ENVIRONMENTAL IMPACT ASSESSMENT AT TNPL PLANTATIONS

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

AT TNPL PLANTATIONS

I) INTRODUCTION

Environmental planning of a particular work or the project includes the assessment of the environmental impact of development projects, is gradually being introduced in the developing countries to protect the environment. Far from being a luxury that only industrialized countries can afford, environmental planning is increasingly recognized as an essential adjunct to economic and technical evaluations of projects. Lack of concern for the environmental consequences of large development projects has proved costly. In the case of ill-conceived forestry and agricultural projects, the most dramatic and universal impact is the loss of soil productivity, particularly in the humid tropics. For this and other reasons, tropical high forest has often been described, with some justification, as a non-renewable resource.

There is also growing awareness in the developing countries, as there is elsewhere, that environmental planning, with its emphasis on the evaluation of alternative locations and development methods, improves the overall quality of development planning. Environmental review of projects prevents not only environmental degradation, but also constructive errors and faulty economic analysis. Aside from the intrinsic difficulties of resource use in the tropics, a number of institutional developments, both in the developing countries and elsewhere, are also providing the impetus for introducing environmental impact assessment (EIA) and other forms of environmental planning. One development is the establishment of regulatory agencies concerned with the environment in developing countries. Pressure to include explicit and systematic review of the environmental consequences of development projects is also coming from international funding and other agencies, from individual donor countries, and from international scientific and conservation bodies.

In view of the resource-management problems and institutional developments described above, FAO, as the UN agency responsible for promoting the rational management of the world's forests, has prepared the present Guidelines as part of its series of Conservation Guides. The Guidelines are intended to fill a gap in the growing literature on environmental planning for a publication devoted specifically to the environmental assessment of forestry projects in developing countries.

The guidelines were written primarily to assist environmental and other officials in developing countries who wish to institute a system of environmental review of forestry projects. For this reason, the Guidelines have included, wherever possible, procedural or institutional options, the merits or demerits of which may depend on the circumstances of a particular national or sub-national jurisdiction.

The guidelines were also intended for the planners or proponents of forestry projects - whether in the public or private sector, in the host country or as a part of aid missions - who have to meet the requirements of regulatory agencies or of funding agencies regarding the environmental review of projects. More generally, the Guidelines are designed to assist any forestry planner who wishes to expand the scope of his planning to include broad environmental concerns. The specific uses foreseen for the Guidelines are described in detail below. The guidelines apply to all forestry activities and their environmental impacts, except for the operation of pulp and paper mills. Guidelines concerning the impact of these mills (primarily the generation of liquid, solid cod gaseous wastes) are being prepared separately. Forestry activities include logging, the clearing of forests for agriculture, construction or forest roads and other infrastructure needed to support forestry operations, log transport by land and water, re- and afforestation, tree-clearing for disease control, saw-milling, charcoal-making and other transformation of wood (other than pulping and papermaking) and other activities that involve, at some point, the removal or the addition of forest cover and other physical impact on the landscape. Thus excluded are administrative activities such as the evaluation of forest resources or the strengthening of educational facilities in the forestry sector.

The purpose and intended use of the Guidelines are

- Assist the forestry, environmental and other officials of developing countries who wish to integrate explicit environmental concerns into forestry planning; the Guidelines call attention to the regulatory options available, and outline the possible contents of the various documents used to assess environmental impact; the Guidelines also list potential impacts of forestry projects as well as sources of environmental information.
- Assist the authors of forestry project documents who need to decide the scope and nature of the environmental planning required.
- Assist forestry planners or host country regulatory agencies who wish to conduct a preliminary assessment of environmental impact with the aid of a checklist especially designed for forestry projects.

- Assist those authors of detailed feasibility studies of forestry projects who have to submit detailed environmental impact reports in conjunction with cost-benefit analyses and technical evaluations to host country regulatory agencies or to bi-or multilateral funding agencies.
- Assist environmental regulatory bodies in those jurisdictions where those bodies assume the responsibility for preparing detailed environmental impact reports.
- In general, provide public and private forestry officials with checklists of the potential consequences of forestry activities, especially large-scale deforestation in the humid tropics.
- The Guidelines envisage EIA as a step-wise procedure, with the more formal and complex steps reserved for those cases where it is clear that forestry activities will have serious environmental consequences, or where the nature of these consequences is not predictable from casual inspection. In many cases, screening or preliminary impact assessment will be sufficient to determine that the consequences are acceptable, or sufficient to modify the project so as to make it environmentally acceptable.

Environmental impact assessment (EIA) was the pioneer environmental safety assessment method for safeguarding the environment problems that are faced by the surroundings.

PROJECT BACKGROUND

Tamil Nadu Newsprint and Papers Limited (TNPL) was established by the Government of Tami Nadu during early eighties to produce Newsprint and Printing & Writing Paper using bagasse, a sugarcane residue, as primary raw material. The Company commenced production in the year 1984 with a initial capacity of 90,000 tonnes per annum (tpa). Over the years, the production capacity has been increased to 2,45,000 tpa and the Company has emerged as the largest bagasse based Paper Mill in the world consuming about one million tonnes of bagasse every year. In addition to that TNPL operate 300 TPD each hardwood and waste paper fibre line. The Company completed a Mill Expansion Plan during December 2010, with addition of Paper machine 3, to increase the mill capacity to 4,00,000 tpa. TNPL exports about 1/5th of its production to more than 50 countries. Manufacturing of quality paper for the past three and half decades from bagasse is an index of the company's technological competence. A strong record in adopting minimum impact best process technology, responsible waste management, reduced pollution load and commitment to the corporate social responsibility make the company one of the most environmentally compliant and socially responsible paper mills in the world.

TNPL commissioned its lime sludge and fly ash management project to convert the inorganic waste generated from the mill into cement. Also a new green filed project with 2,00,000 TPA capacity to manufacture multi layer paper board. In view of TNPL Mill Expansion plan at TNPL Unit-II, the pulpwood requirement was increased from 5 lakh MT to 12 lakh MT from the year 2022 onwards. To procure the required pulpwood from plantation sources the plantation target has been fixed as 25,000 acre per year from 2018-19 to 2022-23 and 30,000 acres per year from 2023-24 onwards. TNPL is committed to sustainable use and management of the resources, such as fibre, fuel, water and other natural capitals throughout its operational boundaries.

The wood based industries in the country have been directed by the state and central government policy and legal guidelines to generate their own raw material resources by establishing necessary linkages with farmers and other stake holders. This Policy and legal guidelines also regulated the supply of raw materials to wood based industries from the regular forests. This besides, the international consumer countries also demanded production of paper from known and established plantations and not from native forests in order to ensure conservation and sustainable utilization of forest resources. The regional policy and legal restriction coupled with compulsion made by International consumers demanded establishment of strong and sustainable plantation development programme which will ensure the long term availability of industrial wood raw material besides protecting the regional, local and community based social, cultural and environmental values.

As per the National Policy 1988 guidelines, Tamil Nadu Newsprint and Papers Limited (TNPL), Kagithapuram has introduced two contract farming models during 2004-05 to augment the pulp wood raw material in order to create sustainability and self reliance in meeting the raw material demand through established plantation in non forest area through a people centered participatory approach which will be economically viable, socially acceptable and environmentally compatible.

Against this backdrop, the Environmental Impact Assessment (EIA) study at TNPL plantation area has been taken up by Society For Social Forestry Research And Development, Chennai. The assessment was carried out to determine the impacts on climate, edaphic, biotic and waste management issues towards achieving the sustainable forest management practices.

Based on the above understandings, the following objectives was framed

- To study the effect on climatic factor, soil properties and hydrological system
- To analyse the environmental safeguard plan and clean development mechanism.
- To study the flora and fauna of TNPL plantation areas.
- To analyse the negative environmental Impact at plantation areas and its remedial measures.

II) PRIORITIZED AND IDENTIFIED ENVIRONMENTAL ISSUES

The environmental issues were categorized into three, namely climatic (Temperature, rainfall, relative humidity, winds, carbon sequestration), edaphic (Soil) and biotic factors (Flora & fauna, pest & disease and societal impact). The environmental issues are described in details here below:

2.1. CLIMATIC FACTORS

2.1.1 Temperature

Temperature plays a vital role in all biological activities and the increase or decrease in temperature influences the biological process and hence monitoring of annual temperature is essential and deserves regular assessment.

2.1.2. Rainfall

The mean annual rainfall is an important factor for all cropping systems coupled with recharging of all water resources. Hence rainfall has been identified as one of the important impact factor for assessment.

