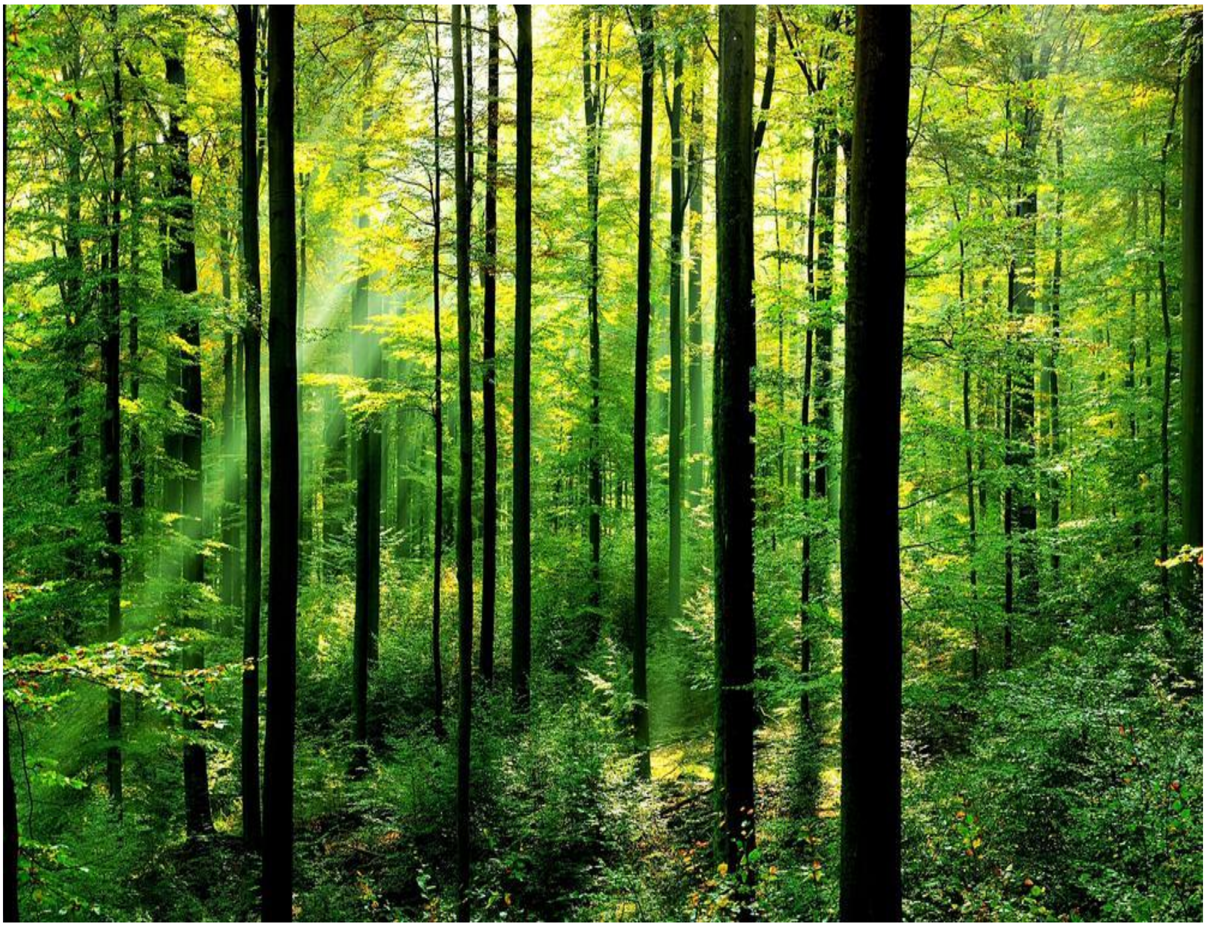

Carbon Sinks (Afforestation & Agroforestry):
Identification of Green Business Potential in India

HIGHLIGHTS

Growth Forecast for Carbon Sinks sector in India
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Job potential for Carbon Sinks sector
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Occupational map for Carbon Sinks sector
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Preamble

Forests play a critical role in elimination of natural and man-made carbon emissions from the atmosphere, and can essentially be classified as one of the most significant terrestrial carbon sinks. Planting new trees, rehabilitating degraded forests, and enriching existing forests can contribute to addressing climate change by augmenting the rate of carbon sequestration. In the wake of rapid development in the Indian economy, the levels of Green House Gases and Particulate Matter have risen to alarmingly high levels in several cities across the country, leading to operational impediments, health hazards, and various other associated functional risks.

Efforts towards increasing India's forest and tree cover can go a long way in curbing the menace of climate change. Besides enhancing the overall carbon stock, forests also assist in improving the ecological climate by facilitating the growth of flora and fauna. Forest natives, tribal groups, as well as nearby population shall significantly benefit through increased access to forest produce. Forests also provide wide-ranging avenues for creation of employment through activities of plantation, maintenance, gathering of produce, processing, and sales and marketing of finished goods, among others.

Consequently, it becomes imperative to devise breakthrough interventions at the regulatory and operational levels so as to further promote the increase in forest and tree cover in India.

Executive Summary

Rapid increase in the rate of urbanization has led to a rise in the demands of Indian citizens. In order to supplement this demand, India has witnessed a fast rise in the rate of industrial activity encompassing a versatile range of business functions across different geographic regions. This has correspondingly led to an increase in emissions of Green House Gases and other particulates from industries and application of their finished products, and has also placed immense pressure on natural resources such as Coal, Petroleum, and other minerals. The need of the hour is to successfully transition towards adoption of alternate and non-conventional sources of energy so as to reduce the burden on exhaustible minerals and contribute towards reducing emissions.

India's Nationally Determined Contribution (NDC) envisions the creation of an additional carbon sink of 2.5 to 3 Billion tonnes of CO_2 equivalent by the year 2030. India's National Forest Policy also targets the improvement in India's forest cover from the current coverage of 24.16 % of its geographic area to 33% by the year 2030. By keeping these two national targets as a basis for development of green business while simultaneously addressing the issue of climate change and resource scarcity, this report highlights the promotion of Tree Borne Oilseeds (TBOs) as a viable economic venture.

Open forests present a practicable destination for cultivation of TBOs. The seeds obtained from TBOs can be further processed for obtaining biodiesel which can help India reduce its oil import dependence. Biodiesel can be blended to conventional diesel for powering of automobiles, thereby leading to fewer emissions. Plantation of TBO species shall also aid in creation of an additional carbon sink to help improve the climate landscape of India. Besides, this venture shall also provide livelihood to numerous persons through various activities such as plantation, maintenance, seed processing, biodiesel production, and production of associated products such as animal feed, organic fertilizer, cosmetics, etc. Thus, the promotion of TBOs can be considered as a viable option in the current Indian socio-economic context.

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Chapter 1

Afforestation under GIM and CAMPA

- **Background**
- **Key National Policies / Mission / Guidelines**
- **Technologies in the Forestry Sector**
- **India's Progress towards Enhancing Climate Performance**
- **Tree Borne Oilseeds**
- **National Policy on Biofuels**

Background

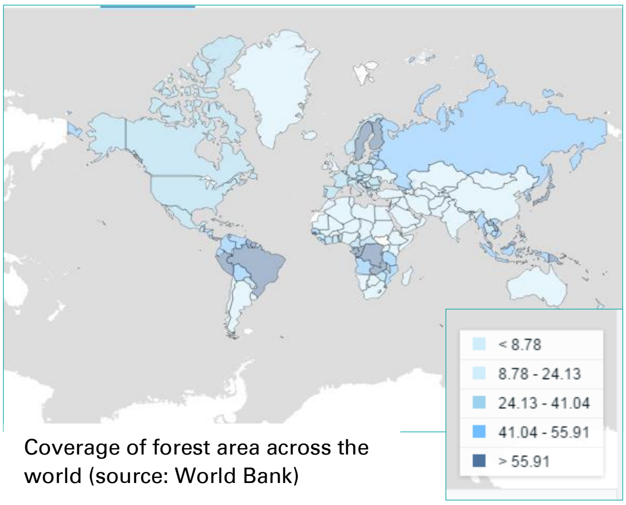
A carbon sink is a reservoir that accumulates and stores some carbon containing chemical compound for an indefinite period. Forests are important carbon pools which continuously exchange carbon di oxide with the atmosphere, due to both natural processes and human action. The sink of carbon sequestration in forests and wood products helps to offset sources of carbon di oxide to the atmosphere, such as deforestation, forest fires and fossil fuel emissions. Sustainable forestry practices also increase the ability of forests to sequester atmospheric carbon while enhancing other ecosystem services, such as improved soil and water quality.

The IPCC Guidelines define afforestation as the "planting of new forests on lands which, historically, have not contained forests." *Afforestation* and *reforestation* both refer to establishment of trees on non-treed land. Reforestation refers to establishment of forest on land that had recent tree cover, whereas afforestation refers to land that has been without forest for much longer.

The biomass and carbon stocks in forests are important indicators of forests' productive capacities, energy potential and capacity to sequester carbon. The role of forests as terrestrial sinks and sources of carbon dioxide has received increasing attention since the adoption of the 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Global Status of Forests

Forests and forest management worldwide has changed substantially over the past 25 years. The forest area (as a percentage of land area) has declined from 31.8% in 1990 to 30.8% in 2015. Figure 1 provides the coverage of forest area across different countries.



Coverage of forest area across the world (source: World Bank)

The forestry sector is considered to be a significant source of wealth and employment, especially in developing countries. **Overall, the sector provides 1.2 percent of global GDP, with more than 10 percent of GDP in the poorest countries and about 5 percent in many developing countries**. (FAO, State of World's Forests Report, February 2006)

Economic development, population growth and urbanization are increasing the demand for forest products, which is projected to grow dramatically in the coming decades. Demand for global industrial round wood alone is predicted to quadruple by 2050.

As per the Food and Agriculture Organization, the rate of global forest area net loss has however, reduced by more than 50 percent between the periods 1990-2000 and 2010-2015 as shown in the table below:

			Annual net change	
Year	**Forest (thousand ha)**	**Period**	**Area (thousand ha)**	**Rate * (%)**
1990	4128269			
2000	4055602	1990-2000	-7267	-0.18
2005	4032743	2000-2005	-4572	-0.11
2010	4015673	2005-2010	-3414	-0.08
2015	3999134	2010-2015	-3308	-0.08

*Calculated as the compound annual growth rate

Status of Forests in India

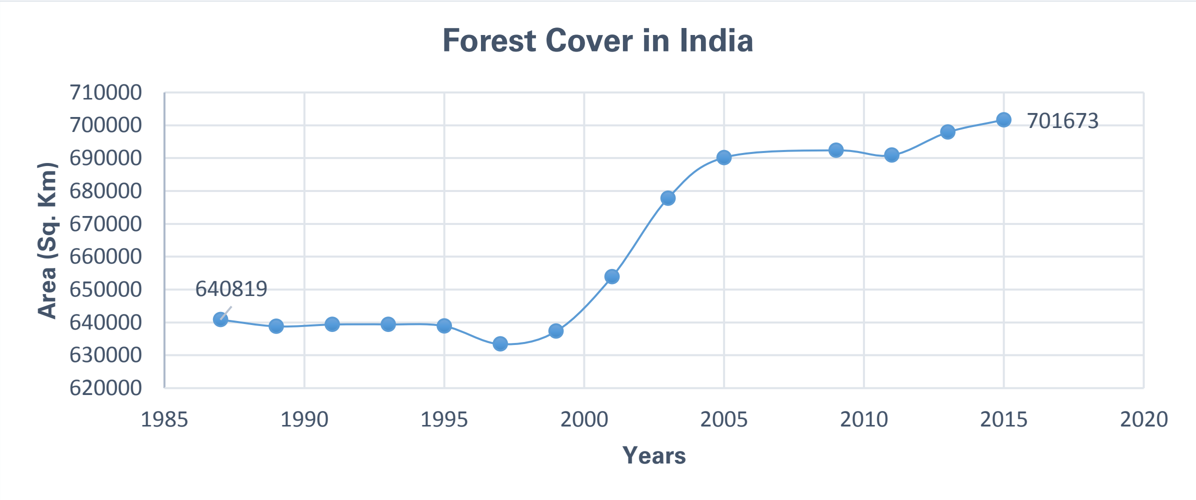
The total forest and tree cover of India as per the India State of Forest Report (2015) is 794,245 square km (79.42 million ha) which is 24.16 percent of the geographical area of the country. There is an increase of 3,775 square km in the forest cover of the country as compared to 2013 assessment.

The table below shows the forest and tree cover in India in 2013 and 2015:

Class	2013		2015	
	Area (sq. Km)	Percent of geographical area	Area (sq. Km)	Percent of geographical area
Very dense forest	83,502	2.54	85,904	2.61
Moderate dense forest	318,745	9.70	3,15,374	9.59
Open forest	295,651	8.99	3,00,395	9.14
Total forest cover	**697,898**	**21.23**	**7,01,673**	**21.34**
Tree cover	91,266	2.78	92,572	2.82
Total forest and tree cover	**789,164**	**24.01**	**7,94,245**	**24.16**
Scrub	41,383	1.26	41,362	1.26
Non forest	2,547,982	77.51	25,44,228	77.40
Total geographical area	**3,287,263**	**100**	**32,87,263**	**100**

(Source: FSI Report, 2013 and 2015)

The below chart depicts the change in forest cover area over the years.



Forest Cover in India, Ministry of Statistics and Programme Implementation

Forest Survey of India estimates the carbon stock in India's forests as per the methodology of 'Good Practices Guidance' (GPG) developed by Inter-governmental Panel on Climate Change (IPCC). In the present assessment, the total carbon stock is estimated to be 7,044 million tonnes which is an increase of 103 million tonnes as compared to the assessment done in 2013.

Forests provide goods and services to society and constitute the life support system to the planet. The survival of mankind depends on the continuance of forest systems. Over time, anthropogenic pressure on our forests increased manifold and transcended the threshold limit. The pace of degradation of forests is faster than the present human endeavor to rehabilitate. Hence, there is an imperative need to arrest the process of further degradation on one hand and rehabilitate the already degraded forests on the other.

