15. AGRO FORESTRY

The present trend of growing trees in the farm lands demands for identification of economically potential tree species suitable to different climatic conditions and soil types. The concept of agroforestry implies sustained, combined management of the same piece of land for silvicultural, agricultural and pastural crops leading to an overall increase of production compared to single crop management. This practice is of immense importance to our country for it is intimately linked with the question of increasing wood and food production to meet the needs of burgeoning population and conservation of soil, land ,moisture resources which is vital for the tropical regions. Properly distributed tree growth acts as a foster mother to agriculture. This is particularly true in dry inhospitable climatic conditions. Tree growth in such cases conserves soil moisture, increasing atmospheric humidity, improves soil fertility, protects field crops against the scorching and desiccating effects of winds and generally makes the climate more equable and pleasant, thereby stepping up agricultural production.

The silviculture of important agroforestry tree species viz., *Eucalyptus sp., Casuarina spp, Ailanthus excels*a, *Melia dubia*, *Tectona grandis, Santalum album , Pterocarpus santalinus, Neolamarckia cadamba* and *Leucaena leucocephala* are given hereunder .

1. SILVICULTURE OF EUCALYPTUS

Species		:	*Eucalyptus camaldulensis, Eucalyptus tereticornis*
Family		:	Myrtaceae
Common Name		:	Red gum, Mysore gum
Locality Factors	Altitude	:	0 - 1000 m
	Mean Annual Rainfall	:	600 – 1500 mm
	Mean Annual Temperature	:	2°C to 32°C
	Soil type	:	Sandy loams Gravels and Alluvial Soil
Phenology	Flowering	:	Flowering occurs twice a year May to June October to November
	Fruit ripening	:	July December
Silvicultural Characters		:	Strong light demander Coppice - coppices freely and vigorously

Nursery Techniques	Seed Propagation	:	Seeds are raised in the mother bed Germinated seedlings are transplanted Six month old seedlings are ready for planting
	Vegetative Propagation	:	Clonal technology – mini clonal Establishment of clonal mother garden management of mother garden with irrigation and fertilizer Induction of micro suits Cutting of 5 to 10 cm Planting in root trainer filled with coir compost Root initiation within 21 days Hardening 45 to 60 days 90 days old plants are ready for planting
Silvicultural Treatment	Spacing	:	3m x 1.35 m
	Pit Size	:	30 cm x 30 cm x 30 cm
	Basal Application	:	250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP
	Planting Time	:	June to October
	Irrigation	:	3 to 6 litres per day
	Fertilizer Application	:	2kg of FYM and 100g – 500g all 19 every six month once
	Weeding	:	Two weedings per annum for 2 years
	Pruning	:	Self Pruning
	Thinning	:	Only dead and diseased
Rate of growth		:	Fast growing short rotation trees. It yield an average of 125 - 150 tonnes / ha in 3 years.
Rotation		:	3 Years for Biomass, 5-6 Years for Pulpwood 6-8 Years for Ply wood
Utilization		:	Eucalyptus is an excellent raw material for pulp and paper production due to higher pulp yield ranged between 44 and 48 percent. Fuel wood and charcoal due to high calorific value of over 4500 kcal / kg. Wood is strong and used in particleboard and hardboard industries. The leaves of the Eucalyptus species are rich in essential oils

2. SILVICULTURE OF CASUARINA

Species		:	*Casuarina equisetifolia, Casuarina junghuhniana*
Family		:	Casuarinaceae
Common Name		:	Beefwood, She-oak
Locality Factors	Altitude	:	0 - 1000 m
	Mean Annual Rainfall	:	900 – 3800 mm
	Mean Annual Temperature	:	10 - 47° C
	Soil type	:	Best in loose, fine coastal sands. For inland conditions - Well drained sandy soils. It tolerates Lateritic and red soils and also saline, alkaline and acidic conditions.
Phenology	Flowering	:	Flowering occurs twice a year February to April September to October
	Fruit ripening	:	June December
Silvicultural Characters		:	Strong light demander and drought resistant. Susceptible to fire. Coppices badly. Tolerate waterlogged conditions
Nursery Techniques	Seed Propagation	:	Seed treatment – Nil Seeds are raised in the mother bed Germinated seedlings are transplanted Six month old seedlings are ready for planting
	Vegetative Propagation	:	Clonal technology – mini clonal Establishment of clonal mother garden management of mother garden with irrigation and fertilizer Induction of micro suits Cutting of 5 to 10 cm Planting in root trainer filled with coir compost Root initiation within 21 days Hardening 45 to 60 days 90 days old plants are ready for planting