2.1.3. Relative Humidity

The conjoint effect of temperature, wind and rainfall decides the relative humidity of the locality which is identified as a key factor for assessment.

2.1.4. Winds

The wind and the wind movement are very essential in a biological process not only for pollination but also for general physiological activity hence it has been identified as an important factor for assessment.

2.1.5. Carbon sequestration

The current climate change and its implications are very important towards sustaining agriculture and other related activities. The developmental activities coupled with science and technological advancements have contributed accumulation of air pollutants and in particular the predominant release of carbon-di-oxide is very well evidenced. Hence carbon sequestration by the TNPL plantation has been identified as one the critical factor for assessment.

2.2. EDAPHIC FACTORS

2.2.1. Soil

Soil is potential factors of locality in the environment which decides the success and failure of plantations. The plantation activities from land preparation upto harvest operation create greater impact on the soil physical, chemical and biological properties which in turn decides the nutritional quality. Hence impact of plantations on soil has been identified as one of the prioritized environmental issue.

2.3. BIOTIC FACTORS

2.3.1. Flora and fauna

The native flora and fauna of any ecosystem is an important attribute for sustaining the food chain. The developmental activities should protect native flora and fauna and hence these factors are incorporated in the assessment programme.

2.3.2. Pest and Disease

The promotion of mono cultures of pulpwood plantations with limited species diversity may become a resource pool for pest and diseases. In some cases, there are chances of epidemic occurrence which needs continuous monitoring and assessment.

2.3.3. Societal impact

The population engaging in pulpwood cultivation and the community dwelling in and around the plantation programme are very important because they influence the success and failure of plantations. In certain circumstances, the people's demand and need to meet their domestic needs in terms of firewood collection, celebration of religious festivals, etc., are met from the plantation activities.

III) METHODOLOGY ADOPTED FOR ESTIMATING ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The plantations established by Tamil Nadu Newsprints and Papers Limited, Karur across state of Tamil Nadu formed the basis for current evaluation. The methodologies adopted by the scientific team towards assessment of environmental impact due to the establishment of TNPL plantations is given below based on the sample analysis from the permanent sample plots marked in the 13 Districts of Tamil Nadu. The factors like climatic, edaphic and biotic factors were documented from the permanent sample plots across the state.

3.1. Study area and study period

The captive plantation established by Tamil Nadu Newsprints and Papers Limited, Karur across the state of Tamil Nadu formed the materials for the current evaluation. The species planted in the captive plantation was Eucalyptus. Based on the list obtained, five percent proportionate sampling was carried out from all the districts where the captive program was implemented. Totally 26 taluks coming under 13 districts were chosen for the assessment with 49 FMUs with an area of 1839.01 hectares (Table 1). The Study conducted and the data collected were related to the year 2022-23.

Table 1. District wise TNPL captive plantation

SL NO	FARMER CODE	NAME OF THE SITE	DISTRICT	LOCATION	EXTENT (HA)
1	C00388	TNPL-WIND FARM	TIRUNELVELI	N8 56.897 E77 39.193, N8 56.537 E77 39.027	100.00
2	S04024	A/M MASIMAGA SOMASUNDARA MUDALIYAR ARAKKATTALAI	TIRUVANNAMALAI	N12 41.092 E79 34.246	17.12
3	S04017	A/M NITHIYAKALYANAPERUMAL THIRUKOIL	KANCHIPURAM	N12.73396 E80.16943	22.69
4	T00315	GOVT.WASTE LAND BLOCK-3	KARUR	N10 33.788 E78 14.125	8.00
5	T00315	GOVT.WASTE LAND,BLOCK-1	KARUR	N10 36.417 E78 13.347	8.10
6	T00315	GOVT.WASTE LAND,BLOCK-4	KARUR	N10 33.981 E78 14.293	8.11
7	T00315	GOVT.WASTE LAND,BLOCK-5	KARUR	N10 33.573 E78 12.944	8.70
8	T00315	GOVT.WASTE LAND,BLOCK-6	KARUR	N10 34.029 E78 12.601	11.19
9	T00315	GOVT.WASTE LAND,BLOCK-7	KARUR	N10 34.952 E78 09.800	10.00
10	T00315	GOVT.WASTE LAND,BLOCK-8	KARUR	N10 36.675 E78 12.424	15.00
11	T00311	GOVT.WASTE LAND	THANJAVUR	N10 42.482 E78 53.381	19.49
12	S04039	A/M KALLALAGAR THIRUKOIL,ALAGARKOIL	MADURAI	N9 46.171 E77 58.202	14.70
13	S04045	A/M EKANTHALINGASAMY THIRUKOIL	THOOTHUKUDI	N8 27.649 E77 48.871	46.15
14	S04040	A/M NARUMBUTHASAMY THIRUKOIL	TIRUNELVELI	N8 45.278 E77 28.696	108.10

15	S04046	A/M BOOMINATHASAMY THIRUKOIL	TIRUNELVELI	N8 40.635 E77 29.415	78.54
16	S04042	A/M SUBRAMANIYASWAMY THIRUKOIL	TIRUNELVELI	N8 39.540 E77 38.671	136.44
17	S04041	A/M SUBRAMANIYASWAMY THIRUKOIL	TIRUNELVELI	N8 39.833 E77 38.846	41.34
18	S04031	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 35.019 E77 46.483	208.58
19	S04030	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 33.578 E77 47.465	82.60
20	S04029	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 34.012 E77 46.734	155.25
21	S04038	A/M MEENAKSHI SUNDARESWARAR THIRUKOIL	VIRUDHUNAGAR	N9 36.048 E77 54.033	26.86
22	T00316	GOVT.WASTE LAND	TRICHY	N10 39.975 E78 45.924	15.19
23	T00316	GOVT.WASTE LAND	TRICHY	N10 39.287 E78 47.206	10.55
24	T00316	GOVT.WASTE LAND, SOORIYUR (HAPP)	TRICHY	N10 42.247 E78 47.162	9.75
25	T00316	GOVT.WASTE LAND, SOORIYUR (VAARIKADU)	TRICHY	N10 40.512 E78 46.182	9.67
26	T00317	GOVT.WASTE LAND	TRICHY	N10 20.032 E78 20.834	25.00
27	T00318	GOVT.WASTE LAND BLOCK-I	TRICHY	N11 06.847 E78 24.182	10.00
28	T00318	GOVT.WASTE LAND BLOCK-II	TRICHY	N11 06.400 E78 24.324	10.00
29	T00318	GOVT.WASTE LAND BLOCK-III	TRICHY	N11 06.210 E78 24.103	6.00
30	T02505	TNPL UNIT I OWN LAND	KARUR	N11 03.733 E77 59.443	21.12
31	T02506	TNPL UNIT II OWN LAND	TRICHY	N10 41.372 E78 29.318	195.77
32	M01749	MARIYA ANTONY PRAKASI.S	SIVAGANGAI	N9 46.559 E78 29.027	41.53
33	S04629	SCAD KRISHI VIGYAN KENDRA	THOOTHUKUDI	N8 44.532 E78 00.724	10.93
34	R03834	RAVEENDAR.V	SIVAGANGAI	N9 47.007 E78 30.057	24.21
35	C03351	CHAIRMAN BS BIOFUEL COMPANY PVT LTD	SIVAGANGAI	N9 43.160 E78 32.976, N9 43.675 E78 33.088	58.30
36	U00126	UDAIYAPPAN & CO	SIVAGANGAI	N9 50.560 E78 41.785	26.82
37	V01825	VILLAGE RECONSTRUCTION ORGANIZATION	KARUR	N10 46.908 E78 28.714	30.36
38	G03204	K.P.GANESAN & CO	SIVAGANGAI	N9 49.923 E78 48.546	27.18
39	A02476	ACRI, KILLIKULAM	THOOTHUKUDI	N8 41.662 E77 52.176	90.69
40	O01423	ORS,TINDIVANAM	VILUPPURAM	N12 13.126 E79 40.293	6.88
41	A02494	ARS, VAIGAIDAM	THENI	N10 01.065 E77 33.795	8.10
42	D02784	DRYLAND AGRICULTURAL RESEARCH STATION	SIVAGANGAI	N10 10.838 E78 48.109	21.78
43	A02477	ARS, BHAVANISAGAR	ERODE	N11 29.121 E77 07.844	12.96
44	C03434	CHATHIRAM LAND	THANJAVUR	10.30475 79.35513	19.03
45	C03434	CHATHIRAM LAND	THANJAVUR	10.29103 79.32526	20.24
TOTAL					**1839.01**

In farm forestry, consisting about 57 percent casuarina and 43 percent eucalyptus were assessed five percent sampling in 96 Taluks and 13 Districts with an area of 46434.37 acres as shown in table 2.