Land degradation may be curtailed through application of plant species which can rehabilitate wastelands by addition of nutrients such as Nitrogen and Silica back into the soil. For such circumstances, Bamboo presents a viable choice as it can provide natural mulch to degraded soil leading to its reclamation. Bamboo is highly versatile and can be easily grown in a variety of soils derived from various parent rocks. Bamboo also finds widespread use in industries such as Chemicals, Textiles, Pulp & Paper, Food & Beverage, and Medicine, among many others.

BAMBOO PLANTATION IN INDIA

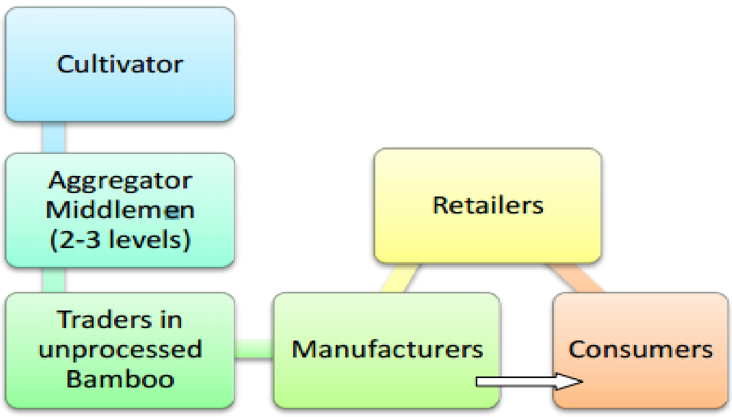
With a view to harness the potential of bamboo crop, Department of Agriculture & Cooperation (DAC), Ministry of Agriculture is implementing a 100% Centrally Sponsored Scheme called Mission for Integrated Development of Horticulture (MIDH) in which National Bamboo Mission (NBM) is being implemented as a sub scheme. National Bamboo Mission (NBM) commenced in 2006 was renamed as National Agriculture Forest and Bamboo Mission (NABM).

The Mission envisages promoting holistic growth of bamboo sector by adopting area-based, regionally differentiated strategy and to increase the area under bamboo cultivation and marketing. Under the Mission, steps have been taken to increase the availability of quality planting material by supporting the setting up of new nurseries and strengthening of existing ones. To address forward integration, the Mission is taking steps to strengthen marketing of bamboo products, especially those of handicraft items.

The mission along with its limited resources has been implemented across 28 states in the country with the assistance of State Bamboo Missions. Since the initiation of mission, bamboo has been planted on 349,864 hectare of land and 1,436 nurseries have been established to supply the quality saplings of bamboo.

The total bamboo bearing area of the country is estimated to be 13.96 million hectare. Arunanchal Pradesh has maximum bamboo bearing area (1.6 million hectare). The bamboo industry engages other industries which produce handicrafts, food products, and construction material using bamboo as the raw material. As per the State Forest Report, 2011, over 39% of the total area under Bamboo in India lies in the North Eastern region of India. According to a study conducted by UNIDO in 2014, the net worth of India's bamboo market was estimated to grow up to 5.5 Billion USD in 2015, while the North East's production was to grow up to 1.25 Billion USD in the same period. Four states in the North East, i.e. Tripura, Assam, Mizoram, and Nagaland have formulated their own policies for development of Bamboo industry and conservation of Bamboo forests.

The figure below illustrates the generic value chain predominant in the bamboo sector in India.



BAMBOO VALUE CHAIN IN INDIA

Key National Policies / Mission / Guidelines

S. No.	Policy guidelines	Description
1	***Nationally Determined Contribution (NDC)***	• India's Nationally Determined Contribution (NDC) recognizes the importance of aggressively restoring forest cover, in a manner consistent with supporting livelihoods. • NDC specifies the **creation of an additional carbon sink of 2.5 to 3 billion tonnes of carbon di oxide equivalent** through additional forest and tree

		cover by 2030. This would require average annual carbon sequestration to increase by at least 14% over the next 15 years relative to the 2008-13 period. • According to the estimations based on 14th Forest Conservation data, this initiative has effectively given afforestation a massive boost by conditioning about USD 6.9 billion of transfers to the states based on their forest cover, which is projected to increase by up to USD 12 billion by 2019-20.
2	***National Mission for Green India (GIM), 2015***	• The Green India Mission (GIM) launched in 2010 aims to increase and improve the quality of forest cover and contribute to enhance ecosystem services along with carbon sequestration as a major co-benefit.
3	***Compensatory Afforestation Fund Management and Planning Authority (CAMPA)***	• The **Compensatory Afforestation Fund Bill, 2015** was introduced in the Lok Sabha on May 8, 2015 with an objective of allocating funds to be primarily spent on afforestation to compensate for loss of forest cover. The bill has been passed by both the houses in July 2016. • Currently, more than INR 40,000 crore has accumulated from these sources, and the fund is increasing at the rate of about INR 6,000 crore every year. • The money collected under CAMPA comes in lieu of forest land diverted under the Forest (Conservation) Act, 1980, for non-forest purposes, such as industrial projects. The Bill is expected to mitigate impact of such diversion by encouraging afforestation projects.
4	***Indian Forest Act, 1927***	• The Act makes various provisions for conservation of forests and in the scheme it provides for a State Government to constitute any forest land or waste land, which are property of Government or which the Government has proprietary rights, as a reserved forest.
5	***Forest Conservation Act 1980 (Amended in 1988)***	• The Forest Conservation Act 1980 was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.
6	***National Forest Policy, 1988***	• The National Forest Policy aims at maintenance of environmental stability through preservation and, where necessary, restoration of the ecological balance that has been adversely disturbed by serious depletion of the forests of the country. • It further lays emphasis on people's participation through Joint Forest Management Programme. • The policy expects investment of US$ 26.7 Billion by 2020, to pursue nationwide afforestation coupled with forest conservation, with the goal of **increasing India's forest cover to 33**%.
7	***Tribal Sub Plan Strategy***	• Introduced in India during the Fifth Five Year Plan, the TSP Strategy is aimed towards channelizing the flow of outlays and benefits from the general sectors in the Central Ministries/Departments for the development of Scheduled Castes and Schedules Tribes at least in proportion to their population, both in physical and financial terms. • The Special Central Assistance (SCA) is provided by the Ministry of tribal Affairs to the State Government as an additive to the State TSP. SCA is primarily meant for family-oriented income-generation schemes in sectors of agriculture, horticulture sericulture and animal husbandry cooperation.
8	***Vanbandhu Kalyan Yojana, 2014***	• The scheme proposes to bring tribal population of the country at par with other social groups and include them in overall progress of the nation. • It seeks to erect sound institutional mechanisms which will help all the benefits of all Central and State schemes to reach the target populations by convergence of resources. • The government aims for holistic development of tribals by plugging in the infrastructural gaps and lags in human development indices.

9	***National Afforestation and Eco-Development Board Guidelines***	• The guidelines are issued with an objective of creating an enabling environment through capacity building at various levels for tree planting, and production and use of quality planting material. • The focus of these guidelines is on increasing and/ or improvement of forest and tree cover. • The National Afforestation Programme contributes to about 15 to 20% afforestation efforts in the country. It is implemented through three-tier institutional set-up, namely State Forest Development Agency (SFDA) at the State / UT level, Forest Development Agencies (FDAs) at the forest divisional level and Joint Forest Management Committees (JFMCs) or Eco-development Committees (EDCs) at the village level. At present, there are more one lakh JFMCs functioning in India.
10	***National Policy on Bio-fuels, 2009***	• The Policy aims at mainstreaming of biofuels and, therefore, envisions a central role for it in the energy and transportation sectors of the country in coming decades • The Goal of the Policy is to ensure that a minimum level of biofuels become readily available in the market to meet the demand at any given time. An indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol, by 2017 is proposed.

11	***National Bamboo Mission, 2006***	• The main objective is:
		  • to increase the coverage of area, with suitable species to enhance yield
		  • promote marketing of bamboo and bamboo based handicrafts
		  • promote, develop and disseminate technologies
		  • to generate employment opportunities especially amongst the unemployed youth

Technologies in the Forestry Sector

With the introduction of geographic information systems (GIS), global positioning systems (GPS) and remote sensing (RS), farmers can now refine nutrient recommendation and water management models to the site-specific conditions of each field. The technologies are being used with an objective of monitoring and management of plantation

Remote Sensing (RS)	• The use of satellite data permits timely and accurate information on very short repetitive cycles needed for monitoring.
Geographical Information System (GIS) and Global Positioning Technology (GPS)	• Computer-based method for collecting, managing, analyzing, modeling, and presenting geographic or spatial data. • GPS would help in precision plowing, field mapping, plantation and fertilization, etc
Technologies in Plantation	• Use of quality seeds, root trainers, rhizobium inoculation, hormonal treatment, bio-fertilizers and integrated pest management, etc

India’s Progress towards Enhancing Climate Performance

The National Mission for Green India (GIM), launched in 2010, is one of the eight missions under the National Action Plan on Climate Change (NAPCC), launched in order to safeguard the country’s biological resources and associated livelihoods against the perils of climate change, recognizing the vital impacts of forestry on ecological sustainability, biodiversity conservation, and food, water, and livelihood security to the nation.

The overarching objective of the Mission is to increase forest / tree cover, improve the quality of forest cover and contribute to enhance ecosystem services along with carbon sequestration as a major co-benefit. The Mission will help in improving the ecosystem services from 10 million hectares of these lands, increase forest based livelihood income of about 3 million forest dependent households and enhance CO2 sequestration by 50 to 60 MT in the year 2020. The Mission proposes to have a decentralized participatory approach with the involvement of grass root level organizations in planning, decision making, implementation and monitoring. The Mission links with other ongoing land-based greening programs and schemes of different agencies as well as programs of MoEF&CC.

Mission Aims and Objectives

- Increased forest/tree cover to the extent of 5 million hectare (mha) and improved quality of forest/tree cover of another 5 mha of forest/non-forest lands
- Improved/enhanced eco-system services like carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; along with provisioning services like fuel, fodder, and timber and non-timber forest produces (NTFPs)
- Increased forest based livelihood income of about 3 million households
- Enhanced annual CO2 sequestration by 50 to 60 million tonnes in the year 2020.

The Mission will have clear targets for different forest types and ecosystems which will enable achievement of the overall objectives of the Mission. The Mission targets 10 m ha of forest/non-forest lands and includes:

a) qualitative improvement of forest cover/ecosystem in

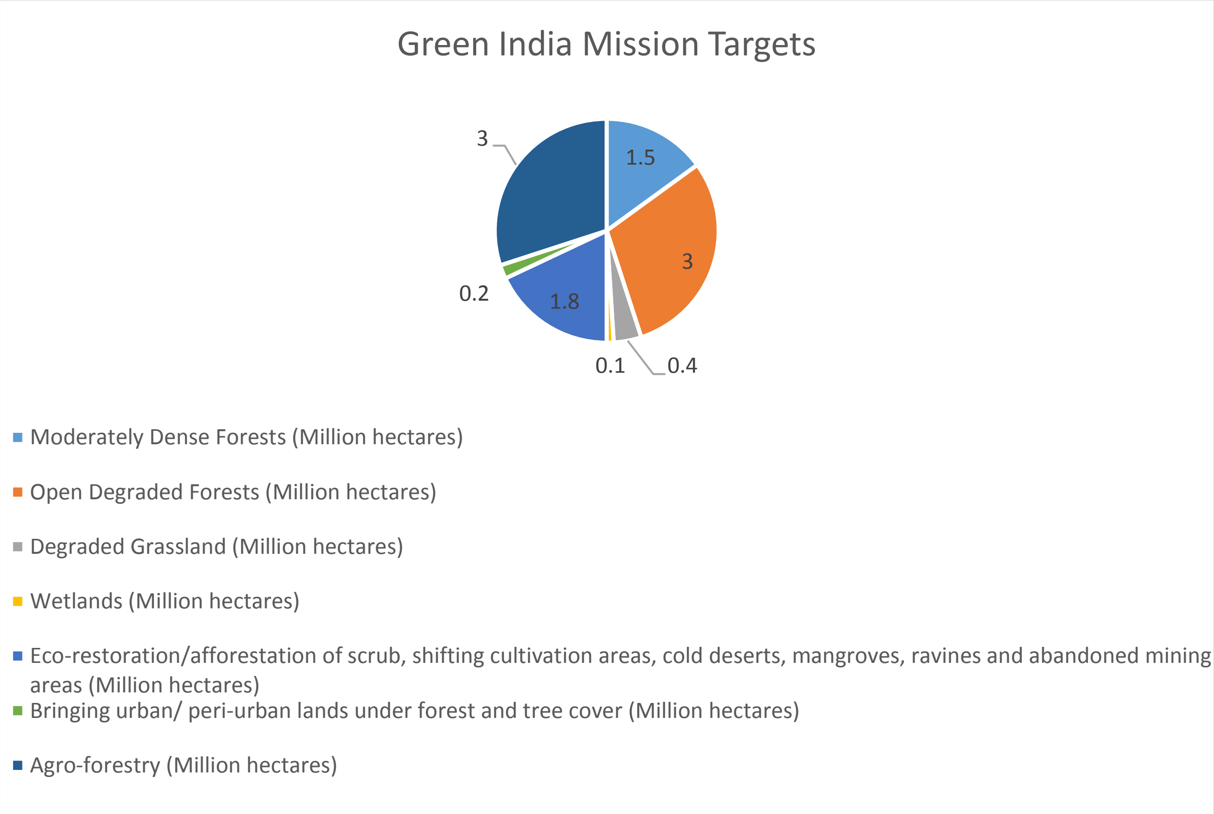
- moderately dense forests (1.5 m ha)
- open degraded forests (3 m ha)
- degraded grassland (0.4 m ha)
- wetlands (0.1 m ha)

b) eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas (1.8 m ha);

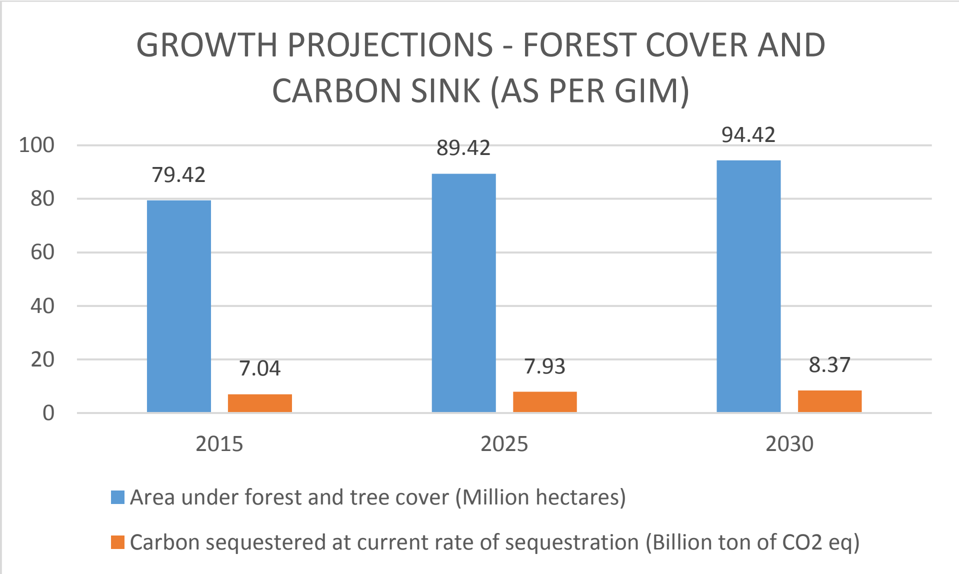
c) bringing urban/ peri-urban lands under forest and tree cover (0.20 m ha);

d) agro-forestry /social forestry (3 m ha). The Mission also targets improvement of forest- based livelihoods for about three million households living in and around forests.

