PRACTICAL MANUAL

ON

Plantation Forestry

FSA 303 3(2+1)

For B.Sc. Forestry VI Semester students

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2020

College of Horticulture & Forestry
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Syllabus: Study the tools and materials for plantation establishment- Visit small and large plantations- study their management and functioning- Exposure to plantation project preparation- economic evaluation and feasibility studies of plantation projects. Study of planting operations- study of tending techniques- Planting methods and techniques for different types of plantations including energy plantations, canal bank plantations - pulp wood plantations- study of Forest Development Corporation plantations-road side plantations plantation planning- Plantation journal- Choice of species for plantations-economic considerations in plantation- Study of govt. vs. pvt. Plantations.

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CONTENTS

Practical No. 1

Objective: Study the tools and materials for plantation establishment

Forest plantation is defined as “a forest crop or stand raised artificially, either by sowing or planting”. Establishment of a forest plantation is broadly divided into three management phases: seed collection and handling; nursery practices and plantation establishment & management. All the operation required certain tools for execution of the specified work of tree planting.

Plantation Tool and material: The tool is equipment that is used in order to make and repair something. On the other hand, when we talk about material then these are the substances that are used in making things. For example, hammer is a tool whereas organic manure, fertilizer, pesticides etc are materials.

Problem 1: Write the importants of tools in plantation establishment

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Problem 2: Enlist the material required for plantation establishment.

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Problem 3: Write the used of tool and material used in plantation establishment.

Sr. No	Operation	Tools and materials	Use(s)
1.	Site preparation	Pick axe	.....
		Crow bar	.....
		Disc plough	.....
		Mould Board Plough	.....
		Tractor mounted auger	.....
		Sand, cement	.....
		Barbed wire and nails	.....
2.	Soil working	Rakes	.....
		Spades	.....
		Shovel	.....
		Hoe	.....
		Grub hoe	.....
		Digging bar	.....
		Tractor mounted auger	.....
3.	Planting	Auger	.....
		Grub hoe	.....
		FYM/Fertilizer	.....
4.	Maintenance operations	Secateaur	.....
		Pruning saw	.....
		Pruning shears	.....
		Khurpis	.....
		Rose cane	.....
		Pesticide & insecticide	.....

Problem 4: Draw the diagram of the tools used in the establishment of a plantation and write its function.

Diagram	Function
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	…… …… …… …… ……
	…… …… …… …… ……
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Practical No. 2

Objective: Visit to a small-scale plantation- study their management and functioning

Forest plantations are defined as forest stands established by planting/seeding the area for afforestation or reforestation. They are either of introduced or indigenous tree species with minimum area of 0.5 ha; tree crown cover of at least 10 percent of the land cover and total height of adult trees above 5 m.

SCALE OF PLANTATIONS:

These plantations are either small scale or large scale in nature depending on various factors with large-scale plantations of fast growing tree species occupying 54 million ha in 2012 and predicted to double in extent by 2050.

Small-scale plantations are referred to as trees raised under farm forestry, social forestry, agro-forestry and integrated forestry practices on small area.

Large-scale plantations are referred to as plantations raised on large area by businesses or government agencies other than farmers for commercial purpose and to meet out large demand for wood/timber.

Field Exercise:

1. Name and location of the visiting sites: ……..

2. Date of visit: ……

3. Detail of work:

Sr. No	Species planted		Pattern of planting and spacing	Funding agency	Year of plantation	Duration of plantation	Area (ha)
	Scientific Name	Common Name					
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

What are the objectives of plantation? ……..

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Write the Characteristics of small-scale plantations.

Characteristics	Small Scale
Ownership	.....
Objective	.....
Species diversity	.....
Type of species	.....
Management	.....
Cost of establishment	.....
Profitability	.....

Question No. 6. Write the advantages and disadvantages of small scale plantations.

Advantages: ……..

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Disadvantages: ……..

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Management strategies used by respective authority.

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Practical No. 3

Objective: Visit to a large-scale plantation and study their management and functioning.

Field Exercise:

1. Name of the visiting sites:

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2. Forest Division:

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3. Range: ……

4. Date of visit:

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5. Detail of work:

Sr. No	Species planted		Pattern of planting and spacing	Funding agency	Year of plantation	Duration of plantation	Area (ha)
	Scientific Name	Common Name					
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

What are the objectives of large-scale plantation?

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Write the Characteristics of large-scale plantations

Characteristics	Large Scale

Ownership	.....
Objective	.....
Species diversity	.....
Type of species	.....
Management	.....
Cost of establishment	.....
Profitability	.....

Write the advantages and disadvantages of large-scale plantation.

Advantages: ……..

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Disadvantages: ……..

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Management strategies used by Forest Department.

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Factors affecting scale of plantation:

1)……

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Practical No. 4

Objective: Studies of planting operations in Plantation Forestry.

We all know tree planting is beneficial - as the good word says; “he who does good to humanity, does good to God”. There is no doubt tree planting serves God’s will to make the world a better environment for all. In addition, trees hold the soil, provide shade, food for wildlife, absorb carbon dioxide and clean the air by breaking down pollutants. Tree Planting involved seed sowing/seedling planting, land preparation operations, hazard management, insect –pest and domestic and wild animals’ protection.

Planting objectives: The objective of tree planting is to (successfully) establish a uniform and healthy tree crop. Planting operation is generally done to fulfill the objective of afforestation/ reforestation.

Field Exercise:

Explain the different planting operation performed in forestry operation.

S. No	Steps of operation	Operation done
1.	Site preparation	…… …… …… ……
2.	Soil working	…… …… …… ……
3.	Nursery	…… …… …… ……
3.	Planting	…… …… …… ……
4.	Protection and maintainance plantation area	…… …… …… ……

Name of the tree species selected for plantation: ……

Date of seed collection: ……

Number of seed/kg: ……

Nursery preparation:

a) Size of nursery bed: ……..…….

b) Total Number of seed/cutting in nursery bed: ……..……...

c) Number of seed germinates: ……

d) Germination success: ……...

e) Planting out age (month/year) and height (cm): ……

Site preparation:

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Planting:

a) Planting pattern: ……..…….

b) Planting distance (spacing): ……..…….

c) Planting material (entire planting/stump planting): ……..……...

d) Planting season: ……

e) Pit size: ……

Plantation protection measures use:

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Practical No. 5

Objective: Study of tending techniques carried out in plantation area

Tending is an operation carried out for the benefits of forest crop at any stage of its life. It essentially covers operation on the crop itself and competing for vegetation and include weeding, cleaning, thinning, felling, pruning, climber cutting, girdling but exclude soil working, drainage, irrigation, and burning, etc. These operations are carried out in the forest crop at different stages of growth in order to provide a healthy environment for their development. It is generally carried out for the benefits of forest crop at any stage of its life between the seedling and the mature stages.