Table 2. District wise and year wise TNPL farm forestry plantation

SL NO	DISTRICT	2019-20		2020-21		2021-22		2022-23		TOTAL FMU	TOTAL EXTENT (AC)
		FMU	EXTNT (AC)	FMU	EXTNT (AC)	FMU	EXTNT (AC)	FMU	EXTNT (AC)		
1	ARIYALUR	174	742.97	542	1725.51	755	2283.60	1012	2977.82	2483	7729.90
2	CHENGALPATTU	6	26.13	100	492.18	100	794.95	145	763.71	351	2076.97
3	CUDDALORE	12	99.65	291	1636.69	267	1287.97	251	1079.04	821	4103.35
4	ERODE	54	98.27	100	165.03	84	136.74	77	131.62	315	531.66
5	KALLAKURICHI	0	0.00	12	88.00	12	63.07	6	28.80	30	179.87
6	KARUR	107	498.78	275	929.50	190	498.23	246	497.69	818	2424.20
7	NAMAKKAL	50	114.00	128	307.39	127	274.62	129	214.22	434	910.23
8	PUDUKOTTAI	268	2144.03	370	1869.13	612	3690.49	735	2957.21	1985	10660.86
9	SALEM	60	203.73	128	307.75	97	262.14	72	195.49	357	969.11
10	SIVAGANGAI	56	1075.95	130	743.53	106	1464.47	60	382.10	352	3666.05
11	TRICHY	30	321.69	43	190.89	40	159.51	97	366.15	210	1038.24
12	TIRUPPUR	17	38.37	27	79.80	39	113.75	39	88.12	122	320.04
13	VILLUPURAM	1	2.00	645	3085.67	1336	4804.99	1040	3931.23	3022	11823.89
TOTAL		**835**	**5365.57**	**2791**	**11621.07**	**3765**	**15834.53**	**3909**	**13613.2**	**11300**	**46434.37**

3.2. CLIMATIC FACTORS

The climatic data, such as maximum and minimum air temperature (^{0}C), relative humidity (%), wind speed (Kmph), soil moisture (%), soil temperature (^{0}C), rainfall (mm), solar radiation (cal/cm^2), atmospheric pressure (hpa), leaf wetness (hr) recorded over years have been obtained from the metrological stations established in various climatic zones nearer to the permanent sample plots for periodical monitoring.

3.2.1. Estimation of carbon sequestration

Carbon sequestration was quantified using 6 randomly selected trees for various age gradations from each sample plots. Trees were measured for the following parameters to assess the carbon sequestration potential

- Estimation of biometric values of plantation.
- Estimation of biomass of trees.
- Estimation of biomass carbon of trees.

3.2.1.1. Biometric evaluation of trees in the captive plantation

To assess the growth rate of the planted trees the following biometric observations were recorded.

- Height (cm)
- Diameter at breast height (cm)

3.2.1.1.1. Height

The total height of each planted trees was initially measured from the ground level to the leading terminal tip using the standard scale or haga altimeter and expressed in meter.

3.2.1.1.2. Diameter at breast height (cm)

The diameter was measured at height of 1.37 from the ground level using digital callipers and expressed in cm.

3.2.1.1.3. Volume estimation

The volume of trees was estimated using the following formula (Chaturvedi and Khanna, 1982) and expressed in cubic centimetre (cm^3).

$$V=\pi r^2 h.$$

Where,

V= Volume

R= Radius

H= Total height

3.2.2. Estimation of biomass in planted trees

The biomass of the planted trees was estimated using non destructive sampling method. The biomass was calculated for the entire plant as described below.

a) Above Ground Biomass

b) Below Ground Biomass

c) Total Biomass

3.2.2.1. Above Ground Biomass (AGB)

The above ground biomass of the planted trees was estimated using non destructive sampling method. In order to estimate the biomass, the values namely volume and wood density are required. The volume calculated in the 3.2.1.1.3 was utilized and the value of wood density for required tree species was obtained from the website www.worldagroforestrycentre.org/sea/products/AFDbases/WD. AGB of the trees were calculated using the following formula. The biomass was calculated as per the formula given below by Pandya *et al.,* 2013

$$\text{AGB (kg/tree)} = \text{Volume of tree (m}^3\text{)} \times \text{Wood density (kg/m}^3\text{)}$$

Note: The wood density of tree species was unavailable, the standard average value 0.6 gm/cm^3 were taken.

3.2.2.2. The Below Ground Biomass (BGB)

The below ground biomass of the planted tree seedlings was estimated by non destructive method. Below ground biomass includes all biomass of live roots excluding fine roots having < 2 mm diameter. The below ground biomass was calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. Below ground biomass was calculated by following formula

$$\text{Below Ground Biomass (Kg./tree) or (ton/tree)} = \text{AGB (Kg/tree) or (ton/tree)} \times 0.26$$

(Ravindranath and Ostwald, 2008)

3.2.2.3. Total Biomass

Total biomass of trees includes both above ground and below ground biomass of the tree was calculated by following method

$$\text{Total Biomass (Kg./tree) or (ton/tree)} = \text{AGB} + \text{BGB}$$

(Ravindranath and Ostwald, 2008)

3.2.2.4. Biomass Carbon Estimation

The biomass carbon content of trees were calculated utilizing the arithmetic value of biomass estimated in the item 3.2.2.3.

Carbon Storage = Biomass x 50% (or) Biomass / 2 (Suryawanshi *et al.*, 2014)

3.3. EDAPHIC FACTORS

3.3.1. Soil samples

Soil samples were collected from multiple depths from all the permanent sample plots at randomly selected three sampling points. Soil sampling locations at these sites were limited by the size of plot. Bulk soil samples were obtained by using spades and sharp tools to dig soil from the side wall of pit.

The following soil physio-chemical properties *viz*., Soil reaction (pH), electrical conductivity (EC), organic carbon (OC), available major nutrients (N, P and K) were analysed as per standard method (Table 3).

Table 3. Soil physio chemical properties analysis method

Property/ nutrients analysed	Method adopted	References
Soil reaction (pH) (1:2.5 soil water ratio)	Potentiometry	Jackson (1973)
Electrical conductivity (1:2.5 soil water ratio)	Conductometry	Jackson (1973)
Organic carbon	Chromic acid wet digestion method	Walkley and Black (1934)
Available nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
Available phosphorus	Bray I and Olsen's method	Bray and Kurtz (1945); Olsen *et al*., 1965
Available potassium	Neutral normal NH_4OAc	Stanford and English (1949)

3.4. BIOLOGICAL FACTORS

A pre-tested questionnaire has been prepared and the actual presence of flora and fauna, social issues and pest and disease have been recorded at 5% sampling intensity level in captive plantation (Questionnaire is appended in the annexure).

3.4.1. Assessment of pest infestation:

$$\text{Percent infestation} = \frac{\text{No. of plants infested}}{\text{Total No. of Plants observed}} \times 100$$

3.4.2. Assessment of foliar diseases

Stem/leaf area affected	Grade
0 %	0
1 %	1
1 to 10 %	3
11 to 25 %	5
26-50 %	7
> 50 %	9

$$PDI = \frac{\text{Sum of Individual grades}}{\text{Maximum disease grade}} \times \frac{100}{\text{Total No. of tree observed}}$$

3.4.2. Assessment of root and wilt diseases

$$\text{Percent incidence} = \frac{\text{No. of plants infected}}{\text{Total No. of Plants observed}} \times 100$$

3.5. Other Issues

The actual field and industrial visits were made and waste has been assessed at 5% sampling intensity level in captive plantation. Other negative impact of the plantation has also been discussed in the following chapter.

IV) RESULTS AND DISCUSSION

The environmental impact assessment of the TNPL captive plantation and farm forestry plantations was carried out in 21 districts of Tamil Nadu. There major environmental assessment factors like climatic factors, carbon sequestration value of the plantation, edaphic factor of the plantation and biotic factors (Flora, fauna, pest and disease incidence) were analysed and described here below

4.1. Impact on climatic factors

4.1.1. Temperature

The plantation cover makes the temperature, both of the air and soil, more equable than it is in the open. This is due to the fact that plantation cover acts as a screen and prevents sunrays from heating the air and the soil inside the plantation to the same extent as it does in the open. During night, this screen prevents the loss of heat by radiation. The result is that mean maximum temperature of the air inside the plantation is lower and the mean minimum temperature higher.

