Vol. 4 issue 3 (March 2011) ISSN: 0974- 6846

Biodiesel: The alternative fuel for new era

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Abstract

The economic development of any developing country depends on its self-reliance in energy needs. The current energy requirement of the country necessitates search for alternative renewable resources also which are renewable safe and non-polluting. The souring of alternative renewable resources also gains to most priority in view of uncertain suppliers and frequent like in price of crude oil in the international market. In recent times, the world has been confronted with an energy crisis due to depletion of resources and increased environmental problems. The situation has led to the search for an alternative fuel, which should be not only sustainable but also environmental problems. The situation has led to the search for an alternative fuel, which should be not only sustainable but also environment friendly. This alternative diesel fuel can be termed as bio-diesel. This fuel is biodegradable and non-toxic and has low emission profiles as compared to petroleum diesel. This fuel is biodegradable and non-toxic and has low emission profiles as compared to petroleum diesel. The study based on secondary data and the study aimed to attempt the environmental impact of Biodiesel and the cost of cultivation for jatropha in Salem district Tamil Nadu.
Keywords: Bio-diesel, Jatropha, environmental impact, cost.

Introduction

The economic development of any developing country depends on its self- reliance in energy needs. The current energy requirement of the country necessitates search for alternative sources for energy, which are renewable safe and non- polluting. The souring of alternative renewable resources also gains to most priority in view of uncertain suppliers and frequent like in price of crude oil in the international market. Diesel fuel is largely utilized in the transport, agricultural, commercial domestic and industrial sectors for the generation of power/mechanical energy. The soaring prices of petroleum and their derivatives, made the human being to search for alternative fuels, which should have low price and environmental friendly. In recent times, the world has been confronted with an energy crisis due to depletion of resources and increased environmental problems. The situation has led to the search for an alternative fuel, which should be not only sustainable but also environment friendly. This alternative diesel fuel can be termed as bio-diesel. This fuel is biodegradable and non-toxic and has low emission profiles as compared to Petroleum diesel. Biodiesel is the name of a clean burning mono-alkyl ester-based oxygenated fuel made from soybean oil or other vegetable oils or animal fats. A renewable fuel produced from agricultural resources, Biodiesel is simple to use, biodegradable, non-toxic and essentially free of sulfur and aromatic compounds.

India, a fast growing economy facing the challenge of meeting a rapidly increasing demand for energy, ranks sixth in the world in terms of energy demand. Its economy is projected to grow at 7-8 percent over the next two decades and there will be a substantial increase in demand for oil to mange transportation and to meet various others energy needs. While India has significant reserves of coal, it is relatively poor in oil and gas resources. Due to stagnating domestic crude production, India imports approximately 72 percent of its petroleum requirement.

Objective of the study

The study aimed to attempt the environmental impact of biodiesel and the cost of cultivation for Jatropha in Salem District, Tamil Nadu.

Material and methods

Salem is one of the most important steel city in India and with 5th corporation of the Tamil Nadu state. The geographical area of the district is 52030 ha. Many agricultural products from Salem have a wide spread market throughout the country. Jatropha cultivated in watershed areas of blocks in Salem district. Area under Jatropha cultivation in such blocks of Salem is Panamarathupatti (106.4 acre), Veerapandi(157acre), odayampatti(334.60 acre), Konganapuram(334.4 acre), Mecheri(cultivated area is 739), Nangavalli(314 acre), Magudanchavadi(307.5 acre), Valapadi(90 acre) and Pethanaickempalayam(350 acre). This is an analytical study make use of mainly secondary data. The sources of data based on consulted the following published and unpublished materials, such as journals articles, books magazines, census reports and reports from Directorate of statistics, Tamil Nadu Agriculture University, forest college research institute, DI oil company reports and national biodiesel board.

Biodiesel

Biodiesel is an environment friendly fuel, which has almost no sulphur, no aromatics and has about 10% built in Oxygen. It is a fatty acid ethyl or methyl ester. Biodiesel needs no separate infrastructure for storage, dispensing and the existing tank age and dispensing

stations of conventional diesel can be used. Biodiesel is safe to handle and the flash points of Biodiesel are higher than conventional diesel. Blending of Biodiesel with diesel would result in the reduction of un-burnt hydrocarbons, Carbon monoxide and particulate matter in

Table 1.

