted cost / benefit analysis :** determining the profitability of the agroforestry system.

Data requirements for Analysis of Agroforestry systems

1. Inputs : Quantitative Aspects

Inputs are called as **resources or production factors** or goods and services used to produce an output. The main inputs are land, labour and capital which includes buildings, equipment , livestock, seeds and fertilizers.

- a) Land** should be specified in hectares, tenure status, productive capacity and how it is used over time.
- b) Labour input** is expressed in work days or hours by type, activity , and timing during and over the years.
- c) Capital inputs** are specified in weight, volume, or numbers by type (planting material, fertilizers, agricultural chemicals , water, tools , fodder, equipments, , etc., and source (farm produced , purchased or hired) .

2. Outputs : Quantitative Aspects

Outputs are goods or services produced by the an activity . Major goods are crops and livestock products, wood fuel, timber. Service outputs are live fence , soil conservation works, nitrogen fixation , etc. The outputs need to be specified in terms of units such as volume, weight, numbers, quality and timing.

D) Valuation of Inputs

In a financial analysis, inputs are valued at their market price or at their opportunity cost to the individual concerned. In principle, market prices are applied when inputs are commonly purchased or hired by the individual. Opportunity costs are used where most of the inputs are provided by the farm family.

In a public analysis, the shadow price of the input , representing the true economic worth to society as a whole, has to be used.

a) Land:

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When a farmer wants to change the existing land use to an agroforestry land use, there is no need to value such land. If a farmer has to purchase or rent a land to introduce an agroforestry system, such purchase or rental price has to be entered into the financial analysis.

b) Labour :

In financial analysis, all labour hired is valued at its market price while all family labour is valued at its opportunity cost.

c)Capital:

In a financial analysis all purchased materials, equipments are valued at their market price.

E) Valuation of outputs

Similar to the inputs valuation, outputs are valued at the market price or opportunity cost in a private economic analysis and at shadow price in a public economic analysis.

Agricultural Products: Outputs are valued at the market price or opportunity cost in a private economic analysis and at shadow price in a public economic analysis.

Fuel Wood : In a private economic analysis, fuel wood is valued at the local market price if commonly sold *and/or* purchased by the farmers concerned. To value the standing volume of fuel wood, the price to be used should be the net of the cost of labour for collecting it and transport cost. If neither is the case, fuelwood is valued either in terms of alternative fuels used by the farmers or in terms of labour savings made. A frequently used alternative fuel source is kerosene and sometimes dried cattle dung.

Tree Fodder: Tree leaves and pods have increasingly been recognized as potential sources of animal fodder, especially in arid and semi-arid conditions. However, we have no data on the production of tree fodder and its valuation. In a private economic analysis, tree leaves may be valued at market price if they can be sold locally. However, if leaves are not sold, they can be evaluated on the basic energy or protein value.

Deriving the shadow price of tree fodder for a public economic analysis requires adjustment of market and opportunity prices, subsidies and taxes.

Leaf Litter: Leaf litter from trees and shrubs may be used to add nutrients and organic matter to the soil. So far, there are no recorded instances of leaf litter being sold commercially. The

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market price may be derived, however, on the basis of nutrient content and prices of commercially available fertilizers.

Environmental Outputs

- i) Preservation of productive capacity of a resource
- ii) Improvement of the productive capacity of a resource
- iii) Preservation /Improvement of the productive capacity of a resource

Examples of AF technologies with environmental output are tree based soil and water conservation measures , soil improvement through nitrogen fixing trees, wind protection through shelterbelts and preservation of forest areas or woodlands

In a private economic analysis of environmental benefit, only those points are considered which directly benefit the farmers but in a public economics analysis, all benefits are considered albeit they do not benefit the creator.

The valuation of environmental outputs may be handled in different ways

1. Difference in output stream of the production system affected by the environmental activity
2. Cost of preventing / reducing the damage done to the environment due to the lack of an environmental activity
3. Purchase price of the land affected by the environmental activity.

Lec.12 COMMUNITY FORESTRY- SOCIAL FORESTRY CONCEPTS-SOCIAL FORESTRY IN TAMIL NADU-TAP

Community forestry is defined as the practice of forestry on community lands with the participation of people or community

Evolution of Social forestry concepts

Widespread loss of tree vegetation in the developing world in the past few decades led to the emergence of social forestry. It was a response to meet the growing scarcity of biomass and to preserve the environment. Several countries in the developing world launched this type of programme to meet the demands of an expanding population for fuel, fodder and timber.

Social forestry was new approach to solve the problem of fuel scarcity with the participation of rural people who would plant, tend and maintain trees by themselves. The species planted would be of their choice. People's Republic of China was one of the first countries to embark on a major community reforestation programme. A massive nationwide campaign was launched during 1950s as a means of replenishing the country's stock of trees depleted by the previous decades of war and overexploitation. The Republic of Korea was another country where a nationwide tree growing was taken up. In 1962, Korea took the reforestation programme on a communal basis and as a major national priority.

By early seventies, the problem of deforestation and environmental degradation were expressed at International Conference at Stockholm during 1972 bringing in to sharp focus the changes required in policies towards environment and the crisis of tree depletion.

The World Congress (1978) added the dimension of forestry for the people and by the people. Food and Agricultural Organization also brought the programme of forestry for local community development.

Although it was recognized at most forums that local community forestry was the only solution to the problem of tree depletion but support , both financial and technical was negligible. It was only in the early eighties that several International organizations and agencies agreed to aid rapid tree development programme.

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Social forestry was first recognized as an important component of forestry development and meeting the rural need in the Interim Report of the National Commission on Agriculture on social forestry during 1972. The commission stressed on the socioeconomic importance of social forestry for rural community as well as in the management of forest resources. It was felt that by taking up the programme of raising trees , grasses and fodder in the farmers own lands, village commons, wastelands and degraded forests close to habitations, it would be possible to meet the requirements of fuel wood, fodder, small timber for rural housing and agricultural implements etc.

In our country the concept of social forestry is not new. It is found in the preachings of Buddha about 2500 years ago. Lord Buddha preached that every good Buddhist should plant one tree and look after it over five years so that it grows to a full tree and in this way he should plant about 5 trees in his life time .

The Great Emperor Ashoka is credited to have got planted shady trees and fruit trees long the roadsides for the benefit of travellers. During early period of British rule , need for industrial expansion and communication required timber from the forests. Attempts made by the British were simply to reserve and demarcate forests for their industrial needs. No significance was attached to important role of trees to the local population.

In the monumental Report on Improvement of Indian Agriculture (1893) Voelcker observed that forests had not been preserved. His observation on keeping aside village forests for the local people was probably the first observation of importance of forests to people's economy.

Afforestation in the post independence period can be divided in to three phases. In the first phase '**Van Mahotsav**' was started in fifties which failed to attract attention largely due to ignorance at all levels. In the second phase, farm forestry was started in some states in the 1970's. The third phase was the period when social forestry programme actually took off in eighties with massive programmes and ambitious targets.

Social forestry-definition

The word Social forestry was coined by Westoby and used in the Ninth Commonwealth Forestry Congress in 1968. According to Prasad (1985) "Forestry outside the conventional

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forests which primarily aims at providing continuous flow of goods and services for the benefit of people. This definition implies that the production of forest goods for the needs of the local people is Social forestry. Thus, social forestry aims at growing forests of the choice of the local population.

Shah (1985) stated that Conceptually Social forestry deals with poor people to produce goods such as fuel, fodder etc. to meet the needs of the local community particularly underprivileged section.

Objectives of Social forestry

The objectives of Social forestry adopted by the Commission (1976) were based on the economic needs of the community aimed at improving the conditions of living.

The main objectives are

- i) Fuel wood supply to the rural area and replacement of cowdung
- ii) Small timber supply
- iii) Fodder supply
- iv) Protection of agricultural fields against wind and recreational needs

Components of Social forestry

The scope or components of social forestry defined by the Commission includes **Farm forestry, Extension forestry, reforestation in degraded forests and Recreation forestry.**

1. Farm Forestry

Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land

Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations.

2. Extension Forestry

Extension forestry is the practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth .

It includes the following.

i) Mixed forestry

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Mixed forestry is the practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons

ii) Shelterbelts

Shelterbelt is defined as a belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc.

iii) Linear Strip plantations

These are the plantations of fast growing species on linear strips of land

3. Rehabilitation of Degraded forests

The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio economic needs of the communities living in and around such areas.

4. Recreation Forestry

Recreation forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as **Aesthetic forestry** which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.

Benefits of Social forestry

- i) Increase the supply of fuel wood and fodder
- ii) Generate rural employment
- iii) Maintain ecological balance
- iv) Appropriate use of wastelands
- v) Promote village and cottage industries
- vi) Induce environmental and tree consciousness among people
- vii) Relieve pressures from natural forests
- viii) Stabilize agricultural production

a) TAMIL NADU AFFORESTATION PROJECT (TAP-[FUNDED BY JAPAN BANK FOR INTERNATIONAL CO-OPERATION (JBIC)]

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[Tamil Nadu Afforestation Project\(TAP\)](#) is being implemented in Tamil Nadu of 1000 interface village benefiting about 3 lakh rural population with a assistance of 500 crores.

