Draft

Report on Improving the Productivity of Eucalyptus Clonal Pantations, Mechanization and Marketing of Eucalyptus and Bamboo

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IMPROVING PRODUCTIVITY FROM EUCALYPTUS CLONAL PLANTATIONS OF TSFDC

Introduction:

The genus Eucalyptus belongs to the family Myrtaceae, of Australian origin having more than seven hundred species (Brooker, 2000). The somatic chromosome number in Eucalyptus is 2n = 22. It is a cross-pollinated species resulting in wide variation and heterozygosity in the population. Eucalyptus shows wide adaptability in different climatic zones and is an important species all over the world for the essential oil it produces and, in the paper, and pulp industry, rayon, charcoal, energy, furniture, housing, etc purposes.

A brief on the introduction of Eucalyptus in India

1. It was reported to have been first planted around 1790 by Tippu Sultan, the ruler of Mysore, in his palace garden on Nandi hills near Bangalore. He probably received seed from Australia,

2. After the planting at Nandi Hills, the following significant introduction of Eucalyptus was in the Nigiri hills, Tamil Nadu, in 1843, and later regular plantations of E. globulus were raised to meet the demands for firewood, from 1856.

3. Since then, several other attempts have introduced eucalyptus in various parts of the country. Attempts were made to introduce Eucalyptus without actually knowing its species. This led to the introduction of a large number of sps of Eucalyptus in India.

4. In 1954-55 herbarium specimens of eucalyptus trees grown at Nandi hills were sent to Australia and it was found that by then E. camaldulensis, E. citriodora, E. crebra, E. major, E. intermedia, E. polyanthemos, E. robusta, E. tereticornis, E. tessellaris, a hybrid of

E. robusta x E. tereticornis, and a hybrid of E. botryoides x E. tereticornis, were there in India.

5. The first Forest Departmental Eucalyptus plantation was raised in 1877 at Devarayanadurga, Tumkur District of Karnataka.

6. Since the early 1960s' Eucalyptus has been planted in other states of India. For example- AP experimental plantations of Eucalyptus started in 1874, but regular plantations from 1960 onwards, Gujarat from 1961, Maharashtra from 1961, UP from 1962, Haryana from 1962, Bihar from 1962, Goa from 1963, West Bengal from 1963, and MP from 1965-66 onwards,

7. Till now 170 species/ varieties of Eucalyptus have been tried in India.

Utilization of Eucalyptus

The productivity of Eucalyptus varies from country to country with changing climatic, edaphic, and geographic conditions.

Wood properties are very important for the industry because they have an impact on processing costs, production gains, and the technological qualification of the products and are therefore essential in the production processes of raw materials for industrial use.

The growing importance of Eucalyptus for the pulp and paper industry, particularly in South America and Africa, **led to the establishment of breeding programs selecting better hybrids for cloning and improving the basic populations** introduced from Australia. Lots of research went into this field that led to the development of a large number of hybrids and clones of Eucalyptus, all over the world.

It is interesting to know that the development of **Clonal Techniques in Eucalyptus was started in the year 1975 in the Republic of Congo** (Delwaulle et al., 1983). Outstanding genotypes, usually hybrids, having

large and straight trunks with good wood properties were selected to make rooted cuttings and planted in large extensions of land. Vegetative propagation has been intensively used by the pulp and paper industry, producing highly uniform timber and allowing further gains in productivity in the pulping process. In the mid-1970s the development of tissue culture techniques and in vitro propagation of Eucalyptus spp. provided new opportunities for mass propagation, on a commercial scale, of selected genotypes.

The productivity from the clonal plantations of Eucalyptus is highest in countries like Congo, Brazil, and Papua New Guinea ranging from 80 to 90 m3/ha/year whereas in India, the productivity of Eucalyptus wood ranges from 6 to 10 m3/ha/yr in seed route plantations (Lal, 1993) to 20 to 23 m3/ha/yr in rainfed areas and 50 m3/ ha/ yr in clonal based plantations (Lal, 2001; Kulkarni, 2002).

Breeding and Cloning in Eucalyptus

(A) Breeding in Eucalyptus

1. Development of the **Agrobacterium system**, helped in the **development of the first transgenic Eucalyptus trees**
2. Advances made in the use of **molecular markers** have played an important role in helping breeders select Eucalyptus trees with better wood quality, disease resistance, and stress tolerance.
3. The development of genomic approaches, such as major **expressed sequence tag (EST) sequencing programs**, has increased the interest in the application of biotechnological tools to produce better Eucalyptus trees.

(B) Cloning in Eucalyptus

- The first rooted eucalyptus cutting was obtained in Australia in the 1940s (Eldridge et al., 1993).

- French researchers in the Congo, Tunisia, and Morocco played an important role in understanding physiological phenomena involved in the rooting of Eucalyptus, such as juvenility and maturation, as well as aspects of rejuvenation in Eucalyptus and their importance in cloning adult trees. This knowledge was important in establishing the concept of Eucalyptus clonal forests, which occurred in the 1970s in Tunisia (Chaperon, 1987) and in Brazil (Campinhos and Ikemori, 1980).
- The techniques initially used for the stem-cutting rooting of Eucalyptus, as well as the rooting facilities, remained practically the same until the early 1990s.
- In 1992 the first great change in the rooting technique occurred when micro-cutting and later mini-cutting were created. Micro-cutting is a method where the propagules are obtained from shoot apices originating from micro-propagated plants and in mini-cutting propagules are obtained from auxiliary sprouts of plants cloned by stem cuttings
- Propagule production began to be performed in a super-intensive manner, supported by hydroponic systems in controlled environments (greenhouses). Currently, two hydroponic systems are used: sand bed with drip irrigation (Higashi et al., 2000) and intermittent flooding (Campinhos et al., 2000).

Work on Clonal Seedling Production in India

The year 1984 heralded quite a few remarkable developments leading to the development of commercial-scale clonal plantations in India since then a large number of Eucalyptus clones have been developed in India by Government research institutes like FRI, and UP Forest Department, and by private players like ITC Bhadrachalam, WIMCO,

Ballarpur Industries, J K Paper Mills, Pragati Biotechnologies Limited, Jalandhar, etc to name a few.

Pioneering work was undertaken in India by ITC Bhadrachalam and it produced a large number of Eucalyptus Clones suitable for various physiographic conditions, for example,

- The most important commercial clones are - 3, 6, 7, 10, 27, 71, 72, 99, 105, 115, 122, 128, 130, 223, 265, 266, 271, 272, 273, 274, 175, 277, 284, 285, 286, 288, 290, 292, 316, 319, 405, 411, 412, 413, 417, 439 and 470
- It produced clones that are **adaptable to alkaline soils**, they are - 1, 10, 27, 71, 99, 105, 115, 116, 122, 128, 130, 158, 223, 266, 271, 272, 273, 274, 277, 290, 316, 318, 328, 410, 411, 412, 413 and 417.
- They produced **plastic clones** like- 27, 71, 83, 99, 105, 116, 128, 130, 147, 271 and 285.
- The important disease-causing pathogens of Eucalyptus are Cylindrocladium spp. and Alternaria spp. Scientists developed clones like Cl. 1, 3,6,7,288, and 316 which are **disease resistant**.
- Clones that **develop clear bole** are 1,4,6,7,27,122,22, 265, 266, 272,274, 275, 284, 286,288, 290, 292, 316 and 319
- Clones that **produce the wood the most and the best** are 3,6,7,10,105,130,265,26 6,272,274,284,290,292,316 and 319.
- More than 225 clones are **evaluated for pulp and paper properties**. The high pulp yield of 50 to 53% is recorded for E. tereticornis clones 3, 6, 7, 10, 27, 158, 273, 274, 279, 286, 288, 411, 412, 2014, and its hybrids 2050, 2121, 2129, 2135, 2140, 2143, 2156, 2294, 2306, 2315 and 2401 as against 44% from the wood derived from unimproved seed source plantation.

(***Source**: Pulp and Paper Industry Raw Material Scenario - ITC Plantation A Case Study by Kulkarni H.D*)

(C) Hybridization in Eucalyptus

- The first **Synthetic Eucalyptus hybrids** were produced in the 1970s by open-pollination between compatible species
- Since this technique was limited by crosses between species that flowered at the same time, in the 1980s a **controlled crossing method** was developed in South Africa. This technique has its disadvantages, like cost incurred in repeated visits by the pollinating workers, flowers of eucalyptus trees are to be isolated, etc
- In 1996, a new technique for controlled crossing was developed, called **AIP**. This new technique was initially developed at Riocell S.A. and its great advantage is higher operational yield and better use of the flower buds
- Then came the concept of **indoor breeding orchards**

In India, lots of work happened in the field of Hybridizing the Eucalyptus. Hybrids were produced by crossing the different Eucalyptus species like E. tereticornis x E. urophylla, E. tereticornis x E. camaldulensis, E. tereticornis x E. alba, E. tereticornis x E. torelliana, etc.

Eucalyptus in Telangana by TSFDC

The Telangana State Forest Development Corporation Limited was incorporated on 14.05.2015, under the Companies Act 2013 and a Trust under the India Income Tax 1961. The organization was established to raise man-made forests to meet the domestic and industrial needs of forest produce reclothe the degraded forest areas and bring them under productive use.

The major objectives and the re-defined objectives of the TSFDC are mentioned below:

Objectives:

- To raise industrial plantations like Eucalyptus, Bamboo, etc., to meet the raw material requirement of the wood-based industries in the state.
- Contributing to the protection of the environment and increased forest land productivity.
- Providing gainful employment to the local tribals and rural people.
- To provide consultancy in raising plantations of various species.