4.1.2. Rainfall

Since the TNPL plantations are scattered, there was no influence of the plantation in the rainfall pattern and no.of rainy days.

4.1.3. Relative humidity

Generally living plants/trees absorb water and only a small part of this water (1-2%) is retained in the plants/trees body for building up processes and most part is lost in the farm of water vapour. So the evapo-transpiration at plantation area releases a larger amount of water vapour in the atmosphere adjacent to tree canopy which increases relative humidity. Hence relative humidity is always higher in the plantation areas than barren land.

4.1.4. Windbreak

A strip of trees can reduces wind velocity considerably. The reduction in wind velocity, the height and distance to which it is affected, is dependent on the height of trees and their density. The TNPL plantations are also acting as windbreak and protecting the farmland adjacent to plantation areas from heavy wind in noteworthy way.

These plantations provide the following services,

- Protecting livestock from cold winds

- Protecting crops and pastures from hot, drying winds
- Reducing/preventing soil erosion
- Reducing evaporation from farmlands

The climatic factors namely maximum air temperature, minimum air temperature, relative humidity, soil temperature, wind speed, solar radiation was furnished in the Table 4.

4.1.5. Impact on water sources

Large scale planting of eucalyptus has caused concern to many people as they thought it would have adverse environmental impacts particularly in relation to high water use. A number of studies have been undertaken in various sites on the water use of eucalyptus but none of the findings are conclusive.

Eucalyptus have become the focal point of controversy over the past two decades vis-à-vis their impacts on the environment. The criticism against Eucalyptus that it lowers ground water table is baseless as the roots of Eucalyptus rarely go lower than 3-4 mts and hence it could not tap subterranean water and the shallow root system of Eucalyptus use only surface soil moisture. Eucalyptus roots can break up the soil structure of impervious hard pan and augment rain water percolation creating a net positive effect on the ground water level.

Under TNPL plantation programmes, the clones of eucalyptus alone are used which lack tap root system with a secondary root length of 3-4 feet and the question of depleting water table will not arise as evidenced from the earlier reports.

Table 4. Climatic pattern for the 21 districts of Tamil Nadu in TNPL captive and farm forestry plantations

District	Temperature		Relative Humidity	Wind Speed	Soil Moisture	Soil Temperature	Solar Radiation	Atmospheric Pressure
	Max (°C)	Min (°C)	(%)	(Kmph)	at 15 cm (%)	at 15 cm (°C)	(cal/cm^2)	(hpa)
Ariyalur	28.6	17.9	54.7	2.3	25.3	24.1	481.1	995.5
Chengalpattu	28.8	17.3	57.6	2.9	16.6	29.6	531.4	959.8
Cuddalore	29.8	17.2	87.9	2.9	21.6	28.4	518.8	976.5
Erode	29.1	18	44.6	2.8	25.6	24.3	536.5	964.7
Kallakurichi	30.4	19.8	57.4	2.3	22.9	24.8	512.6	997.8
Kanchipuram	28.8	17.8	39.3	2.9	19.5	25.3	492	1003.2
Karur	29.8	18.2	47	3	8.1	25.6	506.7	991.3
Madurai	30.9	18.2	61.6	2.7	15.7	26	550.7	985.2
Namakkal	29.9	19.2	45.8	3.2	8.6	25.8	505.3	996.5
Pudukottai	30.2	18.6	55.6	2.7	26.5	23.9	497	989.6
Salem	28.9	18.7	45.5	2.9	24.8	23.9	541.2	972.4
Sivagangai	30.7	18.5	50.6	3.1	28.3	28.6	400.7	898.7
Thanjavur	28.5	18.6	57.8	3.6	16.5	24.7	647.4	1001.1
Theni	28.4	18.6	54.5	3.3	26.4	23.8	602.5	977.3
Thirunelveli	30.9	19.9	57.9	3	21.5	27.6	543.7	995.5
Thiruvannamalai	28.6	16.5	39.2	1.8	26.4	22.3	478.1	945
Trichy	29.5	17.9	53.1	2.3	25.7	24.5	482.9	992.5
Tiruppur	29.7	18.6	45.8	2.8	9.2	26.3	508.5	995.1
Thoothukudi	31.6	19.8	66	4	19.3	22.2	570.7	1007.6
Villupuram	30.5	19.7	63.5	2.4	23.2	24	506.4	989.4
Viruthunagar	31.4	19.3	42.1	2.6	27.7	24.1	327	995.4

4.1.6 Carbon Sequestration Potential of TNPL Plantations for Eucalyptus

The carbon sequestration potential of Eucalyptus plantation in captive plantations has been assessed for the 45 FMUs, 13 districts of Tamil Nadu and the results were furnished in Table 5. The carbon sequestration of the Eucalyptus plantation were analysed through the non-destructive sampling mechanism. The total carbon sequestration potential for the 1839.01 hectare captive plantation in the 13 districts of Tamil Nadu was 23655.17 tonnes. Among the 13 districts of the captive plantations, Tirunelveli district secured the maximum carbon storage per hectare with the value of 19.20 tonnes/ha followed by Madurai with the carbon sequestration value of 14.15 tonnes/ha. Carbon sequestration potential for the newly planted areas at Erode and Theni Districts was not estimated as plants are in just establishing stage. The TNPL plantation has contributed maximum to the reduction of the atmospheric carbon level.

Table 5. Carbon sequestration potential of TNPL captive plantations

Districts	Area (ha)	Height (m)	GBH (cm)	Volume (m3)	Total bio mass (tonnes/ha)	Carbon storage (Tonnes)	CO2 equivalent (Tonnes)
Kanchipuram	22.69	14.5	18.2	0.023	14.98	169.89	623.51
Erode	12.96	-	-	-	-	-	-
Karur	120.58	8.5	19	0.015	9.57	576.81	2116.90
Madurai	14.7	14	19.5	0.025	16.60	122.00	447.73
Sivagangai	199.82	13.9	21	0.029	19.11	1909.52	7007.94
Thanjavur	58.76	10.5	18.3	0.017	10.96	322.11	1182.15
Theni	8.1	-	-	-	-	-	-
Thirunelveli	910.85	14.7	23	0.037	24.25	11042.10	40524.52
Thiruvannamalai	17.12	12.1	15.3	0.014	8.83	75.60	277.44
Trichy	291.92	10.6	14.5	0.011	6.95	1014.23	3722.23
Thoothukudi	147.77	7.8	10	0.004	2.43	179.69	659.45
Villupuram	6.88	3.4	6.5	0.001	0.45	1.54	5.65
Viruthunagar	26.86	5.5	7.2	0.001	0.89	11.94	43.82
Total/ Average	**1839.01**					**15255.54**	**55987.82**

4.1.6. Carbon Sequestration Potential of TNPL Farm Forestry Plantations

The assessment of carbon sequestration potential in the farm forestry casuarina and eucalyptus plantations revealed that the major portion of carbon is sequestered in the soil (61.91 % in casuarina and 66.41 % in

eucalyptus) followed by tree biomass (11.46 % in casuarina and 9.24 % in eucalyptus) and in litter stock (3.61 % in casuarina and 1.53 % in eucalyptus) respectively as shown in figure 1. In general, casuarina plantations have more potential to sequester the atmospheric carbon than eucalyptus plantations.

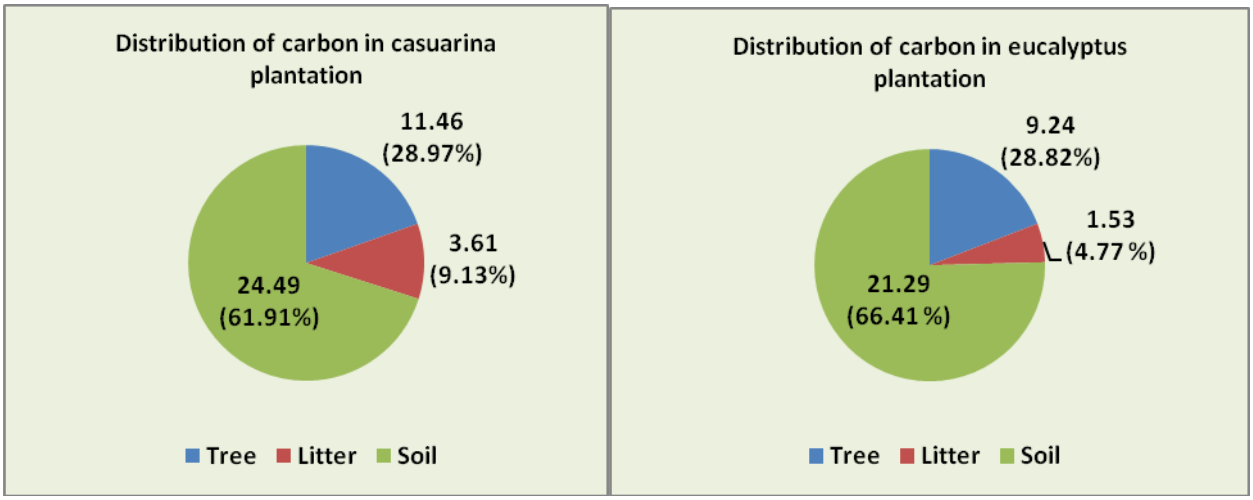

Figure 1. Carbon sequestration pattern of TNPL farm forestry casuarina and eucalyptus plantations

