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Assessment of carbon mitigation potential of various biofuels in Indian Context

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Abstract: Biofuels derived from edible and non-edible oil are gaining interest as next generation fuels for replacement of conventional petroleum fuels. There is a huge potential for producing bio-diesel considering large and wide variety of biomass feedstock cultivated in India. In this context, this paper assesses the land requirements to meet the national biofuel policy target from different edible and non-edible seeds. This study has also been carried out as a comparative analysis between four different biodiesel crops for CO_2 mitigation potential and with possible application for Clean Development Mechanism credits. Research indicates that in Indian perspective the mitigation potential of microalgae is the largest, followed by the Jatropha. Edible food crops Soya bean and coconut considered for this study found to have the smallest mitigation potential.
Keywords: Biofuel, Biodiesel, India, Carbon credit, microalgae, Carbon emission reduction.

1. Introduction

India is the sixth largest greenhouse gases (GHGs) emitter, contributing almost 3% of the world's total emissions. In light of increased evidences of climate change effects and oil prices, several alternate fuels are evolving rapidly. Most of the energy requirements are currently satisfied by the fossil fuels –coal and petroleum based products and natural gas. With the fossil fuel depleting, biofuel as a renewable source of energy affords immense potential. In India, our domestic production of fuel is simply not able to keep pace with the ever growing needs, compelling us depend heavily on imports. With about 70% of domestic demand for fuel to be met by imports, there is a huge outflow of valuable foreign exchange .Oil provides energy for 95% of Transportation and the demand for transport fuel continues to rise in India. The demand for diesel is estimated to grow at an annual rate of 5.0 % over the next couple of decades. India produces about 30% of its annual crude oil requirement of approximately 05 million tonnes. For the balance 70 % the country relies on imports. According to the ministry of petroleum and Natural gas in 2008 the country imported nearly 935 million barrels of crude oil costing US $73 billion per annum [1, 2]. Government of India has developed an ambitious National

Biodiesel Mission to meet 20 per cent of the country's diesel requirements by 2011-2012(Planning Commission 6 April 2003) [3]. National mission on biodiesel has given the Blending mandate of biodiesel with diesel to be 20 % by the end of 2012 [4].

Table 1 shows the biodiesel requirement at different percentage of blending to meet the target of national biodiesel mission. The blending target given by National biodiesel mission is 20% of biodiesel with diesel by the year 2017 .To meet the 20% blending of biodiesel the overall target production would be 16.71 million metric tons of biodiesel. To execute this mandate the biodiesel production by the end of the year 2012 has to be 13.38 million metric tonnes.Human Resource development report also says that the developing countries like India should cut their emission by 20%. It would stabilize CO_2 equivalent concentration at 450 ppm in the atmosphere which is currently at 379 ppm (Human development Report 2007/2008). [5]

Table 1: Projected demand and biodiesel requirement for blending

Year	Diesel demand	Biodiesel requirement			
		@5%	10%	15%	20%
2006-2007	52.32	2.6	5.2	7.8	10.46
2011-2012	66.1	3.3	6.6	10.03	13.38
2016-2017	83.58	4.1	8.3	12.58	16.71
2021-2022	104.15	5.2	10.4	15.62	20.83
2026-2027	114.15	5.7	11.4	17.11	22.82

Table 2: Comparison of oil yield of biodiesel crop

Crop	Oil yield(l/ha)	Land area needed(m ha)
Corn	172	1594
Soyabean	446	594
Canola	1190	223
Jatropha	1892	140
Coconut	2689	99
Oil palm	5950	45
Micro algae(a)	136900	2
Micro algae(b)	58700	4.5

Many energy fuels such as hydrogen, CNG, alcohols, Biogas, Producer gas and host of vegetable oils derived from diminishing commercial sources. Naturally, biofuel are considered as potential substitutes for high pollutant diesel fuel as it is obtained from renewable source of energy. The fuels of bio origin may be alcohols, edible and non-edible vegetable oils, biomass, biogas etc. some of these fuels can be used directly while others need to be formulated to bring the relevant properties close to conventional fuels. Virgin vegetable oil can be harvested from many oil feed stock plants like soybeans, sunflower seeds, rape seeds, palm oils and even some types of algae. Algae offer many potential advantages: algae can potentially produce 1 000-4 000 gallon/acre/year significantly higher than soybeans and other oil crops. The renewable biodiesel that is non-edible based is an interesting prospect as a potential biofuel production in areas that are not suitable for farming. Furthermore, estimates of potential oil production from these crops could be as high as 160 tons/ha which is comparatively 30 times more than palm oil. Table 2 shows the oil yield of various energy crops [6].

