Biofuel Plantation and Seed Production - Analysis of Feedstock for A Sustainable Supply Chain

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Abstract
In India the blending programme of biofuels has gained remarkable significance in recent years. The biodiesel is one of the important fuel which is derived from the plant and animal. The important feedstock is Tree Borne Oil seeds (TBOs) which are non edible oil seeds from pongamia pinnata, neem, mahua, simarouba, calophyllum innophylum, amoora, jatropha etc., and the biofuel plantations can grow in uncultivable waste dry lands with minimum maintenance. The different biofuel species suits to different geographic conditions like soil strata, rainfall etc., of the State. The biofuel species are giving green manure, firewood, seeds for oil, biodiesel and other by products. The sustainable development of supply chain depends upon the consistent and quality feed stock for production of biodiesel. In the present paper, the data were collected on biofuel species planted under various government schemes; expected yield, income and expenditure were calculated by projecting the expected yield for a period of thirty years.

Key words: biofuels, plantation, nonedible oil seeds, yield, oil content, supply chain

1. Introduction

Biofuels are renewable liquid fuels extracted from biological raw material and have proven to be good substitutes for oil in the energy sector. The biodiesel is gaining worldwide acceptance as a solution for problems of environmental degradation, energy security, import reduction, rural employment generation and improvement in agricultural economy [1].
The countries like Africa, Brazil, Malaysia, Indonesia and India have given importance for the development of biofuels. [2, 3]

The objective of biofuel plantation through Renewable Energy Directive (RED) is implemented in the country like Africa, Ghana to improve the livelihood resources in rural area. [4,5] In Brazil the surplus soyabean oil is utilizing in biodiesel production. Also the Brazilian biofuel policy aiming to achieve 40% biodiesel blend by 2035.[6] The other countries getting palm sterine one of the byproduct of palm oil refining to produce biodiesel production [8] In India the edible oils are not allowed to produce biodiesel due the country is one of the major importer as well as big consumer of edible oils. The biofuel policy

envisages biofuel programme implementation by involving farmers in cultivation, seed collection, aggregation and marketing.
[http://mom.gov.af/Content/files/Bruntland_Report.pdf,http://www.un.org/en/ecosoc/docs/pdfs/fina_08-45773.pdf] In this connection fuels of biological origin have drawn a great deal of attention during the last two decades. A number of countries in the world took up initiatives for development of biofuels to meet the increasing energy demand.

The non-edible oil usage as the biofuel is gaining importance in India. The central government has adopted a National Policy to promote biofuel usage in India and to reduce the dependence on fossil fuel. The important aspects of the national policy on biofuels are –

1) The major crops focused are Pongamia Pinnata (Honge) and Jatropha
2) It is proposed to achieve 5% biodiesel blend in diesel by 2030 – National Policy revised in 2018
3) Plantation of non-edible oil bearing plants, setting up of oil extraction, processing units for production of biodiesel and creation of infrastructure for storage and distribution are declared as priority sector for the purpose of lending by financial institutions and banks

The government of India has identified 4, 00,000 square kilometers (98 million acres) of land to encourage the cultivation of biofuel plantation like jatropha in 2008. India was keen on reducing its dependence on coal and petroleum to meet its increasing energy demand and to promote cultivation of biofuel plants, expected 20% reduction in crude import by 2011. The Life-cycle analysis have shown favorable energy balance for production of jatropha based biodiesel in India and also a potential GHG emission saving of 33-42% compared to fossil fuels [11].

As per the Paris agreement in 2015 on climate change, India is intended to reduce import fossil fuels by 10% by 2022 and then 20% by 2030. The 70% population of the country depends upon the biomass based energy which contributes 18% of the total basic energy requirement especially in rural area. The central government has taken various initiatives for the development of renewable energy sources; it is found biofuels are one of the cleaner and an efficient fuel among other renewable energy resources.
[https://www.carbonbrief.org/paris-2015-tracking-country-climate-pledges]

In India also palm sterine was imported to produce biodiesel [13]. The palm sterine export from Indonesia and Malaysia was gradually declined due to price fluctuations and as these countries also started biodiesel production [14].

India is one of the fast-developing countries in the world in all the sectors. The socioeconomics of the country, rural development depends upon the growth of energy sector. The energy sector plays an important role on the overall development of the country. The increasing in energy demand and to address the environment issues time warrants looking at the various options for the development of biofuels in the country. At this

juncture it is very much required to note one third of the union budget outlay utilized for crude oil import which is very much essential for industrial, agriculture sector, automobile and captive power generation. The availability and the crude oil price fluctuations in the international market affect the fuel requirement in the country. In most of the foreign countries biodiesel is being produced from edible oil where surplus oil available for biodiesel production [15, 16]

Presently the Ministry of Petroleum and Natural Gas (MoPNG) of government of India has seriously looking at the various options to push the biodiesel blending programme in the country. Recently the biodiesel blending programme initiated in the States of Karnataka, Andhra Pradesh, Telangana, Rajasthan and Chhattisgarh.[17]

1.1 Biofuel Plants, species and the initiatives in Karnataka

The important non-edible oil species are Pongamia pinnata (Honge/Hulugala) Neem, (Bevu / Azadirachta Indica) Hippe (Mahua /Madhuca Indica), Simaroubha (Lakshmitaru /Simarouba glauca), Jatropha (Jatropha curcas) and Surahonne (Calophyllum Innophylum). These biofuel TBO's have been integrated with agriculture crops (gap plantation) and also grown on bunds and hedges of agriculture land. The Pongamia pinnata seed collection, production of oil is familiar in south Karnataka districts and neem in North Karnataka region. [18]

1.2 Geo climatic zones and specific species

The Karnataka State has been classified into 10 different geo climatic zones (Source: Karnataka: A profile of the study area, Chapter-III, http:/www.shodhganga.inflibnet.ac.in/jspui/bitstream/10603/136228/12/12_chapter%203.pdf) The growth, yield, oil content of biofuel species varies from zone to zone. A systematic identification of plus trees to develop saplings has been carried out by the universities of Agriculture Sciences of Bengaluru, Dharawaada, Raichuru, Forest department and other organizations. The seedlings were raised and distributed since 2009 from the seeds were collected from identified plus trees. The research and development activities under progress for the development of high yielding and oil content.