JOINT FOREST MANAGEMENT(JFM)

The Government of Tamil Nadu is committed to involve the local people in reforestation and protection of degraded forests and to share with them the sustainable benefits from these forests. This arrangement is known as “Joint Forest Management” and the involvement of the people is ensured through [Village Forest Councils](#). The unit of management under Joint Forest Management is a hamlet/group of hamlets/entire village, the abuttant degraded forest, community and private lands. In each of the identified Management unit, the people’s representative body called Village Forest Council (V.F.C) is formed which is fully involved in the planning and execution of works, protection, harvesting and benefit sharing in the management unit with focus on the degraded forests. The Forest Ranger concerned initiates the process of formation of Village Forest Council. The Village Forest Council meets atleast once in three months. Each Village Forest Council elects an “Executive Committee” in such a manner that one hamlet elects atleast two members, one of whom is a woman. Each Village Forest Council elects minimum of 5 (five) and maximum of 15(fifteen) members to the Executive Committee.

Benefit sharing

Sharing the sustainable benefits from the degraded forests, Government lands and Community lands lying within the management unit with the members of Village Forest Council are the most important component of Joint Forest Management. The guiding principle of this benefit sharing is equitable distribution and the Executive Committee decides the individual beneficiaries.

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District/Divisional Forest officers conduct sample survey of the unit of management and decide about the quantity of firewood available for supply to poor households. Fodder and Green leaf manure is given free of cost to members of Village Forest Council except big farmers, subject to availability. Grazing is allowed free of cost depending on the carrying capacity except in regeneration areas, where grazing will be closed for 3 years.

All Non-wood Forest produces (Minor Forest Produce) for domestic consumption is given free of cost to the members of Village Forest Council subject to availability. Executive Committee sells any surplus quantity. District/Divisional Forest Officer decides sustainable Non-wood Forest Produce (N.W.F.P.) available. The Executive Committee as decided by District/ Divisional Forest officer sells any other sustainable yield from the Management unit. The Executive Committee distributes the sale proceeds so received equally among the members of Village Forest Council after remitting 25% to Village Forest Development Fund.

A joint account in the name of Village Forest Council is opened in local or nearest bank or post office with the President and Member Secretary as signatories. All the Village Forest Council Funds are kept in this account. The President and Member-Secretary are responsible and accountable to the Village Forest Committee for all financial transactions.

Lec.13 WASTELAND DEVELOPMENT

Definition (NRSA)

Wasteland is that land which is presently lying unused or which is not being used to its optimum potential due to some constraints.

Classification

National wastelands development board classifies wastelands into two categories:

1. Cultivable wastelands
2. Uncultivable wastelands

The cultivable wastelands have been classified into

- a. Gullied and/or ravenous lands
- b. Undulating land without shrubs
- c. Surface waterlogging land and marsh
- d. Salt affected land
- e. Shifting cultivation area
- f. Degraded forestland
- g. Degraded pasture / grazing land
- h. Degraded forest plantations
- i. Strip lands
- j. Sand dunes
- k. Mining / industrial wastelands

Uncultivable wastelands which cannot be used for vegetation are classified as

- a) Brown rocky / stony / shut of rocks
- b) Steep sloppy areas
- c) Snow covered and / or glacier lands

Extent of Wastelands

NRSA estimates put wastelands at 16.21% of the total land area of the country. Of this, 16.74% is culturable and rest 4.47% is unculturable. The wastelands are found maximum in Jammu and Kashmir 60.10%.

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Total wastelands in India: 129.57mha

Category-wise wastelands of India

Category	Area (sq km)	% of total geographical area covered
Gullied and/ or ravinous land	20553.35	0.65
Land with or without scrub	194014.29	6.13
Waterlogged and marshy land	16568.45	0.52
Land affected by salinity/alkalinity-coastal/inland	20477.38	0.65
Shifting cultivation area	35142.20	1.11
Under-utilized/degraded notified forest land	140652.31	4.44
Degraded pastures/grazing land	25978.91	0.82
Degraded land under plantation crop	5828.09	0.18
Sands-Inland/coastal	50021.65	1.58
Mining/industrial wasteland	1252.13	0.04
Barren rocky/stony waste/sheet rock area	64584.77	2.04
Steep sloping area	7656.29	0.24
Snow covered and/or glacial area	55788.49	1.76
Total wasteland area	638518.31	20.17

Causes of Wasteland Formation

- a) Deforestation
- b) Over-cultivation
- c) Over grazing
- d) Unskilled irrigation
- e) Improper developmental activities such as dumping of wastes, mine wastes

Choice of Species and Planting Technique for Problem Soils

More than timber of land in our country is affected by varying degrees of salinity and alkalinity and it is further estimated that fertile lands are fast becoming problematic at the rate of 10,000 ha/year. In Tamil Nadu alone 0.04 lakhs Ha of land is affected by saline and alkaline condition.

a) Saline Soil

Saline soils have high content of soluble salt usually more than 0.2%, impossible for the plant to absorb water from saline soils. The soil pH value is generally between 7.3 and 8.5.

b) Non-Saline Alkaline Soils

They are also called as sodic soils. They have more than 15% of their iron exchange sites occupied by Na^+ ions. They do not contain any appreciable quantities of soluble salts. PA ranges from 8.5 – 10.0.

Suitable Species

Prosopis juliflora

Tamarix articulata

Prosopis spiagere

Tamarix aphylla

Acacia nilotica

Casuarina equisetifolia

Butea monosperma

Leucaena leucocephala

Azadirachta indica

Eucalyptus hybrid

Melia azadirach

Pongamia pinnata

c) Alkali Soils

These soils have sufficient exchangeable sodium to interface with the growth of crops with or without appreciable quantities of soluble salts, mostly associated with ‘kankar pan’ in sub soil.

Choice of Species

The selected species should be able to produce prolific root system and be able to resist salt content and through well under condition of arid climate with low moisture. The species should be drought resistant.

Soil working in these soils should aim at maximum retentivity and utilization of moisture in all times and reduction of salt content in the active root zone. The tolerance of a species to high percentage of absorbed Na is modified by pH of the soil the accumulation of CaCO₃.

d) Laterite and Lateritic Soils

These soils are dominated by complete minerals and are dominated by hydrous oxides of Fe and Al. The humus is absent and it is also poor in N, P, K, Ca and other nutrients.

Afforestation of these lands require soil and moisture conservation techniques besides application of fertilizers and selection of suitable species.

About 12 m ha of area in eastern, central and southern states of India are covered by laterite of lateritic soils. They occupy high ridges and plains in the high and low rainfall areas. The annual rainfall varies from 750 – 3750 mm.

Suitable Trees for Lateritic Areas

<i>Acacia auriculiformis</i>	<i>Albizia lebbbeck</i>
<i>Bambusa arundinacia</i>	<i>Holoptelia integrifolia</i>
<i>Pterocarpus marsupium</i>	<i>Dendrocalamus strictus</i>
<i>Madhuca longifolia</i>	<i>Shorea robusta</i>
<i>Dalbergia latifolia</i>	

	Sandy soils	High altitude areas
Dry areas		
<i>Acacia tortilis</i>	<i>Acacia auriculiformis</i>	<i>Acacia mearnsii</i>
<i>Eucalyptus camaldulensis</i>	<i>Anocardium occidentale</i>	<i>Ailanthus excelsa</i>
<i>Leucaena leucocephala</i>	<i>Dalbergia sissoo</i>	<i>Rohinia pseudoceae</i>
<i>Prosopis juliflora</i>	<i>Dendrocalamus strictus</i>	<i>Grevillea robusta</i>
<i>Zizyphus mauritiana</i>		
Acid soils	Marshy soils	Alkaline soils

Albizia procera	<i>Acacia auriculiformis</i>	<i>Acacia nilotica</i>
<i>Derris indica</i>	<i>Bambusa</i> spp.	<i>Acacia tortilis</i>
<i>Glyricidia sepium</i>	<i>Terminalia arjuna</i>	<i>Ailanthus excelsa</i>
<i>Gmelina arborea</i>	<i>Thespesia populnea</i>	<i>Prosopis juliflora</i>
<i>Tamarindus indica</i>		

Afforestation for Sand Dune Stabilization

The English word 'Dun' means, hilly topographical feature. The sand dunes are formed by wind. Movement of sand and deposition is most important reason for degradation of otherwise productive lands. As much as 58% of western Rajasthan is covered by moving of semi – stabilised sand dunes.

These sand dunes are distributed almost all the parts of desert, coastal sands and inland riverine areas. In India 11.996m ha lands of Rajasthan and 1.47 mha of Coastal regions are facing serious wind erosion problems.

Classification

a) Based on existence of Vegetation

1. Sand dunes of old system

These are almost stable sand dunes or partially stabilised sand dunes. Only the part of their exists and plants are active due to the biotic stress.

CHOICE OF SPECIES

a) GRASSES

Saccharum spontaneum

S. mungi

Cenchrus ciliaris

b) SHRUBS

Calotropis procera

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Dodonia viscoa

Cassia auriculata

c) TREES

Acacia arabica

Prosopis spicigera

Prosopis juliflora

Dalbergia Sisoo

Tamarind auriculata

Eucalyptus spp.

2. Sand dunes of New system

The Barehan & shrub coppice dunes all the most dominant formation in this new system. They are devoid of nutrients but they are rich in moisture.

b) General classification

1. Active dunes

This includes all dunes of edifices made up of Acolian material regardless of particle size of microrological nature.

2. Fixed dunes

The edifices are formed by the pavement composed of sand particles with grain sizes greater than those which are mobilized by trade winds are termed as joined dunes.

Afforestation of Sand dunes

The different steps included are

a) Protecting of shifting sand dunes against biotic interference.