4.2. Impact of plantations on soil

Periodical soil sampling is being carried out in the permanent sample plot and documented by the plantation department. Apart from the permanent sample plots, soil samples were collected in the captive and farm forestry plantations and the barren areas to know the changes in the soil physio-chemical and chemical properties. Totally about 135 surface soil samples in captive plantations and 33 soil samples in farm forestry plantations consisting four zones were collected. The soil samples were processed and analysed to know the soil fertility under pulpwood plantations.. The soil analysis results are presented in Annexure I & II.

4.2.1. Soil nutrition status under Eucalyptus plantations

4.2.1.1. pH

Among 135 soil samples collected and analysed from captive plantations, the soil samples at Kancheepuram, Madurai and Thoothukudi districts recorded soil pH of more than 8.0.. The highest soil pH was found in Thoothukudi District (8.15) and lowest was recorded in Thirunelveli District (6.95). In farm forestry plantations, the pH ranged from 6.98 to 8.18 in casuarina stand and 6.59 to 8.81 in eucalyptus stand respectively.

4.2.1.2. EC

The electrical conductivity of the soil was ranged from 0.05 dS m^{-1} to 1.65 dS m^{-1}. The highest EC was recorded with Kancheeepuram District and the lowest was recorded with Thirunelveli District. Under farm forestry plantations the EC of casuarina plantations ranged between 0.15 to 0.51 dS m^{-1} and the eucalyptus plantations ranged from 0.03 to 0.36 dS m^{-1}.

4.2.1.3. Organic carbon

The organic carbon content of the soils of TNPL captive plantations was recorded to a range of 0.23 % in Villupuram District.to 0.53% in Thanjavur District. Overall, the OC content can be rated as low in all the sites. This is due to the lands were kept barren for long time before raising the plantation. In increasing soil organic carbon, casuarina plantations contributed more as they recorded a SOC value between 0.27 and 0.54 per cent as against eucalyptus plantations which recorded 0.18 to 0.38 percent.

4.2.1.4. Available nutrient status

The available nitrogen ranged from 178 kgha^{-1} to 388 kgha^{-1} in the plantation sites. The highest N content was recorded with Sivagangai District and lowest content was found with Kanchipuram District. Available phosphorus was recorded high at Villupuram site with 21.5 kgha^{-1} and lowest with Cuddalore, Namakkal and Thiruvannamalai sites with 8.50 kgha^{-1}. Available potassium in TNPL captive plantation sites ranged from 263 kgha^{-1} at Pudukottai to 390 kgha^{-1} at Erode District. The sites with predominantly red soil had higher potassium availability.

In general, the major plant nutrients (nitrogen, phosphorus and potassium) availability status of TNPL captive plantation sites can be rated as low to medium levels. Considerable improvement in nutrient availability was evidenced with Eucalyptus plantations at captive plantation sites. This is due to nutrient addition through leaf litter fall, secretion of root exudates and solubilization of fixed nutrient in the soil.

Table 6. Soil nutrient status of the pulpwood plantation catchment Districts

Districts	pH	EC (dS/m)	O.C (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Pottasium (kg/ha)
Ariyalur	7.56	0.27	0.38	241	12.5	275
Chengalpattu	7.86	0.3	0.41	189	10.5	294
Cuddalore	7.89	0.29	0.43	194	8.5	298
Erode	7.45	0.08	0.45	265	16.5	390

Kallakurichi	8.07	0.12	0.28	202	9.5	326
Kanchipuram	8.02	1.28	0.39	178	18	266.5
Karur	7.94	0.4	0.28	226	14.5	378
Madurai	8.26	0.08	0.52	216	9.5	274
Namakkal	7.56	0.09	0.13	189	8.5	298
Pudukottai	6.92	0.15	0.39	224	12.5	263
Salem	7.12	0.12	0.22	206	10.5	327
Sivagangai	7.26	0.08	0.29	388	12.6	382
Thanjavur	7.15	0.06	0.53	292	12.6	312
Theni	7.15	0.29	0.31	194	11.5	388
Thirunelveli	6.95	0.05	0.39	196	12.5	376
Thiruvannamalai	7.56	0.09	0.33	179	8.5	292
Tiruppur	8.08	0.39	0.18	223	13.5	321
Trichy	7.68	0.16	0.42	277	11.5	302
Thoothukudi	8.15	0.21	0.29	283	15.5	296
Viruthunagar	7.92	0.11	0.31	274	12.5	308
Villupuram	7.92	0.74	0.23	212	21.5	326

4.3. Biotic Factors

The captive and farm forestry plantations established by TNPL have been surveyed and the biodiversity assessment namely the native flora and fauna are identifies and these were categorized as trees, shrubs, herbs and grasses.

4.3.1. Floral composition of the TNPL plantations

4.3.1.1. Trees

Some of the naturally grown trees like *Azadirachta indica* (Neem), *Wrightia tinctoria* (Veppalai), *Derris indica* (Pungam), *Borassus flabellifer* (Palmyrah), *Chloroxylon Swietenia*, *Morinda tinctoria*, *Acacia nilotica* sub species indica, *Acacia leucophloea, Albizia lebbeck, Albizia amara* and *Delonix elata, Prosopis juliflora,* etc. werere observed to the nearby area of the TNPL plantations.

4.3.1.2. Shrubs

The major shrub species found in and around the TNPL plantations were *Chromolaena odorata, Maytenus emarginata*, *Scutia myrtina*, *Abutilon indicum Ageratum conyzoides, Acalypha fruticosa, Acanthospermum*

hispidum, Achyranthes aspera, Carissa carandus, Carissa auriculata, Dvelonaea angustifolia, Ipomoea carnea, Jatropha glandulifera, Lantana camara, Erythroxylon monoxylon and *Scilla hyacinthina.*

4.3.1.3. Herbs

The major herb species found in and around the TNPL plantations were *Mimosa pudica, Rubia cordifolia, Caralluma attenuate*, *Evolvulus alsinoides Tephrosia purpurea*, *Cardiospermum halicacabum, Acalypha indica, Aerva lanata, Barleria cristata, Centella asiatica, Ecclipta prostrate, Evolvulus* alsinoides*, Merremia emarginata, Oldenlandia umbellata* and *Sida rhombifolia.*

4.3.1.4. Grasses

The major grasses found in and around the TNPL plantations were *Bambusa arundinacea, Aristida setaeea, Brachiaria romosa, Cenchrus ciliaris, Cenchrus seligerus, Chlons barbata, Cyondon* dactylon*, Eraagrostis sp, Heteropogon contortus, Iseilema laxum, Sehima nervosum, Themeda Sp.*

The study found that the pulpwood plantation activities of TNPL have not disturbed the native species and also not disturbed the natural regenerations if any present. In case of availability of native vegetation it was evidenced during the study that TNPL has taken care to protect these resources.

4.3.2. Fauna composition of TNPL plantations

Since the plantation areas are discontinuous and scattered blocks in barren, degraded lands and farm lands nearby the human habitat which is not very conducive for wildlife. However there are few sightings of birds, reptiles, butterflies in the plantation areas which is depicted in the plates.

4.3.3. Pest and disease in TNPL plantations

The pest and disease incidence of the eucalyptus and casuarina plantations were carried out by the questionnaire assessment, which was attached in annexure III. Being long duration crops, naturally the tree plantations have to withstand higher pressure load of pests and pathogens. Further, the tree plantations have to withstand throughout the year tolerating all sorts of weather conditions and uncertainties which may favour the development of seasonal bound pests and diseases.

The observation on pests and diseases of pulp wood plantations of TNPL revealed that there is no major incidence throughout the assessment process. With respect to pests, the occurrence of gall wasp and leaf spot in the Eucalyptus plantation were found to be a major pest problem in the TNPL plantation areas. Since resistant clones were developed, there is no incidence of gall wasp at present.