Year	Diesel demand MT	Biodiesel 5% MT	Biodiesel 10% MT	Biodiesel 20% MT
2006-07	52.23	2.62	5.23	110.47
2011-12	66.90	3.35	6.69	13.38
2012-15	80.00	4.00	8.00	16.00

Source: NOVOD board report (IREDA NEWS)

auto emissions, and will be in line with the objectives of the Auto fuel policy of the Government of India. Biodiesel is made from virgin or used vegetable oils (both edible & non-edible) and animal fats. Biodiesel operates in compression ignition engines like petro-diesel. Biodiesel can be blended in any ratio with petroleum diesel fuels. It can be stored just like the Petroleum diesel fuel and hence does not require separate infrastructure. It has various advantages as explains below. It can be produced from various sources including tree borne oilseeds like Jatropha, Karanja, Jojoba, and neem etc.

Need for the biodiesel fuel

1. Road map for vehicular Emission Norms for New Vehicles as per Auto Fuel Policy Report.
2. Biodiesel production generates employment opportunities for rural masses thereby providing them livelihood support.
3. Reduction in import of Petroleum and thus trade deficit.
4. Plantation of oil yielding plants such as Jatropha curcas for Biodiesel will result in greening of waste and fallow lands. It thus help in Eco-restoration, drought proofing and environmental security.
5. Energy security: Bio-fuels can readily displaced petroleum fuels and, in many countries can provide a domestic rather than imported source of transport fuel. Even if imported ethanol and Biodiesel will likely come from regions other than those producing Petroleum (e.g. Latin American rather than the Middle East), creating a much broader global diversification of supply sources of energy for transport.
6. Environment: Bio-fuels are generally more climate friendly than Petroleum fuels, with lower emissions of Co_2 and other greenhouse gases Bio-fuel is climate natural fuel.
7. More sustainability in transportation: bio-fuels are derived from renewable energy.

Sources of biodiesel

Soybean (USA & France), Palm (Malaysia), Lime and olive oil (Spain), Cotton seed oil (Greece), Jatropha oil (Nicaragua, India and several other countries), Beef tallow (Ireland), used frying oil (Australia), other waste oil and fats (USA), *Pongamia pinnate* (Western ghats), Kokum (Indian subcontinent, Bangladesh), Mahua (EL salvador), Simarouba (Western China & Central Asia), willed apricot (USA), Jojoba (India), Kusum (India & Burma), Neem and Sal (Southern Asia).

Production methods of biodiesel

Blending: Vegetable oil without any processing is directly mixed with petro-diesel and then fed into an engine. The blending of vegetable oil with petro-diesel was experiment successfully by various researchers. It has been proved that 100 percent vegetable oil was also suitable with little modifications in engine. Similarly, the performance of Biodiesel blends like B20, B40, B60, and B80 were extensively studied. The performance of B20 was not much deviating from that of petro-diesel. Biodiesel should always be added at the top of the petro-diesel. If the biodiesel is placed at the top of the petrol-diesel. If the biodiesel is placed at the bottom and the petrol-diesel added at the top proper mixing does not occur.

Micro-emulsification: A micro-emulsification is the colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimensions generally in the range of 1-150 nm formed spontaneously from two normally immiscible liquid and one or more ionic amphiphiles.

Cracking or pyrolysis: It is the process of conversion of one substance to another by applying heat or catalyst in the absence of air or oxygen.

Transesterification: Transesterification is the process of exchanging the alkoxy group of an ester compound by another alcohol.

Table 2. Indian production and import of crude oil (Million tonnes).

Year	Production	Import	Total	Import %	Cost in crores
1971	6.8	11.7	18.5	63	107
1981	10.5	16.2	26.7	61	3.349
1991	33	20.7	53.7	39	6.118
2001	32	57.9	89.9	64	30.695
2002	32	73.5	105	20	100000

Source: Forest college and research institute, TNAU.

Jatropha in India

The genus jatropha has 176 species and distributed throughout the world. Among them, 12 species are recorded in India. *1). Jatropha curcas, 2). Jatropha gossypifolia, 3). Jatropha glandulifera 4). Jatropha neynei, 5). Jatropha integerrima, 6). Jatropha multifida, 7). Jatropha tanjorensis, 8). Jatropha vilosa and var villasa, 9). Jatropha villasa var, ramanadesis, 10). Jatropha nava, 11). Jatropha podagrica, 12). Jatropha hastate.*

The spices *Jatropha curcas* is a promising one with economic seed yield and oil recovery. The oil from *Jatropha curcas* can be used as biodiesel blend up to 20% however; the refined oil is a qualified neat bio-diesel. The plant flowers a year after planting and the economic yield is obtained from the 4th year onwards, and the yield stabilization 5th year onwards.