Silvicultural Treatment	Spacing	:	1.5 x 1.5 m to 2 x 2 m
	Pit Size	:	30 cm x 30 cm x 30 cm
	Basal Application	:	250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP
	Planting Time	:	South West and North East monsoon
	Irrigation	:	6 to 8 litres per day
	Fertilizer Application	:	100 kg urea first year in three dozes 150 kg DAP at four dozes in second year 150 complex in three dozes in third year
	Weeding	:	Two weedings per annum
	Pruning	:	Once in every six months
	Thinning	:	Dead and diseases
Rate of growth		:	High Yielding short rotation trees. It yield an average of 100 to 150 tonnes / ha in 3 years.
Rotation		:	Rotation age of Casuarina is 36 months
Utilization		:	Pulp wood: Pulp yield is more than 47 %. Fuel Wood: Calorific value is 4950 Cal/Kg. Timber: Density is 850 Kg/m^3. Wind breaks Poles

3. SILVICULTURE OF MELIA

Species		:	*Melia dubia*
Family		:	Meliaceae
Common Name		:	Malabar Neem, Melia
Locality Factors	Altitude	:	1500 to 1800 m
	Mean Annual Rainfall	:	800 – 1000 mm
	Mean Annual Temperature	:	32 - 40° C
	Soil type	:	Deep, well drained sandy loam soils
Phenology	Flowering	:	November – January
	Fruit ripening	:	January – February
Silvicultural Characters		:	Light demander

			Susceptible to damage by fires Saplings suffer from browsing
Nursery Techniques	Seed Propagation	:	Seed has extracted from this stony endocarp and treated with GA at 100 ppm for overnight. Seed are sown sand bed and germination starts in 30 days Germination is only 40% Germinated seedlings are transplanted in poly bags six month old seedlings area ready for planting
	Vegetative Propagation	:	Clonal technology – mini clonal Establishment of clonal mother garden management of mother garden with irrigation and fertilizer Induction of micro suits Cutting of 5 to 10 cm Planting in root trainer filled with coir compost Root initiation within 21 days Hardening 45 to 60 days 90 days old plants are ready for planting
Silvicultural Treatment	Spacing	:	Plywood : 4m x 4m (or) 5m x 5m (or) 6 m x 6m Pulp & Plywood : a) 6'x 6' (First two years)
	Pit Size	:	30cm x 30cm x 30cm
	Planting Time	:	June to October
	Irrigation	:	Apply light irrigation once in 7 to 10 days. This could be done through drip irrigation
	Fertilizer Application	:	Mixture of compost and organic fertilizers, bio-fertilizer and planting (25-50 g), respectively, to be applied to the pits
	Weeding	:	Annual
	Pruning	:	Annual
	Thinning	:	Thinning of alternate rows at the beginning of 3rd year Thinning alternate diagonals at the beginning of 5th year Final harvest at the beginning of 7th year
Rate of growth		:	For pulpwood: 100-150 tonnes / ha in three years. For Plywood: 200 tonnes / ha in six years
Rotation		:	For Plywood: 5-7 Years For Pulp and Paper: 24-36 months
Utilization		:	The wood is used for packing cases, cigar boxes, ceiling planks, building purposes, agricultural

		implements, pencils, match boxes, splints and Catamarans. It is employed for outriggers of boats. It is suitable for musical instruments, tea boxes and ply board. It is a good fuel wood (Calorific value: 3,400 - 4,100 cal.) The fruit of the plant is bitter. It is considered anthelmintic.