Objective of tending operation:

1. Sanitation: The act of reducing the chanced of insects and other diseases damage to the main crop. It involved removal of injured, broken, weak, diseased, or infected plants.

2. To provide growing space for trees.

3. Reduce the competition for light, moisture, nutrients and space.

Tending operation involves Weeding, Cleaning, Thinning, Improvement felling, Girdling, Pruning, Climber cutting operations.

Field Exercise:

1. Write down weeding its objective and duration of weeding in Forest Nursery and plantation area

Weeding:……

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Objective and duration of weeding in Forest Nursery and plantation area:

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2. Write down the objective of thinning.

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3. Write in brief different types of thinning use in regular forest

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4. What is girdling?

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5. What are the objectives of pruning and enlist the tool used in pruning?

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6. Write the difference between tending operation and cultural operation used in forestry

Tending operation	Cultural operation
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Practical No. 6

Objective: Study of Forest Development Corporations plantations.

After an era of indiscriminate exploitation of Indian forests by British rule, India's National Forest Policy of 1952 re-emphasized the 'need for sustained supply of timber' and 'need for realization of maximum annual revenue from forests. Hence, Indian forests continued to be exploited for timber and remained the main source of timber until the 1970s.

In 1972, the National Commission on Agriculture recommended the establishment of Forest Development Corporation (FDCs) to launch aggressive production forestry programme which would improve the productivity of India's forests and meet the raw material demand for wood-based industries. FDCs are registered bodies under the Companies Act, or any such similar Act, with a memorandum and articles of association of the company. The powers of managing the FDC are vested with a board of directors which are constituted by the state government. The board consists of official and non-official directors. 5 State FDCs come under the purview of the regional offices of the Ministry of Environment, Forest & Climate Change (MoEF&CC), while those in Union Territories are managed directly by MoEF&CC.

Objective of FDCs:

i. Raise the per hectare productivity both in respect of volume and value;
ii. Create much more employment for skilled as well as unskilled hands;
iii. Give substantial support to the economy of the backward areas and the tribal population which depends on growth of forestry activities;
iv. Expand or establish a large number of industries based on raw material from the forests;
v. Enter the export market in wood and wood products ;
vi. Have a sustaining impact on employment in secondary and tertiary sectors.

Field Exercise:

1. Name of the State: ……

2. The main activity performed by the Forest Development Corporations (FDCs).

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3. Explain the role of FDCs in collection of NTFP in relevance to Uttar Pradesh.

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Question No. 4. Future strategy of Development Corporations (FDCs).

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5. Write in a brief activity done by Forest development corporations (FDCs) in following given State in India.

S. No.	State	Activity done by Forest development corporations
1.	Andhra Pradesh:	…… …… …… ……
2.	Chhattisgarh:	…… …… …… ……
3.	Gujarat:	…… …… …… ……
4.	Haryana:	…… …… ……
5.	Himachal Pradesh:	…… …… …… ……
6.	Jammu and Kashmir:	…… …… ……
7.	Karnataka:	…… …… …… ……
8.	Kerala:	…… ……

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9.	Madhya Pradesh:	.....
10.	Maharashtra:	.....
11.	Odisha:	.....
12.	Punjab	.....
13.	**Tamil Nadu:**	.....
14.	**Tripura:**	.....
15.	**Uttar Pradesh:**	.....
16.	**Uttarakhand:**	.....
17.	**West Bengal:**	.....

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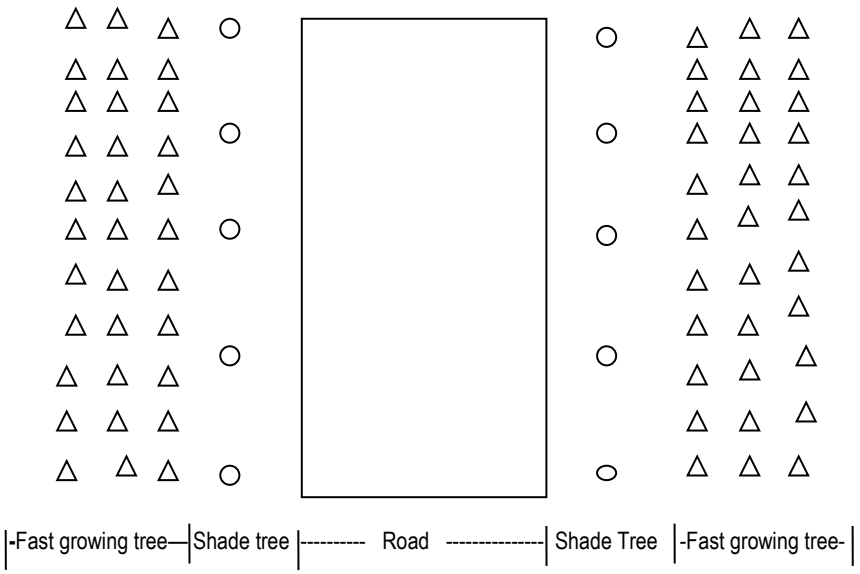
Practical No. 7

Objective: To study road side plantations and plantation planning

Spacing and alignment: The number of rows to be planted on the roadside depends upon the width of the road. The link roads and the roads passing through the towns should be planted withsingular shady trees. In case of multiple rows planting the first row is generally of shade and or ornamental trees and the remaining rows with fast growing species. The crown spread of the species determines the spacing. National Commission on Agriculture has recommended six rowplanting i.e. three rows on either side. In Uttar pradesh pits for first row are dug at a distance of 9-10 meter from the centre of the road in case of national highways and at a distance 7-8 meter from the centre for state highways and other roads. The second and subsequent rows are planted at varing distances according to the requirement of the species. In the first row called shade line or avenue line, the pits are spaced uniformly at 7.5 m for shade trees while in the remaining row planted with other trees the spacing is 3m.



Diagrammatic representation of a typical multiple road-side planting.

Rotation: In roadside plantation inner or first row are manage under physical rotaton and or silvicultural rotaton while the other rows are generally managed under rotation with maximum volume production, technical Rotation and Economic Rotation.

Field Exercise:

1. Name of the visiting sites: ……..

2. Date of visit: ……

3. Field work:

S. No.	Location	Tree species		Spacing	Funding agency	Plantation peroid	Area (ha)
		Scientific name	Common name				
1.							
2.							