The mission targets (outputs) are as given in the chart below:



As per the Green India Mission targets, the contribution towards the carbon sink has been calculated and projected in the graph below. Since the Green India Mission projects the area under forest cover till 2025, the same for the remaining 5 years has been estimated using uniform rate of growth. Also, the projections for carbon sequestered in future have been made by considering current carbon sequestered per hectare of tree cover.



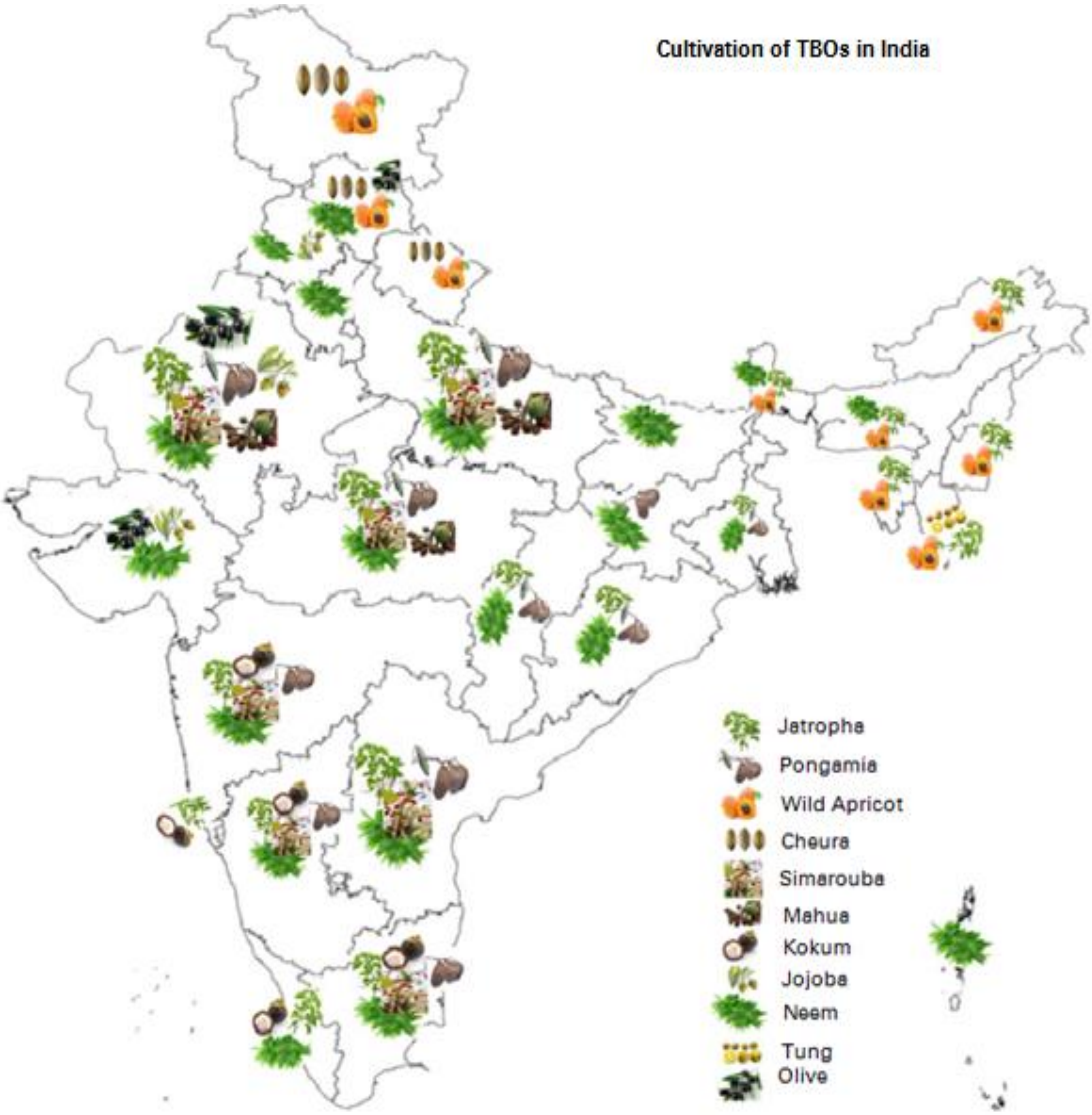
It can be seen from the previous graph that the Green India Mission would only lead to the creation of a carbon sink of size 1.33 Billion ton of CO_2 eq by the year 2030, hence falling short of India's NDC target by 1.17 Billion ton of CO_2 eq. Consequently, additional afforestation activities will be required to be carried out to achieve the targeted creation of an additional carbon sink of size 2.5 – 3 Billion ton of CO_2 eq.

Afforestation through energy plantations in open forests, preferably Tree Borne Oilseeds (TBOs) can be considered a suitable afforestation activity towards achieving the NDC targets as TBOs have the ability to grow even in harsh agro-climatic conditions such as wastelands or saline lands, and shall contribute significantly towards achieving the targets of Ministry of Petroleum and Natural Gas of 20 % blending in diesel. In addition, there would be availability of de-oiled cake, which is superior quality fertilizer / pesticide, and animal feed that would enhance incomes of farm households. Such afforestation activities through TBO plantation would also result in significant creation of jobs.

Tree Borne Oilseeds

Tree Borne Oilseeds (TBOs) are oil bearing multipurpose tree species in an agriculture system. TBOs are cultivated in India under different agro-climatic conditions in a scattered form in forest and non-forest areas as well as in waste land / deserts / hilly areas. The most favorable characteristic of TBOs is that they can be grown and established in varied agro-climatic conditions, such as wastelands or even saline lands. These possess substantial domestic and industrial utility in domains such as agriculture, cosmetics, pharmaceuticals, production of biofuels, cocoa-butter substitutes, carbon sequestration in wasteland, and consumption of oil, among others. Cultivation of TBOs also leads to generation of additional employment opportunities in rural areas. There is a potential to increase biodiesel production in the future by tapping into existing resources of Tree-Borne Oilseeds in the country as well as by establishing new plantations.

The figure below shows cultivation of TBOs across various states in India.



Source: Tree Borne Oilseeds for Oil and Biofuels, ICAR

National Policy on Biofuels

The National Policy on Biofuels aims at the mainstreaming of biofuels and, therefore, envisions a central role for it in the energy and transportation sectors of the country in coming decades. The Policy will bring about accelerated development and promotion of the cultivation, production and use of biofuels to increasingly substitute petrol and diesel for transport and be used in stationary and other applications, while contributing to energy security, climate change mitigation, apart from creating new employment opportunities and leading to environmentally sustainable development.

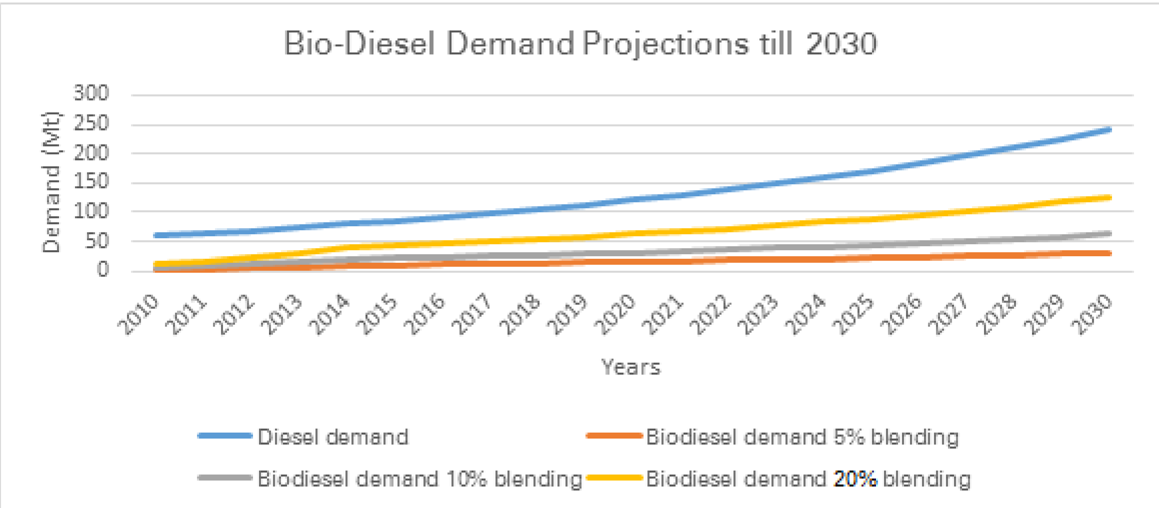
According to the National Mission on Biodiesel, non-edible biofuel crops are expected to use lands that are largely unproductive and those that are located in poverty stricken areas.

The Goal of the Policy is to ensure that a minimum level of biofuels become readily available in the market to meet the demand at any given time. An indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol, by 2017 is proposed. Blending levels prescribed in regard to bio-diesel are intended to be recommendatory in the near term. The blending level of bio-ethanol has already been made mandatory, effective from October, 2008, and will continue to be mandatory leading up to the indicative target.

According to UNEP Report on Promoting Low Carbon Transport in India, June 2014, bio-diesel demand till 2030 and corresponding blending targets are illustrated below.

		(5% blending)	**(10% blending)**	**(20% blending)**
Year	**Diesel demand (Mt)**	**Biodiesel demand (Mt)**	**Biodiesel demand (Mt)**	**Biodiesel demand (Mt)**
2010-11	60.1	3	6	12
2015-16	81.6	4.1	8.2	16.3
2020-2021	110.8	5.5	11.1	22.2
2025-26	151.2	7.6	15.1	30.2
2030-2031	206.4	10.3	20.6	41.3

(Source: UNEP Report on Promoting Low Carbon Transport in India, June 2014)



The above graph indicates the projected increase in requirement of biodiesel till 2030. Consequently, Tree Borne Oilseeds shall have an essential role to play in augmenting this oil demand in order to meet the blending targets.

Large-scale blending of biodiesel with conventional diesel has not yet begun in India. Approximately 20 biodiesel plants produce 140 to 300 million litres of biodiesel annually. Most Indian-produced biodiesel is used locally by the informal sector for irrigation and electricity generation, or by automobile and transportation companies for experimental projects. The National Biofuel Mission primarily focused on the expansion of Jatropha cultivation in two phases - demonstration phase and expansion phase, aiming to make the program self-sustainable by producing enough biodiesel to meet the 20 percent blending target.

However, Jatropha-based biodiesel production projects have not been as promising as expected due to insufficient yield and revenue.

In June 2015, the Indian government made key cabinet decisions on biofuels, including granting marketing rights to private biodiesel manufacturers, provided they meet the quality standards of the Ministry of Petroleum and Natural Gas (MoPNG). An exemption was proposed for B100 biodiesel (pure, unblended biodiesel) in order to explore its use as a standalone fuel. The exemption gives private manufacturing marketing rights for B100 biodiesel and authorizes retailers to sell it directly to consumers. The new policy will also determine the price of biodiesel. With the intention of further promoting biofuels, the government is exploring the use of a five percent biodiesel blend by bulk users such as railways and defence establishments.

Chapter 2

Agroforestry

- **Background**
- **Key National Policies and Guidelines**
- **Classification of Agroforestry Systems**

Background

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components.

Agroforestry can play a key role in:

- Reducing poverty
- Developing sustainable systems of agriculture and improving food security
- Improving the efficiency of water use
- Mitigate the impact of climate change
- Halting the loss of biodiversity and restoring degraded ecosystems

The attributes of agroforestry are:

Productivity: All agroforestry systems aim to maintain or increase productivity such as increased output of tree products, improved yields of associated crops, increased labour efficiency etc.

Sustainability: By conserving the production potential of the resource base,mainly through the beneficial effects of woody perennials on soils, agroforestry can acheive and maintain conservation & fertility goals

Adoptability: Improved or new agroforestry technologies that are introduced into new areas should confirm to local farming practices

Agroforestry is practiced in all continents of the world. A high percentage of tree cover is found in nearly all continents of the world, the highest being in Central America and Southeast Asia.
Almost half of the world's agricultural lands have at least a 10% tree cover, suggesting that agroforestry, an integrated system of trees, crops and/or livestock within a managed farm or agricultural landscape, is widespread.

Agroforestry research at the international level is conducted by the International Centre for Research in Agroforestry, now named as World Agroforestry Centre, which was started in 1978 at Nairobi in Kenya. The Center's aim is to increase use of trees in agricultural landscapes to improve their food security, nutrition, income, health, shelter, social cohesion, energy resources, and environmental sustainability of small holders.