4. SILVICULTURE OF TEAK

Species		:	***Tectona grandis***
Family		:	*Verbenaceae*
Common Name		:	Teak
Locality Factors	**Altitude**	:	0 to 1200 m
	Mean Annual Rainfall	:	1000 - 5000 mm
	Mean Annual Temperature	:	2°C to 48°C
	Soil type	:	Deep and well-drained soil Fertile Alluvial-colluvial soil
Phenology	**Flowering**	:	January to April
	Fruit ripening	:	May to July
Silvicultural Characters		:	Strong light demander Sensitive to frost and drought Good coppicer and pollards vigorously
Nursery Techniques	Seed Propagation	:	Seeds are treated with alternate wetting and drying for 14 days Seeds sown in mother bed Germinations stars after 3rd week 9 – 12 months old seedlings are lifted for stump preparation Stump size 2.5 cm shoot portion 22.5 root portion Stump are used directly for planting
	Vegetative Propagation	:	Nil
Silvicultural Treatment	Spacing	:	2m x 2m
	Pit Size	:	30 cm x 30 cm x 30 cm
	Basal Application	:	2 kg of farmyard manure, 100 g DAP
	Planting Time	:	June – July or September - October

	Irrigation	:	Apply light irrigation once in 7 to 10 days. This could be be done through drip irrigation.
	Fertilizer Application	:	2kg of FYM, 100g of complex fertilizer and 100g – 300g all 19 every six month once
	Weeding	:	Every 3 month once
	Pruning	:	Necessary, Every 6 month once
	Thinning	:	Thinning cycle of 4, 8, 12, 18, 26 and 36 years have been followed for 50 years rotation. In Tamil Nadu the thinning cycle of 5, 10, 18, 25 and 36 years are followed for 50 years rotation. In both the cases, the first two thinning are mechanical and the rest are Silvicultural at C grade thinning.
Rate of growth		:	Teak is a fast grower and attains a height of 15feet to 20 feet in one year under well managed condition.
Rotation		:	20 years under well irrigated and managed condition 40-60 years under forest site condition 15 years under bund plantations.
Utilization		:	Teak is a moderately strong timber with a density of 660 kg/m^3 and is preferred as a most suitable timber both for domestic and industrial utility. Teak is known as a renowned timber due to durability, dimensional stability, working quality and resistant to termites. Teak wood is used in all construction purpose such as beams, columns, doors, windows, flooring, panelling etc. It is one of the best timbers for furniture and cabinet making wagon and railway cadges. For marine construction and ship building teak is preferred due to dimensional stability.

5. SILVICULTURE OF AILANTHUS

Species		:	***Ailanthus excelsa***
Family		:	*Simaroubaceae*
Common Name		:	Tree of heaven
Locality Factors	Altitude	:	0 to 900 m
	Mean Annual Rainfall	:	500 - 1900 mm

	Mean Annual Temperature	:	12.5°C to 47.5°C
	Soil type	:	Porous sandy loams
Phenology	Flowering	:	February to March
	Fruit ripening	:	April to may
Silvicultural Characters		:	Strong light demander Sensitive to drought Moderately frost tender Coppices well and produces root suckers freely. Susceptible to water logging areas
Nursery Techniques	Seed Propagation	:	De winged Seeds soaked in cold water for 5- 7 days by replacing fresh water daily The seeds are dibbled in poly bag and water daily Six month old seedlings are ready for planting.
Silvicultural Treatment	Spacing	:	6m x 6m
	Pit Size	:	30 cm x 30 cm x 30 cm or 45 cm x 45 cm x 45 cm
	Basal Application	:	2 kg of farmyard manure, 100 g DAP
	Planting Time	:	The area is cleared and pits are dug out in the month of February - March and the soil is allowed to weather. The planting in pits is carried out in the month of July.
	Irrigation	:	5 – 8 litres per day
	Fertilizer Application	:	5kg of FYM and 100g – 200g complex fertilizer yearly once
	Weeding	:	Timely and regular weeding for the first two years are very essential
	Thinning	:	The first silvicultural thinning may be carried out in the seventh or eighth year when the tree attains a height of 10-12 m.
Rate of growth		:	Ailanthus is a slow growing tree and attains a height of 10 feet to 15 feet in six year under well managed condition.
Rotation		:	6 – 8 Years
Utilization		:	This species is extensively used for making matchwood boxes and match splints. The wood is extensively used in cottage industries for making wooden toys and cheap quality cricket bats.

		The tree is used for making packing cases and wooden boxes. The wood is used for packing cases, fishing floats and sword sheaths. The leaves are rated as highly palatable and protein rich nutritious fodder for sheep and goats and are said to augment milk production. The stem and branches are used for fuel wood but it gives poor quality fuel as it burns quickly and does not sustain heat for long. The tree is the most adaptable and pollution tolerant. It is suitable for sloppy, degraded and denuded areas and wasteland. It is also yields gum of inferior quality. The bitter and aromatic leaves of the plant show medicinal properties. The leaves are used for the preparation of lotions for scabies. Quassinoids and ailantic acid are isolated from bark. The dried bark is aromatic and burnt as incense.