3.							
4.							
5.							

4. Criteria of selection of Species for road side plantation:

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5. Write the objective of roadside plantation:

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6. Achievements of road side plantation to socieo-economic status of local people:

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7. Management strategy used by the respective authority to managed road side plantation

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Question No. 8. Conclusion:

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Practical No. 8

Objective: Exposure to plantation project preparation

1. To re-establish tree cover on unstocked and degraded forest land, thereby converting such lands to productive use;
2. To produce wood raw materials for industrial use and as alternative sources of construction and fuel wood; and
3. To establish a policy and institutional framework for the development of sustainable industrial plantations

Plantation project preparation:

S. No	Years	Work Description	Unit	Quantity	Cost
1	**1st Year** The **Proposed Project**	The Proposed Project:			
		a) Impact and Outcome:			
		b) Outputs:			
		c) Cost Estimates:			
		d) Financing Plan:			
		e) Implementation Arrangements:			
1.	**2nd Year Establishment**	Land clearing, burning and cleaning, leveling-bulldozer.	Hectare		
2.		Soil preparation	Hectare		
3.		Labor for digging, Fencing, Poles, Barbed wire	Hectare		
4.		Planting	seedlings		
5.		Spacing	Meter		
6.		Species selection	Hectare		
7.		Weeding	Hectare		
8.		Fertilizer	Bag		
9.		Watering	Hectare		
10.		Firebreak established	Meter		
1.	**3rd Year Maintenance**	Weeding	Hectare		
2.		Casualty Replacement	Seedlings		

3.		Firebreak clearing	Meter		
1.	**4th Year**	Weeding	Hectare		
2.	**Maintenance**	Firebreak clearing	Meter		
1.	**5th year**	Final harvesting when our objective is fullfilled	Hectare		
2.	**Harvesting**	Transport to market	Kilometers		

Practical No. 9

Objective: Studies of economic evaluation and feasibility of plantation projects.

Problem: Suggest the better and feasible project with the proper conclusions using NPW, BCR and Payback Period for the following two projects. (discount rate @ 12 per cent.)

Vermi-compost project			Jatropa Bio-diesel project		
Year	**Costs (Rs.)**	**Returns (Rs.)**	**Year**	**Costs (Rs.)**	**Returns (Rs.)**
1.	18,500	-	End of 5th Year	35,800	-
2.	6,300	16,500	End of 6th Year	4,600	12,800
3.	7,400	20,600	End of 7th Year	4,800	14,300
4.	8,000	22,000	End of 8th Year	5,150	15,800
5.	8,300	23,800	End of 9th Year	5,250	17,100
6.	8,450	25,100	End of 10th Year	5,750	18,600
7.	8,100	25,850	End of 11th Year	6,250	19,800

Solution: ……

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Problem 2. Find out the NPW and BC ratio with 10% discount rate for the following two projects and suggest the better and feasible project with the proper conclusions.

Vermi-compost project			Jatropa Bio-diesel project		
Year	**Costs (Rs.)**	**Returns (Rs.)**	**Year**	**Costs (Rs.)**	**Returns (Rs.)**
1.	18,500	-	End of 5th Year	35,800	-
2.	6,300	16,500	End of 6th Year	4,600	12,800
3.	7,400	20,600	End of 7th Year	4,800	14,300
4.	8,000	22,000	End of 8th Year	5,150	15,800
5.	8,300	23,800	End of 9th Year	5,250	17,100
6.	8,450	25,100	End of 10th Year	5,750	18,600
7.	8,100	25,850	End of 11th Year	6,250	19,800

Ans.……

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Problem 3. Find out the IRR (Internal Rate of Returns) for the following two projects and suggest the better feasible project with the proper conclusions.

Vermi-compost project			Jatropa Bio-diesel project		
Year	Costs (Rs.)	Returns (Rs.)	Year	Costs (Rs.)	Returns (Rs.)
1st Year	28,900	-	End of 6th Year	15,000	-
2nd Year	9,239	28,475	End of 7th Year	4,250	10,260
3rd Year	10,575	32,550	End of 8th Year	4,792	12,550
4th Year	11,952	35,610	End of 9th Year	5,368	14,530
5th Year	12,858	39,802	End of 10th Year	5,975	16,275
			End of 11th Year	6,456	19,396
			End of 12th Year	7,187	21,470

Solution:……

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Practical No.10

Objective: Study of canal side plantations

A large network of canals has been established since British times in the Indo- Gangetic plains. Strips of lands on both sides of canals are avalible varing from a width of 40 feet to 100 feet. These strips are generally used as inspection road, paths and borrow pits for repair of cannal. These strips were laying waste, a programme for afforestation these strips to utilize them properly and to augment the production of fuel and timber were stated in Uttar, Pradesh Punjab and Haryana. This work has now been included in social forestry under extension forestry. The National Commission on Agriculture has recommended that all the state should follow the pattern of Uttar, Pradesh Punjab and Haryana in organizing tree planting on canal bank. Canal bank are early managed by irrigation department but now they are managed by respective State Forest Department.

Objective of canal side plantation:

i. To stabilise the canal bank against erosion, checking of shifting sand and dust from getting into the canal courses.
ii. Optimum utilization of wasteland resource for production of forest products for local communities.
iii. To check waterlogging in the strips and adjoining fields by planting fast growing species having high transpiration rates.
iv. To provide shelterbelt in the desert area.

Field exercise

1. Name of the visiting sites: ……

2. Date of visit: ……..

3. Field work: ……

S. No.	Tree species		Spacing	Funding agency	Plantation Peroid	Area (ha)
	Scientific name	**Common name**				
1.						
2.						
3.						
4.						
5.						

4. Criteria for choice of species for canal side plantation.

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5. Management strategy used by the State Forest Depatment:

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6. Planting technique use in canal side plantation in Uttar Pradesh.

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7. Give example of suitable tree species for canal side plantation in Bundelkand region of UP.

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Practical No.11

Objective: Planting methods and techniques for Energy plantations.

Forests and trees provide a significant share of the world's energy use. For developing countries, wood energy is of considerably greater importance than in industrialised. Developing contries are more depent upon the forest for their fuelwood requirment as compare to the developed countries. For developing countries, like India large population depents upon the forest for the fuel wood requirement. Demand for fuelwood in India is increasing day by day. India's current firewood consumption is more than 133 million tonnes; most of it is being used in cooking.