The re-defined objectives:

- Improving the quality and productivity of the degraded forests and plantations.
- Contributing to the protection of the environment and increased forest land productivity.
- Adoption of Watershed Approach.
- Adoption of latest gains in Bio-technology for improved productivity.
- To provide gainful employment to the local people.
- Capacity building.
- Implementation of Eco-tourism projects.

Activities of TSFDC:

In pursuit of fulfilling the objectives of the organization, TSFDC, till now has achieved the following:

- The plantations raised by TSFDC can be broadly grouped under. (i) The Eucalyptus, Bamboo, Teak, Subabul, Casuarina, etc., plantations raised & maintained in Kothagudem, Paloncha, Sathupalli, Warangal, Kagajnagar, Medak and Ranga Reddy divisions. (ii) The Cashew plantations raised and maintained in the plains in red soil belts of Kothagudem and Paloncha divisions of Bhadradri Kothagudem District
- The area under different species raised by TSFDC is as follows

Species	Area
Eucalyptus	
(a) Clonal Plantations	21775.74 ha
(b) Seed origin	680.07 ha
Area under Eucalyptus	22,455.81 ha
Bamboos	6237.82 ha
Cashew	105 ha
Teak	215.86 ha
Other species	67.50 ha
Total	29085.85 ha
Area not under use	1760.40 ha
Area under litigation	2105.38 ha
Total Area	32951.39 ha

- TSFDC apart from raising the plantations for commercial use, is involved in activities like developing the eco-tourism sites like- Botanical Garden and Pala pitta Cycling Park at Kondapur, Mahavir Nischal Van Eco-Tourism Centre, Vanasthalipuram, Shamirpet Deer Park and Mrugavani National Park at Chilkur.
- It has taken up consultancy works for NTPC & RFCL in raising the Avenue plantations along the Rajiv Rahadari Highway in the Peddapalli district
- Involved in the raising of Miyawaki plantations (its adopted model is called the Yadadri Model of Plantations.

- The organization always tried to manage its plantation areas with a watershed approach to improve the site quality of plantation areas and make them ecologically sustainable, socially acceptable, and commercially viable.

General Description of The Growing Stock

Champion and Seth's classification, the Forests of the State fall under Dry Mixed Deciduous Forest (accounts for 60.52 percent), Dry Teak Forest (14.84 percent), Dry Bamboo (0.07 percent), followed by Dry Savannah Forest at 0.22 percent, and Southern Thorn Scrub Forest in the selected areas.

The forests under the management of the TSFDC can be classified based on H.G. Champion and S.K. Seth (1968) into the following types:

i) Southern Tropical Secondary Dry Deciduous Forests (SA/2S1) These forests are found in districts like Khammam, Warangal, Karimnagar, and Adilabad, where large forest areas are leased out to TSFDC and the organization has undertaken the Eucalyptus and Bamboo Plantations. The main floristic composition in these areas being Tectona grandis, Pterocarpus marsupium, Terminalia alata, Adina cardifolia, Stercurlia urens, Soymida febrifuga, Terminalia bellerica, Lagerstroemia parviflora, Lannea coramandelica, Chloroxylon swietenia, Cochlospermum gossypium, Diospyros melanoxylon, Aegle marmelos, Buchanania lanzan, Bridelia retusa, Cassia fistula, Emblica officinalis, Bauhinia vahlii, Butea superba, Dendrocalamus strictus, etc

ii) Southern Thorn Forests (6A/C1) These Forests are found mainly in Ranga Reddy and Medak Districts. These forests are mostly open forests. Thorny woody species predominate. Acacia sp. and Fleshy Euphorbias are usually present. The major floristic composition of

these forests is: Azadirachta indica, Chloroxylon swietenia, Cassia fistula, Bauhinia racemosa, Opuntia dillenii, Gymmosporia montana, Dodonaea viscosa, Dichrostachy scineria, Acacia leucophloea, Canthium didymum, Zyzyphus xylopyrus etc., The soils are also degraded and eroded considerably due to continuous exposure and poor rainfall. The productivity of these forests is negligible. In the leased-out forest areas, the TSFDC has raised eucalyptus plantations.

Few Numbers:

1. Area Division wise, species wise:

Division wise Species wise in TSFDC (Area in hacs)									
Name of the Division	**Area with TSFDC**	**Eucalyptus**	**Bamboo**	**Cashew**	**Teak**	**Other Sps**	**Total area under plantations**	**Area not under use**	**Area under Litigation**
Paloncha	5946.61	4206.00	1230.00	46.00	66.00	4.00	5552.00	181.74	212.87
Kothagudam	7414.68	4043.59	2234.30	59.00	82.87	0.00	6419.76	309.51	685.41
Sathupally	5573.71	2148.66	2463.48	0.00	0.00	0.00	4612.14	119.78	841.79
Kaghagnagar	4713.79	4115.39	0.00	0.00	25.04	0.00	4140.43	348.49	224.87
Warangal	2965.59	2167.16	206.55	0.00	0.00	0.00	2373.71	522.88	69.00
Ranga Reddy	4195.74	3753.46	103.49	0.00	41.95	63.50	3962.40	233.34	0.00
Medak	2141.27	2025.41	0,00	0.00	0.00	0.00	2025.41	44.66	71.20
Total	**32951.39**	**22459.67**	**6237.82**	**105.00**	**215.86**	**67.50**	**29085.85**	**1760.40**	**2105.14**

(Source: Management Plan of TSFDC)

2. The Plantation area under Clonal Eucalyptus and Seed origin:

S. No	Division	Clonal Plantation area in Ha	Seed Origin Plantation area in Ha
1	Sathupalli	2148.66	0.00
2	Kothagudam	4043.59	0.00
3	Paloncha	4088.83	113.31
4	Ranga Reddy	3656.53	96.93
5	Medak	1595.58	429.83
6	Warangal	2167.16	0.00
7	Kagajnagar	4075.39	40.00
	Total	**21775.74**	**680.07**

Dwindling Yield:

The yield of planted Eucalyptus is going down drastically. As per the information available in the Management Plan of TSFDC, the yield obtained in different species is mentioned below:

The average yield of Eucalyptus division-wise during 2017-18 to 2020-21 (Tons/Ha)

Year	Kothaguda m	Paloncha	Sathupall i	Ranga Reddy	Medak	Warangal	Kagajnagar	Averag e
2017-18	87.96	77.38	75.60	50.34	37.68	82.51	85.29	79.94
2018-19	71.93	65.69	53.88	51.28	38.07	73.27	88.96	60.48
2019-20	77.20	78.03	53.89	34.03	-	94.19	107.82	64.13
2020-21	73.35	76.30	75.49	19.94	-	79.46	81.20	52.84
Average	**82.34**	**73.79**	**65.40**	**30.48**	**37.96**	**82.15**	**87.46**	**65.36**

(Source: Management Plan of TSFDC)

Mian factors that decrease the yield and possible remedies:

The Man remains the Chief Destroyer of the forests. Once the need-based existence of man, now has become greed-based. Nature gives and forgives, but the man gets and forgets. The human populations living in the proximity of forest plantations/ forests exert pressure on them by way of felling, lopping, hacking, setting ground fires, grazing cattle, collecting minor forest produce, etc. These agents of destruction are affecting the soils in a great way.

A brief on these degrading agents that are affecting the overall forest health is mentioned below:

Fire

Fire can be a single factor that can cause considerable and quick destruction of flora and fauna of the Forests. Forest fires can be a recurring feature during the dry and hot periods from April to June. Generally, most forest fires are caused by the grazers, collectors of minor forest produce, and by the negligence of wayfarers.

Forest Fires in general are a major cause of forest degradation and have wide-ranging adverse ecological, economic, and social impacts, including:

- Cause injuries to the trees
- Loss of valuable timber resources
- Degradation of catchment areas
- Loss of biodiversity and extinction of plants and animals
- Loss of wildlife habitat and depletion of wildlife
- Loss of natural regeneration and reduction in forest cover
- Global warming
- Loss of carbon sink resources and increase in the percentage of CO_2 in the atmosphere
- Change in the microclimate of the area with unhealthy living conditions
- Soil erosion affects the productivity of soils and production in long run.

Remedial measures for protection from fire

Fire in the forests always is a major concern to the foresters. Uncontrolled forest fire causes immense damage to the forest ecosystem. The impact of fires on plantations can be lessened by

1. Having a strict vigil during the fire period
2. Having fire lines/ fire breaks in the plantations at regular intervals
3. Lessening the quantity of inflammable materials during winter by way of cold burning the plantation areas,
4. Implementing modern fire-fighting measures in the corporation (use of technology in Forest Fire Management, aided by ergonomic forest fire-fighting instruments)
5. Understanding fire vulnerability and fire spread model that could provide sufficient data for detailed fire control planning,

6. Regular Fire alerts can be received from FSI on the registered mobile numbers and immediate action to be taken by the field staff in dousing off the fires.

Grazing:

Grazing is an obligatory evil that the forests and the plantations have to bear. Livestock grazing and its unsustainability on forest lands have been under debate for the better portions of the last hundred years. Goats allowed stealthily can cause heavier damage to the young crop and plantations and it might prove to be among the most destructive biotic forces.

The grazing animals act as carriers of various pests, pathogens, and weeds. **So, control of the grazing is essential, otherwise, it affects the yield from the plantations**.