6. SILVICULTURE OF SUBABUL

Species		:	*Leucaena leucocephala*
Family		:	Fabaceae
Common Name		:	Subabul
Locality Factors	Altitude	:	0 to 1500 m
	Mean Annual Rainfall	:	650 - 3000 mm
	Mean Annual Temperature	:	15°C to 36°C
	Soil type	:	Calcareous soils Saline soils and on alkaline soils up to pH 8
Phenology	Flowering	:	Two flowering season July – November February – May
	Fruit ripening	:	December June

Silvicultural Characters		:	Strong light demander Vigorous coppicer Moderate frost tender Drought resistance
Nursery Techniques	Seed Propagation	:	Seeds are treated with concentrated sulphuric acid and sown directly in the poly bag 3 – 4 months old seedlings are ready for planting
	Vegetative Propagation	:	Seeds sown in mother bed Germinations starts after 3rd week 9 – 12 months old seedlings are lifted for stump preparation Stump size 2.5 cm shoot portion 22.5 root portion Stump are used directly for planting
Silvicultural Treatment	Spacing	:	1.5m x 1.5m; 2m x 2m; 3m x 3m
	Pit Size	:	30 cm x 30 cm x 30 cm
	Basal Application	:	2 kg of farmyard manure, 50 g of super phosphate, 50 g DAP
	Planting Time	:	2-4 month old seedlings can be used to planting out in the month of July.
	Fertilizer Application	:	2kg of FYM and 100g – 500g all 19 every six month once
	Weeding	:	3 month once for first two years
	Pruning	:	Regular during first one year
Rate of growth		:	High yielding short rotation tree It yield an average of 100 tonnes/ha in 3 to 4 years
Rotation		:	4-6 Years depends on location
Utilization		:	Subabul is a hard heavy wood (about 800 kg/m) and medium density wood. Subabul is one of the highest quality and most palatable fodder trees. Subabul is an excellent firewood species with a specific gravity of 0.45-0.55 and a high calorific value of 4600 cal/kg.

7. SILVICULTURE OF SANDALWOOD

Species		:	***Santalum album***
Family		:	*Santalaceae*
Common Name		:	East Indian Sandalwood
Locality Factors	Altitude	:	90 – 1500 m
	Mean Annual Rainfall	:	500-2000 mm
	Mean Annual Temperature	:	15-35°C
	Soil type	:	Sandy clayey red lateritic loamy even in black cotton soil Red ferruginous (iron) loam over lying on metamorphic rocks Rocky ground and stony or gravelly soils
Phenology	Flowering	:	Two Flowering Season February – April October - November
	Fruit ripening	:	May December
Silvicultural Characters		:	Shade bearer Root suckers freely Coppices fairly well
Nursery Techniques	Seed Propagation	:	The seeds exhibits initial dormancy for 3-4 weeks and after 4 weeks it starts germination which is about 60% The uniform and very good germination can be obtained soaking seeds with 0.05% gibberlic acid over night. The sandal seedlings are transplanted along with host plants *viz.*, Casuarina, Cajanus cajan, Albizia, Alternenthra, Amaranthus etc.
	Vegetative Propagation	:	Root cuttings of sandalwood gives only 20 % success.
Silvicultural Treatment	Spacing	:	3 X 3 m to 5 X 5 m
	Pit Size	:	30 x 30 x 30 cm (or) 40 x 40 x 40 cm (or) 60 x 60 x 60 cm
	Basal Application	:	Soil mixture with neem cake 25-50 g / pits, Chlorpyrifos 2 g powder / pit