Accoding to FSI Report 2019 Maharashtra is highest dependence on forest for fuelwood whereas, for fodder, small timber and bamboo, dependence is highest in Madhya Pradesh. It has been assessed that the annual removal of the small timber by the people living in forest fringe villages is nearly 7% of the average annual yield of forests in the country. To save forests from degradation/deforestation, fuel wood tree should be grown on the agriculture land through agroforestry in order to meet out their demands of fuelwood, improve the microclimate by means of saving trees in natural forests.

Objective of Energy plantation:

1. To fullfilled the domestic and industrial demand of fuel wood.
2. Energy plantation help in noise, air effluents and water effluents abatement and also combating global warming and climate change effects.
3. Energy plantation such as wind breaks and shelterbelts, may serve as a soil conservation measures and protect agriculture land below
4. It generates employment apportunities particularly in rural areas.

Field exercise:

1. Criteria of tree species planted for energy plantation.

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2. Write the advantage of energy plantation.

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3. Presence of prioritized tree species to the specific energy plantation sites:

S. No.	Tree Species		Uses	Distance		Other Informations
	Common Name	Scientific Name		In rows (m^2)	In plants (m^2)	
1.						
2.						
3.						
4.						
5.						

4. Achievements of energy plantation to socieo-economic status of local people:

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5. Give example of suitable tree species for energy plantation in Bundelkand region of UP

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8. Conclusion: ……

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Practical No.12

Objective: Planting methods and techniques for Pulp and Paper plantation.

Field Exercise:

1. Name of the visiting Pulp and Paper plantation sites: ……

2. Date of visit: ……

3. Plantation area (ha): ……..

4. Presence of prioritized tree species to the specific Pulp and Paper plantation sites:

S. No.	Tree Species		Rotation Period	Uses	Distance		Other Informations
	Common Name	Scientific Name			In rows (m^2)	In plants (m^2)	
1.							
2.							
3.							
4.							
5.							

5. Achievements of Pulp and Paper plantation area to socieo-economic status of local people:

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6. Major Tree and their clone used in Pulp and Paper plantation:

S.No.	Tree species	Clone
1.		

2.		
3.		
4.		
5.		
6.		
7.		

7. List of successful Pulp and Paper plantation:

a):

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b):

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c):

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d):

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e): ……..

8. Give the list of Pulp and Paper Industries operating in India:

a):

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b):

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c):

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d):

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e):

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f): ……..

g):

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9. Conclusion: ……..

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Practical No.13

Objective: To study choice of species for plantation.

India is one of the mega diverse countries in the world. It has a rich variety of indigenous, coniferous and broad-leaved tree species that grow on plain and hilly tracts of the sub-continent and also at different altitudes in the Himalayas. Correct choice of species has great influence on the successful eatablishment of plantations. The job of the forester is to choose the most suitable species in consonance with climato-edaphic conditions prevailing at the site and at the same time meeting the requirment of forest products.

Factor like Purpose of plantation, economic consideration, silviculture characters, ecological zones of species and preference by local farmers influence to determine the choice of species for plantation:

Field Exercise:

1. How the choice of species depend upon the purpose of plantation.

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2. What are the charactersites of the tree suitable for the plantation?

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3. Presence of prioritized tree species to the specific Agro- forestry plantation sites:

S. No.	Tree Species		Rotation Period	MPT's	Distance		Other Informations
	Common Name	Scientific Name			In rows (m^2)	In plants (m^2)	
1.				Timber			
2.				Fuel			
3.				Pulp and paper			
4.				Plywood			
5.				Match wood			
6.				Bio-fuel			

7.				Others			

4. Criteria adopted by the farmer of Bundelkand region of Uttar Pradesh while selecting the tree species for plantation:

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5. Conclusion: ……

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Practical No.14

Objective: Economic considerations in Plantation establishment.

1. Name of the visiting plantation sites:

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2. Date of visit: ……

3. Forest Division: ……..

4. Range: …….. **5. Area (ha):** ……..

6. Purpose of plantation: ……..

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7. Economic consideration taken by Forest Department ……..……

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8. Achievements of plantation to socio-economic status of local people:

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9. Conclusion: ……

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Practical No.15

Objective: Plantation Records – Journal (One of the important plantation records is "Plantation Journal")

1. Circle: ……

2. Forest Division:

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3. Range: …… **Area (ha):**

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4. Plantation Journal of Uttar Pradesh Forest Department in the year, 2018

Circle	Division	Range	Plantation Name	Plantation Year	Scheme	CAMPA Projects	Area (Ha)	No. of plants planted	Raising survival	1st year	survival 2nd year	survival 3rd year	survival Raising cost (Lakh)

5. Objective of prepartion of plantation journal:

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6. Conclusion:

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Practical No.16

Objective: Study of Government Plantations

1. Name and location of visiting site of Govt. Plantation:

2. Plantation area (ha):

3. Field work:

S. No.	Tree Species		Rotation Period	Purpose	Uses	Distance		Other Informations
	Common Name	Scientific Name				In rows (m^2)	In plants (m^2)	
1.								

4. Achievements made by Govt. Plantation to socieo-economic status of local people:

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5. Conclusion:

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Practical No.17

Objective: Study of Private Plantations.

Objective	Trees are planted outside the forest area to full field the industrial requirment.
Purpose	Industrial need (producing wood or fibre for supply to wood processing industry)
Ownership	Industries, farmer
Selection of species	Indigenous and fast-growing species
Rotation	Generally short rotation is preferred
Rate of growth	Fast growing species are given preferred
Species Composition	Even age and pure crop
Aim	Commercial production

1. Name and location of visiting site of Private Plantation: ……

2. Plantation area (ha): ……

3. Field work:

S.	Tree Species	Rotation	Purpose	Uses	Distance	Other Informations

No.	Common Name	Scientific Name	Period			In rows (m^2)	In plants (m^2)	
1.								

4. Achievements made by Private Plantation to socieo-economic status of local people:

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5. Conclusion:

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APPENDICES

Plantation operation: Different operations for the establishing plantations are:

1. Site preparation (land leveling, Fencing, lay out etc)
2. Soil working (pit making, trenching preparation etc)
3. Planting
4. Maintenance operations (Weeding, Cleaning, Irrigation, Fertilizer application, Beating-up operation, Singling, Staking, Pruning, Thinning, Plant protection)

Different operations require certain tools for executing the work in the field while some materials are essential for the completion of these operations.

Tending operation:

Weeding –The removal of unwanted plants is called weeding. Weeding is defined as 'a tending operation done in the seedling stage in nursery or in a forest crop, which involves the removal or cutting back of all weeds.