Climate:

Climatic factors such as wind and drought do cause some injuries to trees in the forests and plantations. But they are not very serious. Wind causes damage to the newly raised plantations. Sometimes mortality is caused in the younger plantations by drought.

Water Stress

Water stress kills the eucalyptus seedlings. Even though eucalyptus is known as a drought-tolerant plant, nevertheless for optimum productivity, it needs at least 25-30 sessions of irrigation in its entire growing cycle. And, this should begin immediately after transplantation in the main field. If monsoon is considerably insignificant, which is often experienced by farmers, consider providing protective watering given the need. Make sure to stay away from overwatering while drip irrigation is always the best choice for eucalyptus plantation. Irrigation is mainly vital in the dry season as well, minimally in winter.

Damage by Wild Pigs:

Wild boars and peacocks are commonly noticed in the areas held by TSFDC and are doing some damage to the plants.

Weeds/ Injurious plants:

Most of our Forests are getting invaded by Invasive Alien Plant Species, causing immense damage to the Forest Ecosystems. Many of our productive and prime forests now have lots of invaders in them, and these invaders are not allowing the natural generation of local species to come up.

In India, at present, there are about 200 Invasive Weed species and these are spreading thick and fast in our natural ecosystems. These invasives have the highest grade of Phenotypic Plasticity that allows them to immediately take up the space of disturbed areas.

These weeds have short phenology. RNA in these plants makes them more adaptive— for example, almost all of the grass weeds produce seeds with very hard seed coats just before summer (whereas natives produce seeds just before the onset of the rainy season) and the seed coat of these seeds gets withered in fire. So, in grasslands, it is next to difficult to eradicate weedy grasses through burning. If we burn grasslands, the seed coats of weeds get withered and the weeds start germinating even well before the native grasses start flowering and thus there is no competition.

Their requirement for water is also very minimal. m-RNA, in the parasitic plants, start communicating with their host plants in such a way that the host plants start recognizing the weeds as a part of their body and because of it, the host plant doesn't produce necessary defense mechanisms like- flavonoids, resins, ABA, Ethylene, Cytokinins, etc. Thus, eradicating weeds from the Forest Ecosystem is a difficult task.

Now, we are in the era of Eco Restoration, hence the need of the hour is all foresters must start equipping themselves with knowledge and make sincere efforts to stop such plant invasions. It's time for the foresters to understand the complex mechanism that takes place in the biology of plants. Need to understand it and need to have more studies done.

Weed Management

In India, weeds are one of the major biological constraints that limit crop productivity. They compete with crops for natural and applied resources besides being responsible for reducing the quantity and quality of agricultural productivity [Rao and Nagamani 2010, 2013; Rao et al. 2015].

Thanks to the wide inter-row spaces and open canopy in the early phases of establishment, Eucalyptus plantations represent ideal places of floristically rich and diverse weed flora. Weeds have an exceptional capacity to adapt to environmental conditions because most of them produce vast quantities of seeds which enable their great expansion. In afforested areas, the weeds can imperil the survival and development of young seedlings by changing the basic living conditions of soil like humidity, light, and nutrients. Damages caused by weeds are greater than those caused by diseases and pests together (Kojic et al.,1996).

Weeds show considerable plasticity in numerous ecological factors. One of the most important traits is their adaptation ability. They have pronounced resistance to unfavorable environmental conditions like drought, moisture, etc. Many weeds are resistant to plant diseases and pests. Also, one of the weed traits is the periodicity of germination. Very often weed seeds do not germinate at once, but rather in different periods, and it is hard to control weeds. In addition, weeds produce an enormous quantity of seed, which makes it easier for them to spread and expand in space. The seeds produced by most of the weeds have a thick seed coat

and wither when they are subjected to fire and the dormancy period of seeds is very high. The weeds spread through vegetative propagation too, which makes them sturdier and more difficult to eradicate.

Classification of weeds:

Weeds are generally classified into the following categories. A brief on their control is given below:

1. Annual, Biennial, and Perennial Weeds:

The main target in the control of **annual weeds** is to destroy these before their flowering period to prevent further seed production in them. Both, tillage and herbicides prove more effective against annual weeds when these are treated at their seedling stages than at their grown-up stages. The control measures of **biennial weeds** are planned along with those of the annual weeds. Some of the annual weeds that are troubling the plantations and crops in India are: Chenopodium album, Phalaris minor, Ageratum conyzoides, Echinochloa spp., Digera arvensis, etc

The aerial parts of **perennial weeds** wither every year at the end of a season after producing flowers and seeds, but new shoots develop again from the underground vegetative organs like roots, rhizomes, tubers, stolons, and bulbs at appropriate times. The root system of these perennial weeds can grow down to about 1 meter. The perennial weeds are very difficult to control. Tillage may temporarily destroy the aerial shoots of perennial weeds to give a clean look to the land, but actually, it spreads its underground parts to the fresh spots by fragmentation. Each piece of rhizome, tuber, or bulb of perennial weed then grows into a new plant which finally takes the shape of a full-fledged infestation.

Some of the **shallow-rooted perennial weeds** that are prevalent in India are: Cynodon dactylon, Agropyron repens, Scirpus sp., Cyperus esculentus, Allium vineale, Rumex crispus, etc.

Some of the **Deep-rooted perennial weeds** are-- Cirsium arvense, Convolvulus arvensis, Sonchus aroensis, Solarium elaegnifolium, Euphorbia esula, Mikania micrantha, Pluchea lanceolata, Cyperus rotundus, Sorghum halepense, etc.

2. Grasses, Sedges, and Broadleaf Weeds

Herbicide 2,4-D (and MCPA) was found to easily kill the broadleaf weeds

3. Woody and Herbaceous Weeds

The herbaceous weeds can be easy, by ploughing and by using herbicides, but the woody weeds like- Lantana (Lantana camara), mesquite (Prosopis juliflora), wild Indian plum (Zizyphus rotundifolia), poison oak (Rhus spp.), blackberry (Rubus allegheniensis), multiflora rose (Rosa multiflora), etc are difficult to eradicate. Uprooting them is the only solution for the control of the spread of these weeds.

4. Parasitic Weeds

In the context of Eucalyptus plantations, these weeds have no role to play. These kinds of weeds affect agricultural crops only.

5. Crop-Associated and Crop-Bound Weeds

In the context of Eucalyptus plantations, these weeds have no role to play. These kinds of weeds affect agricultural crops only.

6. Alien and Invasive Alien Weeds

When a weed is allowed to move from the place of its origin to a new area, and it establishes itself there, it becomes an alien weed in its new environment. In India, there is a large number of introduced weeds brought chiefly from tropical America and Australia, during the eighteenth and nineteenth centuries. By now all these introduced weeds have become so widespread in the country that they look like indigenous species.

Some of the alien weeds are: the seeds of carrot grass (Parthenium hysterophorus), corncockle (Agrostemma githago), and Solatium elaegnifolium came to India with imported food from the USA. The seeds of alligator weed (Alternanthera philexeroides) were brought accidentally with packing material from South America during the Second World War. Chrotnolaena odorata is native to America from where it was navigated to India. Water hyacinth (Eichhornia crassipes), Lantana (Lantana camara), and salvinia (Salvinia molesta) were brought into India as ornamental plants. Fruits and seeds of Clidemia hirta, a tropical American species first noticed in India in Kerala rice fields, were introduced perhaps by the bird Indian Myna. Puncture vine (Tribulus terrestris) was brought to India from the Mediterranean region with aircraft tyres.

When alien weeds are too difficult to eradicate, they are called Invasive Alien Weeds. Some of the IAWs are Ageratum houstorium, Alternantliera philoxeroides, Chromolaena odorata, Eichhornia crassipes, Lantana camara, Mikania micrantha, Mimosa spp., Cuscuta spp., Ipomoea carnea, and Phalaris minor.

7. Facultative and Obligate Weeds

In the context of Eucalyptus plantations, these weeds have no role to play. These kinds of weeds are on agricultural crops only.

8. Noxious Weeds

A noxious weed is defined as a plant that is especially undesirable, troublesome, and difficult to control.

Some common noxious weeds in India today are- Cyperus rotundus, Cynodon dactylon, Parthenium hysterophorus, Eichhornia crassipes, Solanum elaegnifolium, and Orobanche spp.

9. Objectionable Weeds

Weeds that produce seeds that are difficult to separate once mixed with crop seeds are called objectionable weeds. In the context of

Eucalyptus plantations, these weeds have no role to play. These kinds of weeds are on agricultural crops only.

10. Aquatic Weeds

In the context of Eucalyptus plantations, these weeds have no role to play.

11. Industrial Weeds

In the context of Eucalyptus plantations, these weeds have no role to play.

12. Grassland Weeds.

Some grassland weeds have mechanisms to keep the animals away, like bitter leaves, poisonous foliage, prickly shoots, and hard stems. In the context of Eucalyptus plantations, these weeds have no role to play.

Weeds and their requirement of light:

Light plays an important role in the spread and establishment of weeds. Regarding light requirements, the weeds are classified into

Sciophytes – plants developing in the shadow of weakly thinned forest stands or dense forest stands and represent no threat to tree development;

Semisciophytes – semi-shadow plants that develop in thinned stands and can do a lot of harm; and

Heliophytes – plants of open habitats such as clearings, strips, burnt areas, etc., represent a big threat to the development of trees.