Agroforestry at three levels

First level	• Agroforestry practiced by small farmers with the purpose of satisfying family or village-level needs.
Second Level	• It is promoted by local governments, usually on a fairly large scale • *Taungya,* whereby rural people are given incentives to plant trees along with their crops and care for them is onle such method
Third Level	• It consists of large-scale efforts, usually by the private sector. It is aimed at maximizing outputs (profits) on an industrial scale by the production of wood in combination with crops or livestock on a given piece of land.

As per "Vision 2050", by the National Research Center for Agroforestry, the area under agroforestry in India is estimated as **25.32 Mha** or 8.2% of the total geographical area of the country, in the year 2013. There is further scope of increasing the area under agroforestry in future by another 28.0 Mha. The major share of the land to be brought under agroforestry will come from fallows, cultivable fallows, pastures, groves, and rehabilitation of problem soils.

Social Forestry Programmes have been started across India with an objective of **improving tree resources and providing for timber, fuel wood and fodder needs of the state** and thereby complementing supplies from the forest areas; to increase the green cover; to accentuate non timber forest produce and bio-resources; to integrate all available land under the tree cover programmes and to improve carbon stock in the tree cover. The programmes aim at ensuring ecological, economic and social security to the rural masses especially by involving the beneficiaries' right from the planting stage to the harvesting stage.

Presently, in India, about 60% the cropped area is rain-fed, which contribute about 44% food-grain production. Its contribution in coarse cereals and pulses is about 90%, in oilseeds 60% and in the case of cotton it is about 80%. A significant proportion of livestock population (66%) is also in the rain-fed areas. However, these areas are characterized by low input use and low yield levels. The yield levels are highly prone to variety of risks. For such areas, diversification of land use systems with agroforestry is necessary.

At present, agroforestry meets almost half of the demand of fuel wood, 2/3 of the small timber, 70-80% wood for plywood, 60% raw material for paper pulp and 9-11% of the green fodder requirement of livestock, besides meeting the subsistence needs of households for food, fruit, fiber, medicine, timber, etc.

Key National Policies and Guidelines

S. No	Policy guidelines	Description
1	***National Agro-Forestry Policy, 2014***	• The policy encourages tree plantations in complementarity and integrated manner with crops and livestock. • It aims to set up a National Agroforestry Mission or an Agroforestry Board to implement the National Policy by bringing coordination, convergence and synergy amongst various elements of agroforestry.
2	***National Policy on Farmers, 2007***	• The major goal of the policy is to improve economic viability of farming by substantially increasing the net income of farmers
3	***National Agriculture Policy, 2000***	• It underlines the need for diversification in agriculture

		• It strives to promote integrated and holistic development of rain-fed areas on watershed basis and augmentation of biomass production through agro and farm forestry with community involvement.
4	***National Food Security Mission Guidelines***	• It was started with an objective of increasing production of rice, wheat, pulses and coarse cereals through area expansion and productivity enhancement. • It looks at restoring soil fertility and productivity at individual farm level and enhancing the farm level economy

Classification of Agro-Forestry Systems

Some agro-Forestry Systems based on **dominance of operational components** are classified as under:

Method	Description
Silvi-agriculture	The trees are the major component of land use and agriculture crops are integrated with them, e.g. shifting cultivation, *Taungya* cultivation.
Agri-silviculture	The major component is agriculture and trees are secondary, e.g. hedge cropping and alley cropping
Silvi-pastoral system	Trees are the major component and pasture is secondary to allow the animals for grazing.
Pastoral- silviculture	Pasture is the major component and trees are secondary, sometimes allowing overgrazing of forest beyond its carrying capacity.
Agro-silvi-pastoral system	The combination of crops, trees, and pasture, e.g., home garden, wherein trees, herbs, shrubs, climbers, and grasses are grown on the same land.
Silvi-agri-pastoral	Silviculture is the dominant component, agriculture and pasture are secondary.

Some Agro-forestry systems based on **structure**

Method	Description
Agri-silviculture	Tree species are grown and managed in the farmland along with agricultural crops. The aim is to increase overall yield of the land.
Improved fallow species in shifting cultivation	Fallows are croplands left without crops for a period ranging from one season to several years. The objective of improved fallow species in shifting cultivation is to recover depleted soil nutrients
Taungya System	The *Taungya* is one of the earliest forms of land use in which trees are regularly arranged and agricultural crops are harvested on a temporarily basis.
Multi-species tree garden	In this system of agroforestry, various kinds of tree species are grown mixed.
Alley cropping	Food crops are grown in alleys formed by hedgerows of trees. The woody plants are cut regularly and leaves or twigs are used as fodder or mulch on the cropped alleys
Multipurpose trees and shrubs on farm lands	Various multipurpose tree species (MPTs) are scattered haphazardly or according to some systematic pattern on bunds, terraces or plot/field boundaries
Crop combination with plantation crops	Perennial trees and shrubs such as coffee, tea, coconut and coco are combined into intercropping system in numerous ways including (a) multistoried agroforestry system (b) mixture of plantation crops in alternate or other regular arrangement (c) shade tree for plantation crops (d) intercropping with agricultural crops
Agroforestry for fuelwood production	Various multipurpose fuelwood/firewood species are intercropped on or around agriculture lands. The primary objective is to produce firewood

Shelter beds	Wide belt of trees, shrubs and grasses, planted in rows at right angle to the direction of wind velocity and planted for wind protection.
Windbreaks	Any barrier erected to break or slow down the effect of wind
Soil conservation hedges	Trees are planted on soil conservation works (grass strips, bunds, risers, and terraces), wherein they play two roles: to stabilize the structure and to make productive use of the land they occupy.
Silvi-pastoral system	Improved pasture species are introduced with tree species. In this system, grass or grass-legume mixture is grown along with the woody perennials simultaneously on the same unit of land.
Protein bank	Various multipurpose trees (protein rich trees) are planted on wasteland and rangelands for cut and carry fodder production to meet the feed requirements of livestock

The significance of agroforestry as a land use system has been highlighted extensively in recent years. In India, agroforestry had always been a common practice in which useful trees or bushes were grown at regular intervals or along the hedges, which helped in augmenting the fertility of the soil, and assisted in supplying necessary nutrients to the primary crop. Modern agricultural theories again advocate going back to this old practice to get additional benefits accruing from it to the farmers. Today, the emphasis lies on obtaining worthwhile utility from the supplementary crops grown under agroforestry. As discussed earlier, meeting the energy needs of a rapidly-growing economy is a matter of apprehension for India. Biodiesel has emerged as an apt solution to help India curb its import dependence for oil and gas, as well as reduce its carbon footprint. Tree Borne Oilseeds (TBOs) are a possible venture under the agroforestry route in order to obtain biodiesel.

Chapter 3

Meeting India's Future Biofuel Demand

- **Biodiesel Production through TBO Plantation**
- **Second Generation Biofuels**

Biodiesel Production through TBO Plantation

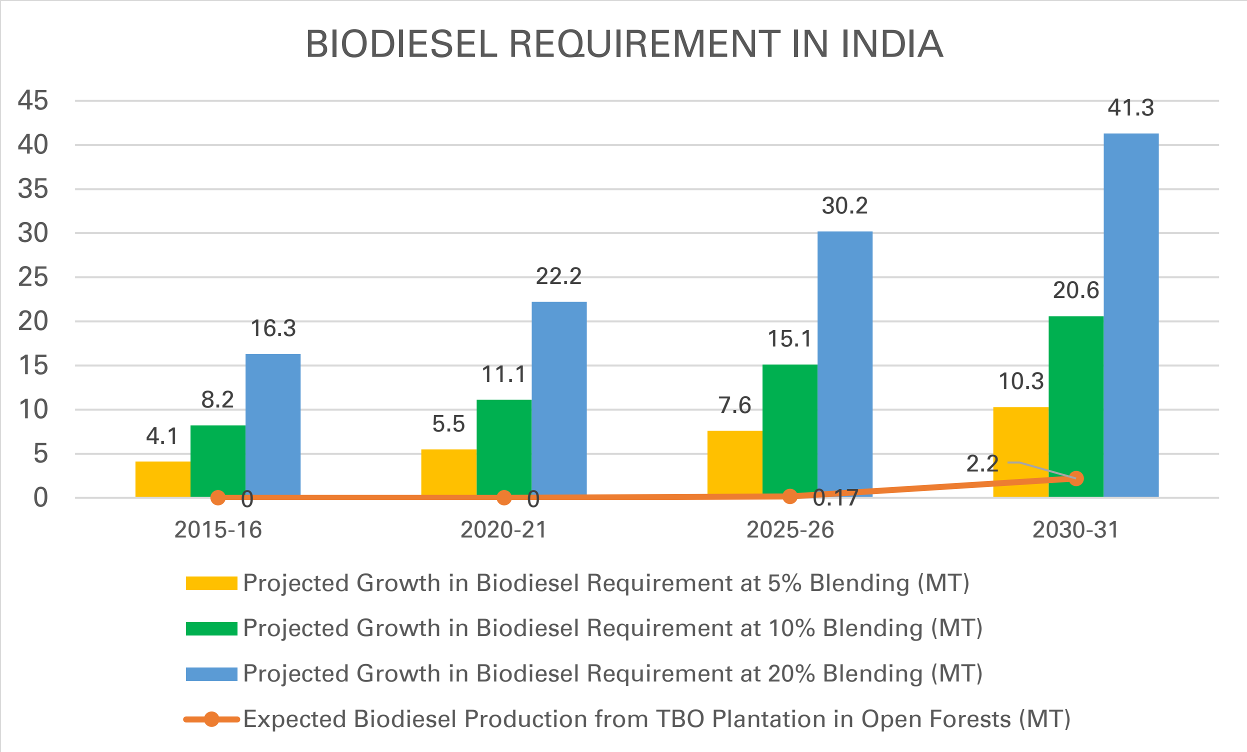
Afforestation through plantation of TBOs in 'Open Forests' also yields benefits through the production of non-edible oil which can be processed to form biodiesel. The Government of India envisages to encourage private sector players to participate in afforestation activities and has a plan to revive 25 Million Hectares of forests through Public Private Partnerships to meet its climate change plan target (as part of its NDC) of reducing carbon emissions by about 35 % by the year 2030. In order to estimate the potential of biodiesel production through TBOs, it is assumed the TBO plantation is taken up in approximately 25 % of the area currently under Open Forests by private players under the Public Private Partnership route.

The net area under open forests in India stands at approximately 30 Million hectares. As mentioned above, TBO plantation is carried out in 25 % of this land (7.5 Million hectares). Four species of TBOs namely **Pongamia, Mahua, Simarouba,** and **Neem** have been identified to be planted in equal numbers in this area as per the plantation plan below:

Years	**Plantation (Hectares / year)**
2018	100,000
2019-2020	200,000
2021-2025	500,000
2026-2030	900,000

According to UNEP Report on Promoting Low Carbon Transport in India, 2014, India's biodiesel requirement is expected to reach 41.3 Million Tonnes by the year 2030 assuming a 20% requirement for blending. The below table shows realization of this demand through biodiesel production from TBOs cultivated across open forests. The total biodiesel produced from TBOs till the year 2030 has been calculated from annexure – I. It is also assumed that the average density of non-edible oil from TBOs is 0.9 kg / litre.

Total Biodiesel Production		
Year	Oil Produced (liters)	Oil Produced (Million ton)
2018	-	0.00
2019	-	0.00
2020	-	0.00
2021	-	0.00
2022	-	0.00
2023	15,900,000	0.01
2024	79,500,000	0.07
2025	193,450,000	0.17
2026	400,150,000	0.36
2027	757,900,000	0.68
2028	1,213,170,000	1.09
2029	1,773,380,000	1.60
2030	2,446,480,000	2.20



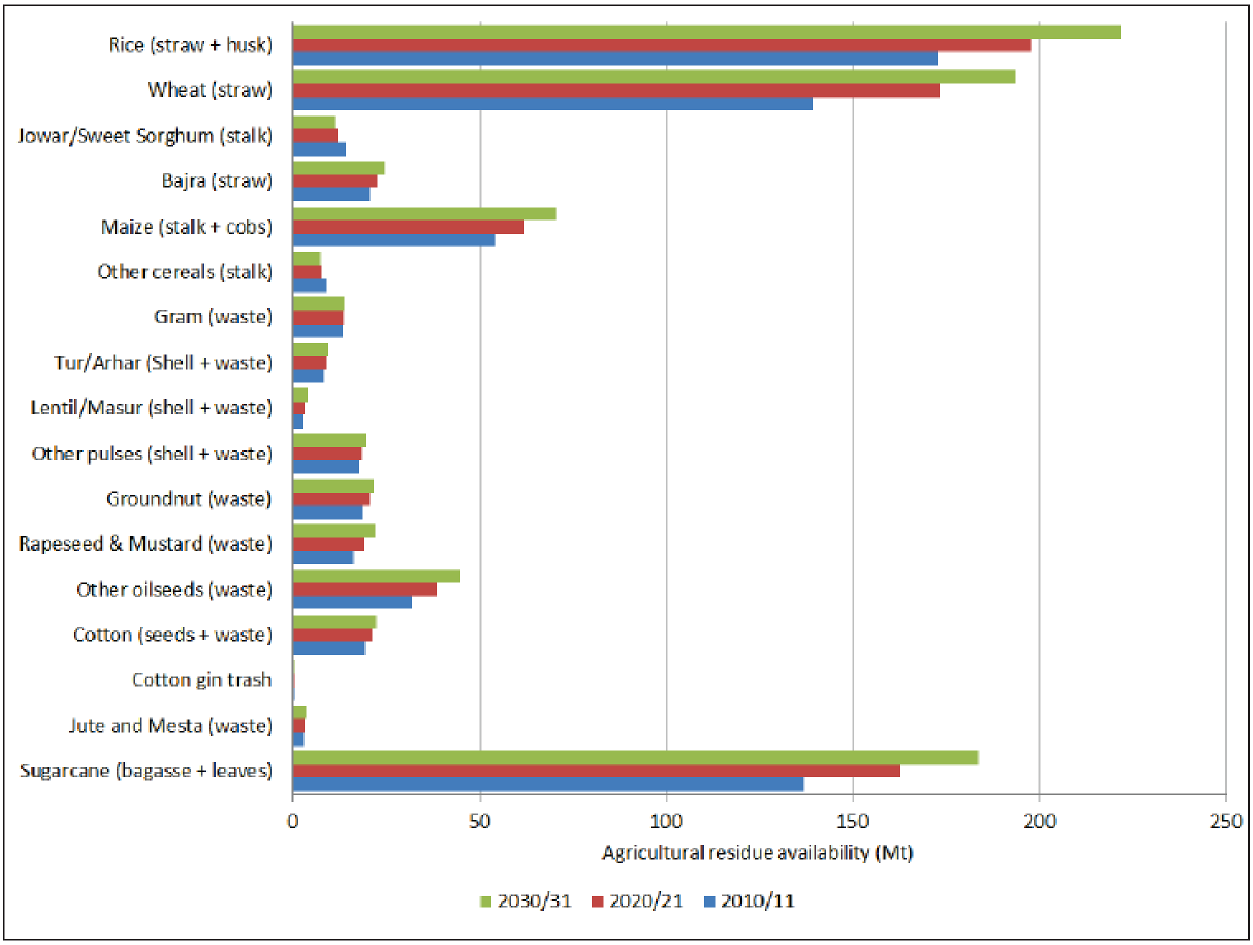
It can be seen from the above graph that TBO plantation in open forests can contribute significantly towards meeting India's biodiesel requirements in the coming years.