This biodiesel is simple to use, biodegradable, nontoxic, and essentially free from sulfur aromatics. Biodiesel is a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oil or animal fats, designated as B100. Biodiesel is a domestic, renewable fuel for diesel engines derived from natural oils like Rapeseed oil, Sunflower oil, Soybean oil, Palm oil and Jatropha oil. Biodiesel is produced by a chemical process called Trans-esterification which removes the glycerin from the oil. Its viscosity is only twice that of diesel fuel and it's molecular weight is roughly 1/3 of vegetable oil, hence it can be used as a straight Petro-diesel replacement or it can be used in any concentration with petroleum based diesel in existing compression ignition engine with little or no modifications. It is better for the environment because it is obtained from renewable resources and almost completely eliminates lifecycle carbon dioxide emissions. Biodiesel can be produced from edible plants crops such as palm, rapeseed, coconut, soybean and non-food crops like Jatropha curcas, karanja, neem, or from waste cooking oil .There is a great potential for Clean Development Mechanism projects by the use of biofuels. In this context, this paper assesses the land requirements to meet the national biofuel policy target from different edible and non-edible seeds. Figure 1 shows the different biofuel crops. This study has also been carried out as a comparative analysis between four different biodiesel crops for CO_2 mitigation potential and with possible application for Clean Development Mechanism credits. [7]

(a) Coconut **(b) Soyabean** **(c) Jatropha** **(d) Microalgae**

Figure 1: Picture of various biofuel crops.

2. Methodology

A theoretical analysis was carried out to study the potential of each bio fuel crop .The basic equations used in the analysis are given below. An excel spread sheet was used for solving the equations (1)–(8).

Percentage Diesel Requirement

Total requirement of diesel in the year = α Million metric tons

Amount of biodiesel required for 5 % blending= [(α*5)/100] Million metric tons (1)

Amount of biodiesel required for 10 % blending= [(α*10)/100] Million metric tons (2)

Amount of biodiesel required for 15 % blending= [(α*15)/100] Million metric tons (3)

Amount of biodiesel required for 20 % blending= [(α*20)/100] Million metric tons (4)

Percentage land area

Land area required for cultivation = (Oil yield of crop *amount of biodiesel needed for blending) (5)

% of land area required= (Amount of land area required for cultivation/total land area)*100 (6)

Amount of CO_2 emission reduction

Diesel produces =2.67 kg of CO_2 per liter

Biodiesel produces= 0.73 kg of CO_2 per liter

CO_2 emission reduction by biofuel substitution = 1.94 kg of CO_2 per liter

CO_2 emission reduction potential = 1.94 X amount of biofuel substituted (7)

Certified emission reduction (CER)

1 CER = 1 ton of CO_2 reduced

Carbon trading potential of biofuel (USD) = Tons of CO_2 Reduction x 40$ (8)

Parameters and values used

Value of 1 CER /Carbon credits= 40 $

Total land area available for agriculture in India=328 million hectares.

Annual growth of diesel requirement=5% per year.

3. Result & discussion

Percentage of land requirement

The biodiesel yield estimated for various energy crops from this preliminary study suggest that there is ample opportunity for carbon mitigation .It also suggests of opportunities for carbon credits based on clean development mechanism projects. Fig 2-5 shows the land required for 5%,10%,15% and 20% blending of vrious biofuel crops.It is demonstrated that microalgae and oil palm has got the higher biodiesel yield, therefore requires less % land area followed by Jatropha and Soyabean. Coconut in the present study requires 2-8% land area cultivation to meet the biodiesel blending target of 5-20%.Oil Palm and microalgae has got the potential to supply significant percentage of our diesel demand in a lesser land area ranging from 0.1-2%. To meet the demands of biodiesel in India by 2017, all potential bio fuel crops need to be cultivated in large scale.

Table 3: Projected carbon emission reduction by blending biodiesel with diesel

Year	% blending	CO_2 reduction (10^9kg)
2006-07	5	1.21
	10	2.43
	15	3.65
	20	4.93
2011-12	5	1.46
	10	3.11
	15	4.64
	20	6.21
2016-17	5	1.86
	10	3.96
	15	5.95
	20	7.39
2021-22	5	2.52
	10	5.06
	15	7.58
	20	10.11
2026-27	5	3.21
	10	6.46
	15	9.68
	20	12.92

Table 4: Projected Carbon credits earned by blending biodiesel with diesel

Year	% blending	Carbon credits (million $)
2006-07	5	48.4
	10	97.2
	15	146
	20	197.2
2011-12	5	58
	10	124.36
	15	185.6
	20	248.76
2016-17	5	79.44
	10	158.4
	15	238
	20	295.88
2021-22	5	100.64
	10	202.64
	15	303
	20	404.4
2026-27	5	128.4
	10	258.4
	15	387.2
	20	516.8

CO_2 emission reduction

Biofuels are treated as carbon neutral fuels, meaning almost 100% of the existing emissions from the fossil fuel are removed by switching to biofuels. If the biofuels will be used to replace fossil fuels, CO_2 emissions could be reduced. The use of biofuels may help to create opportunities for Clean Development Mechanism (CDM) and reduces the release of anthropogenic emissions of Green House .Based on the biodiesel potential and oil yield, blending biofuel with diesel could reduce 1 to 13 Mega Tonnes of CO_2annually.Table 3 illustrates projected carbon emission reduction by blending biodiesel with diesel.