Heliophytes cause immense damage to the Eucalyptus plantations

How to eradicate the Weeds from the Eucalyptus plantations

The easiest way to kill the weeds in the plantations is by applying weedicides and herbicides. However, the Corporation is aiming at certifying the wood that they are producing in their plantations and as they are committed to social responsibility of not releasing harmful chemicals into the environment, they are avoiding these chemicals.

There are numerous measures and procedures for weed control in forestry today, but to fight weeds successfully, they should consist of different care and control measures. Some of the measures to control weeds are listed below:

Preventive measures

The main goal of preventive measures is to prevent the spread of weeds,

Preventive measures include:

- Showing only pure crop seeds that prevent the spread of weeds over sown surfaces. This is a very important activity because TSFDC is sowing seeds of species like alternatha, etc in their plantations,
- Destruction of weeds in the nearby plantations, so that the weeds will not spread from there,
- Prevention of the spread of weed seeds by human activities by keeping the machinery and objects clean.
- Limiting soil disturbances;
- Immediate re-vegetation of disturbed sites;
- Use of “weed-free” hay bales for erosion control and
- Early detection and eradication by training field staff in the identification of invasive plants,
- Conducting invasive plant survey before the commencement of any land-disturbing activity to identify potential problem areas,
- The primary aim of the managers should be **not to feed the weeds**.

Mechanical measures

Mechanical measures for combating weeds include basic treatment such as ploughing, hand and rotary hoeing, farrowing, disking, tilling, mowing (cutting the weeds to the ground), harrowing, and the use of rototillers and cultivators.

The mechanical methods are **effective** for controlling larger weeds, as they have a higher impact on root-propagated weeds, bury the weeds and their seeds deep in the ground, prevent their germination, improve the soil moisture status and accessibility of decomposers to organic residues, etc. However, the main **disadvantage** of these techniques is that they are short-term, expensive (especially hand hoeing), and can potentially lead to mechanical damage of soil structure.

For tillage, ploughs are used. Ploughs are the instruments that are used for opening and loosening the soil. Different kinds of mechanical ploughs are available in the market, they are Subsoil ploughs, Chisel ploughs, Rotary ploughs, Cultivators, Disc Harrows, Blade Harrows, etc are used in eradicating weeds.

Sauser formation and getting the inter rows free from the weeds help in achieving the primary aim of the managers -**not to feed the weeds**.

Soil Solarization

Soil solarization is the technique of placing a cover (usually black or clear plastic) over the soil surface to trap solar radiation and cause an increase in soil temperatures to levels that kill plants, seeds, plant pathogens, and insects. In addition, when black plastic or other opaque materials are used, sunlight is blocked which can kill existing plants. Polyethylene plastic film is the most useful for soil solarization.

Clear and black films both trap infrared radiation that is re-radiated from the soil surface, therefore keeping the soil hot. Transparent film allows more radiation to reach the soil than black films, as it lets visible light in, causing even greater temperature increases.

Because black films exclude visible light, however, they stop photosynthesis, which can be enough to kill some young annuals and perennials given sufficient time (Elmore 1990). Double layers of film have been found to increase soil temperatures by three to ten degrees over single layers (DeVay 1990).

Soil solarization, however, can cause significant biological, physical, and chemical changes in the soil that can deter the growth of desirable native species.

Mulching

Most of the weeds that affect the Eucalyptus plantations are Heliophytes (which require direct sunlight for their survival and propagation), mulches are very helpful in the control of weeds in Eucalyptus plantations.

Mulches in weed control are beneficial at multiple levels, mulching enacts a direct mechanical pressure on weeds and prevents or postpones their germination and emergence, thus providing crops with a competitive advantage, by creating favorable conditions for their development. Meanwhile, it indirectly regulates the soil pH and humidity, prevents temperature oscillations, and reduces pest and disease incidence.

The efficiency of mulch depends on the type of material used for mulching (organic or synthetic) and its thickness and durability during the application period. Application of natural (organic) mulches prevents seed germination, enriches the soil, improves its structure, and provides nutrients for the crop. An additional advantage of mulches is that it is not necessary to remove them from the surfaces where they have been applied, leading to no additional investments needed for their removal.

Synthetic mulches can be biodegradable, and different types of PVC sheets are most often used. Compared to natural mulches, they are more

efficient in weed control, despite increasing production costs. Biodegradable and photodegradable materials used for mulching ensure better environmental protection and reduce the use of manual labor needed for their removal, making them more valuable in ecological weed management practices.

Living mulches (legumes, etc) are also often used, and they are more practical for weed control. Their application is more acceptable for many reasons: they reduce weed presence, enrich the soil with nitrogen, and improve soil structure. Environmentally these living mulches are more acceptable, as the environment remains unpolluted, and there is no danger of harmful elements entering the food cycle.

Flaming

Flaming is an old and well-known non-chemical weed control method. The first practical experiences in flaming are mentioned as early as the 1930s. Due to the emergence of cost-effective herbicides, flaming was discontinued, but the interest in flaming as a weed control method has seen a comeback lately due to prioritizing organic methods of weed control.

The drawback of this technology is it uses very high fossil fuel consumption, resulting in energy inefficiency.

To Sum up

For the control of weeds from the Eucalyptus plantations- a mixture of measures like Preventive, Mechanical, live mulches, and soil solarisation methods are to be employed.

Black Plastic sheet Mulch/ Soil Solarization

White transparent Plastic sheet for Soil Solarization

Mulch

Rotavator

Diseases and loss of productivity:

Diseases cause enormous loss to the standing crop by way of killing them and/ or reducing their productivity. The loss can occur from seed sowing to harvesting and storage. Failure of Crops due to diseases caused epidemics like the Irish Famine (due to the late blight of Potato, in 1845), the Bengal Famine (due to brown spot of Rice, in 1942), etc, such epidemics devastated the economy of the said countries and led to massive deaths.

Diseases amongst forest tree species are also quite common all over the world. Many causative organisms like Viruses, Viroids, Bacteria, and Insects are killing the commercially important timber species. India has experienced about 21 major Sal Borer attacks that killed millions of Sal trees and severely affected the health of forest ecosystems.

So, if we want our trees to grow disease-free and contribute to the economy of the Country, and keep the forest ecosystems disease-free, we need to have some basic idea about the diseases, their symptoms, virulence (spread), causative organisms, and control.

To control diseases, we need to understand the fundamental concept of disease management. Disease Management involves mainly three components of the disease triangle, viz Pathogen, Host, and Environment.

The managers of the Forest Ecosystems must always aim at reducing the incidences of diseases in the forests by way of

- Exclusion and Eradication of the Pathogen,
- Treating the affected plant (s) through Therapy, Improving the resistance of the trees, and
- Securing the Environment through Protection and Avoidance.

Classification of plant diseases

Diseases in plants are grouped based on the symptoms or signs (rust, smut, blight, etc.), nature of infection (systemic or localized), habitat of the pathogens, mode of perpetuation and spread (soil, seed, and airborne, etc.), affected parts of the host (shoot, root disease, etc.).

In the trees, most diseases are caused by pathogens. **Disease is a symptom caused by a pathogen that can survive, perpetuate, and spread, and "pathogen" is any agent or factor that incites 'pathos or disease in an organism or host.**

Living Pathogens that cause diseases in the trees are mainly Fungi, Algae, Bacteria, Insects, Phanerogams, Phytoplasma, Protozoa, Nematodes, etc,

In nature, there is another group of pathogens that are neither living nor non-living (**Mesobiotic**), which cause severe diseases to the trees, for example, Viruses and Viroids

Impacts of Diseases on plants

Diseases cause immense damage to Trees and Forest Ecosystems. They are responsible for:

1. Mortality: trees killed by diseases.
2. Destruction of wood: The losses from heart rot that destroy or disintegrate wood.
3. Reduction in growth increment: decreased height and girth, which adds up to volume loss.
4. Delayed regeneration: years lost in getting a new crop started.

5. Deficiencies in stocking: The affected areas get understocked.

6. Changes in the composition of species in the forest strands.

7. Deterioration of site: soil erosion, compaction, leaching, etc.

8. Reduction in wood quality

In the background of Knowing your pest and its importance in the eradication of Plant diseases, a note on diseases that affect the Eucalyptus in its plantations is given below

Health Management of Eucalyptus Plantations/ Forests

Disease	Symptoms	Causative	Treatment
Seedling blight	Minute spots on the leaf leading to apical dying. Stem lesions and leaf spots are noticed	Cylindrocladium spp	Spraying of 100 ppm solution of Bavistin, Benzimidazole, Diconil, N-P Fluorophenyl 2,3 dichloromaleimide, Topsin M (Thiophamate methyl) and in 1000 ppm solution of Bordeaux mixture at fortnightly intervals.
Damping off	The collapse of stem tissue at the soil level causes the seedlings to fall over	Species of Pythim, Rhizoctonia, Cylindrocladium, and Fusarium	Spraying of Bavistin (0.01% a.i.), Dithane M-45 (0.01% a.i.) and Emissan-6 (0.0025% a.i.) as soil drench each applied separately at 4-hour intervals
Web blight	Profuse mycelial growth entangles seedlings leading to the death of seedlings	Rhizoctonia solani	Soil drench with Emissan-6 (0.005% a.i.) and avoiding watering after treatment
Seedling wilt	Change in pigmentation in	Rhizoctonia solani	Soil drenching with Bavistin (0.05% a.i.)