Species found in sand dune ecosystem

Prosopis cineraria

Tecomella undulata

Acacia senegal

Zizyphus spp.,

Acacia jacquemonti

Tecomella stans

Tamarindus indica

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Suitable tree species for sand dune stabilization according to rainfall pattern

a) **Rainfall 150-300mm** : *Acacia tortilis*, *A. senegal*, *Prosopis chilensis*, *Prosopis cineraria*, *Tecomella undulata*

b) **Rainfall 300-400mm**: *Acacia tortilis*, *A. senegal*, *Prosopis chilensis*, *Prosopis cineraria*, *Tecomella undulate*, *Acacia nilotica*,
Eucalyptus camaldulensis, *Parkinsonia aculeata*,
Zizyphus sp

c) **Rainfall 400mm and above**: *Albizia lebbek*, *Ailanthus excelsa*, *Azadirachta indica*, *Acacia nilotica*

- b) Erection of micro windbreaks for treating dunes.
- c) Forestation of sand dunes by direct sowing or transplanting.
- d) Planting of grass skips or seeds of grasses, castor seeds duly treated with sodium alginate to protect.
- e) Continuous and proper management

Criteria for Choice of species

- * They should be highly drought resistant
- * Should have property of fast development of fibrous root system
- * Capable of deep vertical penetration into soil to reach lower, moisture regime of the soil
- * Should have sufficient capacity to sustain high wind velocity.
- * Net exacting in moisture of nutrients
- * Capable of multiple benefit.

Role of trees in soil and water conservation

The establishment of a vegetative cover is one of the most effective means of soil and water conservation. When the protective cover of vegetation on the soil is removed, the structurally unstable tropical soils are exposed to the beating action of rains. Losses due to

erosion immediately after land clearing are normally alarmingly large.

The potential role of trees in reducing run-off and erosion losses is well appreciated and understood. Natural forest communities provide a multilayer defence against the impact of raindrops. The different state of canopy progressively reduces the force of rain, thereby reducing the adverse effect of its impact on the soil. Further more the litter and the humus layers on the soil surface act as a cushion against erosion.

The soil conservation is particularly important in highlands with undulating topography and steep slopes, which are increasingly being brought under cultivation.

For example, in South-East Asia, there is a long tradition of planting *Leucaena leucocephala* in contour hedgerows for erosion control and soil improvement. These contour rows of leucaena survive through the long dry season because of their long taproots, which can reach water deep in the ground. Loppings and prunings from the hedgerow species also provide mulch to aid in preventing sheet erosion between trees. Removal of vegetative cover from the soil generally results in an increase in bulk density, a decrease in porosity and reduction in infiltration rates.

The use of trees and other woody perennials to protect agricultural fields from these adverse effects is a widespread practice. Trees acting as windbreaks and shelter belts also assist in regulating the ecoclimate within the tree stands. These also reduce evaporation and temperature.

The clearing of vegetation affects not only the farmlands in the immediate vicinity, but also destroys the water catchment areas causing flooding of rivers and rapid silting of dams.

Different vegetative methods for soil and water conservation

- 1. Strip planting:** In this method, erosion permitting and erosion resisting crops are alternatively raised at right angle to the slope of the land to retard the velocity of rain water
- 2. Rotational cropping :** In this method, either grain crops grasses or legumes along with trees are planted in the field . This will help to improve and maintain soil fertility.
- 3. Cover cropping:** Trees and grasses are grown to cover the earth's surface. Trees like *Acacia nilotica*, *Azadirachta indica*, *Eucalyptus tereticornis*, silk cotton, teak and casuarinas can be planted to arrest erosion along with trees. *Agave americana* can be planted for stabilization of gullies. *Acacia nilotica* and *Azadirachta indica* can be planted on the banks of rivers, percolation ponds, lakes to strengthen the bunds and to prevent erosion.

Mine burden reclamation

In mined out areas, the soil is turned over from the bottom and the lower and upper horizons are completely mixed altering the physical and chemical properties of the soil to a level of unsuitability for cultivation. Water holding capacity of such soil is poor.

Planting technique

Before undertaking plantation , it is necessary to level the area with the help of bulldozer. Pits of 60cm³ are dug and then filled with fertile soil. Addition of farmyard manure at the rate of 0.50 kg / pit has been found useful. Container raised seedlings of 9 to 12 months old are to be planted .

Suitable tree species

Acacia auriculiformis

Dalbergia sissoo

Eucalyptus camaldulensis

Grevillea robusta

Albizia lebbek

Cassia siamea

Afforestation in Coastal and Hilly areas

Afforestation in coastal areas

Coastal land occupy an area of about 8.4mha in India in the form of a narrow strip along the eastern and western coasts of the country. The soil is generally alkaline in reaction and the salt content is high . The soil is poor in nutrients and low water holding capacity . The water table is high .The texture of the soil is mostly sandy. Sea water causes a high concentration of sodium salts.Lime deposition is also common at many places.

The urgency of afforestation of coastal areas has been felt due to the continuous occurrence of cyclones. The role of the forest as a moderator of the effect of a cyclone is well

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known. It has been suggested that 1 to 2 kilometre wide forest belt is necessary for moderating the effects of cyclones all along the coastal areas of the country.

In areas with high salinity, it is necessary to leach the salts and plant the trees on ridges. Plantations of *Casuarina equisetifolia* have been raised successfully on a large scale in coastal areas. Where the water table is high, plantations are done on raised mounds and where it is low, in pits. In the first 2 years, irrigation is necessary to save the plants from physiological drought.

Cocos nucifera and *Borassus flabellifer* have been successfully planted in certain areas of Orissa. Other species which have been successful are *Pongamia pinnata*, *Avicennia officinalis*, *Acacia auriculiformis*, *Eucalyptus tereticornis*, *Salvadora persica*, *Salvadora oeroides*, *Simarouba glauca*, *Prosopis sp.*

Afforestation in Hilly areas

The hills have been denuded by unrestricted fellings associated with excessive grazing and frequent fires. In some areas, due to the growth of grasses, the erosion has been less damaging. But in most cases the surface soil has been eroded. In many areas, even subsoil has disappeared, leaving no soil material. The soil is generally poor in moisture and nutrients.

When soil is present in the area, contour trenching may be done as it helps in soil and water conservation. When the slopes are steeper, digging of trenches may not be possible and in such cases, preparation of pits for planting may be adopted.

Suitable tree species for hills in temperate region: *Pinus roxburghii*, *Pinus wallichiana*, *Cedrus deodara*, *Acacia dealbata*, *Ailanthus altissima*, *Cupressus torulosa*, *Morus sp.*, *Juglans regia*, *Robinia pseudoacacia*, *Populus spp.*

Suitable tree species for hills in subtropical region: *Eucalyptus globulus*, *Eucalyptus grandis*, *Eucalyptus tereticornis*, *Acacia mearnsii*, *Acacia decurrens*, *Acacia dealbata*, *Acacia melanoxylon*, *Pinus roxburghii*.

Lec.14 Silvicultural practices for Teak, Eucalyptus and Tamarind

1. Teak

Scientif Name	: <i>Tectona grandis</i>
English Name	: Thekku
Tamil Name	: Teak
Hindi Name	: Sagwan
Family	: Verbenaceae

Distribution

Native to Southeast Asia (India, Myanmar, Thailand and Western Laos), Teak, is the most important of the three species in the genus (*T. hamiltoniana*, *T.phillipensis*). A Tare combination of durability, dimensional stability and strength properties make Teak a paragon of timber and as of date faces no threat of being eclipsed by any other timber species. Its latitudinal limits are 9° N - 25° N and its longitudinal limits 70° E - 100° E. In its natural habitat, teak occurs in mixed deciduous forests normally constituting a small number of individuals but occasionally in pure stands. Since 1840 it is raised in plantations in India and Myanmar.

Physiognomy

A large, deciduous tree, it may reach a height of 30 to 40 m under favorable conditions. On good sites, clean boles of 15 to 30 m length are obtained. Fluting and buttresses are often found at the base of the trees. Bark is thick, grey or lightish brown, fibrous with shallow longitudinal fissures, peeling off in long thin narrow flakes on older trees. Leaves are large (25 - 50cm in length and 15-35 cm in width), elliptic or obovate; upper side green to dark green in colour; underside dense has whitish to tawny matt of wooly hairs. Leaf arrangement is opposite. The flowers are small, whitish and appear in large panicles containing upto a few thousand flower buds which open only a few at a time during the flowering period of 2 to 4 weeks. The fruit is a hard, irregularly rounded drupe containing 4 seed chambers. The pericarp consists of a thin papery exocarp, a thick felty, brown mesocarp and a stony endocarp. Only rarely do all the four seed chambers contain developed seed. Generally in a sample one seeded fruits abound (42-64%); 2 seeded account for 12-25%; 3 seeded vary from 2 to 6%. 4 seeded account for 1-2%.

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Large numbers (11-35%) are also found to be completely seedless. The teak fruit varies from 11 to 18 mm in cross section and average 2000 in a kg.' Phenology Age of trees at first flowering varies markedly depending on site, climate, silvicultural management and genetic linkage. Its natural habitat it comes to flowering in 6-8 year. But under plantation conditions size or height of the trees rather than age exercises a profound influences on flower initiation. Flowering generally occurs during June - July. The fruits attain full size and mature in about four months after fertilization (i.e.during October- November). A sign of maturity is their facile fall to the ground when the tree is agitated.

Silvicultural Characters

Teak seedlings are sensitive to frost and drought. It is a strong light-demander, intolerant of suppression and weeds. It is a fire resistant; seedlings and saplings killed back by fire and frost. It coppices and pollards vigorously, up to about middle age.