In casuarina plantations, the major disease observed were collar rot, root rot and bacterial wilt existed in excess moisture with closer spacing areas. However, these diseases were effectively controlled in the clonal plants production process itself by applying the bio- inoculants like *Trichoderma viridae*, *Bacillus velezensis*, *Psuedomonos flurosence* and *Micromonospora.*

Another interesting point to be noticed in the cultivation of pulpwood trees is the more occurrences of termite mounts. Though termites are a major menace in the young plantations, the well grown trees are not affected by the termites if they are maintained properly. In this case, the enhanced population of termites could be a meritorious process in improving the soil fertility as well as decomposing the litter materials. Further it has several benefits including the aeration of the soil due to burrowing activities, breakdown and release of organic matter and acts as source of protein rich food for many organisms including ants, guinea fowl and other mammals.

4.4. Negative Impact of the TNPL pulpwood plantations

4.4.1. Compaction of soil happens during harvesting

The harvesting operations carried out currently exhibited soil compaction due to felling and conversion and handling of logs. This can be resolved through practicing scientific logging practices to ensure reduced impact logging. The introduction of semi mechanized harvesting is a timely intervention introduced by TNPL, which help to reduce the logging impacts and the associated reduction in logging waste. Further most of the Eucalyptus plantations are coppiced and systematic silvicultual operations ensure the loosening of soil along with incorporation of leaf litters and residue of the harvested materials which resulted in significant improvement in the soil fertility status.

4.4.2. Plantation with the limited species

The large scale plantation programme with a single species may create a problem of monoculture impact particularly in soil physio-chemical properties coupled with occurrence of epidemic status of pest and disease in captive plantations. But the study found that TNPL has created adequate variability through poly clonal concept which will eliminate the negative impact. It was also found that TNPL has incorporated alteast 10% of alternate pulpwood species in their plantation programme which will also serve the purpose of creating variability and eliminating the negative impact.

In another development in the area of enhancing genetic diversity, TNPL uses inter and intra specific hybrids of Casuarina and Eucalyptus species. For example inter specific hybrids of *Casuarina*

equisetifolia × *C. junghuhniana* and in eucalyptus inter specific hybrid of *E. camaldulensis* × E. *tereticornis*, *E. camaldulensis* × *E. pellita* and intra specific hybrids of *E. camaldulensis* × *E. camaldulensis* were promoted in addition to the pure species.

4.4.3. Change in land use pattern

The promotion and popularization of TNPL pulpwood plantation in farm lands may attract many farmers towards tree husbandry. This will create a competition between the food crops versus fibre crops. To mitigate this competition the management has to promote the Agroforestry models which integrate food crops and fibre crops in the same unit of land. The profitable agroforestry models with a judicial incorporation of agricultural, horticulture, animal husbandry and forestry component play a significant role in resolving this conflict.

V) CONCLUSION

Environmental Impact Assessment (EIA) study at TNPL plantation area has been taken up by Society For Social Forestry Research And Development, Chennai. The assessment was carried out to determine the impacts on climate, edaphic, biotic and waste management issues towards achieving the sustainable forest management practices. Based on the above understandings, the following objectives was framed

- To study the effect on climatic factor, soil properties and hydrological system
- To analyse the environmental safeguard plan and clean development mechanism.
- To study the flora and fauna of TNPL plantation areas.
- To analyse the negative environmental Impact at plantation areas and its remedial measures.

5.1. Environmental impact assessment of climatic factor

- The plantation cover makes the air and soil temperature equable than it is in the open.
- There was no influence of the plantation in the rainfall pattern and no.of rainy days.
- Relative humidity is always higher in the plantation areas than barren land.
- The total carbon sequestration potential for the 1839.01 hectare captive plantation was 55987.82 tonnes.

5.2. Environmental impact assessment of edaphic factor

- In the captive plantations of eucalyptus, totally about 135 surface soil samples were collected in 13 districts of Tamil Nadu. Most of the soil is alkaline in the nature with the pH range of 6.95 to 8.15. The electrical conductivity values ranged from 0.05 to 1.25 dS m^{-1}. The organic carbon status in soil varied from 0.23 to 0.53 per cent. In nutrient status of the soil, available N status ranged from 178 to 388 kg ha^{-1}. The available phosphorous status varied from 8.50 to 21.50 kg ha^{-1}. The available potassium status ranged from 266.50 to 390.0 kg ha^{-1}.
- The farm forestry plantations of TNPL have improved the physico- chemical properties of the soil (pH, EC and ESP). An appreciable increase in soil organic carbon content was evidenced with this study.

5.3. Environmental impact assessment of biotic factor

- In the floral composition, there are totally 12 tree species, 16 shrub species, 15 herbs and 12 grasses were found in and around the pulpwood plantations.
- In the fauna composition, there are few sightings of birds, reptiles, butterflies were recorded in the captive and farm forestry plantations.

CONCLUSIONS

- The physico- chemical properties (pH & EC) and exchangeable properties (ESP) of the soil were improved with TNPL pulpwood plantations.
- The soil organic carbon content and available major nutrient status of the area is improved where TNPL plantations were raised.
- The flora and fauna composition was well maintained and there is no degradation of flora and fauna composition in TNPL plantation areas.
- The micro climatic condition in the area of TNPL plantations is improved

Ecological impact of TNPL Plantations:

- Rainwater harvesting: Ploughing, Pitting and Planting facilitates better rain water harvesting as compared with barren lands. It will help in recharging ground water and conserving soil moisture.
- Nutrient recycling: Incorporation of weeds and leaf litter fall into soil adds in nutrient recycling. The biomass of weeds and leaf litters contain appreciable quantity of plant nutrients. Thus pulpwood plantations act as potential carbon sink and reduce the green house gases into atmosphere.
- Addition of organic matter & essential nutrients: By allowing animal grazing inside the plantations, sizeable quantity of organic manure and essential plant nutrients are added into the soil through the dung of cattle's. During harvest, the debarked debris left in the field becomes good organic manure.
- Conservation of natural resources: Aesthetic and rare species (flora & fauna) and micro catchment water bodies are conserved and maintained naturally against anthropogenic factor.
- Improved genetic materials resulted in maximization of yield per unit area.
- The use of bio-inoculants (*Trichoderma viridae*, *Bacillus velezensis*, *Psuedomonos flurosence*, *Micromonospora* and *Frankia*) in TNPL plant propagation nurseries and field besides controlling the diseases naturally/ improves the growth of plantation, nullified the use of chemical pesticides/ fungicides.

Ecological impact on outside Plantation area:

- Employment generation to local village people.
- Allowing firewood collection to local people – minimizing the wastes generated from the plantation.
- Place for grazing of cattle reduce the pressure of farm lands for local village people.
- Converting barren lands into cultivable land (Farm Forestry) by demonstrating tree cultivation.
- By becoming one of the stakeholders, the local people are trained for scientific cultivation-reduction of chemical use and optimum utilization of available resources.