	mature leaves, wilting of seedlings		
Root wilt	Wilting of seedlings and death of seedlings	Rhizoctonia solani	Emissan – 6 (0.05% a.i.) as soil drench repeated after a week if the disease persists
Seedling stem infection	Wilting and eventual death of seedlings	Cylindrocladium spp	Bavistin (0.02% a.i.) as foliar and soil drench
Leaf spot	Minute greyish water-soaked lesions coalesce to large necrotic areas leading to premature defoliation	Cylindrocladium spp	Foliar spray with Bavistin (0.01% a.i.)
Stem infection or collar rot	Greyish water-soaked lesions on stem followed by splitting of bark, wilting, and death	Rhizoctonia solani	Emissan – 6 (0.01% a.i.) as a soil drench
Phaeoseptoria leaf spot	Purple to brownish-purple angular spots on leaves leading to premature defoliation	Phaeoseptoria eucalyptii	Foliar spray with Dithane-M 45 (0.05% a.i.) for 2 times at weekly intervals on both leaf surfaces
Leaf spots	Spots on leaves	Curvularia lunala and C. prasadii	Spraying with Dithane-M-45 (0.2% a.i.)
Stem canker and die-back	Splitting and dying of branches	Cytospora agarwalii	Removal of affected plants
Pink disease	Development of canker and	Corticium salmonicolor	Removal of affected plants. Planting resistant clones or

	epicormism below canker		provenances is a long-term measure

To Sum up:

1. The plantation areas must be kept disease free, by way of proper upkeep, by removing debris, etc
2. Early detection will help in early eradication of the disease. So, the staff must be trained to detect the symptoms, and immediately report the incidence of the disease to the authorities, before the disease becomes virulent,
3. Weeding of bushy unwanted plants is highly recommended. Weeds are the key cause that hinders the growth rate of the species.
4. Immediately after the seedlings are planted in the field, always avoid overwatering as excess water pooled near tree roots can lead to root invasion and also cause leaf diseases.
5. Termites affect planted seedlings and young trees must be chemically restricted. Consider applying Nimbicides 2ml /ltr of water and spurt with sprayers.
6. Eucalyptus is often severely damaged by a harming insect called Leptocybe invasa which result in the formation of galling structures in the stalks, leaves, and stem causing drying leaves and unhealthy stem. In India, the pest attack is widely known as **blue gum gall**. Bordeaux mixture can be applied to save trees from Stem Canker attack.

Nutrient deficiency and its effect on productivity

Plants need 16 elements. The essential nutrients are Carbon, Hydrogen, Oxygen, Phosphorous, Potassium, Nitrogen, Sulphur,

Calcium, Iron, Magnesium, Boron, Manganese, Copper, Zinc, Molybdenum, and Chlorine.

All plant nutrients are used in ionic forms. Most of these nutrients are absorbed by roots although some of them are from air by plants.

Their deficiency in the Soil affects the growth of the plants both in Nursery and in plantations and leads to a fall in productivity. Plants exhibit deficiency symptoms and the officers must act immediately to overcome the deficiency.

S. No	Nutrient	Deficiency Symptom
1	Nitrogen	Pale green-yellow leaves, small leaves
2	Phosphorous	Small purple inter-venial blotched on older leaves Progressing to younger leaves; Reduced shoot and root growth
3	Potassium	Yellowing between veins; tips of leaves die; margins of leaves may curl
4	Calcium	New leaves die at margins; new shoots may die
5	Magnesium	Yellow-tipped leaves; tips of new leaves curl up
6	Sulfur	Young leaves become yellow
7	Copper	Stems may become distorted, non-lignified stems; Foliage droops and may be distorted
8	Zinc	Stunted growth; small crowded leaves in new growth
9	Boron	Malformation of young stems and leaves; growing tips die
10	Iron	Inter-venial areas of young leaves become yellow; Veins remain green
11	Manganese	The pale green margin of leaves expands towards the main vein

To Sum up

- Look at the deficiency symptoms expressed by plants and accordingly use chemical fertilizers

- Application of chemical fertilizers produces tall and lanky seedlings with ill-developed root systems
- Sparingly use fertilizers.
- Use Vermicompost and Vermiwash in the nurseries and plantations.
- Using **Biopesticides like Jeevamrut** helps the plants most naturally, as it provides the most needed major and micronutrients to the plants and kills the pests that affect the plants

Jeevamrut is the traditional Indian biopesticide and organic manure that is prepared by the unique technique of fermentation of the combined mixture of cow dung, cow urine, jaggery, pulses flour, soil, and water.

It is cost-effective and is beneficial for both plants and soil. Jeevamrut is 100% organic and has no harmful effects on soil health.

Jeevamrut is a rich source of Nitrogen, Potassium, and Phosphorus. It also contains all other micronutrients responsible for plant growth and development. It is completely organic and provides all the nutrients required for plant growth and it also prevents plants from pests and diseases. It helps to maintain the pH of the soil, improves aeration, and increases beneficial bacteria in the soil.

Other possible reasons for the dwindling yield of Eucalyptus

1. One single **clone No.7**, which was developed by ITC in 1990 was planted in all divisions. This clone showed lots of prominences but it started losing its vigor as this clone by now is more than 30 years old. Three to four coppice crops were taken from the original Eucalyptus plantations in most of the planted areas. Of late, it was observed that this clone has become vulnerable to diseases like- Cylindrocladium and canker diseases, especially in the high rainfall areas.

In the year 2009, the plants of Eucalyptus (**derived from clones like 3,10,27**) in nurseries and plantations were **affected by the gall insect pest,** Leptocybeinvasa (Blue gum Chalcid), which resulted in huge mortality. Clone 7 is Gall resistant. **Now TSFDC has discontinued raising plants from Clones 3, 10, and 27.**

2. **Multi-generation successive eucalyptus plantations,** have attracted considerable attention regarding their impact on tree growth, soil nutrients, and microorganisms all over the world. Successive plantations of Eucalyptus had a significant negative impact on soil nutrients, leading to decreased soil nitrogen and available phosphorous, and increased pH has a negative impact (significant decreasing trend) on Soil organic matter. In the areas of TSFDC, the stressed soils are not able to give better yields,

From 2021 onwards TSFDC has shifted its attention to clone Nos 405,526,1806,283, EC4, SK 62, and ECXED are these clones are found to be doing well.

What can be done to increase the productivity of Eucalyptus plantations?

1. **Multi-generation Eucalyptus plantations must be replaced with better and well-suited eucalyptus clones**
2. The corporation can venture into the **production of clones** of Eucalyptus and these can be used in their plantations as well as marketed them
3. While planting Eucalyptus in fresh areas, it is to be made compulsory that **every 10th plant in each row is a nitrogen fixer.** These nitrogen fixers help in (a) making the monoculture eucalyptus plantations as mixed plantations and (b) in improving the fertility of soils.

In tropical countries like India, there is an inherent problem of nitrogen deficiency and low availability of phosphorous to the plants, particularly in degraded forest areas. Phosphorous even if it is present in the soil, it is mostly in fixed form and not available to plants. When seedlings raised in fertilized soils of nurseries, planted in such areas tend to die as they fail to meet their nutrient requirements in the field **FROM SOIL**.

Supplementing fertilizers in field conditions is always not possible due to the prohibitive costs involved. Application of chemical fertilizers produces tall and lanky seedlings which are not suitable for the harsher field conditions

So, if we plant the Nitrogen fixers in the plantations, the root nodules fix the atmospheric Nitrogen and gradually release it into the soils, which will be available to the Eucalyptus plantations. The microbes in the root nodules of nitrogen fixers help in the

- Release of microbial metabolic products, which serve as nutrients
- Unavailable forms of nutrients (like N, P, zinc, etc) in soil organic matter and minerals are made available to plants
- Formation of growth regulators and biologically active substances
- Formation of enzymes
- Efficient uptake of water and nutrients by mycorrhizal fungi which are ultimately transferred to host trees
- Suppression of pathogens.

4. Mechanization in harvesting will lessen the wastage.

Mechanization:

All over the world semi mechanization has been adopted by the growers of Eucalyptus plantations. Mechanization reduces dependency on labour, increases efficiency, and decreases wastage and the harvesting process can be completed with ease and at a faster pace.

Commonly used Machines:

The root system of the Eucalyptus tree can be labeled as invasive. The fast growth rate and shallowness of the roots contribute to the invasiveness of Eucalyptus' root system. **Hence, the roots of the felled multi-generation Eucalyptus trees must be uprooted completely**. Manual operations take lots of time and money. For effective removal of the root system of felled Eucalyptus trees the **earth moving machines like- Excavators, Backhoe loaders, Wheel loaders**, **Bulldozers**, etc are commonly used.

For making **trenches** around the Eucalyptus Plantations-**Chain Trenchers**/ **Wheeled trenchers** etc are used.

For preparing the field suitable for undertaking plantations, the soil should be **agitated and broken up for proper aeration which can support plant life** enabling warm air to penetrate the soil and improve growth. Both cultivators and rotavators do this.

The cultivator breaks up soil and supports the formation of numerous tiny underground air pockets. A cultivator is a machine with blades – referred to as **tines** – that demolish clumps of packed soil and remove weeds. The **rotavators** are not always hand-driven, but instead, they are attachable to the back of a tractor. As the tractor moves forward, the rotavator spins its many tines to pulverize any packed soil and remove large obstructions such as rocks. Their tines usually have a depth capacity of over 9 inches. Rotavators also help in the removal of weeds.