Objects of Weeding:

- To reduce root competition
- To reduce transpirational water Loss
- To facilitate cultural operations
- To improve light condition for the main crop.

Weeding is done at seedling stage. A common practice for weeding must be done before weeds start suppressing the seedling crops and when seedlings have stopped growing in the season. Weeding should be carried out when the weeds have tender roots and shoots, otherwise, it will be difficult to uproot. In plantation, weeding is done during and after the monsoon. Although number of weedingsdepends upon the intensity of weed growth and the rate of growth of seedlings of the favored species, three weedingsare usually done in first year, two in second year and one in the third year, whereas fast growing species require weeding for one or two years.

Cleaning- Cleaning is defined as a tending operation done in a sapling crop which involves removal of inferior growth including individuals of favoured species.

Objects of cleaning:

- To improve light conditions
- To reduce root competition
- To reduce transpirational water loss.

Cleaning is done when the crops reach at sapling stage. At sapling stage, plants compete each other to reach the top in order to obtain the light. The best time for cleaning is determined by the growth season of favored species, which is during the monsoon. It is certainly difficult to do the activities in the rainy season; hence cleaning is done before the onset of monsoon.

Thinning- It is the reduction of trees in an immature stand for the purpose of improving the growth and form of the trees that remain without permanently breaking the canopy of future trees.

Objects of thinning:

- To distribute the growth potential uniformly
- To increase the net yield from a unit area.
- To obtain earlier returns from thinned materials.
- To reduce the rotation
- To produce different size timber as per req.
- To maintain hygienic condition
- To obtain timber of desired quality and strength
- To ensure decomposition of raw humus in temperate forests by increasing light and temperature

Thinning in Regular crops:

1. Mechanical thinning (also called stick thinning): A thinning in which the trees to be cut are selected by some rule of thumb, e.g., trees in alternate diagonals or rows, alternate trees in alternate rows or every second, third, etc., line or a minimum spacing gauged by a standard stick.

2. Ordinary thinning (Also called low thiningor German thinning or thinning from below): The method of thinning in common use that consists in the removal of inferior individuals of a crop, starting from the suppressed, then taking the dominated and lastly some of the dominants.

3. Crown thinning (High thinning or French thinning or thinning from above): A method in which thinning is primarily directed to the dominant trees in a regular crop, the less promising ones being removed in the interest of the best available individuals; the dominated and suppressed stems are retained if they are not dead, dying and diseased.

4. Free thinning (devised by Heck): A method of thinning in which attention is concentrated on evenly spaced selected stems (called elites or alphastems) which are retained until maturity or tilthe last thinning or two, thinning being directed to the removal of other stems hindering their optimum development.

5. Maximum thinning: It is the modification of Heck's free thinningdeveloped by Gehrhardt. It is defined as a method of thinning which aims at putting as high a proportion possible of the total potential increment of the area on the retained stems; from an early stage the number of such stems limited to the minimum that can fully utilize the growing tree. It is heaviest form of free thinning so that there are no trees other than elites. As the thinning is extremely heavy, it may result in deterioration of site due to exposure, infestation of the area with shrub growth, production of knotty timber.

6. Advanced thinning (also Craib's thinning): A thinning done in a regular crop in anticipation of suppression. It was developed by Craiband O'Connorfor wattle and pine plantation in South Africa. Thinning is done after the trees have been adversely affected by the competition of their neighbors. It should be done before competition actually sets in.

Thinning in irregular crops: Selection Thinning is applied in irregular crops. A method of thinning directed to obtain and/or maintain selection composition in a crop, with all diameter classes adequately represented.' It is carried out in all canopy classes removing the trees of the following characteristics:

- Dead, dying and diseased trees
- Inferior trees which restrict the development of their neighbors from all sides
- Trees which are less valuable than their neighbors
- Trees which are of no special importance as regards desirable crop mixture presented.
- Trees those reached to the exploitable diameter.

Improvement felling: Defined as the removal or destruction of less valuable trees in a crop in the interest of better growth of the more valuable individuals (usually applied to mixed uneven aged forest). Operation to be done in improvement felling:

- Felling of dead, dying (more than 75% dead) and diseased trees.
- Felling of saleable unsound and over mature trees
- Felling of unsound or badly shaped mature and immature trees.
- Thinning of congested group of poles.
- Cutting back of damaged seedling and saplings.
- Removal of undesirable under growth.
- Climber cutting.

Gridling: It is defined as cutting through bark and outer living layer of wood in a continuous incision all round the bole of a tree. It is generally done to kill the tree inside the forest. Girdling is usually done on trees are more than 20 cm in diameter as it is easier and less expensive to fell trees smaller than this diameter.

Pruning: Removal of live or dead branches or multiple leaders from standing trees for the improvement of the tree or its timber. On the basis of agency of pruning, it is classified into:

a) Natural pruning: The natural death and fall of branches of standing trees from such causes as deficiency of light, decay snow and ice. It is also known as self-pruning.

b) Artificial pruning: The pruning done by forester without waiting for nature to do it in dense natural crops or where nature can not do it due to artificially large spacing between stems in man-made plantations to reduce cost of formation and rotation. It is a costly operation. So, artificial pruning is carried out considering the funds or outcomes.

ROAD SIDE PLANTATIONS AND PLANTATION PLANNING

Planting of tree on roadsides has been advocated in the ancient Indian culture. Emperor Ashoka was the first Indian king who felt the idea of planting shade trees on the road side. The Mughal propagated the idea further and planted trees of *Ficus infectoria*, *Tamarindus indica* (Imli), *Azadirachta indica* (Neem) and *Madhuca longifolia* (Mahua), *Mangifera indica* (Mango), *Syzygium cumini* (Jamun) around mosques and water wells. Mughal were also responsible for introducing Chinar (*Platanus orientalis*) along the Jhelum in Kashmir. After Mughal Britishers continue the plantation, but this work was assigning to the public works department (PWD) who did not foresters to plan the afforestation work. They are more interested in the construction of roads. Felling the urgent need of establishing greenery around the roads, camouflaging with the countryside environment, the work of afforestation of the road side strips was transferred to forest departments of the state.

The National Commission on Agriculture after observing the performance of these states has recommended that all the road strips on the lines of these states should be transferred to the Forest Department for afforestation work. The importance of afforestation of multiple rows along strips has further been increased because of the air pollution level rising steeply in wake of the heavy vehicular traffic. Recognising the imminent threat of global warming and climate change, Ministry of Road Transport & Highways has promulgated Green Highways (Plantations, Transplantation, and Beautification & Maintenance) Policy – 2015.