	Planting Time	:	Monsoon Season
	Host	:	Sandal has association with over 150 species of host. Albizia, Terminalia, Lagerstroemia, Dalbergia, Casuarina, *Acacia nilotica*, *Pongamia pinnata, Wrightia tinctoria* and *Cassia siamea* are the major host plants.
	Irrigation	:	4-5 litres / Day based on the growth
	Fertilizer Application	:	During soil working periods application of farmyard manure @ 5 kg / plant
	Weeding	:	Yearly once
	Pruning	:	Pruning is essential to get good heartwood formation
Rate of growth		:	Slow growing species The heartwood formation in sandal starts after 10 years. The heartwood forms at the rate of 1 kg/annum after 20 years.
Rotation		:	Physical rotation. The dead and naturally fallen trees are harvested
Utilization		:	**Sapwood:** Sapwood is white and scentless used for manufacture of agarbattis. **Heartwood:** Heartwood of sandal is moderately hard, heavy and strongly scented, wood and oil are used in incense, perfumes, soap making and medicines. **Religious:** Sandal is considered sacred by Hindus. **Essential oil:** Valuable oil, 'the sandal oil', is distilled from the heartwood (4-13%) and is used in perfumery, soap making and medicines. Seed oil: Seeds yield oil that can be used in the manufacture of paint. **Medicinal uses:** The wood is bitter, dry, antipyretic, aphrodisiac useful in diseases of the heart, burning sensation, cold, bronchitis, vaginal discharges and small pox.

8. SILVICULTURE OF RED SANDER

Species		:	***Pterocarpus santalinus***
Family		:	Leguminosaceae
Common Name		:	Red sander, Red sandalwood
Locality Factors	Altitude	:	150 – 900 m
	Mean Annual Rainfall	:	350 -1350 mm
	Mean Annual Temperature	:	12 – 47°C
	Soil type	:	Properly drained red soil Dry rocky soil Quartzite, shale, limestone and lateritic soil
Phenology	Flowering	:	April to June
	Fruit ripening	:	February to March
Silvicultural Characters		:	Strong light demander Resistance to fire Excellent coppice Drought resistance even at juvenile stage Produce root suckers freely
Nursery Techniques	Seed Propagation	:	The seeds are soaked with cow dung slurry for 72 hours or seeds are soaked with water for 72 hours with frequent change of water for every 12 hours. Seed rate per bed: 1 kg Germination Percent: 60-70%
	Vegetative Propagation	:	Stump Planting One year old seedlings are preferred for making stumps. The stumps should contain 25-30 cm of roots and 10 – 15 cm of shoot. Survival percentage is 87 %
Silvicultural Treatment	Spacing	:	3 m X 3 m to 6 m X 6 m
	Pit Size	:	30cm x 30cm x 30cm
	Basal Application	:	250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP
	Planting Time	:	September to December Rainy season

	Irrigation	:	Frequent irrigation is essential for initial three years of planting
	Fertilizer Application	:	Farmyard manure @ 4 kg / plant/ year DAP @ 100 g / Plant
	Weeding	:	3-4 weeding per year based on weed pressure.
	Pruning	:	Pruning is essential to obtain straight pole.
	Thinning	:	Thinning is practiced in every 5 year cycle
Rate of growth		**:**	Slow growing tree The maximum height and girth were 12 m and 66 cm respectively Wavy grained tree is preferable.
Rotation		**:**	25 years and above
Utilization		**:**	Wood is fine red colour and beautifully streaked. Wood weight is 900 – 1265 kg / cum with very strong and extremely hard. Timber: Excellent timber with little shrinkage. Musical instruments: wood is used as manufacturing of special musical instrument “Shamisen” The dye santalin extracted from wood is used as medicinal values.

9. SILVICULTURE OF KADAM

Species		**:**	***Neolamarckia cadamba***
Family		**:**	*Rubiaceae*
Common Name		**:**	Kadamba, Japon, Kalempayam, Vellaikkatambu
Locality Factors	Altitude	**:**	300-800 m
	Mean Annual Rainfall	**:**	300 - 1600 m
	Mean Annual Temperature	**:**	5 - 32 ^{o}C
	Soil type	**:**	Prefers well drained entisols
Phenology	Flowering	**:**	May to June
	Fruit ripening	**:**	September to February