Rotavators

Cultivators

Levelling: In the traditional way of farming, the Land levelling process is performed by the **oxen-drawn scraper/ plankers**. These good old-day practices of levelling are labour-intensive and crude and do not achieve a high level of smoothness of the land surface. But with the development of technologies, animal power is replaced by modern machines such as **Land Levellers.** Levelling by land leveller helps in a better irrigation system which allows every part of the field to get irrigated.

Land levelling equipment is used for loosening the soil, it breaks down soil particles and smoothens the land, which increases the soil quality and improves the porosity of the soil. Furthermore, by controlling weeds, this tool increases productivity to a large extent. With this, farmers improve water coverage and reduce weeds by up to 40%. Different kinds

of levellers are available in the market, they are- **Universal Heavy Duty Land Leveller**, **John Deere Green System – Puddler Leveler, etc.** Now **Universal Laser Guided Land Levellers are extensively being used for leveling the fields.**

Laser levelling is a process of smoothening the land surface (± 2 cm) from its average elevation using laser-equipped drag buckets to achieve precision in land leveling. Precision land leveling involves altering the fields in such a way as to create a constant slope of 0 to 0.2%. This practice makes use of large horsepower tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser-guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level. (Walker, Timothy et al. 2003). This technology offers a great potential for water saving, better environmental quality, and higher yields

Laser Levellers

Tractor mounted Land Levellers

For **pit digging**- machines like **tractor-operated post-hole diggers, Soil (earth) augurs,** etc are used**.**

Soil Augurs

Machines used in the Harvest of Eucalyptus:

Extraction of Eucalyptus passes through different phases like- Felling, Processing, Debarking, loading, etc.

For felling of eucalyptus, different machines like Power Chain Saws, and different kinds of Harvesters are used.

Sizing: TSFDC is supplying, **Pulp wood grade Eucalyptus without bark to the paper industries having specifications like a girth**

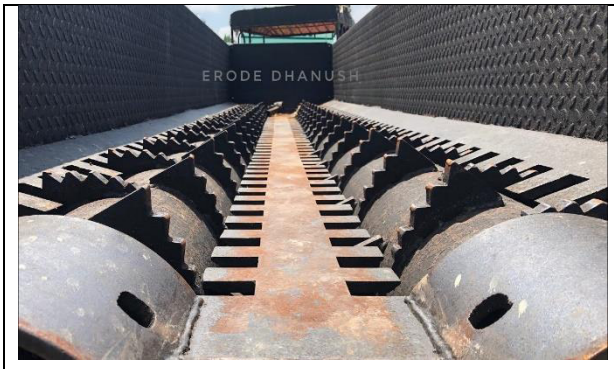
of 13 cm and length of above 1.0 Mt and 1.5 Mt. Eucalyptus logs of these lengths can be cut by using Power Chain Saws.

Power Chain Saws

Harvesters used for felling Eucalyptus

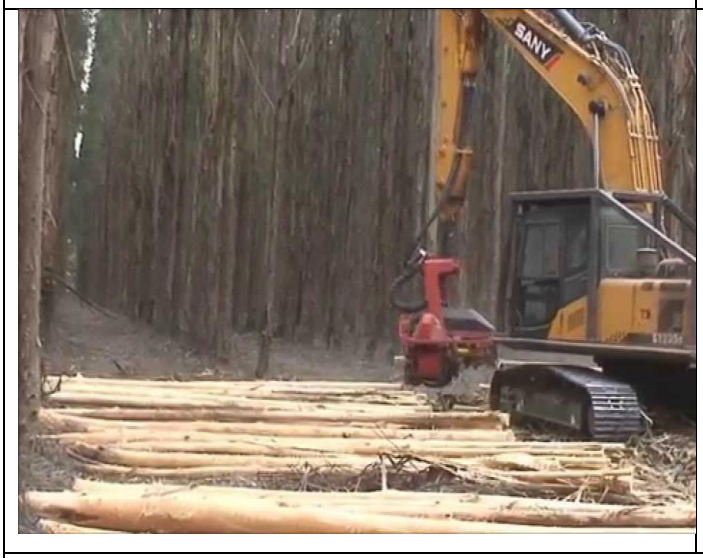
Debarking**:** The paper and pulp wood industry demands debarked eucalyptus wood. **Manual debarking is a time-constrained activity, that needs lots of man days, and by using debarking instruments like chisels, wastage of wood also happens and the process incurs huge expenditure**. The answer to these niggling issues will be to go for

mechanization in debarking of Eucalyptus. Mainly drum-based de-barkers are used for the de-barking of eucalyptus logs.



De-barker used in Erode (Erode Danush)

De-barker



On-site Harvester cum De- Barking Machine

Loading of Eucalyptus**:** Loading by machines reduces the exposure time of de-barked Eucalyptus logs to sun, wind, etc (it helps in preserving of moisture content of the felled wood), saving time, and money spent on this activity. **Loaders like cranes are most commonly used for loading eucalyptus logs onto transport trucks.**

Thus, the mechanization of the Eucalyptus sector helps in saving time and money and improves the efficiency of the organization.

Marketing of Eucalyptus

A brief on the Paper Industry in India:

Papermaking in India is a very old practice and is many centuries old. The beginning of the modern paper industry goes back to 1816 when a factory was set up near Chennai. This venture proved abortive. Another paper mill was set up in 1832 at Serampore (the then Srirampur) on the bank of Hugli in West Bengal. The mill was set up by John Clark Marshman and it was powered by a steam engine. This venture also failed and the first successful effort was made in 1870 with the setting up of the Royal Bengal Paper mills at Ballyganj near Kolkata. Subsequent successful efforts were made at Lucknow in 1879, Titagarh in 1882, Pune in 1887, Raniganj in 1892, Kaukinra in 1892 and Naihati in 1918 (first bamboo-based paper mill to be established).

In 1867, the waste paper has become a source of raw material for making paper in India. Since 1882, the non-wood fibres became raw material for the paper industry. In 1922-23, FRI, Dehradun, developed Bamboo pulping process.

Since then, the industry progressed well and by now there are about 861 paper mills of different capacities operating in India. There are 526 operating units of pulp and paper with operating capacity of 23.64 million tons, having yearly output of 20.61 million tons (***Source***: Indian Pulp and Paper Sector: An insight for an energy efficient tomorrow, by Centre Pulp & Paper Research Institute, a 2021 publication)

These mills are producing about 4.72 % of the total paper produced globally (IPMA). Most of these mills have been in existence for a long time, so you can find paper mills in India using the oldest technologies to most modern technologies. Paper mills in India use – wood, bamboo, recycled fibre, bagasse, wheat straw, rice husk, etc as the raw materials for producing paper.

As discussed above there are 526 paper mills operating in the country. Of which 17 paper mills are sourcing their raw material requirement from Social or Farm Forestry sectors. The combined production capacity of these 17 mills is 4.20 million tons. Whereas, 480 paper mills are RCF (Recycled Fiber) units with a combined production capacity of 14.75 million tons. And 29 paper mills are sourcing their raw materials from Agro-based systems and their production capacity is 1.66 million tons.

A brief on the units which are predominantly wood based and a few others which are using both wood/bamboo, Agro-residues and waste paper is given as below:

S. No	Company	Wood Pulp (t)	Wood Requirement (t)			Area Planted	Estimated Wood Generation (t)/@ 60 T/hac
			Bamboo	Wood	Total		
1	ITC Ltd	300000	0	1125000	1125000	140989	8459340
2	JK Corp (Orissa)	220000	50000	850000	900000	59974	3598440
3	JK Corp (Gujarat)	55000	80000	126250	206250		
4	Orient Paper Mills	80000	167000	173000	340000	33043	1982580
5	Star Paper Mills	70000	100000	180000	280000	72740	4364400
6	Sirpur Paper Mill	120000	0	375000	375000	30921	1855260
7	BILT Ballarpur/Asthi	220000	200000	175000	375000	36055	2163300
8	BILT Sewa	100000	40000	335000	375000		
9	BILT Yamunanagar	100000	0	375000	375000		
10	BILT Kamalapur	100000	0	375000	375000		
11	Andhra Pradesh Paper Mill Ltd	220000	18000	800000	818000	124040	7442400
12	West Coast Paper Mill Ltd	280000	0	900000	900000	44260	2655600
13	HNL Kottayam	80000	0	300000	300000	32000	1920000
14	HNL Naogaon	100000	0	375000	375000		
15	HNL Kachar	100000	0	375000	375000		
16	HNL Nagaland	20000	0	75000	75000		

17	Yash Paper Mills	5000	0	16500	16500	150	9000
Total (A)		**2170000**	**655000**	**6930750**	**7585750**	**574172**	**34450320**
Paper Mills that are using Agro-residues, Waste paper along with Wood and Bamboo							
1	TNPL	280000	0	400000	400000	34542	2072520
2	Century P&P Ltd	280000	168750	958125	1126875	2340	140400
3	Mysore Paper Mill	60000	0	225000	225000	27500	1650000
4	Seshasai P&B Ltd	160000	0	400000	400000	18534	1112040
5	Circar Paper Mill	0	0	5000	5000	0	0
6	Nepa Paper Mills	0	0	50000	50000	0	0
7	Delta Paper Mills	80000	0	300000	300000	0	0
8	Emami Paper Mills	0	0	0	0	5	300
Total (B)		**860000**	**168750**	**2338125**	**2506875**	**82921**	**4975260**
Grand Total (A+B)		**3030000**	**823750**	**9268875**	**10092625**	**657093**	**39425580**

(***Source**: Adopted from, Pulp and Paper Industry Raw Material Scenario - ITC Plantation A Case Study by Kulkarni H.D*)

Localization of the Industry:

Paper and paper board manufacturing uses coarse, cheap and weight losing raw materials and seeks raw material-oriented locations. Chemicals used in this industry are needed in small quantities and are easily transported even over long distances from the place of production to the place of consumption. Paper mills use large quantities of water and power. Therefore, there is a strong tendency among the paper mills to be located near the forest areas along the Western Ghats, the Eastern Ghats, Central India, and the Tarai-Bhabar area at the foothills of the Himalayas, as these places cater to the needs of raw materials, water and provide a cheap source of hydro-electric power.

