



**ENVIRONMENTAL IMPACT ASSESSMENT
AT TNPL PLANTATIONS**

2024 – Issue No.6

Submitted By

**SOCIETY FOR SOCIAL FORESTRY RESEARCH AND DEVELOPMENT
CHENNAI**

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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 and 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 4,40,000 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 consisting captive and farm forestry plantations 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 and farm forestry program were implemented. Totally 46 plantations coming under 13 districts were chosen for the assessment with an area of 1855.18 hectares (Table 1). The Study conducted and the data collected were related to the year 2023-24.

Table 1. District wise TNPL captive plantation

| S.L NO | FARMER CODE | NAME OF THE LAND OWNER | 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 SUBRAMANIASWAMY THIRUKOIL | TIRUNELVELI | N8 39.540 E77 38.671 | 136.44 |
| 17 | S04041 | A/M SUBRAMANIASWAMY 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 (KULATHUKADU) | TRICHY | N10 39.975 E78 45.924 | 15.19 |
| 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, VAIG AidAM | 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 |
| 46 | S07408 | STATE SEED FARM | KARUR | 10.84402 78.48081 | 26.72 |
| TOTAL | | | | | 1855.18 |

In farm forestry, consisting about 54 percent casuarina and 46 percent eucalyptus were assessed five percent sampling in 98 Taluks and 13 Districts with an area of 17712 hectares as shown in table 2.

3.2. CLIMATIC FACTORS

The climatic data, such as maximum and minimum air temperature ($^{\circ}\text{C}$), relative humidity (%), wind speed (Kmph), soil moisture (%), soil temperature ($^{\circ}\text{C}$), 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.

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

| S.No | District | EUCALYPTUS | | CASUARINA | | OTHERS | | TOTAL | |
|--------------------|-----------------|-------------|--------------|-------------|--------------|----------|--------------|--------------|--------------|
| | | FMU | Extent (Ha). | FMU | Extent (Ha). | FMU | Extent (Ha). | FMU | Extent (Ha). |
| 1 | ARIYALUR | 1141 | 1756 | 1905 | 2290 | 3 | 1.9 | 3049 | 4048 |
| 2 | CHENGALPATTU | 5 | 21 | 280 | 677 | 0 | 0 | 285 | 698 |
| 3 | CUDDALORE | 40 | 103 | 552 | 964 | 0 | 0 | 592 | 1067 |
| 4 | ERODE | 270 | 196 | 57 | 29 | 0 | 0 | 327 | 225 |
| 5 | KALLAKURICHI | 1 | 3 | 27 | 70 | 0 | 0 | 28 | 73 |
| 6 | KARUR | 404 | 610 | 472 | 300 | 0 | 0 | 876 | 910 |
| 7 | NAMAKKAL | 92 | 88 | 307 | 219 | 1 | 0.26 | 400 | 307 |
| 8 | PUDUKKOTTAI | 1400 | 3615 | 1282 | 1581 | 0 | 0 | 2682 | 5196 |
| 9 | SALEM | 105 | 181 | 67 | 69 | 0 | 0 | 172 | 250 |
| 10 | SIVAGANGA | 217 | 1067 | 56 | 84 | 0 | 0 | 273 | 1151 |
| 11 | TIRUCHIRAPPALLI | 231 | 428 | 101 | 100 | 0 | 0 | 332 | 528 |
| 12 | TIRUPPUR | 101 | 107 | 26 | 27 | 0 | 0 | 127 | 134 |
| 13 | VILUPPURAM | 3 | 10 | 1850 | 3114 | 0 | 0 | 1852 | 3124 |
| GRAND TOTAL | | 4010 | 8186 | 6982 | 9524 | 4 | 2 | 10995 | 17712 |

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 and farm forestry 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 (cm³).

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

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/cm³ 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.

$$\text{Carbon Storage} = \text{Biomass} \times 50\% \text{ (or) Biomass} / 2 \text{ (Suryawanshi } et al., 2014)$$

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 <i>et al.</i> , 1965 |
| Available potassium | Neutral normal NH ₄ OAc | 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 |

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

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 form 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 reduce 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

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 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 |

Table 5. Carbon sequestration potential of TNPL captive plantations

| Districts | Area (ha) | Height (m) | GBH (cm) | Volume (m ³) | Total bio mass (tonnes/ha) | Carbon storage (Tonnes) | CO ₂ 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.