Objectives: The main objective of the study road side plantation are:

1. To find out on ways of increasing knowledge on how we can enhance various techniques of road side tree planting, as part of road water harvesting activities.
2. To investigate the socio-economic benefits of road side tree planting for local communities, for preferred tree species.
3. To provide insight in health benefits, and other related benefits of road side tree planting. d) To provide an insight in the organization of road side tree planting.

ECONOMIC EVALUATION AND FEASIBILITY OF PLANTATION PROJECTS.

Evaluation of the economic aspects of plantation project provides a basis for estimating financial needs and feasibility, highlights trade-offs between multiple benefits, and monitors economic efficiency. Economic budgeting is a very flexible process. However, effective application of budgets requires an understanding of the commodity, practice or system to which it is being applied.

Economic indicator like Net Present Value (NPV), Benefit - Cost ratio, Internal Rate of Return (IRR) and Payback period are used to study the Feasibility of plantation project.

Net present value (NPV): Net present value (NPV) is a method used to determine the current value of all future cash flows generated by a project, including the initial capital investment. It is widely used in capital budgeting to establish which projects are likely to turn the greatest profit. The selection criterion of the projects depends upon the postive value of the NPV, when discounted at the opportunity cost of the capital.

NPV of the project is estimated using the following equation:

$$\text{NPV} = \frac{P_1}{(1+i)^{t1}} + \frac{P_2}{(1+i)^{t2}} + \cdots \frac{P_n}{(1+i)^{tn}} - C$$

i = Discount rate; t= time period and C = initial cost of the investment

Projects with positive NPV are given weightage in the selection compared to those with negative present values, while zero NPV make the investor indifferent**.**

Benefit – Cost Ratio (B-C Ratio)

Here, we compare the present worth of costs with present worth of benefits. Absolute value of the benefit –cost ratio will change based on the interest rate chosen. While ranking the projects depending upon the B-C ratio, the most common procedure of selecting projects is, to choose the projects, having B-C ratio of more than one, when discounted at opportunity cost of capital. Finally, the given project is opted for implementation, among alternatives based on the highest B-C ratio. Following formula depicts the estimation of B-C ratio.

$$\text{Benefit – Cost Ratio } \frac{\sum_{t=1}^{n}(B_t/(1+r)^n}{\sum_{t=1}^{n} Ct/(1+r)^n} =$$

Internal rate of return: The internal rate of return (IRR) is a metric used in capital budgeting to estimate the profitability of potential investments. The internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. IRR calculations rely on the same formula as NPV does.

Formula and Calculation for IRR

$$\text{O = NPV} = \sum_{t=1}^{T} \frac{Ct}{(1+IRR)t} - C0$$

Where: C_t =Net cash inflow during the period t; C_0 =Total initial investment costs; *IRR* = The internal rate of return, and *T* = The number of times periods

Payback period: Another simple method of ranking a project is the length of time required to get back the investment on the project. The payback period of the project is estimated by using the straight forward formula

$$\text{P} = \frac{I}{E}$$

Where, P= payback period of the project in years, I= investment of the project in rupees and E= Annual net cash revenue in rupees. The preference of the particular project is based on the lesser payback period.

FOREST DEVELOPMENT CORPORATION (FDCs)

In 1972, the National Commission on Agriculture recommended the establishment of Forest Development Corporation (FDCs) to launch aggressive production forestry programme which would improve the productivity of India's forests and meet the raw material demand for wood-based industries. Based on the current activities, FDCs can be classified into the following three broad categories:

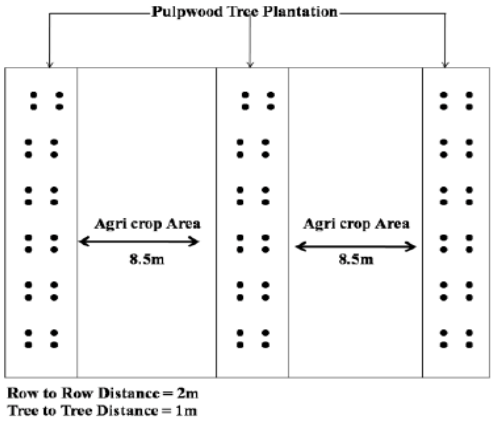
i. *FDCs dealing with replacement of allotted natural forests by industrially important wood species through plantations:* These FDCs have been leased out large tracts of forestland for conversion of 'depleted productive forests to fully productive extremely valuable stands, multiple in value and productivity'. They also carry out harvesting and marketing of timber, which includes timber from felled natural forests as well as from raised plantations on allotted forestlands. The state forest departments identify and lease out the forestlands to their FDCs. Approval of the Working Plan from the regional offices of the MoEF&CC is necessary for these FDCs before they can carry out any felling or plantation activity. Examples of such FDCs are Andhra Pradesh, Chhattisgarh, Karnataka, Kerala, Madhya Pradesh, Maharashtra and Tamil Nadu.

ii. *FDCs that were created with the aim of replacing forest contractors in the harvesting and disposal of forest produce:* Such FDCs have not been allotted any forestland and therefore do not engage in raising plantations. These FDCs have their sale depots where the harvested produce is transported and sold through auctions and tenders. Examples of such FDCs are Uttar Pradesh, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Punjab, Haryana and West Bengal.

iii. *FDCs that deal in cash crops or run industries based on forest product:* Examples of such FDCs are Tripura, Odisha and Gujarat. Tripura FDC raised rubber plantations for restoration of degraded forests, while Gujarat FDC runs forest industries which processes timber and non timber forest produce into finished products and markets them.

PULP AND PAPER PLANTATION

India with a total of 813 pulp and paper mills ranks as 15th largest paper producer and also considered the fastest growing paper market in the world. Indian Paper Industry consumes 8.7 million MT/annum of wood (~13 million cum/annum), and 90% requirement met through farm level plantations (CPPRI 2015, p. 31-33). About 315,000 hectares of land is covered under pulp wood production from which about 75% is run by private farmers. Thus, it is entirely based on plantation forestry, where private farming plays a very large role. It is calculated that the sector employs directly 500,000 people and indirectly even up to 1.5 million people. Therefore, its role in India's employment, especially in rural areas, is significant.