Carbon trading potential

Biofuels, apart from enhancing energy security, ensuring employment and development and mitigation environmental pollution, can be instrumental in carbon trading if certain criteria of the clean development mechanism (CMD) of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) are fulfilled [7]. India has the good potential to capture the carbon trading market.The value of carbon credit is market driven. The calculations in this paper have been done taking $ 40/- CER, which is rising and is estimated to touch $60 by 2015.There is tremendous scope of earning carbon credits by production and use of biofuels and plantation of oil bearing crops like Jatropha, Microalgae, Soyabean, Palm etc. Based on the biodiesel potential, by blending biofuel with diesel could earn 48 million $ to 516 million $ annually. Table 4 illustrates the Projected Carbon credits earned by blending biodiesel with diesel.

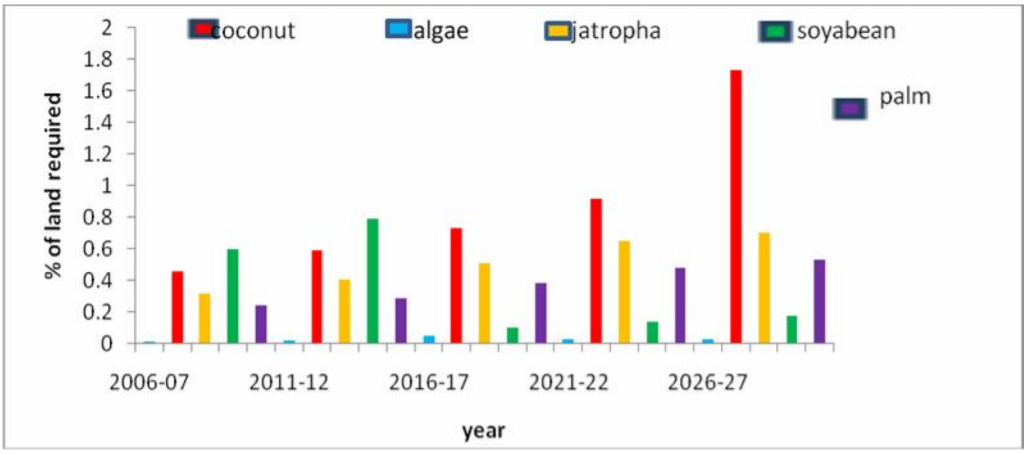

Figure 2 .Percentage of land required for growth of different crops for 5% blending

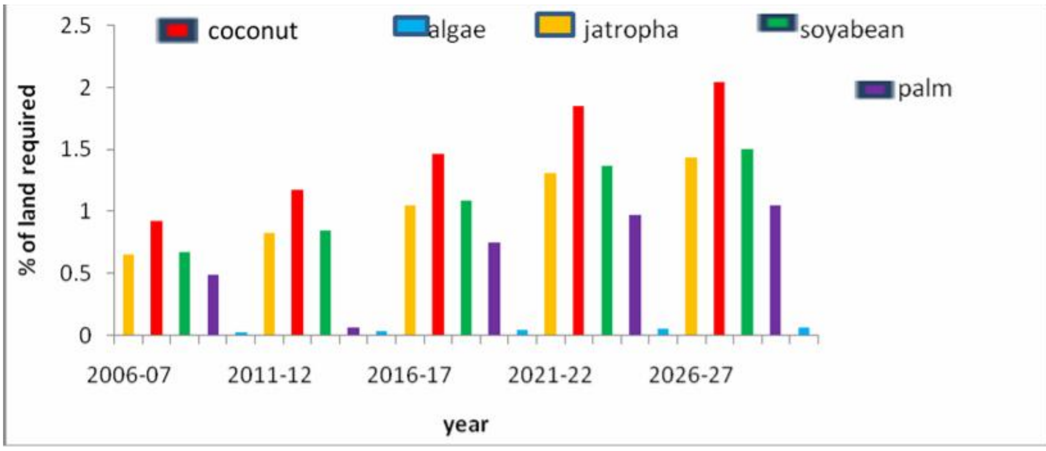

Figure 3 : Percentage of land required for growth of different crops for 10% blending