Second Generation (2G) Biofuels

Second generation biofuels are derived from agricultural residues and by-products, organic wastes, and materials from energy plantations, using a variety of woody, grassy, and waste materials as a feedstock. These new fuels offer considerable potential for promoting rural development and improving economic conditions in emerging and developing regions. Countries such as the United States, Brazil, and Canada have initiated major biofuel programs to produce cost-efficient ethanol and other fuels from agricultural and forest ligno-cellulosic biomass. The potential for second-generation biofuels depends on the several factors: the crop residues generated annually, current usage levels, and the surplus available for energy use.

Biofuels from Agricultural Residues

The figure below shows the total residue production in India from the cultivation of different grains, oilseeds, fibres and sugarcane, according to UNEP Report on Promoting Low Carbon Transport in India, 2014.



Biomass Cost Impact on Bioenergy Plants

Biomass Power Plants tariffs announced by SERCs, generally, assume Specific Fuel Consumption (SFC) in the range of 1.2 to 1.3 Kg/ KWh based on biomass with caloric value of 3200 to 3300 Kcal/ Kg (i.e about 25 to 30% moisture + ash). Factoring in auxiliary power consumption, the biomass requirement would be about 1.4 Kg/ KWh exported. These values would typically apply for husk or wood. The biomass requirement, in case of low density crop residues, would be higher, around 1.6 Kg/ KWh exported, as the combustion efficiency is lower & auxiliary power consumption is higher.

Considering biomass bales delivered cost at Rs. 2,500/ton (with 20% moisture), the fuel cost would be Rs. 4/KWh exported. The O&M costs will be around Rs. 0.8/KWh in case of low density crop residues. Hence the variable cost (fuel + O&M) works out to Rs. 4.8/KWh sold, which is more or less equal to biomass power tariffs in many States, including Karnataka. Adding Capital Servicing costs, Biomass Power Tariff (as per CERC orders) is over Rs. 6.5/KWh, which is much higher than Solar/ Wind tariffs and also is subject to annual escalation. Hence, only few SERCs are adopting the CERC tariff.

Thus, cost of low density crop residue bale is a very high % of Biomass (2 part) Tariffs approved by most SERC's, which itself are higher than Solar/ Wind (fixed) Tariff approved by these SERC's. Consequently, failures of Biomass Power Projects is, largely, due to evolving market dynamics. As a corollary, Biomass Power Plants are not the appropriate solution for large scale utilisation of low density crop residues.

In case of 2G Bio-Ethanol Plants, from 1 ton of low density crop residues bales (20% moisture) around 200 litres of Cellulosic Ethanol would be produced, with price realization of Rs. 9000 (excluding transport costs). Furthermore, about 30% of cost of biomass bale can be distributed to Co-Products (Pellets, Bio-CNG, Compost), which, in value terms, would represent about 30% of value of Cellulosic Ethanol. Thus, cost of low density crop residue bale is a relatively low % of Cellulosic Ethanol price. As a corollary, 2G Bio-Refineries are an appropriate solution for large scale utilisation of low density crop residues.

Biomass Depots – For Derisking Biomass Supply Chain

In case of low density crop residues (being burnt in the fields) the farmers compensation is generally about 30% of delivered cost of biomass bales (on annual average basis). In case of 2G Bio-Ethanol Plants, good quality compost is produced, post anaerobic digestion of residues. This compost is sold to farmers for agriculture/horticulture activity and acts as "cost hedge" for compensation paid to farmers (for collecting low density crop residues from their fields, which are otherwise burnt on the field, with resultant environment pollution & soil nitrogen loss). Furthermore, the availability of liquid CO_2 enhances horticulture yields & availability of 'dry ice' reduces farm losses of horticulture produce.

Thus, Co-Products of Cellulosic Ethanol, enhance incomes of farm households, thereby making them stakeholders to the project. Jobs creation of around 1,500 per 2G Bio-Refinery, is another big incentive for farm households to support these projects.

About 70% of delivered cost of crop residues bales relates to below activities:

- Baling and its handling
- Transportation to biomass depot
- Handling / storage in biomass depot
- Depot administration
- Security
- Fire protection costs
- Transportation of crop residues bales to Bioenergy Plant.

To improve operational efficiency & greatly mitigate costs escalation, it could be necessary to optimize mechanization as well as adopt superior technology (eg further densification of bales in biomass depot, multi-layer stacking of bales, high volume handling of bales, etc). This necessitates significant capital expenditure, around Rs 1.2 crore per Depot, which would supply about 8,000 tons bales/year.

The need for such an approach & investment is evidenced by Chinese government offering "incentive" of 100 yuan per ton of corn stoves/ paddy straw bales, to Depot operators against proof of supply to a Bioenergy Plant. It also reinforces our opinion that appropriate use of low density Crop residues needs to be incentivized.

Comparison between investment requirements on Biomass Depots for feeding Biomass Power Plant and 2G Bio-Ethanol Plant

A typical 12 MW Biomass Power Plant would require about 120,000 tons/year of low density crop residues. Consequently, 15 Biomass Depots of capacity 8000 tons/year can be setup with capital expenditure of Rs 18 crores (representing 33% of Biomass Power Plant Capex, excluding Biomass Depots cost).

60,000 tons/ year Cellulosic Ethanol Plant would require about 400,000 tons/year of low density crop residues. Consequently, 50 Biomass Depots of capacity 8000 tons/year can be set up with a capital expenditure of Rs 60 crores (representing 6% of 2G Bio-Refinery Capex, including Biomass Depots cost). The Capex of Rs 60 crores will be partly amortized through "Compost Yard" that would be established with the Depot, thus reducing the cost impact on Cellulosic Ethanol.

Consequently, 2G Bio-Refineries can absorb investment cost of reliable "Biomass Supply Chain" for low density crop residues, which is not the case with Biomass Power Plants.

Financial Support to 2G Bio-Ethanol Plants by Government of India

Based on commercially proven technology, 2G Bio-Ethanol currently offers the best techno-economic solution for large scale utilisation of low density crop residues, which are burnt in the fields (or inefficiently in rural households).This will mitigate environmental/ health hazards as well as enable achieve 20% blending of Ethanol and thereby meet Hon Prime Minister's mandate of reducing India's Oil Import dependence to 67% by 2022.

Equally important are the Co-Products such as pellets, Bio-CNG, liquid CO2/ Dry Ice, Compost, etc, which will stimulate the growth in horticulture/ food processing industry, create significant rural jobs, and enhance clean energy access in farm households.

Sustainable "low density crop residues" supply chain management has to be left to Private Developers of 2G Bio-Refineries. Transactions related to Biomass Depots & Compost Yards, require decentralized decision making (involving monthly variations in purchase price/stock levels), which a State owned entity will not be able to effectively manage.

Consequently, the 2G Bio-Refinery Project Developer has to arrange financing for 100% of Project cost (with subsidy component being disbursed only after Plant is commissioned & interest subvention, if any, being allowed at time of debt funds repayment). This, inherently, means that 2G Bio-Refinery Project Developer has to have the right credentials, and adequate "due diligence" must be carried out by Equity Investors/ Primary Lenders. Consequently, there is relatively low risk, linked to the Indian government's support to initial 2G Bio-Ethanol Projects.

Compost Produced in 2g Bio-Refinery (Certification as Organic Fertilizer)

The waste water streams of the 2nd Generation Bio-Refinery is approximately 200 KL/ hour for a plant rated 7.5 tons cellulosic ethanol/ hour. This needs to be treated and the preferred route would be anaerobic treatment, to produce biogas.

The biogas plant, digester effluent would need to be further treated to remove suspended solids to < 50 ppm, to comply with State PCB norms. Even lower level of suspended solids, if the treated effluent (containing dissolved solids) is intended to be used as "nutrient rich liquid", integrated with micro irrigation systems.

The separated solids (around 30% dry solids) are then subjected to aerobic digestion to produce Compost. The Compost, so produced (with dry solids > 75%), could be sold as "Manure" and, if so, it would not fall under the purview of Fertiliser (Control) Order 1985 & subsequent amendments. Certification can be sought by Compost manufacturers, terming the product as "Organic Fertilizer" (as per provisions of clauses 14 to 18) of Fertiliser (Control) Order. However, most Compost producers, especially Biogas Plant operators, prefer not to go through the rigors of seeking & maintaining certification under the Fertiliser (Control) Order. Compost producers from segregated MSW, Press Mud, etc, have adopted the certification route.

Compost Produced in 2g Bio-Refinery (Quantity)

Taking approximation of cleaned, lingo-cellulosic biomass feed to 2nd Generation Bio-Refinery as approximately 300,000 tons/ year for plant rated 60,000 tons cellulosic ethanol/ year, this cleaned, ligno-cellulosic biomass, especially agriculture residues, would have relatively higher ash (inorganics) content. While this would vary based on the type of agriculture residue, it may be assumed about 9 to 10% ash on dry matter basis. Consequently, about 27,000 to 30,000 tons of inorganics, which constitute major & minor nutrients that are required for soil fertility management. Bulk of the ash would come out with the digester effluent, through some amount would also travel with the lignin slurry (approximately 20 tons/hour or 160,000 tons/ year).

The biogas plant digester effluent would also contain non digested organic matter, apart from the inorganics (ash). The quantum of organic matter will be a function of efficiency of pre-treatment unit, lignin separation unit (post Beer Column) & biogas plant, where the goal is to optimize separation of lignin and the conversion of cellulose/ hemi cellulose to bio-ethanol or biogas. Generally speaking, quantum of separated solids, processed to compost (on dry matter basis), would be 30,000 tons/year. Consequently, compost (with 75% dry matter) would be 40,000 tons/year, linked to production of 60,000 tons (75 million litres) Cellulosic Ethanol/ year, with feedstock of agriculture residues. This would amount to about 0.53 Kg of Compost/ litre of Cellulosic Ethanol.

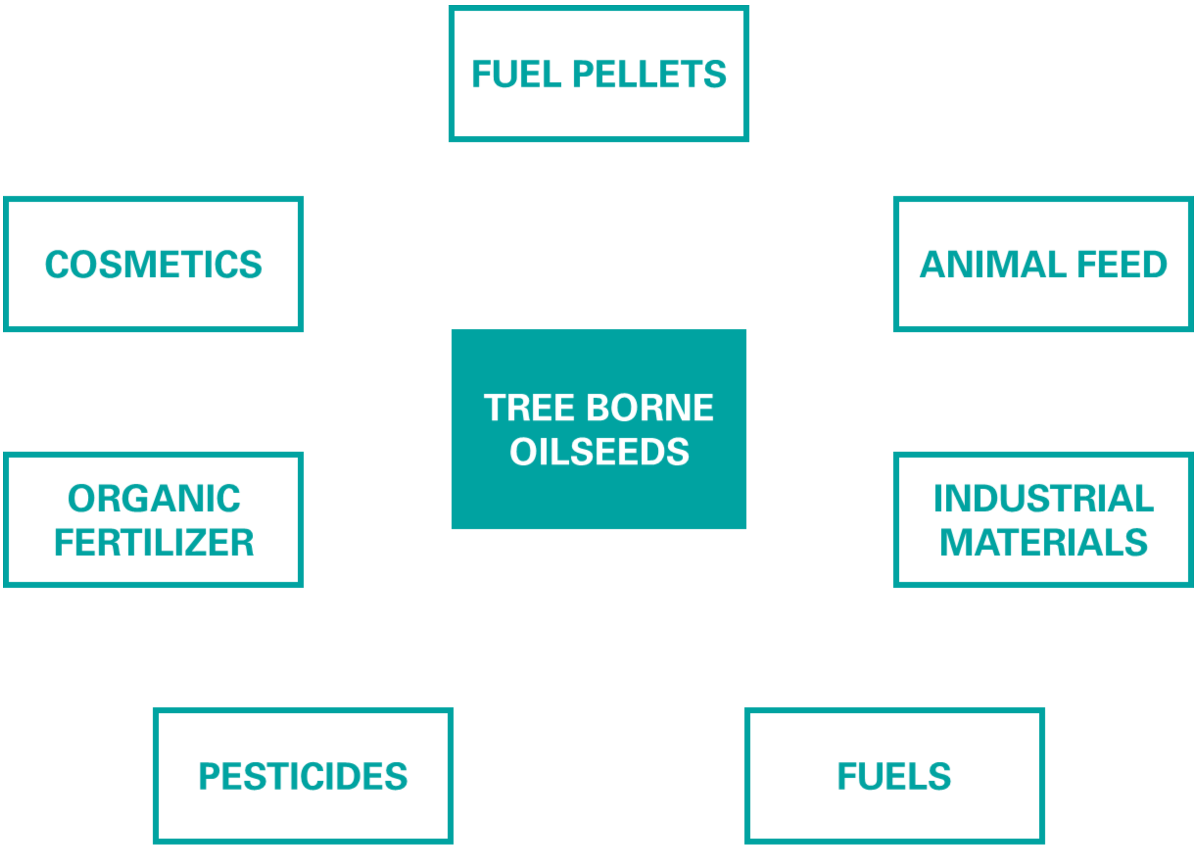
Chapter 4

Business Potential

Business Potential of TBOs

The country has enormous potential for utilizing oilseeds of tree origin like Mahua, Neem, Simarouba, Karanja, Ratanjyot, Jojoba, Cheura, Kokum, Wild Apricot, Bhikal, Wild Walnut, Kusum, Tung etc. are commonly found species of Tree Borne Oilseeds in India, and can be grown in varied agro-climatic conditions. They can also be planted on cultivators' field boundaries, fallow lands, and in public land such as along railways, roads and irrigation canals. Biodiesel development could become a major poverty alleviation program for the rural poor apart from providing energy security in general and to rural areas in particular and upgrading the rural non-farm sector. These have domestic and industrial utility like agriculture, cosmetic, pharmaceutical, diesel and substitute, cocoa-butter substitute etc. Most of these TBOs are scattered in forest and non-forest areas and hardly 20% of the existing potential is utilized.