In India, the diesel consumption alone was about 38 million tones and the subsidies offered by the central government were `9130 crores (Economic survey, 2001-2002). Diesel is the most widely used fuel for transportation purposes apart from other industrial uses. Therefore it Jatropha oil based biodiesel can be used is an extender for mixing with diesel, a huge savings can be made in terms of not only money value but also on the non-renewable resource and decrease our dependency on foreign sources for oil with strategic exploitation of the potential of biodiesel the country will gradually reduce its dependence on huge imports of crude fossil oils and could even become self sufficient in 20 years.

Table 3. Purchases centers of bio-diesel.

State	Location
Andhra Pradesh	Ghatkesar(HPC) also for Jharkhand and Orissa states
Chattisgarh	Ghatkesar (HPC) also for Jharkhand and Orissa states) Mandirhasaud (HPC)
Delhi	Bijwasan (IOC) kandla (BPC)
Gujarat	Rewari (IOC)
Haryana	Devanaginthi (Bangalore) (IOC) Mangalore (IOC)
Karnataka	Mangliagaon- Indore (IOC)
Madhya pradesh	Monmad (BPC) borkhedi- Nagpur (BPC) Loni (HPC) vashi (HPC)*
Maharashtra	Monmad (BPC) Borkhedi- nagpur (BPC) Loni (HPC) vashi (HPC)*
Punjab	Bhatinda (IOC)
Rajasthan	Sanganler- jaipur (BPO) Salawar(HPC)
Tamil Nadu	Korukkupet- Chennai (IOC) Narimanam (IBPO) karur (IBPO)*
Utter pradesh	Panki (IOC) also for Utlaraunchal state amousi- lucknown(IBP)

**To be upgraded for carrying out full specifications tester for BIS standards*
Source: Repositions Jan - March, 2006.

Table 4. Oil content and K/SC ratio of Jatropha curcas.

State	Oil content		K/SC	
	Range%	Average%	Range	Average
Madhya pradesh	15-42	34	0.66-1.08	1.73
Maharashtra	27-41	35	1.56-1.80	2.05
Gujarat	21-33	30	0.71-1.90	1.41
Utter Pradesh	22-38	33	1.25-1.86	1.65
Punjab	8-30	16	0.36-1.27	0.77
Uttaranchal	26-44	36	1.17-2.12	1.74
Tamil Nadu	16-31	26	1.21-1.70	1.48
Rajasthan	26-39	34	1.22-1.88	1.63
Orissa	21-30	27	1.4-1.6	1.5
Jammu	10-30	29	0.54-1.64	1.46

Source: Forest College and Research Institute, TNAU.

Development of biodiesel

A national biodiesel mission is being launched by the planning commission to cover 25 lakh ha area in the country, which will meet 5% replacement of the diesel requirement of the country. The ministry of petroleum and natural gas (MPNG) has launched a biodiesel procurement policy 1-1-06, ` 25 per liter through state-owned petroleum companies in 12 states. However, petroleum companies could not procure any quantity due to low price. Government of India has fixed the target to replace 20 percent petrol-diesel up to 2011-12 by producing 13.38 million tones of biodiesel annually through plantation of Jatropha in 11.19 million ha area. The demand target may be 124.00 million tonnes for 2006-07. The domestic production of crude oils and natural will remain around 33.97 million tonnes during 2006-07. The gap between demand and supply, 90.0 million tones is to be met only by import or by producing biofuel.

Purchase centers

Purchase centers have been identified in consultation with the oil marketing companies like Indian oil corporation, Hindustan Petroleum Corporation and Bharat Petroleum Corporation on the basis of available of minimum testing facilities for B100 and for diesel to the extent of 5%.