1.3 Quality planting material propagation

The KSBDB has also established Clonal orchards in association with forest department in 5 forest divisions of 3 forest circle of the State. In clonal orchards the work is under progress for the development quality planting material (grafted)

1.4 Biofuel Policy – 2009 – Implementation by the KSBDB

In 2008 a nongovernmental organization (NGO) "Samagra Vikasa Trust" submitted a proposal to the government titled "Drought proofing of Karnataka through biofuel

plantation". The State government accepted this proposal and constituted a Biofuel Taskforce (first State in the country) in 2008.The Biofuel Taskforce entrusted to draft a biofuel policy after considering the various issues of biofuel sector. The Biofuel Task Force had worked for two years and submitted recommendations for the development of biofuel sector in the State. The recommendations were submitted to the government suggestions were made effective planning and implementation of biofuel programme in the State. The issues analysed about feed stock availability, seed collection mechanism and supply chain management. It is proposed to carry out the biofuel programme in co-ordination with various line departments, universities and non government organizations. The government adopted a Karnataka State Biofuel Policy - 2009 and established the Karnataka State Bioenergy Development Board (KSBDB) in 2010 under Rural Development & Panchayat Raj Department (RD&PR) to plan and to execute the schemes on overall development of bio fuel sector in the State.

1.4.1 The Policy highlights related plantation activities are;

1. Planting of tree bearing non-edible oilseeds will be taken up on government, community waste lands, degraded, fallow lands in forest and non-forest areas. Contract farming on private wastelands could also be taken up through the Minimum Procurement Price (MPP) mechanism proposed in the policy. Pertaining to land use for plantation the issue to be consulted with local community through Gram Panchayat/Taluk Panchayat and Zilla Panchayat where the non-edible oil bearing trees (TBOs) which are spread over more than one village/block/taluk. Further, the provisions of Panchayat Extension to the Scheduled Areas (PESA) in case of government lands would be considered while taking up cultivation of biofuel plants
2. Employment provided in plantation of biofuel plants would be covered under the Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREP).
3. Only non-edible oil seed would be harnessed for the purpose of producing biodiesel so that the edible oil is left for cooking purposes for the people. Plantation of tree bearing non-edible oilseeds will be taken up on government lands.
4. A multi-species approach to the production of feedstock depending upon the agro-climatic conditions of the area and of being conducive to a healthy biodiversity.
5. Cultivation of non-edible oil seed plants required for bio-diesel would be promoted on dry land, marginal land, waste and degraded forest land owned by private or government including block plantations. Use of agriculture lands to grow non-edible oil seeds is not encouraged just not to create debate food vs. energy security. The government also looking at the various options to promote public-partnership models in case of biofuel plantation activities. The government lands may allocated to the private agencies through long-term lease to promote biofuel species in the State. The plantation activities initiated

since 2008 through forest department has some issues related to gestation period, productivity. The KSBDB Biodiesel Programme implementation through set of initiatives (schemes, projects and activities) planned, promoted, organized, funded and overseen by the KSBDB. The board is constantly looking for involvement of small farmers in the supply chain for tree borne oilseeds – from "farm" to "fuel tank". The programme itself is guided by the objectives and aims of the KSBDB, Karnataka State government.

2. Methodology

2.1 Data Collection, analysis and projections

The biofuel programme depends upon the availability of feed stock like nonedible tree borne oil seeds (TBOs), used cooking oil, animal tallow etc., The State programme based on non edible oil seeds which are traditionally grow in waste, fallow and non agriculture lands. The forest department also planted biofuel species through department programmes and schemes. The secondary data collected from the forest department. There are three forest wings closely involved in plantation activities.

1. Research and Development division: Involved in nursery development to supply the saplings of various species
2. Social Forestry division : Involved in institutional, roadside plantations
3. Territorial division : Involved in plantations in low density forest areas

The Forest department is undertaking plantation every year. The saplings were planted during in the month of June-July beginning of the monsoon. Minimum two years of watering and maintenance is required, afterwards biofuel plantations not required much maintenance and will grow on its own. The forest department also taking care of mortalities by replanting the saplings. Secondary data collected from the forest department

1. Data tabulation year wise, district wise, species wise and scheme wise
2. Projected seed quantity for a period of 30 years

3.0 Results and Analysis

3.1 Biofuel plantations, schemes, survival rate and projected yield

The Social and Territorial wings of Forest Department in the State undertaking biofuel plantation species like Pongamia pinnata, Neem, Mahua, Simarouba etc., in the State. Since 2009 -2017 the Karnataka State Bioenergy Development Board (KSBDB) has implemented the plantation programme like "Hasiru Honnu", "Baradu Bangara" and "Suvarna Bhoomi" in co-ordination with Forest and Agriculture departments. The number of plantations of different species in number of hectares of lands by the Social and Territorial wing is given in Table 1. The total number of biofuel species in total hectare of lands and the number of

beneficiaries given in Table 2. The other plantation schemes shown in Table 3. Farmers were encouraged to grow TBO's on the hedges and fencing of their farm land through Hasiru Honnu programme. Free saplings were supplied and wages to carry out the cultivation activities from MGNREGA is provided to the farmers. The biofuel plantation carried out through Baradu Bangara scheme in degraded forest land, village non agriculture land and road side. The biofuel plantation under Suvarna Bhoomi scheme was implemented during 2011-12 and 2012-13 in co-ordination with Agriculture Department. The small and marginal farmers were incentivized with a sum of Rs.10, 000/- in two installments to integrate biofuel plants along the bunds and hedges of the farming lands. There are 62,539 farmers who were benefited from this scheme. The biofuel plantation details of various schemes, number of plants, number of hectares and number of beneficiaries collected from the forest department and tabulated in Table 4 along with expected biofuel seed quantity available over a period of 30 years.