It becomes evident that TBOs present numerous horizons for carrying out a wide range of business activities. The following figure illustrates various products which can be derived out of Tree Borne Oilseeds, and used as alternates to conventional materials.



Chapter 5

Job Potential Estimates

Employment Creation through TBOs

As discussed in Chapter – 3, in order to develop green business around growth of Tree Borne Oilseeds, it is estimated that its plantation is carried out in 7.5 Million Hectares of open forests during 2018-2030. The following plantation plan is followed for cultivation of TBOs:

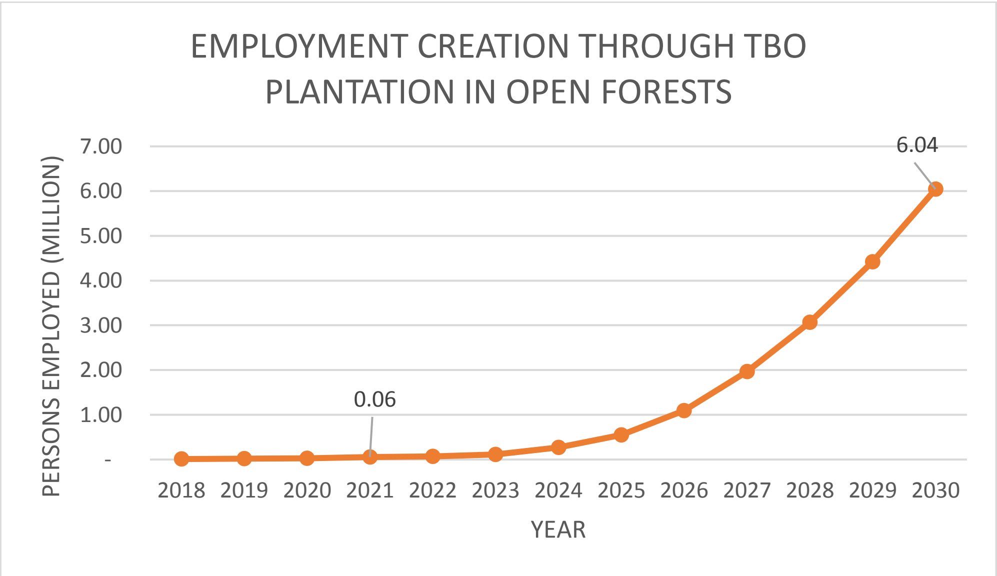
Years	Plantation (Hectares / year)
2018	100,000
2019-2020	200,000
2021-2025	500,000
2026-2030	900,000

Referring to the estimations for creation of employment through plantation of Tree Borne Oilseeds by KSBDB, the following table summarizes the number of jobs created as a result of plantation of TBOs in open forests as per the above plantation plan. Please refer to Annexure – I for details on calculations.

Particulars	Unit	Figure
Area under Open Forests	Hectare	30,039,500
Area in Open Forests to be brought under TBO plantation (Approximately 25 % of area under open forests)	Hectare	7,500,000
No. of saplings planted	per Hectare	265
Number of jobs created by 2030	Million	**6.04**

The cultivation of Tree Borne Oilseeds across open forests presents vast avenues for creation of employment. Various activities associated with plantation and maintenance such as management of nursery, sowing of seeds, soil working, watering and maintenance, trimming, pruning, and harvesting of produce can serve as a major source of livelihood for rural and tribal populations. A number of jobs shall also be created involving activities such as seed preparation, storage, transport, and sale of seeds to oil expeller units and bio-refineries.

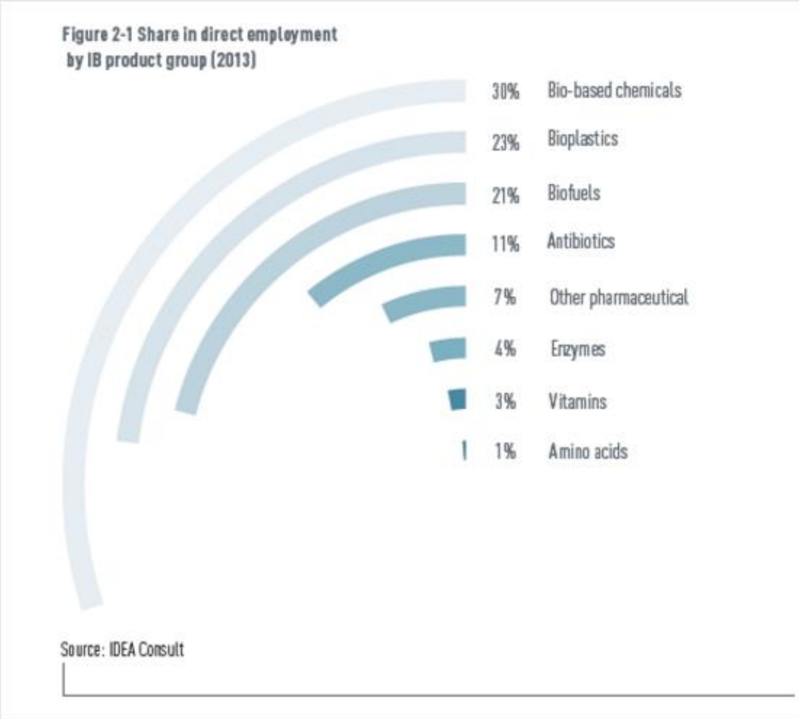
The following graph illustrates creation of jobs through TBO plantation carried out in 7.5 Million hectares of land over 2018-2030.



The number of jobs created gradually increase during the latter half of the timeframe under consideration, as TBO species largely start yielding considerable quantity of seeds from the sixth year of their plantation.

INDUSTRIAL BIOTECH SECTOR IN EUROPE

Industrial Biotech contributes over €30 billion to the EU economy and provides employment to around half a million people. The core IB sector employed about 94.000 FTEs in 2013. Upstream of the IB sector, at the suppliers of goods and services, the associated employment amounts to about 269.000 Full Time Employees (FTEs). Downstream of the IB sector, at companies who process and integrate IB sector outputs, some 97.000 FTEs are employed. In total, the sector employs 480,000 along the value chain.



Share in Direct Employment by IB Product Group (2013)

In all, that's 4 jobs in the value chain for every direct job created. This high job multiplier is a general characteristic of the chemical and pharmaceutical sectors, in which the IB sector is embedded, but is augmented due to the specific characteristic of the IB sector with regard to its sourcing of raw materials in biomass sectors, which creates many more upstream jobs than sourcing fossil resources.

In order to extrapolate the growth in this sector in the coming years, EuropaBio, the European Association for Bioindustries, has considered two growth scenarios in its recent report launched in the European Parliament - the first is the extrapolation of the historical growth rate of IB production observed in the Key Enabling Technologies; the second is the market forecast made for the IB sector in the context of the BIO-TIC market roadmap.

EuropaBio mentions in its report that that total employment for IB will lie between 900.000 FTEs (BIO-TIC scenario) and 1.500.000 FTEs (KETs Observatory scenario).

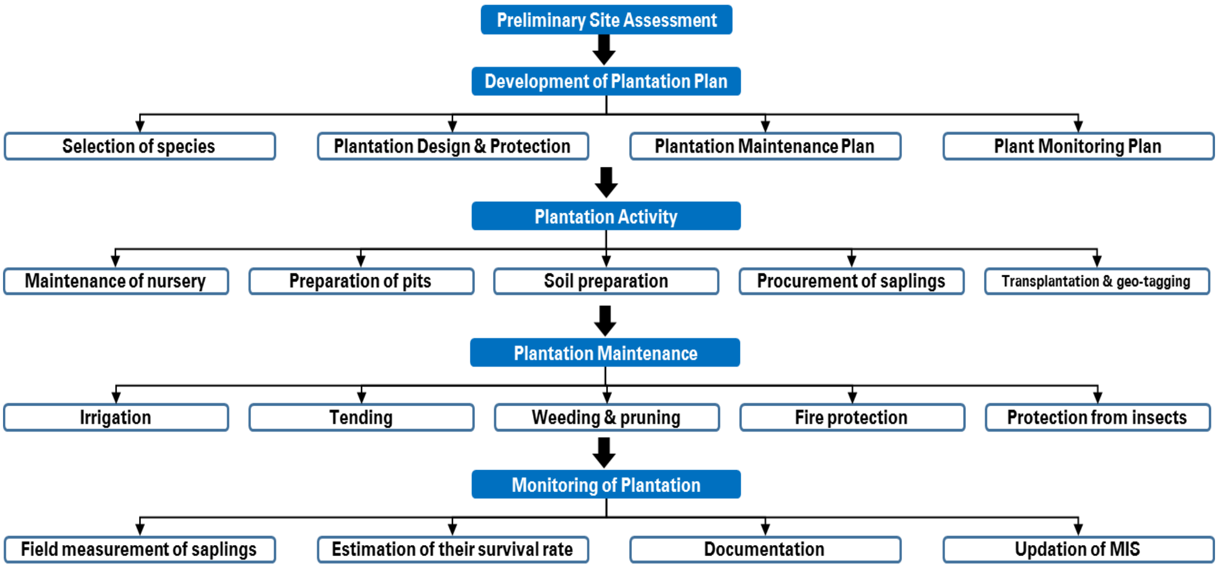
Chapter 6

Process Mapping

- **Afforestation**
- **TBO Plantation and Processing**

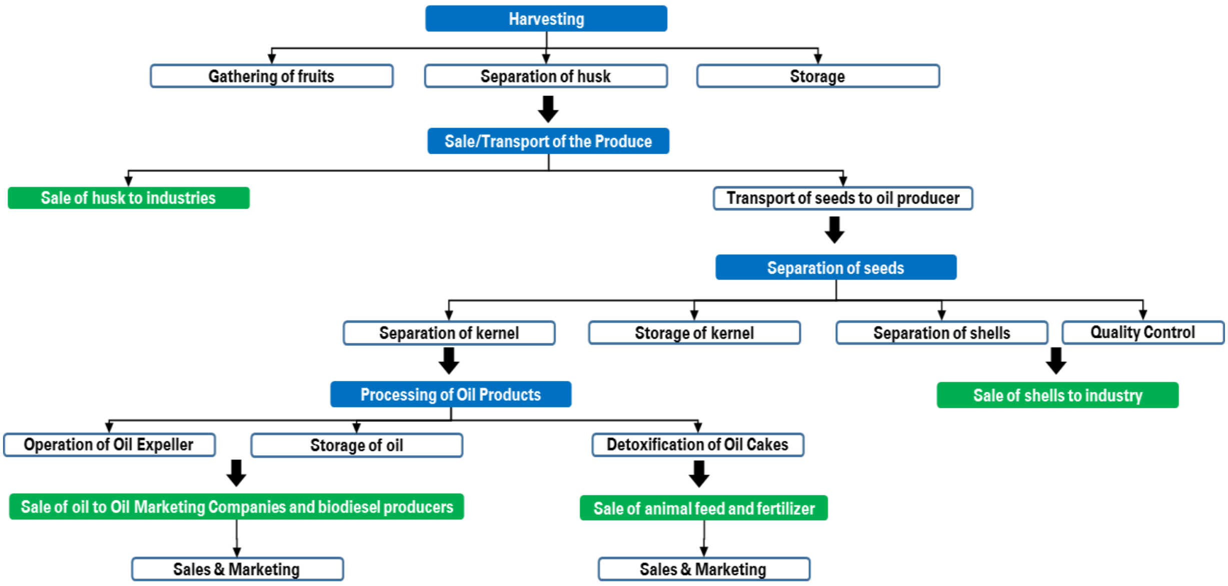
Process Mapping: Afforestation

The following illustration depicts the process mapping of carrying out afforestation in open forests.



Process Mapping: Utilization of Tree Borne Oilseeds

The following illustration depicts the process mapping for utilization of TBOs through plantation in open forests.



Chapter 7

Occupational Mapping

- Occupational Job Roles
- Occupational Map
- List of Job Roles

Occupational Job Roles

The following table describes various activities associated with different steps in the plantation value chain, and corresponding job roles.