PLATES

Figure: Natural Flora and fauna from the TNPL plantation areas

ANNEXURES

Annexure I Soil analysis report of 45 FMU's in Captive Plantations

FMU CODE	NAME OF THE LAND OWNER	DISTRICT	LOCATION	EXTENT (HA)	pH	EC (dS/m)	K (C mol/kg)	Ca (C mol/kg)	Mg (C mol/kg)	Na (C mol/kg)	Total Cations	ESP (%)
C00388	TNPL-WIND FARM	TIRUNELVELI	N8 56.897 E77 39.193	50.00	6.91	0.1	3.6	5.28	4.12	0.76	13.76	5.52
C00388	TNPL-WIND FARM	TIRUNELVELI	N8 56.537 E77 39.027	50.00	7.12	0.1	4.1	5.78	5.12	0.6	15.6	3.85
S04024	A/M MASIMAGA SOMASUNDARA MUDALIYAR ARAKKATTALAI	TIRUVANNAMALAI	N12 41.092 E79 34.246	17.12	6.93	0.03	0.59	12.5	10.3	0.65	24.04	2.7
S04017	A/M NITHIYAKALYANAPERUMAL THIRUKOIL	KANCHIPURAM	N12.73396 E80.16943	22.69	7.59	0.02	0.57	3	2.42	0.62	6.61	9.38
T00315	GOVT.WASTE LAND BLOCK-3	KARUR	N10 33.788 E78 14.125	8.00	6.97	0.05	1.2	3.9	3	0.21	8.31	2.53
T00315	GOVT.WASTE LAND,BLOCK-1	KARUR	N10 36.417 E78 13.347	8.10	6.93	0.09	1.5	2.9	1.2	0.12	5.72	2.1
T00315	GOVT.WASTE LAND,BLOCK-4	KARUR	N10 33.981 E78 14.293	8.11	6.87	0.08	0.8	6.7	4.7	0.21	12.41	1.69
T00315	GOVT.WASTE LAND,BLOCK-5	KARUR	N10 33.573 E78 12.944	8.70	6.92	0.13	2.2	9.4	0.8	0.19	12.59	1.51
T00315	GOVT.WASTE LAND,BLOCK-6	KARUR	N10 34.029 E78 12.601	11.19	7.7	0.25	0.9	10.3	2.7	0.18	14.08	1.28
T00315	GOVT.WASTE LAND,BLOCK-7	KARUR	N10 34.952 E78 09.800	10.00	6.92	0.1	1.6	3.8	1.6	0.18	7.18	2.51
T00315	GOVT.WASTE LAND,BLOCK-8	KARUR	N10 36.675 E78 12.424	15.00	6.73	0.05	1.5	2.8	1.1	0.12	5.52	2.17
T00311	GOVT.WASTE LAND	THANJAVUR	N10 42.482 E78 53.381	19.49	7.2	0.05	0.85	3.06	1.94	0.82	6.67	12.29
S04039	A/M KALLALAGAR THIRUKOIL,ALAGARKOIL	MADURAI	N9 46.171 E77 58.202	14.70	8.37	0.01	0.47	18	12.12	0.38	30.97	1.23
S04045	A/M EKANTHALINGASAMY THIRUKOIL	THOOTHUKUDI	N8 27.649 E77 48.871	46.15	8.01	0.2	0.65	4.7	3.13	0.55	9.03	6.09

S04040	A/M NARUMBUTHASAMY THIRUKOIL	TIRUNELVELI	N8 45.278 E77 28.696	108.10	7.47	0	0.42	4.7	2.02	1.15	8.29	13.87
S04046	A/M BOOMINATHASAMY THIRUKOIL	TIRUNELVELI	N8 40.635 E77 29.415	78.54	6.9	0	0.81	1.7	1.01	0.71	4.23	16.78
S04042	A/M SUBRAMANIYASWAMY THIRUKOIL	TIRUNELVELI	N8 39.540 E77 38.671	136.44	7.92	0	0.86	9.5	6.56	0.72	17.64	4.08
S04041	A/M SUBRAMANIYASWAMY THIRUKOIL	TIRUNELVELI	N8 39.833 E77 38.846	41.34	8.01	0.2	0.65	4.7	3.13	0.55	9.03	6.09
S04031	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 35.019 E77 46.483	208.58	6.94	0.22	0.46	6.5	3.73	2.28	12.97	17.58
S04030	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 33.578 E77 47.465	82.60	7.46	0	0.59	4.5	2.02	0.65	7.76	8.38
S04029	A/M GANDHIMATHIAMMAN THIRUKOIL	TIRUNELVELI	N8 34.012 E77 46.734	155.25	7.6	0.01	0.62	3.5	2.22	0.62	6.96	8.91
S04038	A/M MEENAKSHI SUNDARESWARAR THIRUKOIL	VIRUDHUNAGAR	N9 36.048 E77 54.033	26.86	7.87	0.04	0.41	37	7.27	0.35	45.03	0.78
T00316	GOVT.WASTE LAND	TRICHY	N10 39.975 E78 45.924	15.19	7.8	0.56	0.78	2.43	0.48	1.51	5.19	29.09
T00316	GOVT.WASTE LAND	TRICHY	N10 39.287 E78 47.206	10.55	7.8	0.56	0.94	2.43	0.48	1.51	5.35	28.22
T00316	GOVT.WASTE LAND, SOORIYUR (HAPP)	TRICHY	N10 42.247 E78 47.162	9.75	7.8	0.56	1.16	2.43	0.48	1.51	5.57	27.11
T00316	GOVT.WASTE LAND, SOORIYUR (VAARIKADU)	TRICHY	N10 40.512 E78 46.182	9.67	7.8	0.56	0.78	2.43	0.48	1.51	5.19	29.09
T00317	GOVT.WASTE LAND	TRICHY	N10 20.032 E78 20.834	25.00	7.33	0.06	1.26	3.4	2.53	0.21	7.41	2.88
T00318	GOVT.WASTE LAND BLOCK-I	TRICHY	N11 06.847 E78 24.182	10.00	7.5	0.02	0.68	3.53	2.33	0.53	7.08	7.53
T00318	GOVT.WASTE LAND BLOCK-II	TRICHY	N11 06.400 E78 24.324	10.00	7.5	0.02	0.65	3.53	2.33	0.53	7.05	7.57
T00318	GOVT.WASTE LAND BLOCK-III	TRICHY	N11 06.210 E78 24.103	6.00	7.5	0.02	0.78	3.53	2.33	0.53	7.18	7.43
T02505	TNPL UNIT I OWN LAND	KARUR	N11 03.733 E77 59.443	21.12	7.15	0.14	2.23	6.49	4.03	2.69	15.43	14.41

T02506	TNPL UNIT II OWN LAND	TRICHY	N10 41.372 E78 29.318	195.77	6.94	0.09	1.96	4.67	2.74	0.74	10.11	7.32
M01749	MARIYA ANTONY PRAKASI.S	SIVAGANGAI	N9 46.559 E78 29.027	41.53	6.91	0.22	2.2	5.73	2.42	0.91	11.26	8.08
C03351	CHAIRMAN BS BIOFUEL COMPANY PVT LTD	SIVAGANGAI	N9 43.160 E78 32.976, N9 43.675 E78 33.088	58.30	7.01	0.02	0.31	13.2	7.4	0.65	21.56	3.01
U00126	UDAIYAPPAN & CO	SIVAGANGAI	N9 50.560 E78 41.785	26.82	6.87	0.21	0.49	10.5	5.7	0.72	17.41	4.14
V01825	VILLAGE RECONSTRUCTION ORGANIZATION	KARUR	N10 46.908 E78 28.714	30.36	7.65	0.26	0.58	4.51	2.86	0.52	8.47	6.14
G03204	K.P.GANESAN & CO	SIVAGANGAI	N9 49.923 E78 48.546	27.18	6.98	0.17	0.27	2.56	2.88	0.18	5.89	3.06
A02476	ACRI, KILLIKULAM	THOOTHUKUDI	N8 41.662 E77 52.176	90.69	6.65	0.13	0.51	5.85	4.65	0.14	11.15	1.26
O01423	ORS,TINDIVANAM	VILUPPURAM	N12 13.126 E79 40.293	6.88	7.92	0.74	0.26	3.65	2.9	0.54	7.35	7.32
A02494	ARS, VAIGAIDAM	THENI	N10 01.065 E77 33.795	8.10	7.15	0.29	0.31	6.54	4.85	0.17	12.12	1.4
D02784	DRYLAND AGRICULTURAL RESEARCH STATION	SIVAGANGAI	N10 10.838 E78 48.109	21.78	6.85	0.16	0.47	5.45	5.05	0.16	11.13	1.44
A02477	ARS, BHAVANISAGAR	ERODE	N11 29.121 E77 07.844	12.96	7.36	0.27	0.68	6.5	4.5	1.8	13.68	1.07
C03434	CHATHIRAM LAND	THANJAVUR	10.30475 79.35513	19.03	7.96	0.21	0.19	3.28	2.92	0.92	7.31	12.59
C03434	CHATHIRAM LAND	THANJAVUR	10.29103 79.32526	20.24	7.85	0.23	0.15	3.51	2.88	1.05	7.59	13.83
S04629	SCAD KRISHI VIGYAN KENDRA	THOOTHUKUDI	N8 44.532 E78 00.724	10.93	7.35	0.17	0.21	5.26	4.36	0.89	10.72	8.30
R03834	RAVEENDAR.V	SIVAGANGAI	N9 47.007 E78 30.057	24.21	7.51	0.09	0.52	4.79	4.22	0.92	10.45	8.80