Table 1. Biofuel plantation details at different Divisions : Forest Department 2002-09

Sl.No	Division	Year	No. of Plantations						No. of Hectares
			Honge	Neem	Simarouba	Mahua	Cashew	Jathropa	
1	Chikkamagaluru	2008-09	56820	145100	0	0	342300	0	214.35
2	Belagaavi - TF	2006-07	191700	0	0	0	0	0	
		2007-08	65000	70000	0	0	82000	0	
		2008-09	213500	81500	0	0	228000	0	
3	Belgaavi-SF	2005-06	1000	1000	0	0	0	0	
		2006-07	1352	1000	0	0	0	0	
		2007-08	224225	191542	0	0	0	0	
		2008-09	106000	106000	0	0	0	0	
4	Bagalakote	2002-03	0	9000	0	0	0	0	
		2003-04	4000	10500	0	0	0	0	
		2004-05	5000	11200	0	0	0	0	
		2005-06	2350	7000	0	0	0	0	
		2006-07	4400	8000	0	0	0	0	
		2007-08	2500	3000	0	0	0	3000	
		2008-09	1000	1700	0	0	0	0	
5	Vijayapura - TF	2002-03	0	15885	0	0	0	0	
		2003-04	0	0	0	0	0	0	
		2004-05	0	3840	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	48000	0	0	0	0	

		2007-08	0	39260	0	0	0	0	
		2008-09	0	0	0	0	0	0	
6	Vijayapura - SF	2002-03	0	0	0	0	0	0	
		2003-04	0	3000	0	0	0	0	
		2004-05	0	2700	0	0	0	0	
		2005-06	0	14000	0	0	0	0	
		2006-07	0	23000	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	19400	0	0	0	0	
7	Gokak	2002-03	2028	3876	0	0	0	0	
		2003-04	0	0	0	0	0	0	
		2004-05	5715	4000	0	0	0	0	
		2005-06	0	1000	0	0	0	0	
		2006-07	4078	5100	0	0	0	0	
		2007-08	7787	50000	0	0	0	0	
		2008-09	92508	0	0	0	0	0	**18173.465**
8	Yellapura	2002-03	9900	0	0	0	0	0	**130**
		2003-04	10220	0	0	0	0	0	
		2004-05	15320	0	0	0	0	0	
		2005-06	48580	0	0	0	0	0	
		2006-07	21480	0	0	0	0	0	
		2007-08	26890	0	10000	0	0	0	
		2008-09	31356	0	0	0	0	0	
9	Kalaburagi	2002-03	0	0	0	0	0	0	**1603.25**
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	

		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	0	0	0	0	0	
10	Tumakuru-SF	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	0	0	0	0	0	
11	Haasana	2002-03	15000	0	10000	0	0	0	**283**
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	10000	0	15000	0	0	0	
		2008-09	0	0	0	0	0	0	
11	Haaveri	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	100000	0	0	0	0	0	
12	Chitradurga	2002-03	0	0	0	0	0	0	NA

		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	1376	0	2000	0	0	0	
13	Daavanagere	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	80146	3480	0	0	0	0	
		2006-07	111175	3382	0	0	0	0	
		2007-08	266495	12448	13750	0	0	0	
		2008-09	300154	0	45000	0	0	0	
14	Chamarajana gara	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	0	0	0	0	0	
15	Gadaga	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	

		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	0	0	0	0	0	
16	Dharawaada	2002-03	0	0	0	0	0	0	NA
		2003-04	0	0	0	0	0	0	
		2004-05	0	0	0	0	0	0	
		2005-06	0	0	0	0	0	0	
		2006-07	0	0	0	0	0	0	
		2007-08	0	0	0	0	0	0	
		2008-09	0	0	0	0	0	0	
	Total		2039055	898913	95750	0	652300	3000	20404.065

Source : Biofuel Plantation details from Karnataka State Forest Department (Social and Territorial forest wings)
TF - Territorial Forestry
SF - Social Forestry

Table 2. Biofuel plantation under government schemes (Forest department)

Sl.No	Schemes	Year	Plantation Details			Remarks
			No. of plants (in lakhs)	Area (in Hectares	No. of beneficiaries	
1	plantation from other programmes (schemes implemented by the Forest dept)	2002-09	36.89	20404	0	
		2009-10	0	0	0	
2	Baradu Bangara (BB)	2010 -11	120.00	30,000	0	BB,HH,SBY schemes by Task force/ KSBDB
		2011-12	104.00	26,000	0	
		2012-13	80.00	20,000	0	
		2013-14	35.20	8,800	0	
		2014-15	0.00	0	0	
		2015-16	35.16	56,186	0	
		2016-17	46.70	42,685	0	
	Total		421.06	1,83,671	0	
3	Hasiru Honnu (HH)	2009-10	3.20	800	3,000	
		2010-11	55.00	13,750	55,000	
		2011-12	74.00	18,500	74,000	
		2012-13	60.00	15,000	60,000	
		2013-14	60.00	15,000	60,000	

		2014-15	25.03	6,730	26,934	
		2015-16	3.01	7,891	28,000	
		2016-17	4.01	9,897	30,000	
	Total		284.25	87,568	3,36,934	
4	Suvarna Bhoomi (SB)	2011-12	8.70	2,175	8,733	
		2012-13	37.66	9,416	53,806	
	Total		46.36	11,591	62,539	
	Grand Total (1+2+3+4)		788.56	303234.00	399473.00	

Source : Biofuel Plantation details from Karnataka State Forest Department (Social and Territorial forest wings)
TF - Territorial Forestry, SF - Social Forestry

Table 3. Biofuel plantation under various programmes initiated by the KSBDB in co-ordination with Forest Department (2009-17)

Year	Baradu Bangara	Hasiru Honnu	Suvarna Bhoomi	Total
2009-10	0	3,20,000	0	3,20,000
2010-11	1,20,00,000	55,00,000	0	1,75,00,000
2011-12	1,04,00,000	74,00,000	8,70,000	1,86,70,000
2012-13	80,00,000	60,00,000	37,66,000	1,77,66,000
2013-14	35,20,000	60,00,000	0	95,20,000
2014-15	0	25,03,000	0	25,03,000
2015-16	35,16,000	3,01,000	0	38,17,000
2016-17	46,70,000	4,01,000	0	50,71,000
Total (Nos)	4,21,06,000	2,84,25,000	46,36,000	7,51,67,000