Important points about Indian Paper Industry:

1. India is the 15th largest paper producer of the world
2. It is one of the largest wood-based industrial sectors in India.
3. Paper consumption in India was 10 kg per capita as compared to world average is 56.7 kg per capita, in 2013
4. India imported about 370,000 metric tons wood in the year 2014. (Wood Resources International LCC 2015)
5. Government of India in Union Budget 2016-2017, reduced the customs duty from 5% to current 0%, on the imported wood for manufacturing paper or pulp.
6. Paper Industry consumes 8 million MT/annum of wood.
7. 90% wood requirement is met from farm forestry plantations and Social Forestry.
8. Plantation forestry in form of agroforestry, farm forestry and social forestry is playing a big role to meet wood requirement of paper industry.
9. The industry is playing a significant role in providing employment in rural sector.
10. It is estimated that the sector employs directly 500,000 people and indirectly even up to 1.5 million people.
11. Paper mills use mainly wood from three different genera: Eucalyptus sp., Leucaena sp. and Casuarina sp.
12. The wood raw material is transported to the mill either as logs or chips.
13. Industry is also importing wood chips mainly from South-Africa, Myanmar and Thailand.

ITC Ltd. (Information and Communications Technology) is one of the largest papers and pulp manufacturers -in India.

Pulp wood tree plantation under Agroforestry Model: ITC Ltd. Screened out promising clones: 107 for Eucalyptus, 15 for Casuarina & 12 for Subabul (*Leucaena* sp) short listed for mass multiplication and planting. This has increased productivity from 6 MT/ha/annum to ~40 MT/ha/annum and reduced rotation age from7 to 4 years. Developed improved package of practices for planting eucalyptus under a new concept of "Paired Row Design", where two rows of eucalyptus are planted between agri crop area of 8.5m. it accommodating 2000 Trees/Ha. (Under Agroforestry Model)

ACTIVITY SCHEDULE FOR ROAD-SIDE PLANTATION

Year	Month		Activities to be done
1st Year	Jan- March	1	Surveying & cleaning of the area
		2	Digging of Pits
		3	Procurement of brushwood and live fencing
2nd Year	April-June	1	Purchase of Farm yard manure
		2	Fencing
		3	Plantation along the road
		4	Filling up of Pits with Farm Yard manure and soil
	July- August	1	Transportation of Plants
		2	Planting of Saplings
		3	Watering
		4	Weeding and hoeing
	Sep-Nov	1	Weeding and hoeing
		2	Watering 4 times a month
	Dec-Feb	1	Weeding and hoeing
		2	Maintenance
3rd Year	March		Watering 4 times a month
	April-June	1	Watering 6 times a month
	July- August	1	Casualty Replacement (20% of the total plants)
		2	Weeding
		3	Maintenance by Mali
	Sep-Nov	1	Watering 2 times a month
		2	Maintenance by Mali
	Dec-Feb		Maintenance by Mali
4th Year	March	1	Watering 4 times a month
		2	Maintenance by Mali
	April- March	1	Watering
		2	Casualty Replacement (10% of the total plants)
		3	Maintenance by Mali

Table 2. Species used in energy plantations with their respective calorific value and specific gravity.

Sr. No	Species	Sp. gravity Calorific value	K cal/kg
1.	*Acacia auriculiformis*	0.60-0.78	4800-4900
2.	*Acacia catechu*	1.00	5142-5244
3.	*Acacia dealbata*	0.70-0.85	3500-4000
4.	*Acacia leucophloea*	0.78	4899-4886
5.	*Acacia mearnsii*	0.70-0.85	3500-4000
6.	*Acacia nilotica*	0.67-0.68	4800-4950
7.	*Aegle marmelos*	0.91	4495
8.	*Albizia lebbek*	0.55-0.64	5163-5166
9.	*Albizia odoratissima*	0.73	5131-5266
10.	*Albizia procera*	0.68	4870-4865
11.	*Alnus nepalensis*	0.32-0.37	4600
12.	*Anogeissus latifolia*	0.94	4948
13.	*Anogeissus pendula*	0.94	4900
14.	*Anthocephalus cadamba*	0.94-0.53	4800
15.	*Artocarpus heterophyllus*	0.51	5318
16.	*Baringtonia acutangula*	0.58	5078
17.	*Bauhinia retusa*	0.72	5027
18.	*Dalbergia sissoo*	0.75-0. 80	4908-5181
19.	*Dodonaea viscosa*	1.20-1.28	5035-4939
20.	*Emblica offcinalis*	0.70-0.80	5200
21.	*Eucalyptus globulus*	0.80-1.00	4800
22.	*Eucalyptus grandis*	0.40-0.70	4900

23.	*Eucalyptus tereticornis*	0.70	4800
24.	*Gmelina arborea*	0.42-0.64	4763-4800
25..	*Eucalyptus camaldulensis*	0.6	4800
26.	*Grevillea robusta*	0.57	4904-4914
27.	*Michelia champaca*	0.45	5068
28.	*Morus alba*	0.63	4371-4773
29.	*Lannea coromandelica*	0.55	4933
30.	*Melia azedarach*	0.56	5043-5176
31.	*Mangifera indica*	0.58	4610
32.	*Madhuca longifolia*	0.56	5043-5156
33.	*Leucaena leucocephala*	0.55-0.70	4200-4600
34.	*Holoptelia integrifolia*	0.63	5228
35.	*Diospyros melanoxylon*	0.79-0.87	4957-5030
36.	*Hardwickia binata*	1.08	4891-4952
37.	*Diospyros montana*	0.70-0.80	5125
38.	*Quercus leucotrichophora*	0.74	4633
39.	*Schleichera oleosa*	0.91-1.08	4928-4950
40.	*Sesbania grandiflora*	0.55	4407
40.	*Shorea robusta*	0.68-0.82	5095-5433
41.	*Syzygium cuminii*	0.67-0.78	4834
42.	*Tamarindus indica*	0.91-1.28	4909-4969
43.	*Tamarix aphylla*	0.60-0.75	4835
44.	*Tectona grandis*	0.55-0.70	4989-5535
45.	*Terminalia alata*	0.71-0.94	5047-5373

ECONOMIC CONSIDERATIONS IN PLANTATION ESTABLISHMENT

Economic consideration for raising plantation are:

1. *Organization costs*: Pay, allowances of field and office staff and their travelling and medical expenses etc.

2. *Labour costs*: It is the payment made to the labour for different operations (survey & demarcation, weeding, cleanning, casuality replacement, fire protection etc). The labour cost would vary according to the species, site method of planting, age and type of nursery stock, type of fencing fire line watch and ward.