Production of seeds & oil

From the experience in India and elsewhere, a plant density of 1,100 per hectare has been found to be optimal, although in rain fed areas on poor soils a lower plant density of 1,666 has been felt to be more desirable. In such plantations Jatropha gives about 2 Kgs of seed per tree. The seed production in plantations various between 2.5 tons/hectare and 5 tons/hectares, depending upon whether the soils are poor or average one hectare of plantation on average soil will on an average give 1.6 metric tons of oil plantation per hectare on poorer soils will give 0.9 metric tons of oil. In Tamil Nadu state, vast stretches of on cultivable lands are available. The annual recurring feature of failure of monsoon brings more area of cultivable lands under wasteland. The uncultivable lands are exposed to uncertain monsoon rains leading to soil erosion thus deteriorating and depleting the condition of land further. Before it becomes totally impossible, to reverse the malady, these lands are to be tacked on war footing scale and speed. In Tamil Nadu land resources are available for Jatropha plantation for production of bio-diesel such as;

Net cropped area	54,67,395 hectares
Net irrigated area	29,59,362 hectares
Net rain fed cropped area	25,08,033 hectares
Government lands	1,25,000 hectares
Private waste lands	10,00,000 hectares

Jatropha will be a suitable crop for wasteland where water Resource is available at minimum and even in low fertile soil. As such, government lands, private wastelands can be very well brought under Jatropha cultivation.

The crop Jatropha has many advantages

- Produces non-edible oil to be used as biodiesel
- Helps environment with low emission of sulphur and carbon monoxide
- Ensures rural prosperity and offers assured income to the farmers.
- Prevents soil erosion
- Oil cake is good organic manure.

Present status in Tamil Nadu

The department of agriculture with National oil seeds and vegetable oils development board (NOVOD) has planned to develop 380 hectares of Jatropha Elite mother plantations in 14 state owned seed farms at a total cost of ` 75.00 lakh. Till 2005-06, 260 ha have been established and the balance 120 ha will be completed by end of 2006-07. The forest college and Research Institute, Tamil Nadu Agricultural University (TNAU), Mettupalayam have evaluated various Jatropha genetic resources during the last two years and identified 3 seed sources which possess more than 40% oil content and gives higher yield over the existing seeds. Tamil Nadu Agricultural University has also received `. 75 lakhs as assistance from NOVOD board for raising elite Jatropha mother plantation forms.

Table 5. Environmental pros and cons of bio-fuels.

Pros	Cons
Closed carbon cycle, reduced CO_2 emission	The production of bio-fuels equired fossil energy
No sulfur content, no SO_2 soot emission	Growing energy -plants bring about ono-cultures
Better energy balance them conventional fuels	The use of fertilizers and pesticides pollute the ground and ground water
Bio- fuels are bio logical degradable	The production of bio fuels might be more expensive than other ways of reducing CO_2 emission.

Environmental impact of biodiesel

Total wasteland in the country is estimated to 55.3 million hectare, out of forest west land is 12.66 million hectare which, can be very well utilized for Jatropha cultivation. Jatropha is seen by many to be the perfect bio- diesel crop and also a gift to the Indian fuel and automobile industry. Jatropha can be grown even in poor soils and is capable of generating topsoil, is drought and pest resilient, and it has seeds with up to 40% oil content. The advantage with Jatropha, a bush, is that it is easy to maintain and starts yielding from the fourth year, while pongamia, a tree requires more areas and yields can be expected from the seventh or eighth year only. The Botanical survey of Indian has identified more than 400 species of plants and trees that can yield such oils. The environmental benefits of bio- fuels appear during the combustion in the engine. The use of bio-fuels results in a closed carbon cycle, since the emitted amount of co2 is as much as the plant absorbed during its vegetation. Due to the low or zero content of pollutants such as sulfur in bio-fuels, the pollutant emission of bio- fuels is much lower than the emission of conventional fuels. The use of bio-fuels, however, has some environmental drawbacks. The raw materials of bio-fuels are plants produced by the agriculture having some negative impacts on the environment. The only scientific way to determine the net environmental impact of Bio-fuels is the so-called life assessment the requirement of diesel in 2001-02 was 39.81 MT. it has increased to 52.33 MT in the year 2006-2007. It is expected that in future the demand for diesel may increase to 80 MT. demands for diesel is going on increasing while the supply is gradually decreasing. Diesel is not a renewable resource. Usage of Biodiesel is the alternate source to solve this problem. Different blending level of Biodiesel was used indifferent times. 20% blending level Biodiesel is 7.96 MT used in 2001-2002, 10.48 MT used in 2006-07. In the future, it is expected to be used up to 16%. With the use of Biodiesel environment emission is reduced and pollution is also reduced.

It is useful both economically and environmentally but the production of Jatropha and biodiesel has not

Table 6. Jatropha yield in various blocks of (Salem/per Acers).