Table 4. Biofuel plantation, survival rate expected seed yield year wise

Sl.No	Plantation Year	No. of plants	Survival rate (70%)		Year wise details: expected yield per plant in kg ; Total quantity of seeds in Mt								
					2009	2010	2011	2012	2013	2018	2023	2028	2033
					6	7	8	9	10	15	20	25	30
				No. of kg /plant	6	9	12.5	17	27	30	30	35	35
1	2002-03	63,661	44,563		267	401	557	758	1203	1337	1337	1560	1560
2	2003-04	27,720	19,504		117	176	244	332	527	585	585	683	683
3	2004-05	47,775	33,443		201	301	418	569	903	1003	1003	1171	1171
4	2005-06	1,58,556	1,10,989		666	999	1387	1887	2997	3330	3330	3885	3885
5	2006-07	4,19,285	2,93,500		1761	2642	3669	4990	7925	8805	8805	10273	10273
6	2007-08	10,07,807	7,05,465		4233	6349	8818	11993	19048	21164	21164	24691	24691
7	2008-09	3,20,000	2,24,000		1344	2016	2800	3808	6048	6720	6720	7840	7840
8	2009-10	3,20,000	2,24,000		1344	2016	2800	3808	6048	6720	6720	7840	7840
10	2010-11	1,75,00,000	1,22,50,000		73500	110250	153125	208250	330750	367500	367500	428750	428750
11	2011-12	1,86,70,000	1,30,69,000		78414	117621	163363	222173	352863	392070	392070	457415	457415
12	2012-13	1,77,66,000	1,24,36,200		74617	111926	155453	211415	335777	373086	373086	435267	435267
13	2013-14	95,20,000	66,64,000		39984	59976	83300	113288	179928	199920	199920	233240	233240
14	2014-15	25,03,000	17,52,100		10513	15769	21901	29786	47307	52563	52563	61324	61324
15	2015-16	38,17,000	26,71,900		16031	24047	33399	45422	72141	80157	80157	93517	93517

16	2016-17	50,71,000	35,49,700		21298	31947	44371	60345	95842	106491	106491	124240	124240
	Total	7,72,11,804	5,40,48,364		324290	486435	675605	918822	1459306	1621451	1621451	1891693	1891693

The traditional biofuel species pongamia, neem, mahua, simarouba, surahonne, amoora and jatropha were analysed on the basis of one acre plantation. The numbers of plants of can be cultivated of different species in one acre of land are 111 in one acre of land and 63 in case of mahua. The saplings cost, preparation for planting, cultivation, maintenance, harvesting and net profit after 6, 7, 8,9,10,15,20,25 and 30 years is tabulated in Table 4. The total expenditure and income also calculated over a period of 30 years. The revenue generation generally starts from 6^{th} year and gradually increased over the years and 30^{th} year is considered saturation level. The financial calculations over a period of 30 years the backward linkage activities are quite encouraging situation to the farmers to involve in cultivation, harvesting, seed collection and marketing.

The important biofuel species which are predominantly found in southern and northern Karnataka districts shown in Table 5. The data available from 5 districts.

Table 5. Plantation data in some districts of Karnataka

District	Plantation data (2004-2010) for Pongamia	Plantation data (2004-2010) for Neem
Chikkamagaluru	60,000	1,45,000
Belagaavi	6,00,000	5,00,000
Bagalakote	20,000	60,000
Yellapura	1,80,000	1,00,000
Davanagere	7,70,000	20,000
Vijayapura	Not available	70,000
Gokak	Not Available	60,000

The number of biofuel plants planted under the government schemes like Baradu Bangara, Hasiru Honnu and Suvarna Bhoomi Yojana shown in Fig.1

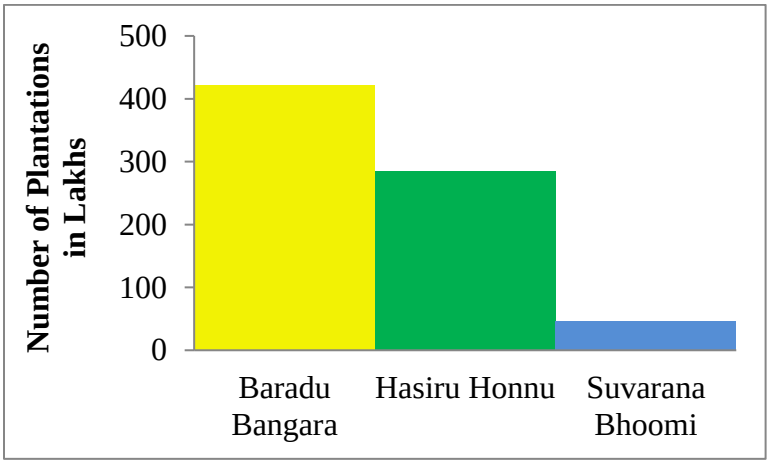

Fig. 1 Biofuel plantation under government schemes

In 2008, government of Karnataka has taken several initiatives to develop the backward linkages to improve the feed stock availability for biodiesel production The KSBDB in co-ordination with Forest and Agriculture department through Baradu Bangara, Hasiru Honnu and Suvarna Bhoomi schemes take up biofuel plantation. This led to 100 to 200% increase in plantation during the period of 2010 to 2012. The initial enthusiasm among the farmers saw a dip in 2014 when they were unable to get their expected rate for the seeds. The market slowly on the path of recovery after creating awareness about usage of biofuel seeds for biodiesel production and other applications. There is now a steady growth, which is strong and robust. Fig.2 shows the plot of number of plants planted, which yield seeds for biodiesel as a function of time.