S.No.	Steps in the value chain	Key activities	Job Roles
1	**Preliminary site assessment**	Identification of land: Acquiring land for afforestation activities Or Acquiring permit to proceed with afforestation activities on land	• Soil Scientist • Soil Collection Worker
		Soil assessment: • Soil assessment - check for parameters like pH, NPK value, salinity, electrical conductivity etc. • Preparation of a soil assessment report by understanding the soil type by collection of soil data, interpretation and inspection relating to soil science • Calculation of soil depth using a measuring tape, ruler or stick graduated in centimetres to assess and measure the location (depth and thickness) of any visible soil layers; in terms of colour, soil structure, root density etc. An optimum Soil pH is within the range of 5.5 to 7 for most plants	
		Checking the site inventory such as: • availability of space for plantations • protection / fencing status • fire protection status • measurement of existing biomass • establishing baseline for carbon inventory (optional)	
2	**Selection of species**	Determination of species on the basis of the following criteria: • Climatic conditions (humidity, temperature, precipitation etc.) • Soil • Site quality • Purpose of plantation • Need of the community (optional) Plantation of vegetation as part of landscaping should be restricted as far as possible to the local species thriving in the area.	• Plantation Manager • Plantation Worker • Silviculture Specialist
3	**Plantation design and protection**	• Deciding number of pits to be planted based on the area available for planting. • Plantation can be in in the form of block plantation, line plantation, sporadic plantation etc. subject to the land available for plantation • Listing of activities for pit preparation including digging of pits in the month of December and turning soil before actual plantation	• Plantation Manager • Silviculture Specialist • Silviculture Worker • Nursery Administrator • Nursery Worker

		• Maintaining an inventory of equipment required for plantations including GPS and tools such as plough, harrow, leveller etc. • The plantation design can be decided in coordination between the Forester who will provide his silvicultural insights and the Landscape architect who will prioritize aesthetics in land design (if required)	
4	**Plantation establishment cost**	• Designing the initial financial outlay for the plantation activity • The outlay will vary depending on the area of plantation established, site characteristics (topography and accessibility), ground preparation techniques, weed control requirements among others	• Silviculture Specialist
5	**Plant maintenance plan**	A plan will be created for the post plantation management and will list down the maintenance activities to be carried out after plantation such as irrigation, geo-tagging, fire protection etc.	• Plantation Manager • Drip Irrigation Specialist
6	**Plant Monitoring plan**	The plan is prepared with an objective of the overview of the land for tracking key indicators. Some of the key indicators are: • Delivery of ecosystem services (including carbon sequestration) • Status of plantation • Plantation performance	• Plantation Manager • Plantation Supervisor
7	**Maintenance of a nursery**	• Maintenance of a nursery for plantation of saplings • The nursery can be in-situ or ex-situ to the plantation site • The areas should be well connected to road / rail networks to facilitate transport in case of an ex-situ nursery • The requirements for maintenance of nursery: containers, nursery media, water and fertilizers, chemicals (pesticides, fungicides, herbicides etc.) electricity, equipment and machinery (for transportation, watering and sales) etc.	• Nursery Administrator • Nursery Worker • Green House Fitter
8	**Preparation of pits**	• Removal of competing vegetation from the site (weeding) • The labour should be trained before engaging them in this activity • Diameter of pits is usually between 15 and 50 cms. • The depth of each pit should be between 5 and 15 cm • Digging of the pits should be done during the dry season, so that the pits are ready when the rainy season begins	• Nursery Worker

		• Ground preparation should be done in a manner so as to improve water retention and provide optimal soil conditions for the plantation by using methods such as ploughing, sub-soiling, pre-planting harrowing, planting pits and terracing	
9	**Soil preparation**	• Soil preparation to be carried out in patches, strips, or by complete cultivation • Other methods include ash-bed method, tie-ridging, contour trenching and "steppe" method	• Soil Scientist • Soil Collection Worker
10	**Procurement of saplings**	• Saplings are put in trays and loaded onto the vehicles. • Loading and unloading of the trays at the plantation site	• Nursery Worker • Tractor Driver
11	**Transplantation activities and geo-tagging**	• Transplantation of the saplings from the nursery to the plantation site (avoiding transplant shock i.e. any damage received to the plantation during the process of transporting them to the plantation site) • Geo-tagging and maintaining a record of all the plantations by numbering them	• Plantation Manager • Plantation Supervisor • Helper
12	**Irrigation**	• Application of right quantity at the right time and effective involvement of the farmers in water management • Scientific estimation of crop water demands • Scheduling of irrigation based on soil - water- plant interactions	• Drip Irrigation Specialist • Plantation Manager • Harvesting Worker
13	**Tending**	These operations will be carried out to provide a healthy environment for the plantation development such as : • Weeding • Cleaning • Thinning • Pruning • Climber cutting	• Harvesting Worker
14	**Fencing**	• Erection / procurement of fencing materials • Fencing the plantation site for protection from any stray animals etc.	• Harvesting Worker
15	**Fire management**	Damage by fire imposes a significant threat to plantations. Fire protection can be done by: • Regular burning of grassland or other bordering vegetation • By adding prescribed burned plantation stands • Ploughing of firebreaks • Scraping of firebreaks • Hand-cleaning fire breaks	• Plantation Manager

		• Maintaining of roads on external boundaries • Protection of internal fire by creation of watershed lines which facilitate optimum water run off	
16	**Protection from insects and pests**	• Adequate precautions have to be taken in guarding against possible future damages from insects and fungi. • Surveys of indigenous pests can be carried out to ensure that none are among the known forms to which the selected species is susceptible	• Plantation Worker • Harvesting Worker
17	**Field measurement of saplings**	• Satellite imagery and site visits for developing geo tagged maps for plantations that will subsequently track the progress of the plantations • **Use of Management Information System (MIS) and Decision Support System (DSS):** This can done by computer assisted MIS & DSS which primarily requires precise discharge measurements and better communication facilities. • **Use of GIS (Geographical Information System):** The data captured shows land use- location of farms, towns, forests. GIS based software can be used for soil fertility mapping, fertilizer recommendations, and liquid bio-fertilizer formulations. Nano technology is also being explored in this area	• Soil Scientist • Geoscientist • Carbon Consultant
18	**Estimation of their survival rate**	Estimation of survival rate of the plantation through the site visit conducted	• Soil Scientist
19	**Estimation of carbon sequestered**	Estimation of survival rate of the plantation through the site visit conducted	• Carbon Consultant
20	**Documentation and MIS**	Regular up-dation of the MIS after site visit to keep track of plantation and to calculate the : • survival rate of plantation • Estimate the carbon sequestered	• Plantation Manager • Carbon Consultant • Data Analyst – MIS

The following table describes various activities associated with different steps in the TBO utilization value chain, and corresponding job roles.

S.No.	Steps in the value chain	Key activities	Job Roles
Harvesting			
1	**Gathering of fruits**	Involves picking of fruits from plantations. Depending on access to technology, mechanized picking may be incorporated, hence making the harvesting process less tedious. Upon gathering, these fruits shall be stored in a warehouse.	• Harvesting Worker
2	**Separation of husk**	Involves removal of husk from the seed either through manual operation or mechanized threshing machine. Mechanization greatly reduces burden on	• Harvesting Worker

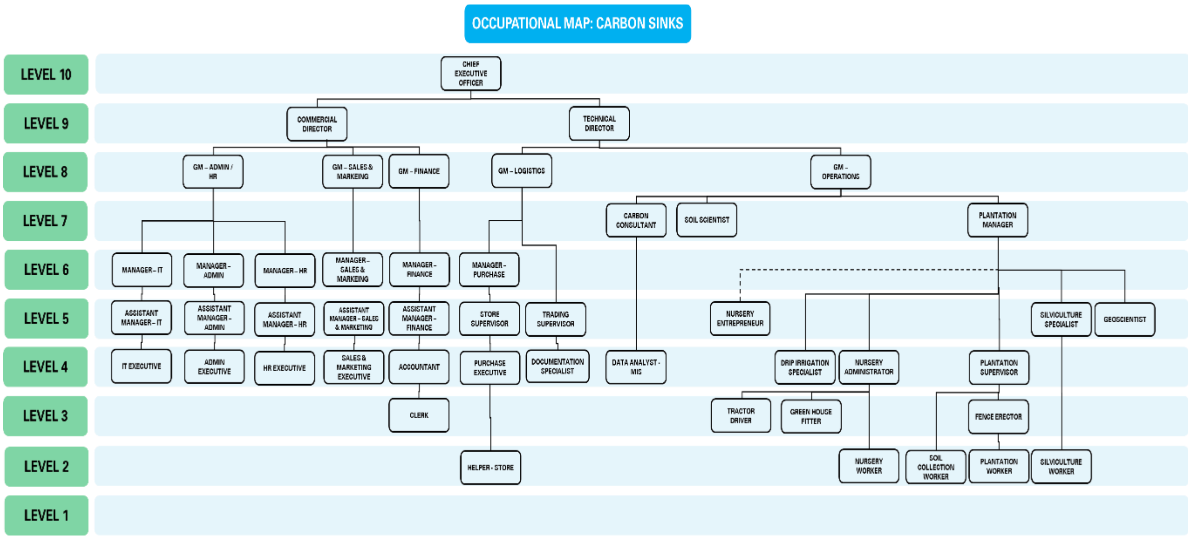
		the workers by reducing total time of operation.	
3	**Storage**	The separated seeds are dried and stored in warehouses for further transport.	• Harvest Quality Inspector • Warehouse Supervisor • Warehouse Executive • Helper • Security Guard • Forklift Operator • Driver
Sale / Transport of the Produce			
4	**Transport of seeds to oil producer**	Dried seeds stored in the warehouse require transportation to the oil manufacturing unit	• Collection Agent • Driver • Helper
Separation of Seeds			
5	**Separation of kernel**	The useful oil content inside a Tree Borne Oilseed lies in its kernel, which is removed from the seed enclosure through a Seed Shelling Machine. This machine optimizes time and labour.	• Seed Quality Analyst • Production supervisor • Helper
6	**Storage of kernel**	The de-shelled seeds require storage in the factory warehouse.	• Warehouse Supervisor • Warehouse Executive • Forklift operator
7	**Separation of shells**	The shells removed from the shelling machine are of material importance to the industry, finding use in the manufacture of recyclable industrial materials. These shells are collected and stored in the factory warehouse, and later transported to respective industries.	• Helper • Forklift operator
8	**Quality Control**	The de-shelled seeds require periodic inspection for checks against quality parameters such as: • Physical qualities of the seed in a specific lot • Presence of diseases and pests within seed lot	• Seed Quality Analyst
Processing of oil products			
9	**Operation of oil expeller**	A seed oil expeller is a pressing machine which extracts oil from de-shelled seeds through the application of mechanical pressure. An automated plant assembly can be established through installation of PLC – SCADA system for automated movement of material through hoppers, weigh feeders, conveyor belts, and more.	• Production Supervisor (Biorefinery) • Seed Processing Operator • Factory labour • Electrical Technician • Mechanical Technician
10	**Storage of oil**	Oil produced from seeds is stored in warehouses.	• Warehouse Supervisor • Warehouse Executive • Forklift operator
11	**Formation of Biodiesel**	Non-edible oil from TBOs undergoes the process of transesterification for conversion to Biodiesel, which is used for blending with conventional diesel for use in automobiles.	• Biorefinery In-charge • Production Supervisor (Biorefinery) • PLC Engineer • Quality Analyst • Lab technician • Helper - Biorefinery
12	**Storage of Biodiesel**	Biodiesel will be stored in warehouse in different categories as per blending	• Biorefinery Warehouse Supervisor

			• Biorefinery Warehouse Executive • Biorefinery Warehouse Security Guard
Sale of products			
13	**Sales & Marketing**	The sales and marketing of biodiesel and other associated products may be done through B2B or B2C routes.	• Business Development Manager • Sales Executive

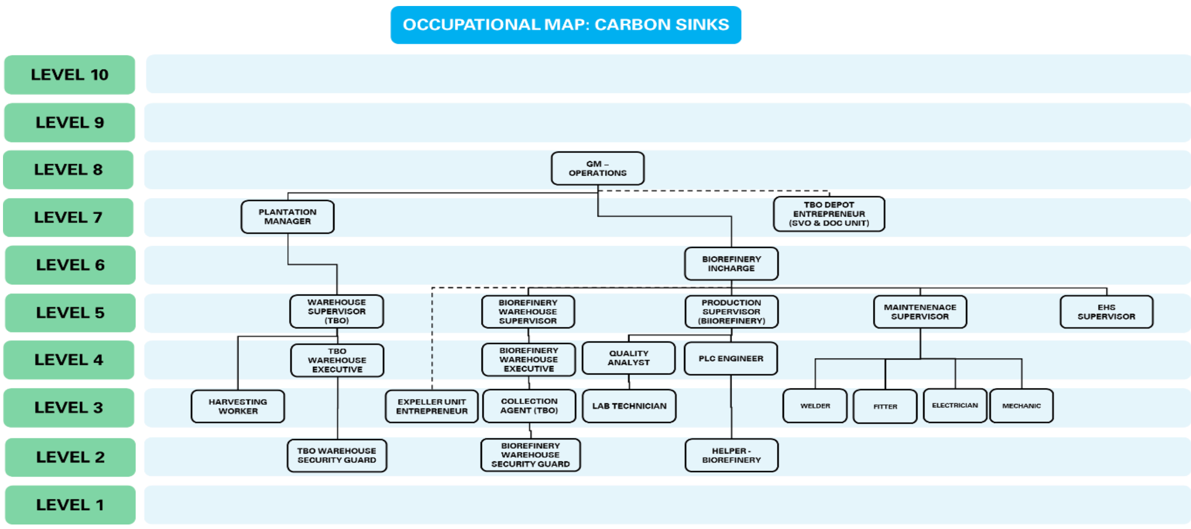
Occupational Mapping

In this section, the occupational map for the Carbon Sinks sector has been split into two parts – one illustrating the map for Afforestation / agroforestry and associated activities; the other illustrating the map for plantation and processing of Tree Borne Oilseeds.

Occupational Map: Carbon Sinks



Occupational Map: Plantation and Processing of Tree Borne Oilseeds



List of Job Roles

The following list comprises of various job roles which are expected to be generated in the Carbon Sinks sector. These job roles have been classified into General and Critical depending upon their significance in this sector. The job roles marked in Yellow color have been selected for preparation of Qualification Packs by the Skill Council for Green Jobs.