Challenges faced by Paper Industries in India:

The Paper Industry in India faces many problems the most important of them are:

- Not enough raw material availability is a challenge faced by the Paper Industry in India. The Indian paper sector relies

mainly on wood-based raw materials like wood chips and bamboo. But there is a shortage of suitable wood and bamboo in many places. This leads to high reliance on imported wood pulp, increasing industry costs.

- Low use of mill ability is another challenge. Most Indian paper mills work at around 70-80% of their total ability due to various reasons like shortage of raw materials, lack of export orders, financial problems, etc. This less use of ability results in higher production costs and lower profits.
- High energy use is also a problem area. The Indian paper industry uses massive amounts of energy, especially electricity, to run its machines. But high energy costs eat into company profits.
- The Paper Industry in India also suffers from technology gaps as most mills still use old machines and ola technology. Only a few Indian companies have adopted new technologies.
- The Paper Industry in India also faces problems related to environmental sustainability. Though the idea of recycling is followed, getting rid of used water and air pollution caused by mills are major concerns that require industry-wide solutions.
- The lack of skilled workers is another problem area for the paper sector. There is a shortage of technically trained employees like machine operators, engineers, chemists, etc. Many paper mills cannot find suitable talent to run hi-tech machines and ways. This contributes to a lower ability to work fast and hampers technological upgrades.

Initiatives of the Government of India and Paper Industries in tackling the problems of this sector:

A brief on the problems faced by the industry and the attempted solutions are as follows

1. **Technology and Investment related**: To overcome these problems, The Government of India declared this sector as a **core sector and allowed FDI** into the sector. Money brought in new technologies- that enabled the paper industry to implement efficient manufacturing processes that **reduce water usage and waste**, such as closed-loop water systems that recycle water in the production process. Similarly in the **energy-saving front**, energy-efficient dryers are an important innovation in the paper manufacturing industry, as they help to reduce energy consumption and improve sustainability. Traditional paper drying processes typically rely on high-temperature drying methods, which can be energy-intensive and expensive. Energy-efficient dryers, on the other hand, use advanced technology and design to reduce energy consumption and improve efficiency. ITC Bhadrachalam introduced environmentally benign **elemental chlorine free (ECF),** bleaching process for the first time in India in the year 2000-01, soon followed by other paper companies. Similarly, APPM introduced **NCG incerination technology** in their paper plant in 2001-02.

   Market forces, short supply of raw materials and concerns of profit, are forcing the paper industry to innovate

2. **Innovations**: Companies are always Strongly market (profit) driven, thus they always focus on Value Addition, New Product Development, Quality Enhancement, and Sustainability backed by strong RD, Marketing, and technical teams. Forest based industries like Pulp and Paper industries are not an exception for it. With News Print out of the production lines of most of the paper industries and ever-decreasing demands of paper for notebooks (laptops, iPads,

etc have taken their place) these industries are facing problems in sustaining themselves, as most of them operate at a meager 4% margins of profit. Eroding profitability is either driving the players of this industry into closures or diversifying their products and product lines.

In this context I would like to give an example: the Leading paper industry that is ITC Bhadrachalam.

It's one month production from 4 lines (out of its 14 production lines) is good enough for producing its Classmate Note Books, (this brand has a market share of 25%) in its Chennai based setup. They send paper in roll form to its Chennai unit and with these rolls, they produce Class Book Note books round the year.

A big question loomed in front of them is what to do and why to produce notebook quality paper when there is no much demand for it in the market? So they tried to diversify their production lines and found out that, paper board (a three-layered paper- used for making tetra packs) has more market potential (with Tetra packs taking a lot of space in the packaging industry), and they changed the technology and machinery.

Now their technology uses/ takes in more Lignin (up to 75%), for making of Mechanical Pulp, whereas while making white papers more than 90% Lignin gets washed away (in the form of black liquor, white liquor etc, a potential pollutant from this industry)

Now this company has mechanical grinders for making Mechanical Pulp (used as core of the board-middle layer, that gives strength and the strength comes from Lignin) and for the 1st and 3rd layers, they are using Chemical Pulp.

For Mechanical Pulp, they need soft wood species, that have more lignin content (for it they need 9-10 years old trees) and for chemical pulp, they need trees of lesser ages.

Now the problem is how to make the older soft wood species available to this industry, whereas the order of the day is harvesting eucalyptus trees at their tender age. Will the farmers be ready for the change? Are we ready? What will happen if many paper mills change their production lines? Shall they have to depend on the import of Pines and Spruce (wood/pulp), to meet their demands for Mechanical Pulp?

3. **Initiatives in the direction of solving raw material problems:**

As per the directives of the National Forest Policy 1952, the **National Commission on Agriculture** fully acknowledged the role to be played by forestry in the development of the country and recommended large scale plantations on degraded forest areas and social forestry in community and private lands to reduce the growing gap in timber and firewood requirements. This led to the inception of social forestry scheme in India since the 7th five year plan. This helped in the creation of tree lands on rail side, road side, on the community lands etc,

This policy initiative helped in the creation of **Forest Corporations** to raise plantations in degraded forestlands.

The **Industries** have been specifically advised to network with farmers for production of industrial raw material instead of depending on subsidized supply from government forests **by the National Forest policy 1988.**

Several initiatives have been taken up by the Indian industry for meeting the demand of raw materials; these attempts have

mostly started after 1988 National Forest Policy prescriptions that advocated **industry-farmer interface**.

A few tree plantation companies in India undertook plantation of wood species and supply logs of wood to other companies which use them as raw materials for their industries e.g. plywood and board manufacturers, paper and pulp manufacturers, furniture manufacturers, match manufacturers etc.

About 343, 000 hectares of farm forestry plantations have been promoted by the paper industries, which are the members of Indian Paper Manufacturers Association (IPMA). It is estimated that this land mass can produce approximately 20 million tons of wood at 60 tons/hectare yield.

The private players invested huge amount of money in the R & D works, in developing a variety of clones (QPMs), that suit the different bio-ecological regions and different soil types of the country. They developed the a good working relationship with the growers (farmers), with their superior extension programs. The Agro-forestry models adopted by the farmers helped them in getting good financial returns.

4. **Other initiatives:**

Government of India, recognised the importance of having a simple and ungulated atmosphere for the growth of the Paper and Pulpwood Industry. So it came out with Agro-forestry Policy at National Level and a few States like MP. UP etc have followed the suit and they framed their own policies.

For further promoting planting on the private lands, the Ministry of Environment and Forests issued guidelines to the states in 2004 for relaxing the transit rules. Many of the state governments have made progress in relaxing these rules,

Bamboo, a grass, was declared as non-forestry timber species, it aimed at promoting this species as an Agro-forestry species,

The Government of India, with an aim of focusing on improving land capabilities, the **National Afforestation and Eco-development Board (NAEB)** was established with a **mandate to regenerate degraded forests** in the country with the active involvement of the people and the stakeholders.

A number of Research Institutions (Government and Private) are working in the field of Agro-forestry and

Even though lots of work is done in this field, still there is deficit in the availability of raw materials, that is forcing the paper industry to depend on the imports.

Having discussed about the industry, let us discuss on marketing of Eucalyptus and Bamboo by TSFDC

Marketing of Eucalyptus and Bamboo by TSFDC:

Marketing is an important part of eucalyptus and bamboo farming by TSFDC, and it involves identifying the target market for the products and developing a marketing strategy that reaches the ideal customers.

In the words of Phillip Kotlar, the Marketing Management Guru, who wrote a legendary Book titled "Marketing Management" – **marketing** is an organizational function and a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders. He mentions that **4 Ps** (**seller**) **of marketing mix**: Product, Price. Place, Promotion and **4 Cs (customer):** Customer's solution, Cost, Convenience, Communication is very important for the marketing of produce.

So, who are our customers?

At present, TSFDC is supplying Eucalyptus to ITC Bhadrachalam and SPM and a very little quantities of pulp wood to others. Details of wood supplied in the last 4 years is mentioned below:

Pulp Wood Supplies per Annum			
S. No	**Financial Year**	**Agencies**	**Qty in MT**
1	2017-18	ITC Bhadrachalam	239183
		Others	42957
	Total		**282140**
2	2018-19	ITC Bhadrachalam	110422
		Others	12241
	Total		**122663**
3	2019-20	ITC Bhadrachalam	92886
		SPM	39356
	Total		**132242**
4	2020-21	ITC Bhadrachalam	85087
		SPM	70072
		Others	9751
	Total		**164910**

Where does our clients stand with reference to the 4 Cs as advocated by the marketing guru, Phillip Kotler.