Annexure II Soil analysis report of some of the farm forestry plantations

Year of Planting	Farmer code	Name of the farmer	District	Zone	Species	Extent (AC)	pH	EC (dS/m)	K (C mol/kg)	Ca (C mol/kg)	Mg (C mol/kg)	Na (C mol/kg)	Total Cations	ESP (%)
2022-2023	M03838	MURUGAN.P	VILUPPURAM	NORTH	CASUARINA	3.42	7.92	0.15	0.02	1.64	1.24	0.01	2.91	0.39
2022-2023	D03040	SELVARAJ .D	VILUPPURAM	NORTH	CASUARINA	5.00	7.74	0.23	0.02	0.6	0.2	0.05	0.86	5.33
2022-2023	E00540	ELUMALAI G	VILUPPURAM	NORTH	CASUARINA	1.33	7.08	0.17	0.01	0.8	1.16	0.02	2.00	1.22
2020-2021	R03989	RANGARAJ.R	VILUPPURAM	NORTH	EUCALYPTUS	4.13	7.89	0.09	0.01	0.24	0.16	0.01	0.43	2.86
2020-2021	V01972	VIJAYAN.A	VILUPPURAM	NORTH	EUCALYPTUS	3.00	7.68	0.03	0.02	0.56	1.64	0.08	2.31	3.64
2020-2021	S05769	SUMATHI	VILUPPURAM	NORTH	EUCALYPTUS	6.50	7.59	0.18	0.01	0.44	0.24	0.01	0.71	2.09
2021-2022	G03420	GOBALA VASUDEVAN	VILUPPURAM	NORTH	CASUARINA	2.66	6.98	0.25	0.02	1.6	1.8	0.02	3.44	0.58
2022-2023	J03879	JAYACHITRA	ARIYALUR	EAST	CASUARINA	4.30	8.01	0.51	0.01	0.32	0.24	0.15	0.72	20.62
2022-2023	S07111	SANGEETHA	ARIYALUR	EAST	EUCALYPTUS	1.20	6.97	0.23	0.03	0.4	0.24	0.08	0.75	10.72
2022-2023	I00121	IRUDAYASAMY.S	ARIYALUR	EAST	CASUARINA	4.50	7.22	0.43	0.15	2.92	0.32	0.02	3.41	0.55
2022-2023	K04778	KALAISELVI	ARIYALUR	EAST	EUCALYPTUS	2.60	8.06	0.21	0.01	0.52	0.12	0.03	0.68	4.32
2022-2023	G03606	GOVINDHARASU	ARIYALUR	EAST	CASUARINA	2.00	8.18	0.15	0.01	2.28	1.36	0.03	3.68	0.79
2022-2023	S04956	SOUNDARARAJAN T	ARIYALUR	EAST	CASUARINA	2.83	7.32	0.12	0.01	0.2	0.16	0.04	0.42	10.74
2019-2020	S05067	SELLAMUTHU UDAYAR.A	ARIYALUR	EAST	EUCALYPTUS	4.00	7.77	0.09	0.02	0.48	0.2	0.02	0.71	2.38
2022-2023	A03033	ANBARASAN	ARIYALUR	EAST	EUCALYPTUS	4.50	8.32	0.16	0.02	0.32	0.28	0.09	0.71	12.65
2022-2023	A01948	ARULMANI.S	PUDUKKOTTAI	SOUTH	EUCALYPTUS	5.00	8.14	0.27	0.01	0.2	0.24	0.03	0.48	6.17
2022-2023	M03870	MANICKAM T	PUDUKKOTTAI	SOUTH	CASUARINA	2.50	7.52	0.23	0.01	0.6	1.4	0.18	2.19	8.02
2022-2023	S07208	SELVAPANDIAN A	SIVAGANGA	SOUTH	EUCALYPTUS	6.00	7.71	0.31	0.01	2.2	0.24	0.16	2.61	6.29
2022-2023	C03609	CHANDRASEKARAN	PUDUKKOTTAI	SOUTH	EUCALYPTUS	6.30	6.86	0.08	0.01	0.4	0.16	0.02	0.59	3.08

2019-2020	D02638	DHAMOTHARAN.P	PUDUKKOTTAI	SOUTH	EUCALYPTUS	6.50	6.59	0.17	0.01	1.4	1.6	0.02	3.03	0.66
2019-2020	S05458	SELVARAJ.S	PUDUKKOTTAI	SOUTH	EUCALYPTUS	20.00	6.92	0.26	0.03	0.92	0.72	0.18	1.85	9.68
2021-2022	T02912	THANGARAJ	PUDUKKOTTAI	SOUTH	EUCALYPTUS	1.70	7.05	0.23	0.06	0.32	0.64	0.01	1.03	1.06
2022-2023	A03021	ARANGAN	PUDUKKOTTAI	SOUTH	EUCALYPTUS	4.00	6.94	0.32	0.02	0.28	0.08	0.18	0.56	31.88
2022-2023	K04831	KARTHICK MURUGAPPAN	SIVAGANGA	SOUTH	EUCALYPTUS	3.00	7.72	0.05	0.02	0.48	0.4	0.01	0.91	1.15
2019-2020	G03198	GUNAPATHI.S	KARUR	WEST	EUCALYPTUS	4.50	7.15	0.03	0.01	0.32	0.2	0.01	0.54	1.93
2019-2020	K03624	KARTHIKEYAN	ERODE	WEST	EUCALYPTUS	3.00	8.05	0.21	0.04	0.64	0.28	0.11	1.07	10.24
2020-2021	S05553	SARASWATHI.R	SALEM	WEST	EUCALYPTUS	2.00	8.81	0.36	0.07	0.48	0.56	0.00	1.11	0.31
2020-2021	S04224	SUBRAMANIYAN.P	KARUR	WEST	CASUARINA	2.00	8.72	0.25	0.01	0.88	0.08	0.19	1.16	16.49
2020-2021	R02833	RAMALINGAM.K	KARUR	WEST	CASUARINA	1.00	7.95	0.17	0.01	0.88	0.08	0.18	1.15	15.62
2020-2021	S06030	SUBRAMANI	SALEM	WEST	CASUARINA	4.00	8.09	0.22	0.01	0.12	0.24	0.08	0.45	17.86
2021-2022	T02702	THANGAVEL.P	KARUR	WEST	EUCALYPTUS	1.00	7.19	0.21	0.01	0.16	0.36	0.14	0.67	20.39
2022-2023	N02872	NALLASAMY	TIRUPPUR	WEST	EUCALYPTUS	5.00	7.76	0.15	0.02	0.2	0.16	0.00	0.38	1.26
2022-2023	A01723	ARAVINTH NALLATHAMBI.S.S	TIRUPPUR	WEST	CASUARINA	3.33	8.17	0.28	0.03	0.16	0.08	0.01	0.27	2.24

ANNEXURE-III

TNPL – Assessment Report- Eucalyptus

Famers Name& Reg. No	**:**	
Father Name ; Contact Number	**:**	
Year of Planting	**:**	
Species	**:**	**Area : Acre/ Ha**
Location	**:**	
Hamlet	**:**	
Village	**:**	
Taluk	**:**	
District	**:**	
Region	**:**	
Survey No/ Latitude /Longitude	**:**	

S. No	Height (m)	DBH (cm)	Pest	Disease	Survival Percentage
1.					Spacing : Total No of plants : Sampling Intensity : 5 % (Farm Forestry) 100 % (Captive Plantation) Total No of rows evaluated : No of plants in a row : 1. Eucalyptus Gall Wasp (%) 2. Termite (Nos) 3. Pink Disease/Cankers (%) 4. Leaf Spot (%) 5. Bacterial Wilt (Nos) 6. Root rot/ Stem Rot (Nos) No. of plants infested Percent infestation = ---------- x100 Total No. of Plants observed Sum of Ind. grades 100 PDI = ---------- x ---------- Max disease grade Total No. of tree Obs. No. of plants infected PI = ----------x100 Total No. of Plants observed
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TNPL – Assessment Report- Casuarina

Famers Name& Reg. No	**:**	
Father Name; Contact Number	**:**	
Year of Planting	**:**	
Species	**:**	**Area : Acre/ Ha**
Location	**:**	
Hamlet	**:**	
Village	**:**	
Taluk	**:**	
District	**:**	
Region	**:**	
Survey No/ Latitude /Longitude	**:**	

S. No	Pest	Disease	Survival Percentage
1.			Spacing : Total No of plants : Sampling Intensity : 5 % (Farm Forestry) 100 % (Captive Plantation) Total No of rows evaluated : No of plants in a row : No. of plants infested Percent infestation = ---------- x100 Total No. of Plants observed 1. Mealy Bug (Nos) 2. Termite (Nos) 3. Bark Feeder/Stem Feeder (Nos) 4. Needle Blight (%) 5. Stem Wilt (Nos) 6. Root rot/ Stem Rot (Nos) Sum of Ind. grades 100 PDI = ---------- x ---------- Max disease grade Total No. of tree Obs. No. of plants infected PI = ----------x100 Total No. of Plants observed
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