Climate and Soil

The tree grows under a wide ambit of pedo climatic situations from sea level up to an altitude of 1200m and in a precipitation range of less than 900 mm to more than 2500 mm. The most suitable soil for teak is the deep, well drained alluvium having relatively high contents of calcium and phosphorus. It tolerates a pH range of 6.5 to 8.0 but good growth is attained on soils of pH 6.5 and an annual rainfall or 1500 mm. Teak is a pronounced light demander and does not tolerate suppression at any period of its growth. It is also fairly fire tolerant.

Nursery Technique

The unit of sowing is the fruit (drupe) which for practical reasons is termed seed; seeds that have been stored for at least one year germinate better than fresh seed. If use of seeds of the same year is necessitated they before sowing are subjected to a process of alternate wetting and drying of 24 hr duration each for 14 days. Use of large seeds more than 14mm in diameter gives better germination. Seeds are sown @ 1 kg m⁻² on raised nursery beds 10m long, 1 m wide and 0.5m in height and covered with soil to a depth equivalent to the fruit diameter.

To prevent soil erosion beds are reinforced on the sides with bamboo splits or other such material. Germination commences in about 15 days, accelerates during the next 15 days, declines thereafter. Majority of germinates will have appeared in 40 days, when the germinability is around 40 per cent. The beds are watered twice daily for the first two months, once daily for the next three months and on alternate days thereafter. Super sized seedlings called "wolf" smother

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others. For field planting only stumps prepared from one year old seedlings are used as these promote faster growth and ideal bole form. Stumps are prepared by cutting away from the seedling everything except 2.5 cm of the shoot and 22.5 cm of the root. The stem portion receives an oblique cut and the root portion an horizontal cut. All laterals from the tap root are pruned away. The stumps should preferably be planted within 2 to 3 days.

Planting

Stumps are flush planted (in level with the ground) at a spacing of 2 x 2 m in crow bar pits. The initial plant density of 25000 ha-t is reduced in a phased manner to an ultimate 80 to 100 ha-t by an operation called thinning. A total of four thinning is given in the 5th, 10th, 18th and 28th years and at each thinning the existing population is reduced by half. The first two thinning are mechanical and are done according to a rule of thumb, in the first thinning alternate diagonal rows are removed; in the second thinning alternate rows are felled. The 3rd and 4th are silvicultural thinning in that they are restricted only to diseased and malformed trees. Trees possessing clean bole, cylindrical bole, straight bole, less taper, small crown and less fluting are retained. Final felling is done at the end of 60 years. A single tree will yield 1.5 m³ of timber. Its rotation is 40-60 years; its yield is about 6500 cu.ft of stem wood per acre.

Utilization

Teak wood is globally renowned for its strength, durability, dimensional stability, working quality and non-corrosive property when in contact with metal. The durability is attributable to the deposition of polyphenols in its heartwood. On account of these outstanding properties, Teak is sometimes hailed as the Queen of timbers. Increasingly large quantities of Teak are used by the plywood industry for high grade commercial and tea-chest categories of plywood. Lops and tops and other rejects serve as fuel wood. The seeds contain oil to the extent of 44.5% and the oil is used in soap manufacture. Teak leaves are often used as platters.

2. Eucalyptus

Scientific Name	: <i>Eucalyptus tereticornis</i>
English Name	: Eucalyptus hybrid
Tamil Name	: Thailam
Family	: Myrtaceae

Distribution

Native to Australia, *E. tereticornis* was first introduced in the Nandi hills (Karnataka) by Tiuppu Sultan between 1782 - 1790. Now it is grown over one lakh ha in Peninsular India. Extensive plantations have been raised to meet the needs of fuel wood, small timber and pulpwood in Punjab and Haryana, where area under forest is negligible. It has been planted in strips, 3-6 rows deep along highways, canals and railways. Large scale plantations of the species were taken up in Uttar Pradesh from 1962 onwards.

Physiognomy

It is a tall tree with stout trunk, attains a height of 50 m. It is an evergreen, glabrous tree usually secreting an aromatic gum. The leaves and flowers contain conspicuous oil glands. Leaves of the saplings are generally opposite, sessile, cordate and held horizontal; those of the adult tree as a rule are alternate, petiolate and held vertical. Flowers are borne in umbels usually pedunculate. Calyx tube encloses the ovary which is covered with a deciduous operculum. The operculum is much longer than calyx and is formed by the union of the petals and falls off entire when the stamens emerge. Flowers are white in colour. Fruit consisting of the enlarged calyx-tube is usually hard and woody, full of resin sacs. Seeds are numerous but a large proportion of these is abortive and sterile seeds outnumber fertile ones. Bark is grey, exfoliating in long flakes.

Phenology

It flowers almost throughout the year. The capsules are collected six months after anthesis when they just turn dark brown. If the capsule is left for long on the tree it will burst and shatter the seeds. Hence capsules are collected and kept in trays / tarpaulins. After sun-drying for 3 or 4 days, the empty capsules are removed. Mature seeds are dark brown / black in colour. The seeds retain viability for up to 5 years.

Silvicultural Characters

It is a light demander. It produce good coppices freely and vigorously. It is a fast growing species and adaptability to a wide range of soil and climatic condition

Climate and Soil

It grows up to an altitude of 500 m. It is sensitive to frost. It grows in alluvial, black cotton, gravelly, lateritic, skeletal rocky and murram soils and even on shifting sand dunes. Highly calcareous, very saline and alkaline soils, clay and kantar pan is limiting. Deep, fertile and well-drained loamy soil gives best growth. Temperature range tolerated is 0-48°C. It is

suited for the plains receiving a rainfall of 800-1000 mm. The tree prefers sandy loam to loamy soils within a pH range of 6.00 - 7.5.

Nursery Techniques

Seeds are sown in raised beds measuring 1 x 1 x 0.15 m. after wetting the bed, sieved seeds @ 5 g m⁻² are mixed with a small quantity of sand and evenly spread on the bed. The seeds are covered with a film of soil. The nursery beds need to be kept moist by watering at least twice daily. A mulch of hay prevents soil erosion during watering. Watering is done through a fine rose. BHC 10% has to be applied on the bed to prevent ants/termites. Five and 10 days after sowing 2% copper fungicide must be applied. Germination starts on the 5th day. Since seedlings are sensitive to extreme sunlight, the bed has to be protected by a shade-screen during the first fortnight. Thirty day old seedlings are gently lifted from the bed and containerized in 200 gauge polypots measuring 20 x 10 cm. The polypots are filled with 4: 1:1 mixture of red soil, sand and FYM. After wetting the filled polybags seedling are pricked one per polypot. The pricked out seedlings should be provided shade for a week and watered twice a day. Six month old seedlings are used for planting. The containers must be shifted once every fortnight from the second month to prevent rooting.

Planting

The seedlings are field planted at a spacing of 2 x 2 m in pits measuring 30 cm³. Quality of seedlings is determined by the thickness of the root collar region than by height. The trees are felled at the end of seven years. Thereafter two coppices are taken at intervals of five year each. Coppice management is important in eucalyptus. Hundreds of new shoots develop on the margin of the cut stem. Felling of the trees prior to or immediately after the monsoon helps in rapid callus formation and thicker coppice shoots. Care should be taken to fell the trees with a gentle slope at the cut so that rainwater does not collect as a pool and cause decay of the callus tissue. Though hundreds of coppice shoots develop yet only four to five stems ultimately remain on the stump and the others are edged out in natural competition. There is no need to manually regulate the number of coppices as nature itself does the job. The health and number of coppice stems are positively related to the diameter of the stump. The productivity of coppice plantation is generally higher by 20 -25 % than the first seedling plantation. At the end of the second coppice growth it is necessary to uproot the roots. Its rotation is about 8 - 10 years. The productivity of

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rainfed plantations in Tamil Nadu Plains ranges from 50 -75 t per ha at the end of seven years. The ratio of first, second and third harvests is 1:1.2:0.8.

Utilization

Eucalyptus wood is the main stay of paper industry in Tamil Nadu. Currently, it is used for making packing cases and 70% of the requirement in Himachal Pradesh for apple transport is met by this species. Leaves contain oil. Bark yields oxalic acid. It is preferred by the farmers by virtue of several desiderata like (i) fast growth; (ii) not browsed by cattle; (iii) immunity to pests and diseases; (iv) good coppicing ability.

3. Tamarind

Scientific Name : *Tamarindus indica*

Tamil Name : Puli

Hindi name : Imli

Family : Caesalpinae

Distribution

Tamarind is native to dry savanna of tropical Africa. In ancient times it was introduced to Asia by Arab traders. In Tamil Nadu, it is being extensively cultivated in Dharmapuri, morappur, Krishnagiri, Anjatti and Hosur areas.

Physiognomy

Tamarind is a medium large-sized evergreen tree, up to 24 m in height and 7 m in girth. The bark is brownish or dark grey and fissured longitudinally and horizontally. Leaves are paripinnate and 15 cm long. Leaflets vary from 10-20 pairs; oblong and measure 8.30 x 5.10 mm. Flowers are borne in small terminal, drooping racemes on current season's growth.

Pods are 7.5 - 20 cm long, 2.5 cm broad and 1 cm thick, more or less constricted between the seeds, slightly curved, brownish - ash in colour. A tree in Urigam. Village (Dharmapuri) possesses long pods measuring 30-45 cm. There are 3 to 12 seeds in each pod which are obovate, oblong, compressed with a shallow, oblong pit on each side of the flat face, 1.5 x 0.8 cm, smooth dark brown and shining. Seeds are contained in loculi, enveloped by a tough, leathery membrane, the so-called endocarp. Outside the endocarp is the light brownish,

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red sweetish, acidic, edible pulp, traversed by a number of branched, ligneous 'strands. The pod shell is fragile and easily separable.