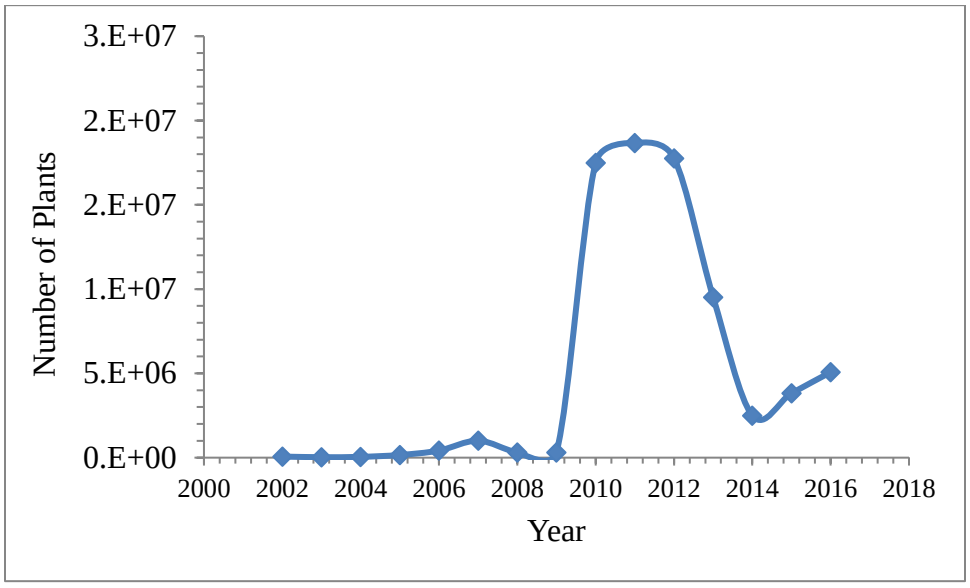

Fig.2 Plot of Number of Plantations as a function of Time

3.2 Income and expenditure analysis of Biofuel species

Table 6 and Fig. 3 presents the data of net income and expenditure cost for cultivation of pongamia plants and harvesting of pongamia seed per acre. Typically it takes 5 years for pongamia plants to yield seeds which can be used for extraction of oil. In one acre of land nearly 111 pongamia plants can be sown. The cost of each plant would be Rs.16/- with additional pitting charges of Rs.25/- . Typical maintenance charges for one acre of plot including manure would be Rs.3300/-. Thus an amount of Rs.22000/- is incurred during the first five year period. Subsequently once the harvesting begins, the typical harvesting cost for pongamia is Rs.10/- per kg.The yield of the pongamia seeds for the first year would be 3 kg per plant and will gradually increase to 36 kg per plant during a time period of 15 years. From 7^{th} year onwards the farmer can expect a net income of Rs.15000/- per year and gradually increase to Rs.65000/- per year as shown in the Fig. 3. Table 7 shows the data of net income and expenditure cost for cultivation of neem and harvesting of neem seed per acre, compared to pongamia, the yield of the neem seeds for the sixth year would be 0.5 kg per plant and will gradually increase to 20 kg per plant during

a time period of 15 years. The typical harvesting cost for neem is Rs.5.20/- per kilogram. From 9th year onwards the farmer can expect a net income of Rs.15000/- per year and gradually increase to Rs.10000/- per year as shown in the Fig. 4. The breakeven point for a farmer growing pongamia seeds would be 7 years while that for neem would be 8.5 years.

Table 6. Pongamia Seedlings 1 acre

Expenditure		Income			Harvesting	Net Profit
Distance	6x6m	Years				
1 acre (plants)	111	6	Yield (Kg)	3		
8"x12" seedlings Rs	16		1 acre (kg)	333		
Amount Rs per acre	1776		Rate (Rs)	28		
Replace Seedlings 10% 30 Rs per plant	333		Amount (Rs)	9324	3263	6061
Pitting Rs per pit	25	7	Yield (Kg)	9		
Amount Rs per acre	2775		1 acre (kg)	999		
Planting Rs per plant	5		Rate (Rs)	28		
Amount Rs per acre	555		Amount (Rs)	27972	9790	18182
Manure Rs per acre	5	8	Yield (Kg)	12.5		
Amount Rs per acre	555		1 acre (Kg)	1388		
1st year maintain Rs per plant	30		Rate (Rs)	28		
Amount Rs per acre	3330		Amount (Rs)	38850	13598	25252
2nd year maintain Rs per plant	30	9	Yield (Kg)	17.5		
Amount Rs per acre	3330		1 acre (Kg)	1943		
3rd year maintain Rs per plant	30		Rate (Rs)	28	19037	35354
Amount Rs per acre	3330		Amount (Rs)	54390		
4th year maintain Rs per plant	30	10	Yield (Kg)	23		
Amount Rs per acre	3330		1 acre (Kg)	2553		
5th year maintain Rs per plant	30		Rate (Rs)	28	25019	46465
Amount Rs per acre	3330		Amount (Rs)	71484		
		15	Yield (Kgs)	35		
			1 acre (Kg)	3885		
			Rate (Rs)	28		
			Amount (Rs)	108780	38073	70707
		20	Yield (Kg)	50		
			1 acre (Kg)	5550		
			Rate (Rs)	28		

			Amount (Rs)	155400	54390	101010
		25	Yield (Kg)	50	54390	101010
			1 acre (Kg)	5550		
			Rate (Rs)	28		
			Amount (Rs)	155400		
		30	Yield (Kg)	55	59829	111111
			1 acre (Kg)	6105		
			Rate (Rs)	28		
			Amount (Rs)	170940		
Total Expenditure Rs	22644		Total Income (Rs)	792540	277388	515152