Silvicultural Characters		:	light demander Tree coppices well
Nursery Techniques	Seed Propagation	:	The young seedlings are highly susceptible to weeds and should be weeded regularly. 2-month seedlings can be transplanted in nursery beds or into polythene bags, where they can be retained before planting at the start of the monsoon rains
	Vegetative Propagation	:	Clonal technology – mini clonal Establishment of clonal mother garden management of mother garden with irrigation and fertilizer Induction of micro suits Cutting of 5 to 10 cm Planting in root trainer filled with coir compost with the treatment of IBA 1000 ppm Root initiation within 21 days Hardening 45 to 60 days 90 days old plants are ready for planting
Silvicultural Treatment	Spacing	:	3 m x 3 m
	Pit Size	:	30 cm x 30 cm x 30 cm
	Basal Application	:	250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP
	Planting Time	:	June to October
	Irrigation	:	4 to 8 litres per day
	Fertilizer Application	:	2kg of FYM and 100g – 500g all 19 every six month once
	Weeding	:	Two weedings per annum
	Pruning	:	Once in two months
	Thinning	:	Only dead and diseased
Rate of growth		:	Fast growing short rotation trees. It yield an average of 125 - 150 tonnes / ha in 3 years.
Rotation		:	3-4 Years for Pulpwood 6-8 Years for Ply wood
Utilization		:	The wood has a density of 290-560 kg/cu m at 15% moisture content, a fine to medium texture; straight grain; low luster and has no characteristic odour or taste. It is easy to work with hand and machine tools, cuts cleanly, gives a very good surface and is easy to nail

		The timber is used for plywood, light construction, pulp and paper, boxes and crates, dug-out canoes, and furniture components. Kadam yields a pulp of satisfactory brightness and performance as a hand sheet. A yellow dye can be obtained from the root bark Kadam flowers are an important raw material in the production of 'attar', which are Indian perfumes with sandalwood (*Santalum spp*.) base in which one of the essences is absorbed through hydro-distillation The dried bark is used to relieve fever and as a tonic. An extract of the leaves serves as a mouth gargle

MASS MULTIPLICATION OF BAMBOOS USING ENTIRE CULM

Bamboos are the versatile trees, which flowers only once in its life cycle (40-60 years) and dies what is popularly known as parthenogenesis. Hence, seed availability is very less at the same time the seeds are less viable. This difficulty promoted bamboo propagation through two nodal culm cutting with rooting hormone treatment. This conventional technique accounts only less than 25 percent success rate. The present technology is developed using entire culm without rooting hormone treatment and achieved 90 percent rooting.

Remove one year old culm from the matured mother clump at 5-10 years growth stage. Care should be taken to remove the culm without damaging the culm as well as mother clump. The removed culm should be delimbed carefully by leaving growing buds in the nodes. Then, the culm should be placed it in the raised nursery bed and covered with loose soil and sand mixture for half inch thickness. After providing adequate shade to the culms in the nursery bed with coconut sheaths or rice straw, watering should be done to field capacity. Watering twice a day should be continued and shoot emergence will be observed after one month from all buds present in all nodes of the entire culm. Continue watering up to three months. The root emergence could be observed in 2-3 months. After rooting, the rooted culm should be removed entirely from the soil without any damage. To facilitate uprooting the rooted culms without damage, watering should be done. Each rooted node with shoots should be separated with small hand saw. The separated cutting can be transferred to poly bag.

MINI CLONAL PROPAGATION FOR TREE CROPS

A mini clonal technology has been developed for casuarinas and Melia which is one of the pioneering attempts in the country for these industrial wood species. Under this technology, the superior clonal plants were planted in a mini clonal garden and are provided with regular irrigation and fertilization in order to enhance shoot multiplication. In this method, the mother plants are planted at 10 cm x 10 cm spacing and 60 days old plants are ready for collection of cuttings.

Clonal Garden establishment

The clonal garden can be established at a size of 10 x 1 x 0.6 m or 5 x 1 x 0.6 m or 3 x 1x 0.6 m using cement trough or GI trough. The bed should be filled with 20 mm stones upto 25 cm and over which finely sewed river sand can be filled. The trough should have facility for drainage. The raised beds can be covered with 100 micron UV stabilized polyethylene film on the top and covered with insect proof mesh to protect the plants and to ensure its freeness from pest and diseases.

Fertigation

The clonal garden should be maintained with irrigation at an interval of every one hour and supplemented with the following nutrients.

- Urea – 300-400 g/m^2
- SSP – 150-175 g/m^2
- KCL – 175-250 g/m^2
- Micro nutrient mixture – 100 g/m^2

The nutrients can be applied twice or thrice depending on the rate of growth of plants.

Clonal Management

The plants are allowed to grow upto 60 days by applying the required nutrient composition. After 60 days the plants are pruned at required size preferably at half of the plant to induce new shoots. With continuous irrigation and nutrient management the cuttings will start producing shoots from 8-10 days onwards and after 15-20 days the cuttings can be collected and treated with 2% carbendazim solution.