Phenology

Tamarind flowers from April - July in most areas of South India. Peak flowering occurs during May - June. New leaves appear in May and are closely followed by the flowers and occasionally fresh leaves and flowers are seen in September in Calcutta region. Fruits mature during winter season in South India. Time and duration of anthesis varies with prevailing weather conditions in different locations. Anthesis occurs as early as 5.30 am and continues up to 8.30 am with peak anthesis at 6.30 am.

Silvicultural Characters

It is a light demander; very sensitive to frost; drought resistant. It is deep rooted and wind-firm; slow-growing. It coppices fairly well; produces root suckers freely.

Climate and Soil

It is a tree of tropical climate, tolerating temperatures up to $47^{\circ}C$ but is very sensitive to frost and fire. Prefers mean annual rainfall of 500 to 1500 mm and tolerates water logging. But also grows well with only 350 mm annual rainfall if watered for establishment. It can be grown under a variety of soils ranging from gravelly to deep alluvial. It thrives best on deep alluvial soil with adequate supply of moisture.

Nursery Technique

Pods are collected during February - April. The fruits are dried in sun; the outer shell is removed by hand or by beating with a mallet; the seed is separated from the pulp by hand kneading and washed in water. Washed seeds are dried under shade and stored. Seeds from crown collection are superior to those of ground collection. About 1800-2000 seeds weigh one kg.

Seeds are normally sown directly in sand medium or polybags. Germination takes place in 5-10 days and is completed in 30 days. Young plants grow fast on porous soil and a soil mixture of 1: 1: 1 red soil, sand, farmyard manure.

A low cost technology of soaking for 24 hr in a solution prepared by dissolving handful of cow dung or cow's urine (1: 1 in 10: 1 water) results in vigorous seedling to the extent of 75-80 per cent. One year old seedlings are field planted at a spacing of 10 x 10 m. A full grown tree yields 180-225 kgs of fruit and 80 kg of seeds per tree.

Planting

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One year old seedlings are planted at a spacing of 7m X 7m in pits. Seedlings are fit for planting out in July to August. .

Utilization

All plant parts find some use, but the most useful is the fruit which contains sweetish acidic pulp. The Tamarind of commerce which is widely used for souring curries, sauces, chutneys and certain beverages. The pulp is also employed in medicine. Leaves boiled along with gingelly oil is applied to relieve swelling caused by sprains / fractures and also to relieve pain. Pulp mixed with sugar and made into Tamarind balls is used for seasoning other food. Refreshing acid drink and syrup are also made. Leaves serve as good fodder. Tender leaves, flowers and young seedlings are used as vegetable. Seeds are eaten after roasting or boiling. Powdered seeds are used as cattle feed. Processed seed powder is used in confectionery. Kernels contain a polysaccharide having very good sizing properties and extensively employed as a source of sizing powder in cotton and jute industries. The tree yields valuable timber, hard and difficult to work. The tree is extensively used for avenue planting.

Lec.15. Silvicultural practices for Ailanthus,Neem, Pungam and Prosopis

1. Ailanthus

Scientific Name	: <i>Ailanthus excelsa</i>
English name	: Tree of Heaven
Tamil name	: Pimaram, Pinari, and Perumaram
Hindi name	: Arna, Ardu, Maharukh, Arusa
Family	: Simarubiaceae

Distribution

Ailanthus excelsa is considered a native of the Indian peninsula, but occurs throughout the tropical and subtropical regions of India, especially in the dry districts of Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, Orissa and the Deccan plateau. It is not found in the high rainfall regions of the West Coast.

Physiognomy

It is a large deciduous tree, attains a height of 18-24 m. Bark is light grey and smooth in young trees, with large conspicuous leaf scars, rough, granular and greyish brown in older ones. Leaves are pinnately compound, up to 1m long, with 8-14 pairs of leaflets and an unpleasant smell when crushed. In seedlings and saplings imparipinnate leaves are the rule for the first three or four years, after which the terminal leaflet becomes reduced in size or is represented by a mere prolongation of the rachis and finally the typical abruptly paripinnate leaves are formed about the fourth or fifth season. The fruit is a red one-seeded samara 5-7.5 cm long and 1.2-1.5 cm wide, prominently veined, acute at both ends and twisted at the base; about 9 to 10 fruits weigh one g. The fruit being winged is adapted for dissemination by wind.

Phenology

The panicles of small yellowish flowers appear in February - March and the fruits ripen in May - June. Old leaves fall during February and new ones appear in March - April. In Central India, flowers appear during February and March and in the North during April.

Silvicultural Characters

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It is a strong light demander and is susceptible to frost and prolonged drought, though poles and trees are resistant. It coppices well and produces root suckers freely. It is very susceptible to water-logging and wind break.

Climate and Soil

It grows well in semi-arid and semi moist regions, both in the plains and the hills. In Rajasthan, it grows in areas with an average annual rainfall of 400 mm. It avoids moist areas with high monsoon rainfall. The average mean temperature is about 10 ° C and maximum about 30oe. Average annual temperature is above 27°e. Though it can grow on a wide variety of soils, it thrives best on porous sandy loams. It avoids clay with poor drainage and waterlogged areas. It can be grown on shallow dry soils but growth is poor.

Nursery Techniques

For maximum viability and vigour, fruits are collected when the colour of the pericarp changes from yellowish brown to brown. The samaras are dried in the sun. These lose their viability in about four months. Nicked samaras are kept in wet gunnies for 48 hour. At the end of storage sprouted samaras are separated and sown in polybags. By this method, the number of empty containers is considerably minimized. Samaras number about 9600 in a kg. Germination takes about 5-12 days and is completed in about 30 days. The radical and plumule emerge through the winged covering, the cotyledons being carried up and the testa usually left inside the fruit. The hypocotyl arches somewhat at first, soon straightening. The cotyledons usually persist for about 2-3 months after which they turn yellow and fall.

Planting

Nine month old seedlings are planted at a spacing of 5 x 5m. Seedling growth is fairly fast attaining a height of 0.2, 0.6, 2.4 and 4.2 m at the end of first, second, third and fourth growing seasons respectively.

Utilization

A ten year old tree approximately yields 50-75 tonnes of match wood. The wood is soft, white, very light but fairly strong and easy to saw. It is used for match splints, packing cases, fishing catamarans and floats. It is also used for commercial plywood. The wood is perishable in the open but not under water. It is grown as shade and avenue tree in hotter parts of India. It yields an inferior type of gum. Its bark and gum are of medicinal value. Leaves are highly palatable and nutritious fodder for sheep and goats; and extensively used in Rajasthan. The green

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fodder yield is 500-700 kg twice a year. The chemical composition of the leaves shows that the leaves are rich in crude protein, ether extract and calcium but poor in phosphorus when dry or when chaffed with twigs. The crude fibre content is also low. Green leaves are considered highly palatable and animals relish them more than dry leaves even when the latter are treated with molasses. Digestibility coefficients are fairly high for all nutrients except ether extract whose digestion from leaves in the ruminants is low.

2. Neem

Scientific Name : *Azadirachta indica*

English name : Neem, Nim, Indian Lilac, Chinaberry

Tamil name : Vembu, Vempu, Veppamaram, Veppan

Hindi name : Bal-nimb, Neem, Neim, Nimb, Nind

Family : Meliaceae

Distribution

The tree is believed to be a native of upper Myanmar. Its occurrence in the Siwalik forest of Uttar Pradesh is also considered natural. In India, neem occurs in tropical dry deciduous and thin forests in drier parts upto 1500 m. It is found in almost all states of India.

Physiognomy

A large evergreen tree, it attains a height of 12 to 15 m and occasionally upto 25 m with a clear bole of 3-7.5 m, 1.8-2.8 m girth. It branches early and forms a broad rounded crown of bright green foliage. Bark is moderately thick with scattered, small tubercles between numerous longitudinal and oblique wrinkled furrows, dark grey outside and reddish inside. Leaves are imparipinnate, 20-38 cm long, crowded near the end of branches, leaflets 9-13 nearly opposite, 2.5-7.5 x 1.2-4.0 cm oblique, lanceolate, some times falcate, acuminate, deeply and sharply serrate, glabrous on both surfaces, petioles very short. Inflorescence, an axillary, many flowered panicle, shorter than the leaves. Flowers are white, fragrant. Smelling of honey, shortly pedicelled, bisexual and male flowers occur on the same tree (polygamous). Fruit is a drupe, 12-18 mm long, ovoid-oblong, yellowish/green smooth, dark yellow or purple when ripe, endocarp

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thin cartilaginous, intercellular spaces appear between the epicarp and the endocarp; their walls break down and form the mucilaginous pulpy mesocarp. Seeds 1-2, reticulate.

Phenology

Neem is almost evergreen but becomes near leafless in dry localities for a short period during February-March. New leaves appear in March-April, before the old ones are shed. Flowering occurs from January-March; in the southern parts of India. In Kerala flowering starts in January, in Karnataka, Tamil Nadu and Andhra Pradesh during February-March; in Central India during the first week of April. Thus flowering is progressively delayed from South to North in the sub-Himalayan area, flowering occurs during the first week of May. Fruiting also follows the pattern of flowering; fruits ripens from June to August. The tree starts fruiting at the age of five years but economic yield of fruits is obtained at the age of 10-12 years. About 3300-4500 seeds weigh one kg and on an average, a medium sized tree produces 37-55 kg fruits.