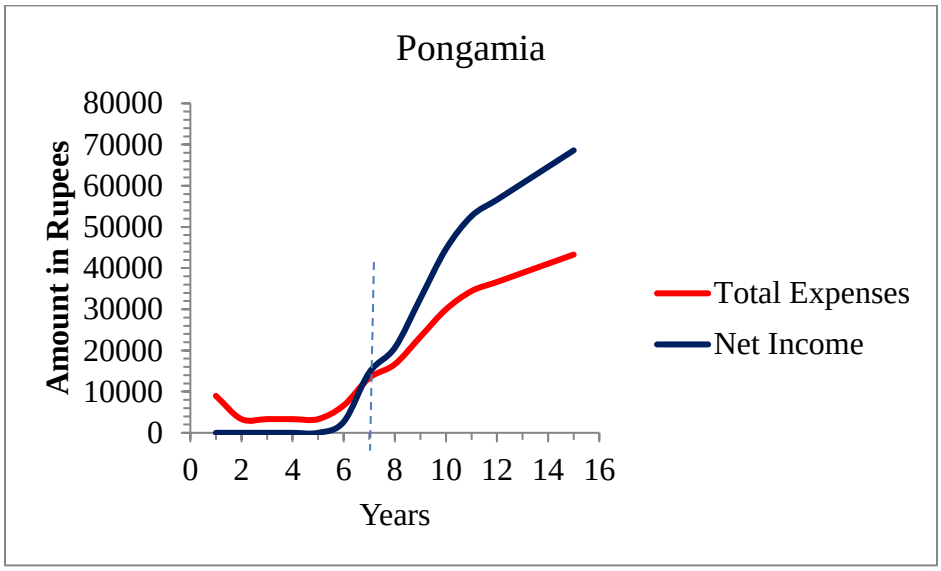

Fig. 3 Plot of Net Income and Expenditure for Pongamia Plantation & Harvesting of Seed

Table 7. Neem Seedlings 1 acre

Expenditure		Income			Harvesting	Net Profit
Distance	6x6m	Years				
1 acre (plants)	111	6	Yield (Kg)	0.5	289	1154
8”x12” seedlings Rs	16		1 acre (Kg)	55.5		
Amount Rs per acre	1776		Rate (Rs)	26		
Replace Seedlings 10% 30 Rs per plant	333		Amount (Rs)	1443		

Pitting Rs per pit	25	7	Yield (Kg)	1.5		
Amount Rs per acre	2775		1 acre (Kg)	166.5		
Planting Rs per plant	5		Rate (Rs)	26		
Amount Rs per acre	555		Amount (Rs)	4329	866	3463
Manure Rs per acre	5	8	Yield (Kg)	4		
Amount Rs per acre	555		1 acre (Kg)	444		
1st year maintain Rs per plant	30		Rate (Rs)	26		
Amount Rs per acre	3330		Amount (Rs)	11544	2309	9235
2nd year maintain Rs per plant	30	9	Yield (Kg)	6.5		
Amount Rs per acre	3330		1 acre (Kg)	722		
3rd year maintain Rs per plant	30		Rate (Rs)	26	3752	15007
Amount Rs per acre	3330		Amount (Rs)	18759		
4th year maintain Rs per plant	30	10	Yield (Kg)	10		
Amount Rs per acre	3330		1 acre (Kg)	1110		
5th year maintain Rs per plant	30		Rate (Rs)	26	5772	23088
Amount Rs per acre	3330		Amount (Rs)	28860		
		15	Yield (Kg)	18		
			1 acre (Kg)	1998		
			Rate (Rs)	26		
			Amount (Rs)	51948	10390	41558
		20	Yield (Kg)	27.5		
			1 acre (Kg)	3052.5		
			Rate (Rs)	26		
			Amount (Rs)	79365	15873	63492
		25	Yield (Kg)	30		
			1 acre (Kg)	3330		
			Rate (Rs)	26		
			Amount (Rs)	86580	17316	69264
		30	Yield (Kg)	30		
			1 acre (Kg)	3330		
			Rate (Rs)	26		
			Amount (Rs)	86580	17316	69264
Total Expenditure Rs	22644		Total Income Rs	369408	73883	295525

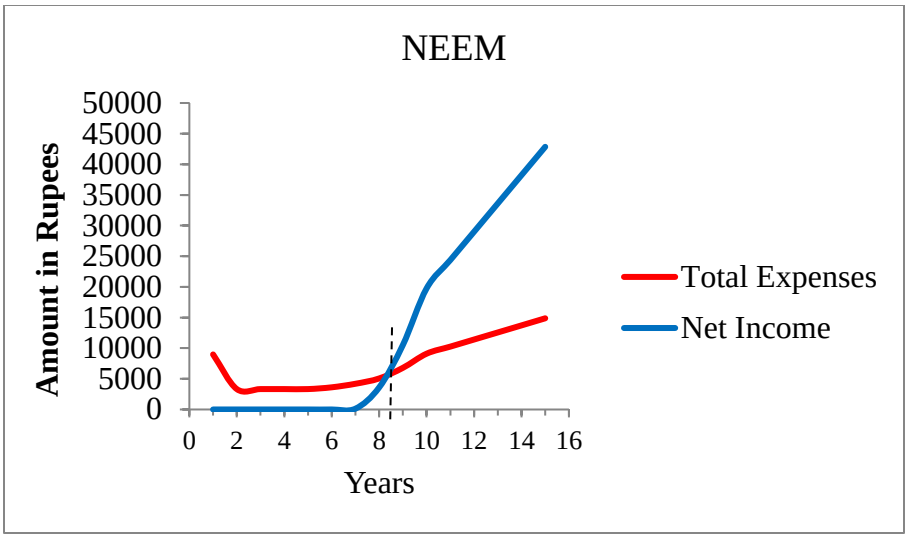

Fig. 4 Plot of Net Income and Expenditure for Neem Plantation & Harvesting of Seeds

Table 8 and Fig. 5 show the net income and expenditure cost for cultivation of Mahua plants and harvesting of mahua seed per acre. Typically it takes 8 years for these plants to yield seeds which can be used for extraction of oil. In one acre of land nearly 63 plants can be sown. The cost of each plant would be Rs.20/- with additional pitting charges of Rs.25/- . Typical maintenance charges for one acre of plot including manure would be Rs.1890/-. Thus an amount of Rs.20585/- is incurred during the first nine year period. Subsequently once the harvesting begins, the typical harvesting cost is Rs.3.5/- per kilogram. The yield of the seeds for the first year would be 0.5 kg per plant and will gradually increase to 25 kg per plant during a time period of 15 years. From 10th year onwards the farmer can expect a net income of Rs.1300/- per year and gradually increase to Rs.21000/- per year as shown in the Fig. 5. The breakeven point for mahua seeds is 11 years.