Block	Area (in acre)	No. of plants	3rd year projected yield	Projected oil (kg)	4th year projected yield (kg)	Projected oil (kg)	5th Projected yield (kg)	Projected oil (kg)
Magudanchavadi	307.5	308001	462001	138600.3	554401.8	166320.54	646802.1	194040.63
Panamarathupatti	106.4	106664	159996	47998.8	191995.2	57598.56	223994.4	67198.32
Veera pandi	157	157330	235995	70798.5	283194.0	84958.2	330393.0	99117.9
Kadayaampatti	462.1	462168	693252	207975.6	831902.4	249570.72	970552.8	291165.84
Konganauram	334.4	334668	502002	150600.6	602402.4	180720.72	702802.8	210840.84
Mecheri	356.5	347164	535746	1607723.8	642895.2	192868.58	750044.4	225013.32
Nangavalli	314	314668	472002	141600.6	566402.4	169920.72	660802.8	198240.84
Valapadi	90	96,000	135000	40500	162000	48600	189000.0	56700
Pethanaickenpalayam	350	3,50000	524000	157500	630000	189000	735000.0	220500
Total	2477.9	2480663	3720994	1116298	4465193.4	1339558.04	5209392.3	1562817.69

Source: Records from DRDA, Salem.

progressed. As for the first 3 years, the yield of Jatropha is very low, and cost is high, so people think that its production is unprofitable and gives it up but it gives more yield form the fourth year. So the government should provide encouragement by giving more incentives and financial assistance to develop the production of Jatropha.

Health effects

Biodiesel is safer for people to breathe. Researchers conducted in the bio- diesel emissions have decreased levels of all target Polycyline Aromalie Hydrocarbons (PAH) and nitrite PHA compounds have been identified as potential cancer causing compounds. Targeted PHA compounds were reduced by 75% to 85%. With the exception of benzo(a) anthracene, which was reduced by roughly 50%. Target NPHA compounds were also reduced dramatically with Biodiesel fuel, with z-nitrofluorene and 1- nitrophrene reduced to only trace levels. All of these reductions are to due to the fact the bio- diesel fuel contains no aromatic compounds.

Table 7. Cost of cultivation of Jatropha in Salem (Amount in Rs.)

Particulars	1 year	2 years	3 years	4 years	5 years
Preparatory cultivation	8000	-	-	-	-
Planting material	2500	-	-	-	-
Planting charge	1000	-	-	-	-
Manures &fertility	2000	2000	2000	2000	2000
Weeding	750	750	750	750	750
Irrigation & miscellaneous	1250	1250	1250	1250	1250
Total	8300	4000	4000	4000	4000

Sources: Records from DRDA, Salem.

Jatropha cultivation in Salem district

Jatropha cultivation is used for promotion of Biodiesel production in all states.
Especially Tamil Nadu to promote the Jatropha cultivation is divided into 4 zones.

- Namakkal, Erode, Salem
- Trichy, Pudukottai
- Karur, Dinidugal, Madurai
- Virudhunager, Sivagangai, Thoothukudi.
- Additionally Villupuram and Thiruvannamalai district also to cultivate the jatropha production for bio-diesel. Particularly in Salem districts 10 blocks are selected and cultivated that jatropha production in D.Mohan bio-oils pot limited such as Attur, Gangavalli, Pethanaickenpalayam, Valapadi, Mecheri, Nangavalli, Sangairi, Kolathur, Edapadiand the Government separately to choose a blocks such as Magundenchavedi, Panamarathupatti, Veerapandi, Kadayampatti, Konganapuram, Mecheri, Nangavalli, Valapadi, Pethanaickenpalayam.Table 7 shows that the cost of cultivation of Jatropha yields in salem district. In Jatropha cultivation is only expenditure for the first 3 years. Because we could not get any yield for the first 2 years. But from third year we could get the yield of 1.5 kg seed for a plant. Similarly 4th and 5th year it increases from 1.8 kg to 2.1 kg of seed for a plant. For five years, the expenditure of producing Jatropha is nearly `.24, 300 per acre. But we could get the profit of `.9000 per year. So it is a useful product. After 3 years Jatropha started to produce its seed the yield will expect to 5209392.3 kg in 2010. The expected yield is determined, because, the Jatropha plant is initial stage in Salem district. The yield of Jatropha depends on the quality of soil, irrigated facilities, climatic condition and so on.