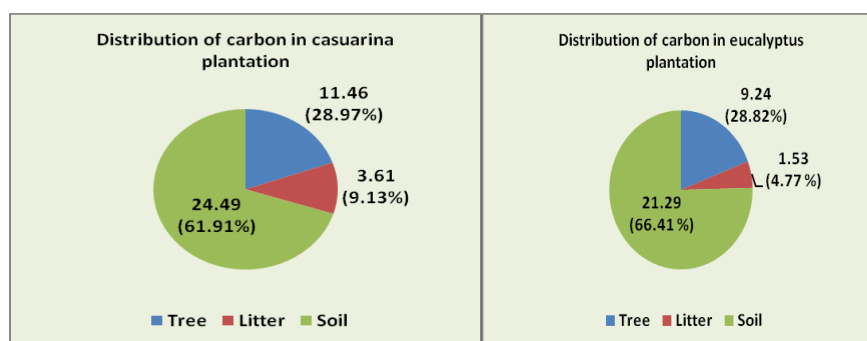


Figure 1. Carbon sequestration pattern of TNPL farm forestry casuarina and eucalyptus plantations

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 138 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 138 soil samples collected and analyzed 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 Kancheepuram 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.

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 Potassium (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 |

4.2.1.3. 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 kg ha^{-1} to 388 kg ha^{-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 kg ha^{-1} and lowest with Cuddalore, Namakkal and Thiruvannamalai sites with 8.50 kg ha^{-1} . Available potassium in TNPL captive plantation sites ranged from 263 kg ha^{-1} at Pudukottai to 390 kg ha^{-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.

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 identified 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 lebeck*, *Albizia amara* and *Delonix elata*, *Prosopis juliflora*, etc. were 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*, *Delonaea 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*, *Chloris barbata*, *Cyndon dactylon*, *Eragrostis sp*, *Heteropogon contortus*, *Iseilema laxum*, *Setaria 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*.

In addition to liquid bio- inoculants formulations, TNPL produce Airbuscular Mycorrhizal fungi (VAM) to enhance the rooting ability of clonal cuttings and better nutrient acquisition from the soil after their transplantation in the field.