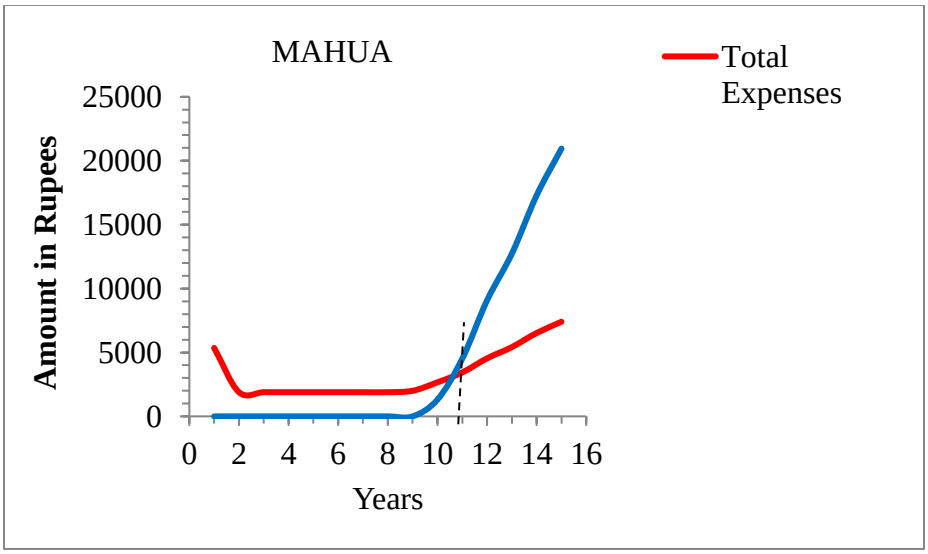

Fig. 5 Plot of Net Income and Expenditure for Mahua Plantation & Harvesting of Seeds

Table 8. Mahua Seedlings 1 acre

Expenditure		Income			Harvesting	Net Profit
Distance	8x8m	Years				
1 acre (plants)	63	9	Yield (Kg)	0.5	113	454
8”x12” seedlings Rs	20		1 acre (Kg)	32		
Amount Rs per acre	1260		Rate (Rs)	18		
Replace Seedlings 10% 30 Rs per plant	189		Amount (Rs)	567		
Pitting Rs per pit	25	10	Yield (Kg)	3.5	1399	5594
Amount Rs per acre	1575		1 acre (Kg)	388.5		
Planting Rs per plant	5		Rate (Rs)	18		
Amount Rs per acre	315		Amount (Rs)	6993		
Manure Rs per acre	5	15	Yield (Kg)	25	5670	22680
Amount Rs per acre	315		1 acre (Kg)	1575		
1st year maintain Rs per plant	30		Rate (Rs)	18		
Amount Rs per acre	1890		Amount (Rs)	28350		
2nd year maintain Rs per plant	30	20	Yield (Kg)	40	9072	36288
Amount Rs per acre	1890		1 acre (Kg)	2520		
3rd year maintain Rs per plant	30		Rate (Rs)	18		
Amount Rs per acre	1890		Amount (Rs)	45360		
4th year maintain Rs per plant	30	25	Yield (Kg)	75	17010	68040
Amount Rs per acre	1890		1 acre (kg)	4725		
5th year maintain Rs per plant	30		Rate (Rs)	18		
Amount Rs per acre	1890		Amount (Rs)	85050		
		30	Yield (Kg)	100	22680	90720
			1 acre (Kg)	6300		
			Rate (Rs)	18		
			Amount (Rs)	113400		
Total Expenditure Rs	13104		Total Income Rs	279720	55944	223776

Table 9 and Fig. 6 show the net income and expenditure cost for cultivation of simarouba plants and harvesting of simaroubha seed per acre. Typically it takes 6 years for plants to yield seeds which can be used for extraction of oil. In one acre of land nearly 111 plants can be sown. The cost of each plant would be Rs.16/- with additional pitting charges of Rs.25/- . Typical maintenance charges for one acre of plot including manure would be Rs.3300/-. Thus an amount of Rs.22000/- is incurred during the first five year period. Subsequently once the harvesting

begins, the typical harvesting cost for is Rs.4/- per kilogram. The yield of the seeds for the first year would be6 kg per plant and will gradually increase to 30 kg per plant during a time period of 15 years. From 7th year onwards the farmer can expect a net income of Rs.13000/- per year and gradually increase to Rs.50000/- per year as shown in the Fig.6. The breakeven point for simarouba seeds is 6 years.

Table 9. Simarouba Seedlings 1 acre

Expenditure		Income			Harvesting	Net Profit
Distance	6x6m	Years				
1 acre (plants)	111	6	Yield (Kg)	6		
8"x12" seedlings Rs	16		1 acre (Kg)	666		
Amount Rs per acre	1776		Rate (Rs)	20		
Replace Seedlings 10% 30 Rs per plant	333		Amount (Rs)	13320	2664	10656
Pitting Rs per pit	25	7	Yield (Kg)	9		
Amount Rs per acre	2775		1 acre (Kg)	999		
Planting Rs per plant	5		Rate (Rs)	20		
Amount Rs per acre	555		Amount (Rs)	19980	3996	15984
Manure Rs per acre	5	8	Yield (Kg)	12.5		
Amount Rs per acre	555		1 acre (Kg)	1388		
1st year maintain Rs per plant	30		Rate (Rs)	20		
Amount Rs per acre	3330		Amount (Rs)	27750	5550	22200
2nd year maintain Rs per plant	30	9	Yield (Kg)	17		
Amount Rs per acre	3330		1 acre (Kg)	1887		
3rd year maintain Rs per plant	30		Rate (Rs)	20	7548	30192
Amount Rs per acre	3330		Amount (Rs)	37740		
4th year maintain Rs per plant	30	10	Yield (Kg)	27		
Amount Rs per acre	3330		1 acre (Kg)	2997		
5th year maintain Rs per plant	30		Rate (Rs)	20	11988	47952
Amount Rs per acre	3330		Amount (Rs)	59940		
		15	Yield (Kg)	30		
			1 acre (Kg)	3330		
			Rate (Rs)	20		
			Amount (Rs)	66600	13320	53280
		20	Yield (Kg)	30		
			1 acre (Kg)	3330		
			Rate (Rs)	20		