(A) Customer's solution: Customers are in need of industrial wood (pulp wood) from the corporation in large quantities and TSFDC is catering to the needs of the customers. Indeed, the customers are in need of huge quantities of wood, and as it is not available in requisite quantities, they are forced to import pulp from other countries and are spreading their captive plantations, even into the neighbouring states like Chhattisgarh and Odisha. TSFDC, has approved Management plan and hence logging will not be an issue. By replacing multi-generation Eucalyptus plantations with better clones, and practicing proper Silvicultural practices, the yield of the plantations can be improved tremendously. Measures for improving the yield are discussed earlier.

(B) Cost: Cost of the eucalyptus supplied by TSFDC is reasonable and affordable by the companies and the price offered is financially viable to TSFDC at present.

(C) Convenience: All the eucalyptus plantations of TSFDC are very close to the factories of ITC and SPM. So, it is convenient and cost effective to supply the raw materials at the factory gate,

(D) Communication: There is a very good two-way communication between the producer and the consumer. No middle man is involved in the transactions. The processes and procedures are transparent.

Where does the organization stand in the perspective of 4Ps as pronounced by Phillip Kotler?

(A) Product: TSFDC is producing a product, which is in great demand by the paper manufacturing companies and this demand is going to be there in the coming many decades. Product, that has been produced in large quantities (production ranged from 1,22,663 Mt to 2,82,140 Mt in the last 4 years) will always have a good market. No buyers will be ready to lose such a big producer. **So, TSFDC has a luxury of dictating its own price, based on its production costs**. No other competitor (like farmers who are growing wood on their farms), can't enjoy this kind of luxury.

(B) Price: As discussed above, as a producer, TSFDC enjoys the monopoly and can dictate its price.

Generally, Pricing of products in the market are controlled by the following four pricing mechanisms.

- **Cost-based pricing**- in most of the cases the producer decides his price for the product that he produce. Unfortunately, Farmers are the ones, who doesn't enjoy

this luxury, he is dependent on the market forces and can't decide his price based on his production cost.

- **Customer-based pricing** — it refers to the price the customer is ready to pay. This, in a way, gets reflected in the auctions conducted, like auctions by FDC for its produce. Farmers can't enjoy this luxury too for their products produced in their fields
- **Competition-based pricing**— it is happening in the Indian Farm Forestry sector, only when there is fall in production/ availability of produce in the market the prices go up. It does happen but rarely it does.
- **Statutory pricing**— it is the minimum price decided by an order of Government- like MSP. It takes various measures in to count and tries to fix the rates, favourable to the producers (Farmers).

Even if the consumer (factory owner) is not ready to take the product at the producer's offered price, TSFDC has a capacity to hold the trees from being felled and can increase the rotation period temporarily.

The paper industry is **witnessing a paradigm shift** from the demand perspective, with demand for newsprint papers and printing writing papers dwindling ICRA expects a healthy demand for packaging papers to drive growth for paper manufacturing companies in the medium term.

The installed capacity levels in packaging paper is seen picking up progressively, aided by the capex incurred in the recent past over FY2017 to FY2022

With the continued demand from FMCG, pharma and e-Commerce sectors, particularly for packaging paper, the sector is expected to grow in the range of ~30-31% in FY2022

On an aggregate basis, the long-term demand potential for the India paper industry remains intact

Steady capacity augmentation seen in domestic paper manufacturing industry for the packaging paper segment during FY2017 to FY2022; 2.4 lakh metric tonnes and another ~4.0 lakh metric tonnes expected to be added in the next two fiscals

As discussed above and in the innovation part of this write-up, now there is a good market for the long rotation Eucalyptus trees, as they have more **lignin** content in them and pulp obtained through mechanical digestion process from such long rotation trees is used in making, **paper board** that enjoys more market price than the traditional paper. So, even if the felling of trees is delayed by few years, the Eucalyptus from these plantations will get more price.

(C) Place: The plantation areas are nearby to the factories, so the TSFDC has an advantage in this respect too.

(D) Promotion: As such promotional activities are not needed to promote their products, but still TSFDC has a good website and the corporation is a **good brand** in its own terms. It has its own brand identity, and has a good social media presence, and is participating in industry events and trade shows. In its endeavor to research the market and identify trends and opportunities for growth, now it had tied up with CIPS, Hyderabad. Acting as a responsible corporate, trying to replace Eucalyptus with other ecologically suitable species in the RRR areas of Hyderabad.

Risk Management

Risk management is important for protecting the eucalyptus from unexpected events such as natural disasters, crop failures, or economic downturns.

This can include purchasing crop insurance, diversifying the farm's product offerings, and developing contingency plans for unforeseen events.

In this regard, would like to mention **Pulpwood Tree Insurance,** as pronounced by Agriculture Insurance Company of India Limited. The corporation can think of insuring their plantations. For easy reference, the brochure of this scheme is as annexed as **annexure-I.**

Marketing of Bamboo by TSFDC**:**

As mentioned in the table-, Paper Industries like Bhadrachalam, SPM are not using Bamboo as their raw materials. Developing **CFCs** for bamboos in a large scale and producing value added materials, is the solution for proper and better utilization of bamboo that is produced by TSFDC.

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Agriculture Insurance Company of India Limited
Head Office: Plate B & C, 5th Floor, Block 1, East Kidwai Nagar, New Delhi - 110023

PULPWOOD TREE INSURANCE

(UIN: IRDAN126RP0004V01200708)

BROCHURE

Applicability:

This insurance scheme is applicable to Pulpwood tree growers and producers, whose produce/ yields are likely to be affected by the specified perils. The product shall be offered for Pulpwood trees in specific geographic locations with adequate infrastructure and facilities to grow the crop. The trees covered under the policy are:

1. *Eucalyptus*
2. *Poplar*
3. *Subabul*
4. *Casuarina*

Scope of Cover

The policy shall cover and indemnify the insured against pecuniary loss suffered by the insured in respect of cost of inputs (agreed value) on account of the total loss or damage to the trees occasioned by specified perils/risks like Fire, Flood, Cyclone, storm, Frost and Pest & diseases etc., either in isolation or concurrently. Total loss shall mean loss or damage to individual Pulpwood plant or entire plantation or part thereof leading to death of the plant or making the plant economically unproductive.

Sum Insured

1. Sum Insured is based on cost of inputs (agreed value) per unit area of insurance covered which will depend on nature of tree, age of tree. Sum Insured is broadly equivalent to input cost, and can extend up to 125% / 150% of the input cost at the discretion of the insurer. The insurable age and age-wise indicative 'input cost' is provided below:

			Input cost per Acre (Rs.)				
Sl. No	**Pulpwood Tree**	**Insurable life span**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
1	*Eucalyptus*	1 - 5 years	33000	40000	48000	57000	68000
2	*Poplar*	1 - 5 years	50000	60000	72000	85000	100000
3	*Subabul*	1 - 5 years	25000	30000	36000	43000	51000
4	*Casuarina*	1 - 5 years	20000	24000	29000	35000	41000

Premium

The premium rate has been arrived at on the basis of (a) risk profile of the tree / crop; (b) nature of risks covered; (c) geographical location; (d) rate charged by other insurers for similar risks; (e) deductibles, and (f) loading for various costs and expenses of the insurer. The rate charged may vary from 1.5% - 2.5% depending upon the age of the plant, geographical location of the plantation, & optional drought coverage, etc.

Period of insurance: The Policy period is annual, with a provision to go for policy of up to 5 years duration.

LOSS ASSESSMENT PROCEDURE

On occurrence of any insured perils leading to the total loss of damage to the plant /plants the insured has to submit the claim form to Agriculture Insurance Company of India Limited (AIC). AIC shall send a Loss Assessor/ Agriculture Expert to the field for assessing the loss to facilitate claim processing. For the purpose of claims, death / totally damaged plants making the plant economically unproductive shall be considered as loss under the policy. Decline and / or retardation of growth shall not be deemed as loss.

The amount of loss assessable under this policy shall be such sum as is arrived at after applying the percentage of death/ damaged plants in the insured area to the amount of sum insured, subject to the terms, conditions, salvage, excess and any other deductions specified in the policy.

Claim Settlement

At the time of settling claims the insured shall be required to furnish one or more of the following documents to AIC:

i) Loss intimation / Copy of Claim Form
ii) Copy of Cover Note / Policy
iii) Proof of insurable interest: Land record proof/ proof of financing or lending Documents / proof of loss (operation of insured peril)

At all times during the period of insurance of this policy the insurance cover will be maintained to the full extent of the respective sum insured. However the sum insured shall stand reduced by the loss amount during the balance period of policy in case of payment of claim. In no case the liability (sum of all claims during the policy period) of the company will exceed the sum insured.

How to avail insurance

The insurance product is available through the existing network of AIC. Cultivators can obtain insurance information also from financing banks, participating agencies / organizations, input suppliers, farmers' associations, insurance brokers etc. Individual growers can directly purchase the policy from AIC or from authorized individual / corporate agents.

COMPANY PROFILE

Agriculture Insurance Company of India Limited (AIC) was promoted by General Insurance Corporation of India (GIC) and National Bank for Agriculture and Rural Development (NABARD) and four Public Sector General Insurance Companies, and incorporated under Companies Act on 20th December 2002.

AIC has taken over the implementation of National Agricultural Insurance Scheme (NAIS), which until FY03 was implemented by General Insurance Corporation of India. In future, AIC would also be transacting other insurance businesses directly or indirectly concerning agriculture and its allied activities.

AIC's mission is to provide financial security to persons engaged in Agriculture and allied activities through Insurance Products and other Support Services.

Insurance is the subject matter of solicitation.