3. *Material cost*: it includes:

a) Cost of vehicles viz. jeep, tractor, truck etc.
b) Cost of machinery viz engine, water pump, sprinkler, tiller etc.
c) Cost of implements viz.pic-axe, spade, cow bar etc.
d) Cost of watering, seeds, farmyard manures, fertilizers, polythene tubes, stationary, medicines etc.

While making the budget, it is necessary to calculate average cost per hector and to phase out the expenditure over the period, for which the programme will be in operation. The year wise expenditure is worked out for the different items expenditure which are classified as below.

Plantation operation	**Activity to be done**
Preparatory year operation (PYO) taking up two years in advance of the financial year of planting.	Survey and demarcation, Zonation and treatment map, Nursery preparation, Seed collection and treatment etc.
Pre- Planting Operation (PPO) preceding the year of planting.	TMC fencing, pits, trenches and other soil work, nursery operation, nalla bunding etc.
First year operation (FYO)	Soil and nursery work to be continued during April- June. Plantation and tending operations, watch and ward etc.
Second Year operation (SYO)	Beating up causalities, weeding, soil working, repair to TCM fencing, Nalla bunding and other soil conservation works, watch and ward etc.
Third Year Operation (TYO)	Beating up of causalities, weeding, singling, tending, fir line, watch and ward etc.
Fourth year and Fifth year operation	Tending, Fire line, Watch and ward etc.

4. *Economic returns from the plantation*: Establishment of plantation is a very costly affair. The cost varies depending upon various factors e.g. cost of labour, capital, nurseries, planting stock, equipment, site preparation and various planting operations and treatment after planting. Planting cost is low where the labour is cheap and area is free from fire and biotic interference. The economic return from the plantation will be higher than the cost of investment in raising plantation up to rotation age. There may not be any revenue if the plantation is carried out solely for protection of soil and water or wildlife and aesthetic improvement. In these cases, indirect benefits are many.

PLANTATION RECORDS – JOURNAL (One of the important plantation records is "Plantation Journal")

Plantation journal is a register in which all the details works carried out in a plantation are recorded and properly maintained for reference. It is an important record and should be maintained separately for each plantation and kept up to date. Generally, the journal contains following information:

S. No.	Particulars	Remark(s)
A.	Plantation Map	On the 1st page.
B.	Description of the Area Details of old vegetations Crop felled Revenue received Method of site clearance Soil (Work) preparation Fencing Species selected for plantation Method of sowing /Planting Cultural & Tending operation Growth data of plants Protection	On the next page (2nd page). Area, Compartment number and positional coordinates. The period / time of each activity is recorded and maintained.
C.	Expenditure (Cost of all operations)	3rd page. Tabular form showing expenditure data for each activity.
D.	Detail of Fencing	4th page. Type of fencing and its specifications.
E.	Remarks	Last page contains the remarks of inspecting officer regarding the progress of plantation

The inspecting officer records his remark in the plantation register for the guidance of field staff. It is a very important document to be preserved for ever. It is maintained in duplicate (a) one in the Range Office and (b) other in the division office. They offer the best option for assessing progress of young plantations. Plantation journals should have provision for suitable sampling strategy for the survey. Now-a-days the plantations are well recorded and in many of the cases their positional coordinates are also mentioned in the records.

GOVERNMENT PLANTATIONS

Objective	To achieve objective of First national forest policy, the nation should have a minimum of one-third of the total land area 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.
Purpose	Fuel wood, soil and water protection, mitigation of climate change and increase forest cover.
Ownership	Government and NGO's
Selection of species	Indigenous and
Rotation	Long rotation and short rotation
Rate of growth	Both-slow and fast
Species Composition	Uneven age and mixed crop
Aim	Environmental stability and maintenance of ecological balance

GLOSSARY

Nursery: An area where plants are raising for eventual planting out.

Weeding: A tending operation done in the seedling stage in nursery or in a forest crop, which involves the removal or cutting back of all weeds.

Cleaning: A tending operation done in a sapling crop which involves removal of inferior growth including individuals of favoured species.

Thinning: It is the reduction of trees in an immature stand for the purpose of improving the growth and form of the trees that remain without permanently breaking the canopy of future trees.

Improve Felling: the removal or destruction of less valuable trees in a crop in the interest of better growth of the more valuable individuals (usually applied to mixed uneven aged forest).

Girdling: It is defined as cutting through bark and outer living layer of wood in a continuous incision all round the bole of a tree. It is generally done to kill the tree inside the forest

Pruning: Removal of live or dead branches or multiple leaders from standing trees for the improvement of the tree or its timber.

Block Plantation: Tree plantations in compact blocks of more than 0.1 ha on lands outside recorded forest areas.

Farm Forestry: The practice of cultivating and managing trees in compact blocks on agricultural lands.

Forest Cover: All lands, more than one hectare in area, with a tree canopy density of more than 10 percent irrespective of ownership and legal status. Such lands may not necessarily be a recorded forest area. It also includes orchards, bamboo and palm.

Tree: A large woody perennial plant having a single well-defined stem (bole or trunk) and more or less definite crown. It also includes bamboos, palms, fruit trees, etc. and excludes non-perennial non-woody species like banana and tallmshrubs or climbers. For the purpose of assessing growing stock and tree cover, only those trees having diameter at breast height (dbh) of 10 cm or more are measured.

Tree Cover: It comprises of tree patches of size less than 1 ha occurring outside the recorded forest area. Tree cover includes trees in all formations including scattered trees.

Trees Outside Forests (TOF): TOF refers to all trees growing outside recorded forest areas irrespective of patch size.

Very Dense Forest: Lands with forest cover having a canopy density of 70 per cent and above.

Plantation journal: Plantation journal is a register in which all the details works carried out in a plantation are recorded and properly maintained for reference. It is a important record and should be maintained separately for each plantation and kept upto date.

Nationally Determined Contributions (NDC): Nationally Determined Contributions (NDC) articulates commitments by each country to reduce its national emissions and adapt to the impacts of climate change. Countries across the globe adopted this international climate agreement at UNFCCC Conference of the Parties (COP21) in Paris in December 2015.

Non-Timber Forest Products (NTFPs): It is defined as product or service other than timber that is produced in forests. NTFPs are useful materials or commodities obtained from forests without harvesting (logging) of trees.

Protected Forest: An area notified under the provisions of the Indian Forest Act or other State Forest Acts, having limited degree of protection. In protected forest all activities are permitted unless prohibited.

Reserved Forests: An area so constituted under the provisions of the Indian Forest Act or other State Forest Acts, having full degree of protection. In Reserved forests all activities are prohibited unless permitted.