Sector: Carbon Sinks			
S.No	Title	Critical /General	NSQF Level
1	Chief Executive Officer	General	10
2	Commercial Director	General	9
3	Technical Director	General	9
4	GM - Admin/HR	General	8
5	Manager - IT	General	6
6	Assistant Manager - IT	General	5
7	IT Executive	General	4
8	Manager - Admin	General	6
9	Assistant Manager - Admin	General	5
10	Admin Executive	General	4
11	Manager - HR	General	6
12	Assistant Manager - HR	General	5
13	HR Executive	General	4
14	GM - Logistics	General	8
15	Manager - Purchase	General	6
16	Store Supervisor	General	5
17	Purchase Executive	General	4
18	Helper - Store	General	2
19	Trading Supervisor	Critical	5
20	Documentation Specialist	Critical	4
21	GM - Sales & Marketing	General	8
22	Manager - Sales & Marketing	General	6
23	Assistant Manager - Sales & Marketing	General	5
24	Sales & Marketing Executive	General	4
25	GM - Finance	General	8
26	Manager - Finance	General	6
27	Assistant Manager - Finance	General	5
28	Accountant	General	4
29	Clerk	General	3
30	GM - Operations	Critical	8
31	Soil Scientist	Critical	7
32	Soil Collection Worker	General	2
33	Plantation In-charge	Critical	6
34	Drip Irrigation Specialist	General	4
35	Nursery Administrator	Critical	4
36	Green House Fitter	General	3
37	Tractor Driver	General	3
38	Nursery Entrepreneur	Critical	5

39	Nursery Worker	General	2
40	Plantation Manager	Critical	7
41	Plantation Supervisor	Critical	4
42	Fence Erector	General	3
43	Plantation Worker	General	2
44	Silviculture Specialist	General	5
45	Silviculture Worker	General	2
46	Geoscientist	Critical	5
47	Carbon Consultant	Critical	7
48	Data Analyst - MIS	General	4
49	Warehouse Supervisor (TBO)	Critical	5
50	TBO Warehouse Executive	General	4
51	TBO Warehouse Security Guard	General	2
52	Thresher Operator	General	3
53	Harvesting Worker	Critical	3
54	Expeller Unit Entrepreneur	Critical	3
55	TBO Depot Entrepreneur (SVO & DOC Unit)	Critical	7
56	Biorefinery Incharge	General	6
57	Biorefinery Warehouse Supervisor	Critical	5
58	Biorefinery Warehouse Executive	General	4
59	Collection Agent (TBO)	Critical	3
60	Biorefinery Warehouse Security Guard	General	2
61	Production Supervisor (Biorefinery)	Critical	5
62	PLC Engineer	Critical	4
63	Helper - Biorefinery	General	2
64	Quality Analyst	Critical	4
65	Lab Technician	General	3
66	Maintenance Supervisor	General	5
67	Welder	General	3
68	Fitter	General	3
69	Electrician	General	3
70	Mechanic	General	3
71	EHS Supervisor	General	5

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Annexure – I: Calculation of Jobs Created through TBO Plantation in Open Forests

It is assumed that TBO plantation is carried out in 7.5 Million Hectares of Open Forests as per the following plantation plan. The column "Year" denotes the year in which plantation activities commence in the concerned batch.

Year	Batch	Area Under TBO Plantation (Hectares)	Total Area Under TBO Plantation (Hectares)
2018	Batch 1	100,000	100,000
2019	Batch 2	200,000	300,000
2020	Batch 3	200,000	500,000
2021	Batch 4	500,000	1,000,000
2022	Batch 5	500,000	1,500,000
2023	Batch 6	500,000	2,000,000
2024	Batch 7	500,000	2,500,000
2025	Batch 8	500,000	3,000,000
2026	Batch 9	900,000	3,900,000
2027	Batch 10	900,000	4,800,000
2028	Batch 11	900,000	5,700,000
2029	Batch 12	900,000	6,600,000
2030	Batch 13	900,000	7,500,000

As per a KSBDB report, the following table shows the seed yield in a Pongamia plant for 15 years.

Year	Yield per Plant (kg)
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	3.00
7	9.00
8	12.50
9	17.50
10	23.00
11	25.40
12	27.80
13	30.20
14	32.60
15	35.00

Through consultations with KSBDB, the following figures for creation of employment have been obtained through activities such as plantation, maintenance, watering, harvesting, and processing, among others.

Year	Total mandays / hectare
1	31.03
2	4.94
3	3.99
4	3.99
5	3.99
6	118.20
7	346.64
8	479.90
9	670.26
10	879.67
11	971.04
12	1062.42
13	1153.79
14	1245.17
15	1336.54

The above figures of employment creation through plantation and seed processing activities are applied to different batches during the period under consideration, thus giving the following figures for overall employment creation.

Year	Persons Employed (Million)
2018	0.01
2019	0.02
2020	0.03
2021	0.06
2022	0.07
2023	0.11
2024	0.27
2025	0.55
2026	1.09
2027	1.96
2028	3.06
2029	4.42
2030	6.04

Annexure – II: Estimation of Carbon Sequestered through TBO Plantation

The following table represents the carbon stock contained in three TBO species namely Jatropha, Simarouba, and Neem. To estimate the overall carbon sequestered by the TBO species planted in 7.5 Million Hectares of land during 2018 – 2030, the average carbon stock contained in these three species is considered. It is also assumed that the carbon stock grows at the rate of 10% per annum.

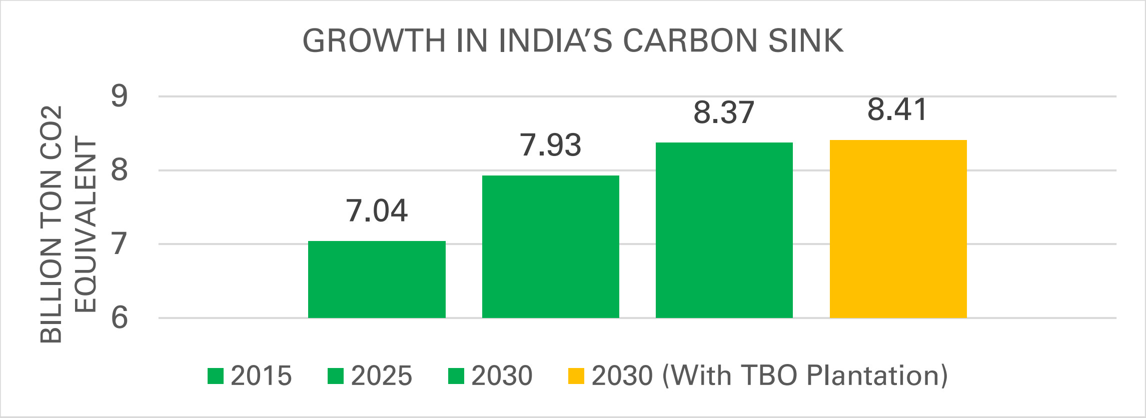
Particulars	Unit	Quantity	Source
Jatropha: Total plant biomass Carbon for 4 years	kg / plant	3.07	"Carbon sequestration and land rehabilitation through Jatropha curcas plantation in degraded lands"
Jatropha: Total plant biomass Carbon for 1 year	kg / plant	2.31	Assuming 10% yearly growth in sequestration potential
Simarouba: Total carbon stock in 10 year old plant	kg / plant	36.89	"Biomass and Carbon Allocation in Different Components of Simarouba glauca and Azadirachta indica"
Simarouba: Total plant biomass Carbon for 1 year	kg / plant	15.64	Assuming 10% yearly growth in sequestration potential
Neem: Total carbon stock in 10 year old plant	kg / plant	49.79	Biomass and Carbon Allocation in Different Components of Simarouba glauca and Azadirachta indica
Neem: Total plant biomass Carbon for 1 year	kg / plant	21.12	Assuming 10% yearly growth in sequestration potential
Average carbon stock in 1 year old TBO plant	kg / plant	13.02	

The above figure for the average carbon stock in 1 year old TBO plant is used to compute the overall carbon sequestration through TBOs planted in 7.5 Million Hectares of Open Forests. The following table shows the year on increase in carbon sequestered through the plantation of TBOs.

Year	Total Carbon Sequestered (Million Ton of CO2 eq)
2018	0.35
2019	1.07
2020	1.87
2021	3.78
2022	5.88

2023	8.20
2024	10.74
2025	13.54
2026	18.00
2027	22.91
2028	28.30
2029	34.24
2030	40.77

This plantation is bound to result in creation of an additional carbon sink of 0.04 Billion tonnes of CO2 equivalent. The graph below explicates the significance of TBOs in the enhancement of India's carbon sink.

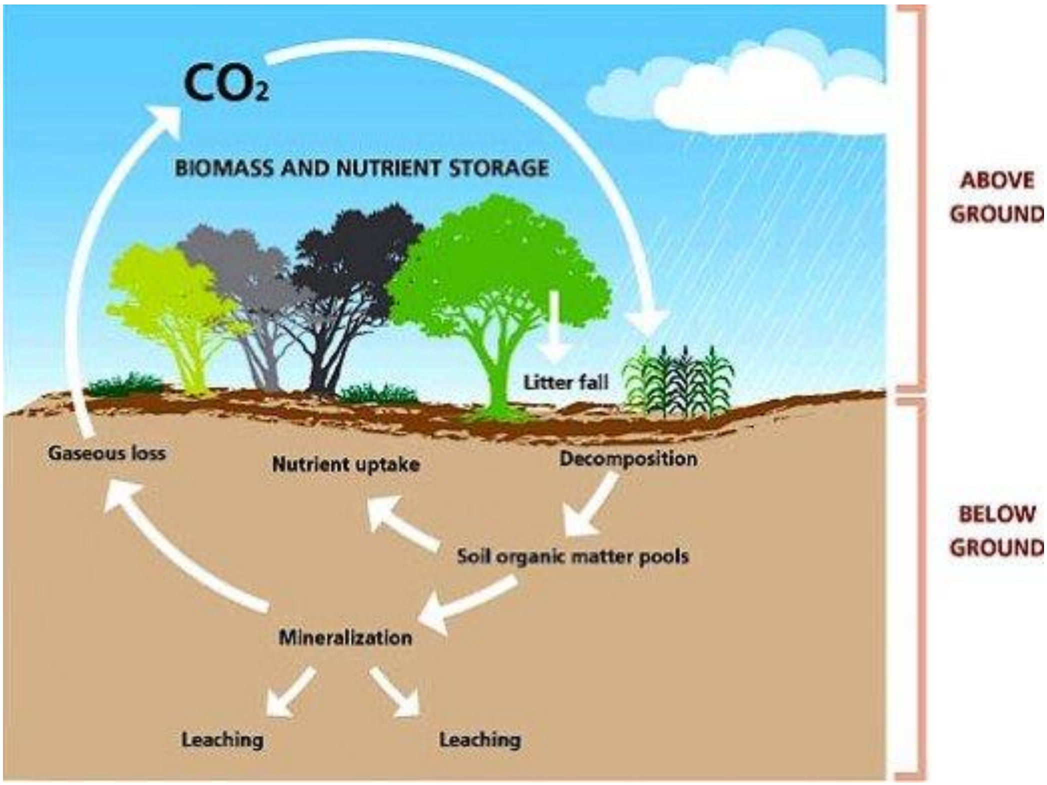


Annexure – III: Carbon Cycle of a Tree

The capture and release of carbon dioxide (CO2) by the forest is the net result of many biological processes. The green parts of plants perform the first and most important step in the carbon capture via the photosynthesis. Plants can use the energy from sunlight to transform the atmospheric carbon dioxide into organic molecules. These molecules become the building elements for growth and the basic material to maintain existing components of vital functions. Roughly half of the dry biomass of plants is made up of carbon molecules.

As plants grow, carbon becomes locked as part of the accumulating plant biomass. In trees, approximately half of the carbon bound in photosynthesis is used for construction of new biomass. Part of this biomass is allocated to long-lived stem, branches and coarse roots; the rest is seasonally shed as falling fruits, needles, branches or bark and discarded roots. This organic material is slowly decomposed by the soil microbiota, releasing carbon dioxide back to the atmosphere. The same happens with the biomass of the whole plant when it dies. Thus, as plants die, some of the carbon becomes locked in the soil.

At the same time, as carbon-locking processes take place, some of the carbon returns back to the atmosphere as respired carbon dioxide from plants as well as soil microbiota. Respiration is the basic cellular process to obtain chemical energy from the oxidation of organic molecules, and CO2 results as a waste product of the overall metabolism. Generally, about half of the caught carbon is released in respiration.



Carbon Cycle of a Tree

Canopy

Plant leaves retain the carbon dioxide by the process of photosynthesis and release it by the process of respiration. Photosynthesis needs light, whereas respiration happens both in light and dark. Both processes are strongly affected by temperature and water availability.

When there is enough light and the air temperature is above zero, we can see photosynthesis as a flow of carbon dioxide molecules towards the crown: carbon dioxide enters needles through the pores located at the needle surface (the stomata). At the same time, we can see carbon dioxide being released out of the canopy. This carbon dioxide is produced in respiration. When it is dark, the only flow of CO_2 comes from respiration and it is thus outwards from the canopy.

Ground vegetation

Boreal forests have a vegetation structure that consists of the trees. It also has of a diverse layer of ground vegetation that photosynthesizes, transpires and respires similarly to trees but the volumes are smaller due to the smaller sizes of ground vegetation and diminished light environment at the ground level. Low shrubs and mosses predominate the ground level in mature forests such as in our measuring site. In addition, some grasses and herbs also exist.

Trunk

The tree mostly release carbon dioxide due to the respiration of the living cells in its interior. In some part of the stems, some photosynthesis may also happen. Trunk respiration is most affected by temperature. On a sunny day, the bark of the tree may become warmer than the surrounding air, producing a rise in CO_2 outflow from the trunk.

Roots and soil

Trees may allocate almost one-third of the total biomass to the roots. Roots provide the physical anchorage of the tree to the soil and its main activity is the absorption of water and inorganic nutrients. The uptake and transport of ions, together with growth and maintenance of roots themselves need energy, and thus, root respiration releases CO_2 to the soil and into the air. In addition to plant roots, a complex soil microbiota lives below ground. Their activity results in the release of carbon dioxide to the soil, which flows out to the atmosphere. More than half of the total respiration in the soil may be respired from this soil microbiota, which is responsible for the decomposition of litter and in general, all dead organic matter in the soil. Soil temperature and moisture heavily influence the activity of roots and microbes. Soil respiration is highest in warm and moderately moist soil.