Findings & suggestions

- The study find out that the wasteland available in the country will be developed and utilized for cultivation of Biodiesel producing crops and it would fulfill the basic requirement of fuel, fodder, food.
- The study finds out that the Jatropha is used in the production of biodiesel. Jatropha can be cultivated in the wasteland also. Total surface area in India is nearly 63851831 acre among these 20.17% is remained as waste land.
- In this research we came to know, how produce biodiesel from various edible and non-edible can oil seeds, waste vegetable oils, animal fat and other all seeds. The study highlights the Biodiesel produced from 450 species and plants and trees in the world.
- The study spells out that there are 176 species in Jatropha around the world. In India, only 12 types of species are familiar. But in Tamil Nadu only 4 types of Jatropha species is cultivated.
- It is expected that creation of pre-processing and processing facilities would increase the collection of quality seeds in the catchments areas. This will help in enhancing the existing potential and will also help in augmenting future potential in the surrounding districts of the center.
- The study reveals that the investment in the sector would give boost to supporting and ancillary rural based industries by providing raw material for extraction of oils, value addition, packing, transport, marketing etc.
- The study finds out that the Biodiesel policy will reduce import burden and to save substantial foreign exchange enabling our country to strengthen infrastructure facilities with increased GDP.
- The study describes that the biodiesel programme would generate employment in the rural areas, besides increasing income of tribal and landless laborers. It will generate regular employment opportunity to about 6-8 million unemployed people annually and also enhance the socio-economic status

of rural poor masses including tribal and women farmers.

- The study highlights that the biodiesel production would improve the ecological balance by covering waste land and also reducing hazardous emission.
- Each state should develop policies and Mechanisms needed to regulate access to these lands for Jatropha plantation.
- Contract farming through farmers Co-operatives could be promoted for benefiting farmers and increasing Biodiesel production.
- Cluster approach for large-scale plantation of Jatropha could be adapted.
- The approach should be to promote large-scale plantations with etherification at the national level and also small-scale clusters at the village level. Linkages should be created between various rural development schemes, especially the minimum Employment Guarantee schemes of the Government of India and the biodiesel mission.

Conclusion

Biodiesel is the only alternative fuel to voluntarily perform EPA tier I and Tier II testing to quantify emission characteristics and health effects. That study found that B20 reduced total hydrocarbons by up to 30%, carbon monoxide up to 20%, and total particulate matter up to 15%. Typically, emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of the engine and testing methods used. Increases in nox can be effectively eliminated with the use of normal mechanical remediation techniques. The fact that the ozone forming potential of the hydrocarbon emissions of the pure Biodiesel is nearly 50% less than that of petroleum fuel. Pure Biodiesel does not contain sulfur and therefore reduces sulfur dioxide exhaust from diesel engines to virtually zero. Biodiesel can also help meet national goals for the net reduction of atmospheric carbon and blends of Biodiesel and blends of Biodiesel reduce the net amount of carbon dioxide in the biosphere. Biodiesel reduces air toxins, carbon monoxide, soot, small particles, to 90% with pure bio-diesel. The better fuel economy of diesel engines leads to lower emissions of carbon dioxide out of the atmosphere, the net carbon dioxide from both production and use of Biodiesel reduces green house gas (co2) emissions by more than 75%. In Jatropha production is more advantages, but our farmers are not interested in Jatropha cultivation. Because they think that the production of Jatropha is unprofitable. So the government would take some steps to improve the Jatripha production. The government would provide encouragement by giving more subsides and incentives to develop the production of Jatropha and decrease the diesel deficit and import bill. In the present situation to decrease the oil dependence and protect the environment is the important role of the government. So the Jatropha production for bio- diesel is benefited for them. Its more advantages for economic environment in the country.

There are no detailed potential estimates of bio-fuel that consider the competing usages of biomass available for the remaining reference areas. In many studies, it is assumed that the total available biomass is to be used in the fuel sector. Overall, there is a considerable need for further research on bio-fuels for transportation. There is still a paucity of publications about the energy and green house gas balances of many bio-fuels and biodiesel from Jatropha. There is a lack of studies on detailed examinations on emissions of bio-fuels like BTL in the modern motor concepts. Also, other environmental impacts than green house gases are missing in many important individual studies. Nevertheless, there is a great potential for bio-fuels for transportation, which should be developed in accordance with the use of biomass of electricity and heat generation.