Silvicultural Characters

It is light-demander. It is sensitive to frost and fire. It is drought-hardy;

Climate and Soil

The species grows on almost all kinds of soils including sandy, clayey, saline, alkaline, black and cotton soils and laterite crusts. However, it does not grow on salty flats, inundated areas and soils with finely divided mica. The tree has a very wide range of climatic adaptability and grows well in areas with a mean annual temperature ranging between 0°C to 45°C. It is a light demander species but survives under shade. The rainfall in the areas of its occurrence varies from 450 to 1150 mm.

Nursery Techniques

Physiologically mature seeds with maximum germination capacity and longevity are obtained 10-12 weeks after flowering. The fruit attains peak-green weight and the embryo is fully developed. Green fruits are collected by beating the branches and heaped in the shade by mixing ash, till the seed becomes easily extractable. Seeds are dried in shade for 3-4 days and then sown or stored. Neem seeds do not require any special pre-treatment but seeds do not retain viability very long and have to be sown within 2 or 3 weeks after collection. De-pulping and cleaning of seed improve the germination per cent and seeds passed through digestive system of birds show better germination. Seeds are sown in the nursery beds 15-cm apart in rows, 25 cm apart at a depth of 2.5 cm germination normally takes one or two weeks and it may vary from 9

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to 55 days. The beds should be sparingly watered and soil kept loose to prevent cutting, excessive water should be avoided.

Seedlings are pricked out to transplanting beds at 15 x 15 cm spacing or to polypots when they are about 5 cm high; neem seedlings do not require shade except during pricking out stage. In frosty localities, the plants should be provided with shelters. Seeds can also be sown in polypots directly.

Planting

Polypot seedlings or root-shoot cuttings are more successful for agroforestry, silvi-pastoral and roadside avenue plantations. One year old seedlings are preferably planted at a spacing of 5 x 5 m.

Utilization

For centuries the neem tree, has provided man with twigs for tooth brushes, pharmaceuticals for aches and pains and pest control agents against insects. The drought tolerant neem helps to reduce soil erosion and produces soap, lamp oil, lubricant and lumber. It is also a good shade tree. Every part of neem has its own importance.

Neem wood is moderately heavy, stable and resembles mahagoni in appearance; is resistant to fungi and most borers. It is used for making furniture cart axles; yokes, naves and felloes, boards and panels, cabinets, packing cases, ornamental cuttings, ship and boat building, helms, oars, oil-mills, cigar boxes carved images, toys, drums and agricultural implements. The leaves are palatable to cattle and buffaloes and constitute a traditional feed in several parts of the country. In Andhra Pradesh, these are regularly fed to cattle and goats to increase secretion of milk immediately after parturition. They are carminative and aid digestion; leaves also used as mulch and manure. Tender leaves in combination with *Piper nigrum* are found to be effective in intestinal helminthiasis. Neem oil and its derivatives are mainly used in soap making and in preparation of toothpaste. Used in pharmaceutical industry. Oil is a remedy in some chronic skin diseases and ulcers and is externally applied for rheumatism, leprosy and sprain. Warm-oil relieves ear trouble, cures dental and gum troubles and provides relief in asthma when taken with betel leaf. Oil is reported to have anti-fertility properties and it possesses antiseptic and anti-fungal activity.

3. Pungam

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Scientific Name : *Pongamia pinnata*

Tamil Name : Ponga, Pungam

Hindi Name : Karanj, Paper, Kanji

Family : Leguminosae

Distribution

Pongamia pinnata grows throughout the greater part of the country chiefly along streams and rivers and in beach and tidal forests. It is considered to be a native of the Western ghats, ascending up to an elevation of about 1200m. It is a characteristic tree mixed forests in the Andamans. As a scattered tree it grows in to Sub-Himalayan tract also, ascending in the other hills up to an elevation of about 600m. It has been widely planted in differed parts of the country.

Physiognomy

Full grown *Pongamia pinnata* is a moderate sized tree with a short bole and spreading thick crown. Branches are stout. Leaves are imparipinnate, glabrous and light green leaflets are opposite, without stipules 5-12 cm long and shortly acuminate. The stem bark is thin, smooth, grey and yellowish inside. Pods are indehiscent, turgid almost woody pointed at both ends, 4-5 cm long, and 1-2 seeded. Seed is compressed, wrinkled, reddish brown and oily.

Phenology

Pongamia pinnata is almost an evergreen tree exception in dry localities where it becomes leafless for a short period during May, the leaf shedding occurs several times in a year. Flowering takes place during April to June. Pods ripen from March to May of the following year. Pods are generally collected during December to May and the time of collection in different parts of the country differs according to the climate.

Silvicultural Characters

It is a drought resistant; can withstand frost. It is shade tolerant but does well with full over head light. It is an excellent coppicer; puts forth root suckers readily. It is frequently pollard in South India for green manure

Climate and Soil

Its wide distribution in the country shows that *P.pinnata* can adapt itself to a spectrum of climatic conditions. In areas where it has been successfully grown, the absolute maximum shade

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temperature varies from about 27 to 38°C rainfall from about 500-2500 mm. It can grow on a wide variety of soils, ranging from sandy to black cotton soils, but it grows best on deep and well drained alluvial soils with abundant supply of soil moisture.

Nursery Techniques

Pod collection is done by beating the branches or from ground. The pods are dried in the sun and thrashed to extract the seed, which is dried in shade before storage. Seed yield per tree varies from 9 to 90 kg. Soaking of seeds in cold water for 24 hr hastens and improves germination. About 1200 seeds weigh one kg. Seed length varies from 1.3 cm to 2.30 cm. and seed breadth from 0.90 cm to 1.3 cm seed length - breadth - ratio varies from 1.0 cm to 107 cm. About 250 g of seed is needed to sow one m of nursery area. Seeds are sown in drills 15 cm apart and at a depth of about 2 cm.

Germination starts in about 10 days and takes about a month, to complete. The percentage of fertility is high and a germination percentage of about 60 to 80 can be expected. One kg seed will produce about 1000 plants. *Pongamia pinnata* can be raised by direct sowing or by planting out of entire plants or stumps. Branch cuttings can also be used for raising this species.

Planting

One year old seedlings which attain a height of about 50-60 cm are planted out. Entire plants or stumps may be used for planting; the use of the latter is more convenient for large scale plantation. For making stumps, plants of about 1-2 cm collar diameter are preferred. Spacing adopted is either 2 x 2m or 3 x 3 m. For avenue planting a spacing of about 8m is adopted. Pits of 30 cm³ are dug for planting.

Utilization

Leaves of the trees are lopped for fodder, even though their digestibility is poor. Green pods are also fed to cattle in Maharashtra. The seed cake after extraction is used in poultry ration.

4. Prosopis

Scientific name : *Prosopis juliflora*

English Name : Mesquite, Mesquite bean

Tamil Name : Velikaruvel, Seamaikaruvel, Delhimul

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Hindi Name : Vilayati babool, Vilati khejra
Family : Mimosae

Distribution

Mesquite tree is native to Central America and South America. The tree has been planted in many arid zones of the world. It is widely propagated in Africa and Asia, particularly in India. *P.juliflora* was first introduced into India from Mexico in 1877 from seeds obtained through Kew Botanical Gardens, England. It occurs throughout the districts of Tirunelveli, Ramanthapuram, Virudhunagar in Tamil Nadu. Sparse occurrence of *P. juliflora* is restricted to stream courses and road margins in Pudukottai and Thanjavur districts. *Prosopis juliflora* has proved to be a great social asset at no cost to the Government. It has brought back vast stretches of land into use and labour into productive employment in Tamil Nadu (6.34 million man - days and 7.03 million women days per annum).

Physiognomy

Five forms of *Prosopis juliflora* are recognized in India viz., Mexican, Australian, Argentinean, Peruvian and the Arid; the first two named are more common. These forms are however not readily distinguishable. Leaves are alternate on the branchlets of current year and fascicled on those of the previous year; 3 to 13 cm long with petioles enlarged and often glandular at the base; rachis 2 to 13 cm, long slender terete or slightly winged, prolonged beyond the last pinnate as a soft bristle leaflets 8-48 pairs, 5 to 50 mm in length and 4 to 5mm in breadth, linear or oblong reticulately veined. Stipules linear deciduous. Branches are long, zig-zag struggling or pendulous, sometimes armed with scattered stout, subulate thorns, 1 to 5 cm long and often marked with minute dark lenticels and irregularly shaped red blotches. Bark is thick, dark, reddish brown, divided by shallow fissures. Flowers are creamy white, in axillary pedunculate spikes, flowers are creamy white in axillary pedunculate spike, 4 to 10 cm long, solitary or in fascicles of 2-4; peduncles 5 to 18mm long. Pods are 12 to 25 cm by 0.7 to 1.0 cm, linear, compressed when young subterete at maturity, straight or falcate, contracted at the two ends usually with a long stout, base; pale yellow or straw coloured when ripe; mesocarp pulpy; endocarp cartilaginous, surrounding each seed separately. Seeds number 12 - 34 in a pod, oblong, flattened, with thin light brown lustrous testa and thin thorny albumen.

Phenology

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The Australian variety of *Prosopis juliflora* flowers and fruits in India twice a year. First flowering commences September- October and may continue upto end of February. The second flowering which is profuse occurs during February - March. Pods ripen in November - January and again during April -June. The interval between flowering and fruiting is nearly 1 to 1Y2 months. Trees begin to bear fruit in the third year and sufficient quantity of seed is available from the fifth year. Almost every year is a good seed year.

Silvicultural Characters

It is a strong light-demander, hardy, drought-resistant, fast growing. It is a frost -tender. It coppices well and root-suckers freely.