Clonal Treatment

The newly induced shoots were separated from the plants and are treated with or without 1500 ppm IBA (liquid formulation) and planted in 90 cc root trainers filled with decomposed coir pith. The rooting started in 15 days and 25 days old rooted plants are ready for hardening.

Green House Conditions

The root trainers are kept under green house conditions with a temperature regime of 32 – 35°C and a relative humidity of 85-95%. Periodical watering once in every 30 minutes is preferred.

Acclimatization and Hardening

The rooted plants are hardened in a shade house condition with 50% shading for 7-15 days and maintained with adequate irrigations. After hardening chamber, the plants are lifted to open nursery for 30 days. Watering is done 2 times a day and the fertilizer of all

19 (N:P:K) can be applied at the rate of 5g/plant. During this hardening, application of carbendazim (2g/l) or triazophos (2ml/lr) is recommended based on the incidence of diseases and pests.

VALUE ADDITION OF PLANTATION RESIDUES THROUGH BRIQUETTING TECHNLOGY

Briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes besides compacting the loose biomass into dense block.

Raw materials for Briquetting

Almost all agro and forest residues can be briquetted. Agro and forest residues include saw dust, rice husk, groundnut shell, cotton stalks, wood chips etc. Forest residues such as plantation residues, mill residues (ply wood and match wood residues) can be used for making briquettes. All these residues can be briquetted individually and in combination with or without using binders. The factors that mainly influence the selection of raw materials are moisture content, ash content, flow characteristics, particle size and availability of raw materials. Moisture content in the range of 10-15% is preferred because high moisture content will pose problems in binding and more energy for drying. The ash content of biomass affects its slagging behaviour, operating conditions and mineral composition of ash. Biomass feedstock having upto 4% of ash content is preferred for briquetting. Granular homogeneous materials which can flow easily in conveyers are suitable for briquetting.

Briquetting Process

The series of steps involved in the briquetting process are as follows:

i. Collection of raw material

In general, any material that will burn but is not in a convenient shape, size or form to be readily usable as fuel is a good candidate for briquetting.

ii. Preparation of raw materials

Preparation of raw materials includes size reduction, drying, mixing of raw materials in correct proportion, mixing of raw materials with binders etc.

iii. Size reduction

Raw material is first reduced in size by chopping, crushing, breaking, rolling, hammering, milling, grinding, cutting etc. until it reaches a suitably small and uniform sized material (1 to 10). For some material which are available in the size range of 1 to 10 mm need not be sized reduced. Since the size reduction process consumes a good deal of energy, this should be as short as possible. Biomass with irregular size which

was difficult to handle. This size of biomass reduced with the help of Shredder machine. Biomass passed through the shredding machine for size reduction and powder of uniform size is made. Shredder size 22" and sharp rotating blades rotated at a speed of 3300 RPM is used. Generally sieve size is 1/16 inch.

Drying

Raw materials are available with high moisture content than what is required for briquetting. Drying can be done in open air (sun), with a heater or with hot air. At the time of harvesting, the biomass contains more than 40 percentage of moisture content. For briquetting we need the moisture content of biomass to be in the range of 10-12 percent. Moisture reduction is done using a solar dryer.

Raw material mixing

It is done to make briquettes from more than one raw material. Mixing has to be done in proper way so that the product should have good compaction and high calorific value.

Mixing of raw material with binders

Mixing of raw materials with binders in correct proportion is important for the production of briquettes with good compaction. This is best accomplished by a trial and error method of making several briquettes with different mixtures of binding material and testing each for its mechanical strength and burning characteristics. The cost of binding material can be a critical factor for economic success of the project. Natural or synthetic resins, tar, animal manure , molasses, lingo-sulphates, sewage mud, fish water, algae, starch, slime, clay, mud, and cement are some of the binders used in briquetting process.

Compaction

Compaction process takes place inside the briquetting machine and the process depends on the briquetting technology adopted.

Cooling and storage of briquettes

Briquettes extruding out of the machine are hot with temperatures exceeding 200°c and hence they have to be cooled and stored.