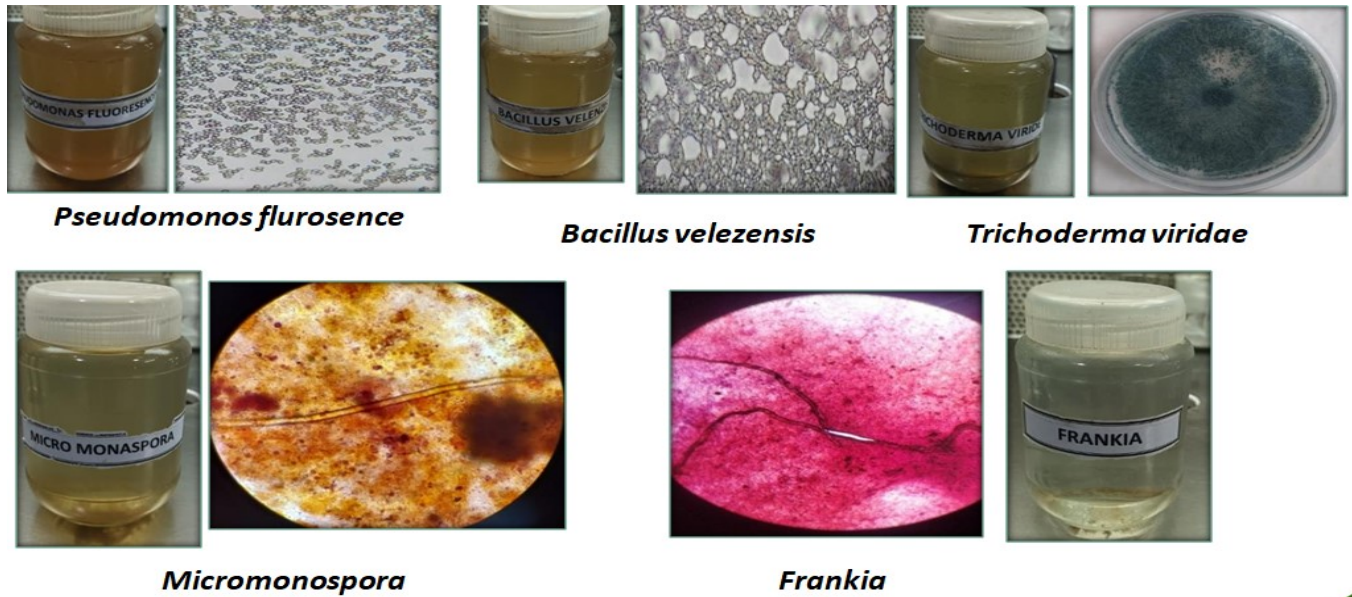


Figure 2. Bio- inoculants produced and inoculated to clonal plants at TNPL

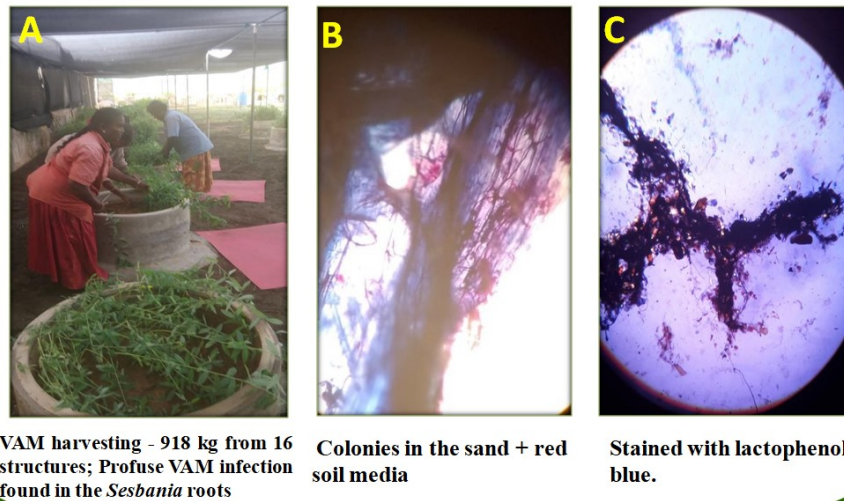


Figure 3. AMF fungi (VAM) produced and inoculated to clonal plants at TNPL

Another interesting point to be noticed in the cultivation of pulpwood trees is the more occurrences of termite mounds. 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 silvicultural 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 atleast 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 judicious 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 fluorescense*, *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 | 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 | 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 | 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 | 8.1 | 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 | 8.7 | 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 | 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 | 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 | 14.7 | 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 | 108.1 | 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 SUBRAMANIASWAMY 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 SUBRAMANIASWAMY 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 | 82.6 | 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 | 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 | 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 | 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 | 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 |
| M01749S | 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 | 58.3 | 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, VAIG Aidam | THENI | N10 01.065 E77 33.795 | 8.1 | 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 | 8.3 |
| 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 | 8.8 |
| S07408 | STATE SEED FARM | KARUR | 10.84402 78.48081 | 26.72 | 7.21 | 0.13 | 0.52 | 4.77 | 2.85 | 0.56 | 8.7 | 6.43 |

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. | | | | | <p>Spacing :</p> <p>Total No of plants :</p> <p>Sampling Intensity : 5 % (Farm Forestry)</p> <p>100 % (Captive Plantation)</p> <p>Total No of rows evaluated :</p> <p>No of plants in a row :</p> <ol style="list-style-type: none"> 1. Eucalyptus Gall Wasp (%) 2. Termite (Nos) 3. Pink Disease/Cankers (%) 4. Leaf Spot (%) 5. Bacterial Wilt (Nos) 6. Root rot/ Stem Rot (Nos) <p>No. of plants infested</p> <p>Percent infestation = $\frac{\text{Total No. of Plants observed}}{\text{Sum of Ind. grades}} \times 100$</p> <p>PDI = $\frac{\text{Max disease grade}}{\text{Total No. of tree Obs.}} \times 100$</p> <p>No. of plants infected</p> <p>PI = $\frac{\text{Total No. of Plants observed}}{\text{Total No. of Plants observed}} \times 100$</p> |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
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| 15. | | | | | |
| 16. | | | | | |
| 17. | | | | | |
| 18. | | | | | |
| 19. | | | | | |
| 20. | | | | | |

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 : |
| 2. | | | Total No of plants : |
| 3. | | | Sampling Intensity : 5 % (Farm Forestry) 100 % (Captive Plantation) |
| 4. | | | Total No of rows evaluated : |
| 5. | | | No of plants in a row : |
| 6. | | | No. of plants infested |
| 7. | | | Percent infestation = ----- x100 Total No. of Plants observed |
| 8. | | | 1. Mealy Bug (Nos) |
| 9. | | | 2. Termite (Nos) |
| 10. | | | 3. Bark Feeder/Stem Feeder (Nos) |
| 11. | | | 4. Needle Blight (%) |
| 12. | | | 5. Stem Wilt (Nos) |
| 13. | | | 6. Root rot/ Stem Rot (Nos) |
| 14. | | | Sum of Ind. grades 100 PDI = ----- x ----- Max disease grade Total No. of tree Obs. |
| 15. | | | |
| 16. | | | No. of plants infected |
| 17. | | | PI = -----x100 Total No. of Plants observed |
| 18. | | | |
| 19. | | | |
| 20. | | | |