Climate and Soil

It is the only exotic species capable of growing on a wide variety of soils including heavy clays, black soil, red loam, coastal sandy soil, alluvial soils, saline and neutral soils, inland as well as loamy soils. It comes up in low as well as high rainfall areas, in hills and plains alike. A hot, dry climate with mild winter clear atmosphere suits the species best. In areas where it has been naturalized, the absolute maximum shade temperature varies from 40.6° C to 45.6°C It comes under a rainfall regime of 150 to 750 m; it can be grown even in areas of still lower rainfall of 70 mm per year. It does not tolerate heavy rainfall.

Nursery Technique

Ripe pods are collected from trees by lopping branches or from the ground, and sun - dried. The fruits turn yellow when mature and fall to the ground. When dry, the pods can be broken into segments by beating with a mallet. Pounding also breaks the pods into bits, each bit containing a seed. The one seeded segments can be separated by winnowing to remove the impurities. It is very difficult to extract the seed from the dry broken bits as the endocarp is hard and does not yield to mechanical pressure. Protracted soaking in water, drying and beating can separate the seeds which then be stored for about two years. As the germinative capacity of the seed is diminished due to attack by some insects the pods are better fumigated with carbon disulphide or hydro cyanic acid before storage. The seed treated with naphthalene powder at the rate of 1g l⁻¹ and stored in sealed tins may retain 60% viability at the end of 5 years. Seeds stored in gunny bags retain only 36% viability after 3 years. Naphthalene is harmless to man and treatment with this chemical is safer. Storage in bins with 5 cm layer of sand on top is stated to prevent entry of beetles. The number of seeds per pod varies from 4 to 32. Seed number varies from

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32,000 to 35,000 in a kg. The germinative capacity of clean treated fresh seed is 80-90%. The seed is very hard with an impermeable seed coat and requires pretreatment to hasten germination. The seed requires dt1eof the following sowing treatments (i) soaking the seed in cold water for 48 hr. (ii) soaking the seed in commercial H₂SO₄for about 20 min; iii) covering the seed with boiling water, allowing it to cool and soak for 24 hr. After pretreatment the seed should be sown in polythene containers of 13 x 25 cm size filled with a mixture of FYM and soil in the proportion of 1:3.

Planting

When the seedlings attain a height of 20-30 cm, they are ready for planting.As the tree has a tendency to become branchy, pruning is of importance when it is grown in avenues and all shoots except one may be cut down. Leading shootsoccasionally require mechanical support for the first one or two year. In 3-4years, the leading shoot makes headway and takes the pleasant appearance initially of a well grown shrub and eventually of a tree. The trees are cut once in three years. The first felling promotes good coppice growth. The second felling is at the end of sixth year. If the growth is very good and if immediate cash is desired the interval may be reduced to two years. The rootstock is generally uprooted at the third felling. At every cutting an approximate yield of 10-15 t ha-I can be expected. Its rotation is 20 years; it attains 28 cm in diameter at the age of 20 years.

Utilization

It is a versatile multipurpose plant; used as fuel, fodder, and several utility timber and therefore described as "Loyal Timber of the poor" *Prosopis juliflora* wood is moderately hard and moderately heavy (specific gravity 0.83 to0.88 air dry and 0.78 oven dry). It is excellent for firewood and makes superior charcoal. Because of its high heat value, the wood has been termed "Wooden anthracite". It bums slowly and evenly and holds heat well. The wood is very durable and is used for fence posts, door and window frames and other light carpentry. The wood is used in making paper pulp. An important wood - consuming activity is brick making and *Prosopis* is the main fuel for pottery, cottage industries also. Heart wood is durable and is suitable for tool handles of all sorts, crushers and such other purposes where both strength and hardness are of importance. The flowers are a source of high quality honey. The mesquitepods are sweet, succulent and edible, having a high nutritive value. The pods are eaten by livestock (sheep and goats) and also made into flour for human consumption during famine.

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Small young leaflets are also eaten by cattle, sheep and goats, Foliar analysis revealed the magnesium and phosphorus contents are less than 1.0% sodium is high indicating the plants tolerance to salinity. The experiment conducted to assess the possibility of utilizing *Prosopis juliflora* pods as cattle feed revealed that even at 45% of pod feeding, there was no adverse effect on dry matter intake and digestibility in Kangeyam bullocks. The bark is a source of tannin; it also produces gum and is used for sizing cloth. The roots yield a fibre for cordage and coarse fabric. It also yields a gum which is used for adhesive purposes. Investigations on the suitability of *Prosopis juliflora* for the production of paper was undertaken at F.R.I Dehra dun. Some difficulty was experienced in chipping this wood due to crookedness of billets. The results show that satisfactory yields of bleached pulps with satisfactory strength properties for production of writing and printing paper can be prepared from *Prosopis juliflora* by sulphate processes. However, the yield is low and the strength property of the pulp is poor as compared to most other hardwoods. The plant makes an impenetrable "live fence" around agricultural fields. Shelter belts and windbreaks are provided by this tree in the arid zone and it has been used widely for this purpose.

Lec.16 Silvicultural practices for Casuarina , Silk cotton, Acacias and Bamboos

1. Casuarina

ScientificName	: <i>Casuarina equisetifolia</i>
English Name	: Beaf wood
Tamil Name	: Savukku
Hindi Name	: Janlisaru
Family	: Casuarinaceae

Distribution

Casuarina is indigenous on the sandy shores and dunes along the Bengal coast, Tenasserim, Andaman and Nicobar islands, etc. It has been raised in many parts of the country as a coastal plantation, an ornamental garden tree and an inland sand dune plantation.

Physiognomy

It is a large evergreen tree with a straight stem. The foliage is feathery and comprises of a number of long, slender, drooping, jointed, angled, leafless branches rising from rough, woody branches. The jointed branchlets are green and perform the function of leaves. They are partly deciduous. Casuarina resembles a feathery, coniferous tree in appearance. The bark is brown, fibrous, rough and exfoliates in longitudinal stripes. The tree may grow upto a height of about 35 m or so; though it generally does not have a life of more than 50 years, becoming hollow and unsound in about 35 years. By habit, casuarina is gregarious in its natural state, forming pure crops. There is little or no undergrowth except grassy patches and a few coastal shrubs.

Phenology

It is generally evergreen. Pieces of the jointed branchlets are shed all round the year. Flowering occurs twice a year once from February to April and again from September to October. Fruit ripening occurs in June and again in December. Seeds are viable for about six months or so, though it is always better to use fresh seed

Silvicultural Characters

Strong light demander and drought resistant. Susceptible to fire. Coppices badly. Young plants susceptible to browsing

Climate and Soil

Absolute maximum and minimum temperature is 35°C-49°C and -4° to 18°C. Normal annual rainfall 750-4,500 mm. Best suited soil is alluvial soil having a considerable proportion of sand and good moisture supply. Also survive on poorly drained sites.

Nursery Technique

Seed is sown in the nursery in May, 5 cm apart in lines 23 cm apart and watered till the break of rains. Seedlings should be shaded during the hot weather. They are suitable for making stumps and/or entire transplanting when 1 year old. In Assam, 2 year old plants are transplanted, when 1-2 m high even taller. In West Bengal, practice is to plant out seedlings about 30 cm high, with ball of earth. One year old stock is used for making stumps.

Planting

Direct sowing may be done in raised patches 3.7 m x 3.7 m, just before the commencement of rains, using 3 to 6 seeds per patch. In taungya plantations of Uttar Pradesh direct sowing are done in continuous lines.

It has been successful in comparatively high rainfall region of Assam, West Bengal and Kerala. For stump planting, stumps are prepared from 1 or 2 years old nursery raised seedlings, keeping only 4 cm of shoot and 30 cm of root and running all side roots. Planting may be done in crow-bar holes or in pits of 30 cm³ Utilization.

Semal wood is very soft and light. Untreated wood is highly perishable and extremely durable under water. It is in great demand as matchwood; is very suitable for light plywood containers. It is also used for packing-cases, shingles, well-curbs, brush handles, dug-outs, etc. Floss from semal seeds is the Silk Cotton or Indian Kapok of commerce, which is used for stuffing cushions, pillows upholstery, packing, etc. Bark exudes a gum,

known as mocha-ras, which is of great medicinal value. Inner bark yields a good fibre suitable for cordage.

2. Silk Cotton

Scientific Name : *Ceiba pentandra*

English : Silk cotton tree

Tamil : Pulai

Hindi : Semal

Family : Bombacaceae

Distribution

It is very widely distributed, almost throughout India, excepting the arid region; ascending upto 1200 m, occasionally even upto 1500 m. It is typical of alluvial savanna type of forests; it grows sporadically in mixed deciduous forests of West Coast, and the evergreen forests of Bengal and Assam. It is very common in Tarai and Bhabar areas of Uttar Pradesh and Bihar. It is also widely distributed in peninsular India. Indo-genetic plain and parts of the sub-Himalayan tract.

Physiognomy

It is a huge tree with a clean bole and development of buttress. Its wood is very soft and light. Untreated wood is highly perishable; is extremely durable under water. Bark exudes a gum, known as mocha-ras, Inner bark yields a good fibre suitable for cordage. Scarlet red flowers appear in February-March. It coppices in early years; produces root suckers

Phenology

Leaf-fall occurs in the month of December. The leaves turn yellow and fall off. The flowering takes place in the leafless period from January to early March. The fruits occur in April and May. Seeds are surrounded by floss and are hence dispersed by wind.

Silvicultural Characters

It is a strong light demander and drought resistant. Fairly resistant to frost and fire. It produces root suckers and early coppicer.