			Amount (Rs)	66600	13320	53280
		25	Yield (Kg)	35		
			1 acre (Kg)	3885		
			Rate (Rs)	20		
			Amount (Rs)	77700	15540	62160
		30	Yield (Kg)	35		
			1 acre (Kg)	3885		
			Rate (Rs)	20		
			Amount (Rs)	77700	15540	62160
Total Expenditure Rs	22644		Total Income Rs	447330	89466	357864

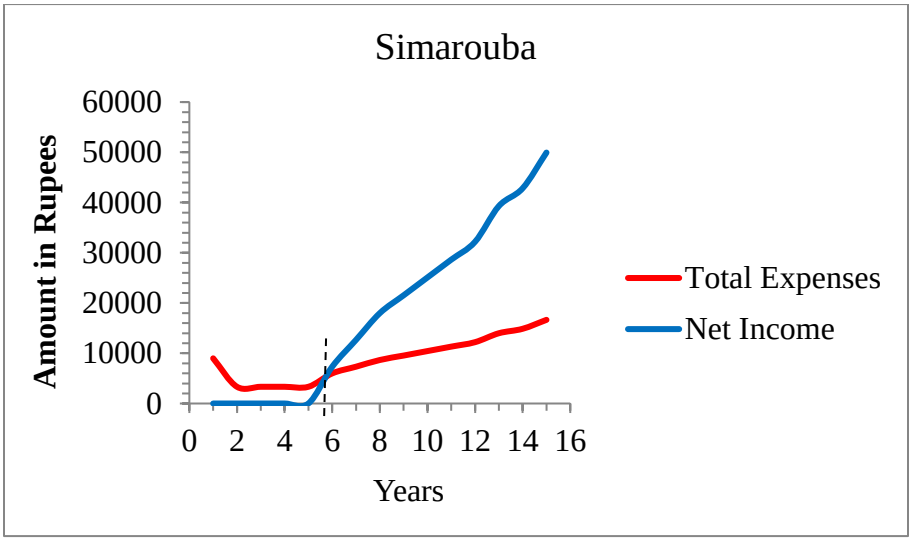

Fig. 6 Plot of Net Income and Expenditure for Simarouba Plantation & Harvesting of Seeds

From the above analysis it is evident that pongamia seeds provided the highest net income to the farmer at the end of 15 years, while Simarouba gives marginally lower income. Purely based on the economics of return on investment on oil seed plantation and harvesting consideration Mahua and Neem are less preferred. However other considerations such as soil, water and weather conditions may be the deciding factors in selection of plants.

4. Suggestions

The data collected and the projections mapped over a period of 30 years will be benefited to develop a sustainable biofuel programme in the State. Also it is very much required in the present scenario due to increasing in energy demand. The biofuel programme depends upon the

availability of feedstock for biodiesel production of consistent quality and availability throughout the year. To develop a robust supply chain of biofuel feedstock it is required to promote biofuel planting (TBOs) through farmers. The biofuel seeds are nonedible with good oil content more useful for biodiesel manufacturing industry. Based on the literature review on biofuel programme in other countries, experience and data collected from the Forest department of various biofuel plants cultivated, analysed the suggestions and recommendations were made as follows.

1) Availability of seeds are seasonal; the different species are giving seeds in different months in a year. The different species cultivation as per the adoptable geoclimatic condition is added advantage for continuous supply of seeds throughout the year.

2) The biofuel plantation will help in increasing green coverage and environment protection. The planting of biofuel species avoids the afforestation. The biofuel species survival rate is high, and maintenance is less when compare to other plants. These two key factors also added advantage to take up biofuel planting by the farmers and the institutional plantation by the forest department. The biofuel plants are in leguminous in nature absorbs nitrogen from the nature and inducts into the soil which benefited in improving the soil fertility.

3) Effective implementation of various department programmes also required to promote biofuel plantation, E.g. "Krishi Aranya Prothsahaka Yojane" adopted by the forest department, financial assistance of Rs 100.00 (Rs 35.00 per year) to maintain a tree for three years. The beneficiary has to maintain the biofuel species for three years by providing survival confirmation of the plant to the Forest department.

4) Development of nurseries, clonal orchards in all the districts through Forest department to provide biofuel saplings of high yielding varieties will motivate the farmers to plant more and more biofuel species.

5) The cultivation of biofuel plants, which are giving lot of green manure, firewood and also suitable to maintain the biodiversity.

6) The cake obtained as byproduct during oil expelling is a good organic manure.

7) The data collection of actual number of biofuel planting, survival rate and the gap planting by the farmers definitely helping in increase biofuel plants in the coming years.

8) The government intervention through various schemes, incentives, benefits to the farmers through farmer's producer's organization, addressing taxation issues on seeds and value-added products definitely will help in overall development of biofuel sector.

5. Conclusion

Biofuel plantation is one of the basic requirements for the development of supply chain of biofuel seeds for the biodiesel industry. The biofuel plantation of various species is undertaking through various schemes of government departments, nongovernmental organizations, institutions also by the farmers on their lands. In the country lot of lands available in the industries, institutions, educational institutions, road side, parks etc., All these available lands, waste lands, uncultivable agriculture lands has to be utilized for biofuel plantations. It is very much required to take up a minimum of 30% biofuel species plantation in forestry plantation. The benefit of biofuel plantation has to introduce in the education curriculum will helps in creating awareness about biofuels. The local bodies and their representatives have to play a major role in developing biofuel plantation in rural areas by creating awareness among public especially the farmers. The success stories of plantation programmes like Hasiru Honnu, Baradu Bangara, Suvarnabhoomi, Biofuel parks and Clonal orchards will create a conducive atmosphere for the overall development of biofuel sector.

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