Parameters considered for design of the briquette machine:

Bio waste used: saw dust / ground nut / coffee husk / agricultural / forest waste
Max Moisture Level in Bio waste: 8 - 10 %

Output Size	40 mm	50 mm	60 mm	70 mm	90 mm
Capacity kg/hr	200/250	250/350	650/750	900/1100	1500/1750
Length	50 - 300	50 - 300	50 - 300	50 - 300	50 - 300
Power Required	25 HP	30 HP	50 HP	70 HP	90 HP

MULTIFUNCTIONAL AGROFORESTRY

Agroforestry is one of the oldest land use practices which combines the components of agriculture and forestry production within the same unit area of the land. This agroforestry combines the production of diverse but essential resources for local subsistence. The traditional agroforestry has not seen as an intensive or highly optimised production concept. However, its importance and strength is located within its diverse usability in long term production system and comparatively sustainable impacts in environment and ecosystem functions. The traditional agroforestry system has been utilized as a land use system to increase the livelihood security and reduce the vulnerability to climate and environmental change. The agroforestry systems have provided food, fuel, and fodder besides protecting the natural resources. But today, the rapid phases of population growth coupled with developmental projects have necessitated large volume of wood and wood products from tree outside forests particularly from agroforestry plantations. The industrialization and globalization has made production process more intensified and highly specialized. However, the agroforestry practices are unable to keep up with the higher economic and mono-culture oriented production.

In India, the agroforestry supports nearly 72% of fuel wood demand, over 70% of plywood, 60-80% of pulpwood and around 11% of fodder needs besides satisfying the domestic needs of the society. In case of timber demand the agroforestry is able to meet 2/3rd of the requirement. The role of agroforestry in soil water conservation, Biodiversity conservation and mitigation and adaptation to climate change are very well established. Hence, agroforestry has played a significant role in extending the multifunctional benefits to the society and to the environment. Against this back drop Forest College and Research Institute has conceived and developed a Multifunctional agroforestry model for adoption to double the farmer's income through enhancing productivity per unit area.

MULTIFUNCTIONAL AGROFORESTRY SYSTEM – A PILOT MODEL

The Forest College and Research Institute of Tamil Nadu Agricultural University has designed and established a multifunctional agroforestry model on a pilot basis in 0.75 acre of land. This multifunctional model has been conceptualized with an idea of ensuring monthly income to the farmers practicing the model. This model is conceived based on the fact that the government officials are getting salary on 30th of every month

and it is based on this idea the model is conceived and implemented that every month the farmer may also get income from one or other components of multifunctional agroforestry systems. Accordingly the model has been established and it consists of the following components.

Table 1. Components of Multi-functional Agroforestry Model

Tree Components	
High value trees	*Santalum album, Pterocarpus santalinus, Aquilaria agallocha and Dalbergia latifolia*
Timber species	*Tectona grandis, Terminalia tomentosa*, *Pterocarpus marsupium*
Plywood trees	*Melia dubia, Neolamarkia cadamba, Swietenia macrophylla, Melia volkensii*
TBO's	*Jatropha curcus, Pongamia pinnata*, *Madhuca longifolia, Callophyllum inophyllum.*
Medicinal Trees	*Terminalia arjuna, Annona reticulata, Strychnos nuxvomica, Aegle marmelos*

Horticultural components	
Fruit crops	Guava, Custard apple, Amla, Jamun, lemon
Leaf crops	Moringa, Curry leaf
Flower crops	Jasmine, Mari gold
Medicinal plants	*Senna auriculata, Hemidesmus indicus*
Agricultural components	
Agricultural Crops	Greens, Pulses, Vegetable, Oilseeds
Pastoral components	
Grasses	CO-3 and CO-4

Intercrops	**No of plants**	**Per plant yield (kg)**	**Total yield (kg/ year)**	**Cost Rs./kg**	**Total cost Rs.**
Jasminum grandiflorum	100	2	200	200	40000
Curry leaf	350		80	20	1600
Jasminum officinale	72	0.8	57.6	200	11520
Nerium oleander	28	0.35	9.8	50	490
Fodder	300	8	2800	2	5600
Moringa oleifera	16	8	128	50	6400
Total Income					**65610**

Beneficiary	:	Family Farming (4 Member Family)
Cost of establishment	:	1 lakh / acre including micro irrigation facility
Revenue	:	Atleast Rs. 550 – 1000 / day

All these components have been incorporated in a circular model and the same .After three to six months of development, the annual crop components start generating income and after one year, the entire model has become functionally active to generate income on monthly basis to the growers. The functionality and its economic impact are monitored from the inception of the model and will bring good database for promoting multifunctional agroforestry system in a long term approach.