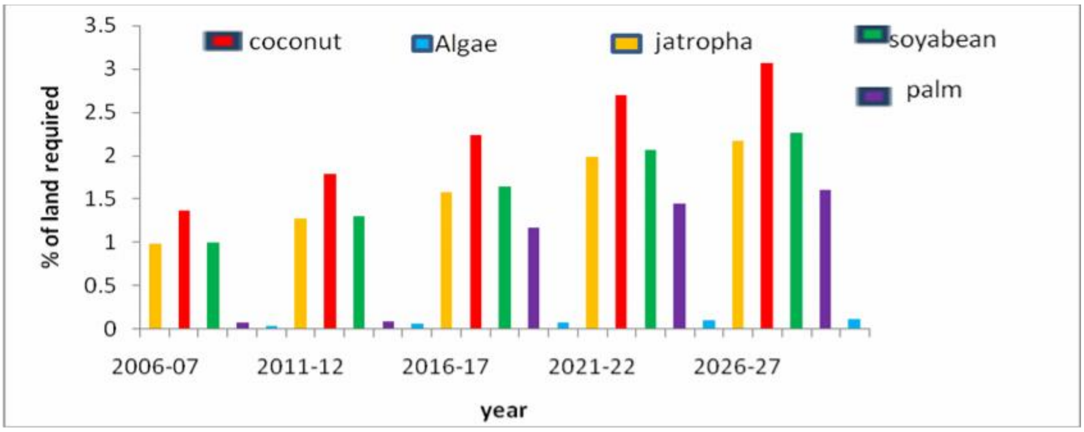

Figure 4 :Percentage of land required for growth of different crops for 15% blending

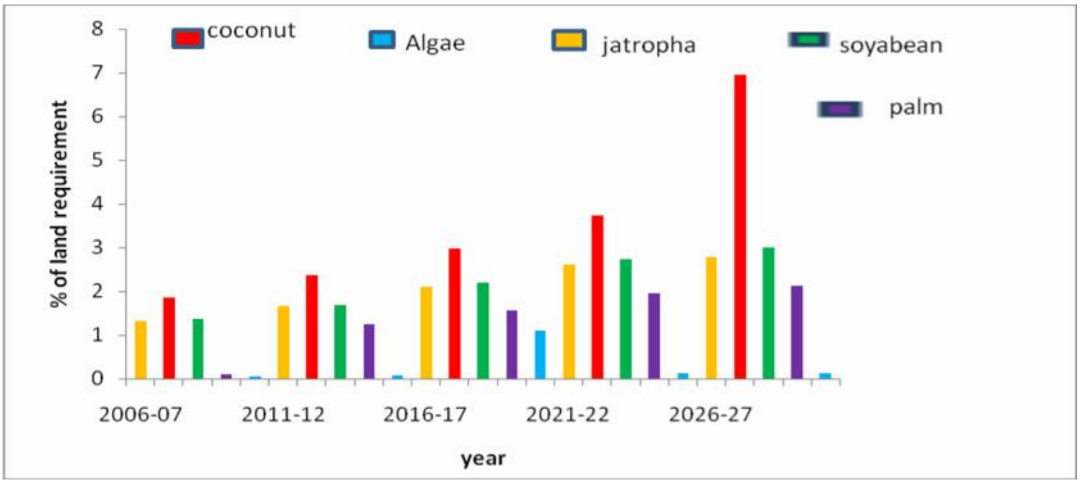

Figure 5: Percentage of land required for growth of different crops for 20% blending

4. Conclusions

This study discussed the potential of various bio fuels crops based on GHG mitigation and Carbon trading potential. Biofuels are going to play important role in meeting India's energy needs .There is a huge market potential for biodiesel considering the ever increasing oil prices. Biodiesel from Jatropha and Algae can earn carbon credits and could substantially reduce the green house gas emission and promote national fuel security. The clear implication of these results suggest that the ambitious target of blending 20% of biofuel by 2017 could be met by cultivating wide variety of oil yielding crops suitable to the specific climatic conditions in different parts of India.The Clean Development Mechanism benefits, via tradable Carbon Credits forms a very important part of the bio fuel projects. A truly integrated approach will have to be followed to achieve the target of national biodiesel mission.

References

1. Ministry of petroleum and Natural gas (2008), Gazette Notification on Blending of Ethanol in Petrol, Government of India, Online source [http://petroleum.nic.in] accessed on 13/05/08.
2. Prabhkar S.V.R.K and Mark Elder (2010) " Not all biofuel are bada- A rural India case our world United Nations University.
3. Planning Commission, Government of India (2003). Report of the Committee on Development of BioFuel, 6 April 2003.
4. Minsitry of New and renewable Energy, Government of India (2008), National mission on Biodiesel.
5. The Human Development concept". UNDP. Human development Report 2007/2008Retrieved 7 April 2012
6. Chisti, Y., 2007. Biodiesel from microalgae, Biotechnol. Adv., 25: 294-306.
7. Clean Development Mechanism (CMD) of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC): Annex B date Retrieved 8 October 2011.

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