Climate and Soil

Absolute maximum and minimum temperature is 35°C-49°C and -4° to 18°C. Normal annual rainfall 750-4,500 mm. Best suited soil is alluvial soil having a considerable proportion of sand and good moisture supply. Also survive on poorly drained sites.

Nursery Techniques

Seed is sown in the nursery in May, 5 cm apart in lines 23 cm apart, and watered till the break of rains. Seedlings should be shaded during the hot weather. They are suitable for making stumps and/or entire transplanting when 1 year old. In Assam, 2 year old plants are transplanted, when 1- 2 m high even taller. In West Bengal, practice is to plant out seedlings, about 30 cm high, with ball of earth. One year old stock is used for making stumps.

Planting

Direct sowing may be done in raised patches 3.7 m x 3.7 m, just before the commencement of rains, using 3 to 6 seeds per patch. In taungya plantations of Uttar Pradesh direct sowing are done in continuous lines. It has been successful in comparatively high rainfall region of Assam, West Bengal and Kerala. For stump planting, stumps are prepared from 1 or 2 years old nursery raised seedlings, keeping only 4 cm of shoot and 30 cm of root and running all side roots. Planting may be done in crow-bar holes or in pits of 30 cm³

Utilization

Semal wood is very soft and light. Untreated wood is highly perishable and extremely durable under water. It is in great demand as matchwood; is very suitable for light plywood containers. It is also used for packing-cases, shingles, well-curbs, brush handles, dug-outs, etc. Floss from semal seeds is the Silk Cotton or Indian Kapok of commerce, which is used for stuffing cushions, pillows upholstery, packing, etc. Bark exudes a gum, known as mocha-ras, which is of great medicinal value. Inner bark yields a good fibre suitable for cordage.

3. Acacias

Scientific Name	: <i>Acacia auriculiformis</i>
English Name	: Australian Wattle
Tamil Name	: Kathivel
Family	: Mimosae

Distribution

It is a native of New Guinea, North Australia and Queensland; and exotic in India. It has been successfully raised in West Bengal, Bihar and Andhra Pradesh for about forty years, and more recently in Kamataka, Orissa, Uttar Pradesh and Maharashtra.

Physiognomy

It is a moderate sized tree, attaining a height of 10m sometimes upto 15m. Bark is smooth, white or light grey, fissure occurs in later years. The leaf stalks are modified into flattened blade called as phyllode, which is narrow oblong slightly curved and sickle shaped, leathery, dull green.

Phenology

Seeds ripen during January - March; best time for collection of pods is February - March, by lopping and spreading out for 5-9 days to open. Seeds retain viability upto 2 years. Germination capacity is about 50%.

Silvicultural Characters

It is a strong light demander but regenerate under shade. It is a fire tender. It is drought-tolerant but sensitive to severe drought. It produces profuse root suckers but is a poor coppicer under Indian condition

Climate and Soil

It grows from sea-level to about 700 m altitude. It does well in temperature of 26-30°C and can survive up to 40°C. It is well adapted to drought and grow with as little as 600 mm rainfall.

Nursery Technique

Seed requires pre-treatment, either 24-48 hours immersion in water at room temperature or in cooling boiled water, for 24 hours. May be sown in nursery beds in polythene bag containers during March to early April, under shade which is removed after germination is completed. Seed is sprinkled with kerosene oil to protect against ants. Germination starts in 15-20 days and is complete in 30-35 days. A thatch barrier on one side of the bed is given to protect against direct winds.

Planting

Four months old nursery seedlings are planted out with ball of earth, when 15-30 cm tall, at the break of monsoon in June - July; can be successfully raised by stump planting also. Planting is done in pits 30 cm³ to 45 cm³ at a spacing of 1 m x 1m to 2m x 2m.

Utilization

It is reasonably good fuel-wood, furniture wood and pulpwood; is suitable as a shade and ornamental avenue tree; useful for afforestation and reclaiming wastelands.

Scientific Name	: <i>Acacia nilotica</i>
English Name	: Indian gum arabic tree
Tamil Name	: Karuvelam
Hindi Name	: Babul
Family	: Mimosae

Distribution

Babul is indigenous to the Western part of the India- Gangetic plains and the Northern part of Deccan plateau, including Andhra Pradesh, Maharashtra, Rajasthan and Gujarat. It is widely planted, or self - sown throughout the hot regions of India, viz., Punjab, Haryana, Uttar pradesh, Madhya pradesh and Karnataka. It is an important constituent of southern dry mixed deciduous tropical forests, Northern and Southern tropical thorn forests of India; at an elevation range of 200-500 m.

Physiognomy

It is a moderate - sized, almost evergreen tree with a short trunk, a spreading crown, and feathery foliage. Bark dark brown, nearly black, pinkish brown and hard inside, with regular deep longitudinal fissures which very often run spirally up the tree. Young branches green, pubescent. Stipulate spines straight, white, up to 2 inches long, variable, sometimes absent in old trees. The tree varies much in size, remaining little more than a shrub in some localities, and in others attaining a height of 50 to 60 ft. or even more, and occasionally a girth of 8 to 10 ft.

Phenology

The young leaves appear from March to May, the old leaves commencing to fall before they appear. Flowering is most general in the rainy season, from June to September, but trees may be found in flowers as late as December or January. The time of fruit ripening varies according to locality, but is usually from April to June.

Silvicultural Characters

It is drought-resistant; frost-tender. It is strong light-demander. Its coppicing power is very variable, generally poor.

Climate and Soil

A nilotica can grow on a variety of soils, provided sufficient moisture is available. It prefers well drained fresh alluvial sandy loam soil in riverain tracts, though it can grow on clay and black cotton soil also. It can stand mild soil salinity provided sufficient moisture is available. In its natural habitat, average rainfall is 400 to 1500 mm; fairly drought resistant, but thrives best in areas with 500-1250 mm.

Nursery Technique

Babul seedlings are raised in polythene bags (5 cm x 22 cm, 150 -200 gauge). Treated seeds are sown, about 1.5 cm deep, 2-3 seeds in each bag in February - March (or May, for freshly collected seed) and regularly watered and weeded. Excessive watering should be avoided; shading is necessary to avoid surface cracking.

Planting

Seedlings are fit for planting out in July - August of the same year (when 3-4 months old). For obtaining bigger plants, seeds is sown in June - July in bigger bags and one year old seedlings are planted out. It's rotation is 30 years for timber and 15-20 years for tannin; it yields 23.02 m³ wood per ha. At the age of 30 years and 8-10 tonnes of pods per ha.

Utilization

Leaves and pods are widely used as fodder. It is an extremely valuable source of fuel wood and charcoal of excellent quality. General utility of timbers for construction of carts, wheels, agricultural tools and implements, doors, windows, mine props, fencing materials etc. Bark is one of the best tanning materials of Northern India. Babul gum is used in inks, paints, matches and confectionery

4. Bamboos

Scientific Name : *Dendrocalamus strictus*

English Name : Solid Bamboo

Tamil Name : Kal Moongil

Family : Graminae

Distribution

Dendrocalamus strictus is the hardest, most widely distributed and important of bamboo species found in India. It occurs throughout the country barring Northern parts of West Bengal, Assam and other very moist areas. It is common in most hilly parts of Peninsular India, except very moist places. It occurs in alluvial plains and ravines, and on hill slopes to an altitude of about 1100 m.

Physiognomy

A bamboo plant has 10 to 30 culms and the plant is usually referred to as a clump. The culms may reach a height of 7 to 20 m and a diameter of 2.5 to 8.0 cm. The culms are almost if not entirely solid, hollowness varying from a pinhole to 2.5 cm in diameter; there is no hollowness in drier localities. The culms emerge from an underground rhizome. *D. strictus* shows sympodial type of rhizome also called pachymorph. Sympodial rhizomes are solid usually short and thick and their lateral buds only produce new rhizomes each of which eventually produces a solitary culm. The sympodial

arrangement ensures that each new culm will have its own new roots. The buds on rhizome nodes enlarge for many months in the soil and tender shoots emerge and pointed cones completely covered with imbricate sheaths. These shoots elongate rapidly attaining full height in four months which is followed by development of branches. At this stage, the culm sheaths cover the lower part of each internode and the exposed upper part is covered with waxy powder. The culm sheaths are modified leaves arranged in two ranks mainly for the protection of the growing culm. The sheath is attached at the node clasping the culm and when old, falls off leaving a scar. Width of the sheath is greater than the girth of the nodes so that the two sides of the sheath overlap. Growth of culm is rapid being 0.3 to 0.9 m per day. Full culm maturity is completed in 3 to 4 years and new culms are produced every year with the commencement of rains. The average life of a culm is 7 years.

Phenology

D.strictus exhibits both spodic and gregarious flowering

Silvicultural characters

It is drought resistant and frost hardy. It is also a light demander.

Climate and Soil

It is commonly found in drier areas and grows on well drained soils and stony soils on hill slopes.

Nursery technique

Seeds are sown in raised bed . Germination commences within 11 days after sowing. Fourty days after sowing , the seedlings are transferred to polybags.

Planting

10 months to one year old seedlings are planted in the main field at a spacing of 5mx5m. The management of bamboo involves two main considerations viz., felling cycle and felling intensity.

The felling rules are observed at every cutting cycle.

- i) Culms less than 2years of age should not be cut
- ii) In a clump, atleast 6 mature culms are to be retained
- iii) The culms should be cut at 15cm above ground level
- iv) While cutting the culms should not be split

Social and Farm Forestry

Utilization

It is mainly used in paper industry. Its seeds are eaten by people. Leaves and young culms are used as fodder.



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