STRAP

Sustainability TRade-offs and Pathways Working Paper #003-2014

Biofuel Feedstock Cultivation in India: Implications for Food Security and Rural Livelihoods

K.S. Kavi Kumar, R.S. Soundar Rajan and R. Manivasagan

Madras School of Economics, Gandhi Mandapam Road, Chennai – 600025

Funded by:

APN

Asia-Pacific Network for Global Change Research

Low Carbon Initiatives Framework

Biofuel Feedstock Cultivation in India:

Implications for Food Security and Rural Livelihoods

K.S. Kavi Kumar, R.S. Soundar Rajan and R. Manivasagan
Madras School of Economics, Gandhi Mandapam Road, Chennai – 600025

Abstract

Biofuels are acquiring importance due to their potential to mitigate greenhouse gas emissions. The two most important biofuels – viz., bio-ethanol and bio-diesel, are largely considered supplementary to the transport fuels. India has extensive programs and aims to blend 20 percent of transport fuels with biofuels by 2017. This paper focuses on three aspects in the context of biofuel production and policy in India. First, the paper looks at feasibility of meeting the biofuel blending targets envisaged. While jatropha remains as the main feedstock for biodiesel production, sweet sorghum could be considered as alternative feedstock to sugarcane for bioethanol production. Secondly, the paper analyzes the competitiveness of jatropha and sweet sorghum using the cost of cultivation data for a number of crops grown in major states of India during the decade of 2000s. The results suggest that both jatropha and sweet sorghum could pose threat to coarse cereals production. Lastly, the paper critically analyzes the viability of jatropha plantations based on insights from field survey conducted in the Southern state of Tamil Nadu. The paper argues that despite aggressive approach adopted by the Government of India, inadequate attention paid to the institutional issues has resulted in unsatisfactory progress in achieving the bio-diesel blending targets.

Key words: Bio-ethanol; Bio-diesel; Energy Policy; Economic Viability; Rural Livelihoods

JEL Codes: Q42; Q56; O13

1.0 Introduction

India is the fifth largest primary energy consumer and the fourth largest petroleum consumer in the world. The growing population, increasing per capita income, infrastructural development and rapid socio-economic development have spurted an increase in energy consumption across all the major sectors of the Indian economy. Currently, India's energy demand is primarily met through non-renewable energy sources such as fossil fuels (coal, natural gas and oil). Being short in domestic production, India mainly depends on crude oil imports that have risen from 57.8 million tons in 1999-2000 to 172 million tons in 2011-12 which accounts for 4 times of the domestic production which stand at 38 million tons in 2011-2012 (GoI, 2012). The Crude oil prices imported from the international market has sharply risen from 26.65 USD/bbl to 111.12 USD/bbl in 2011-2012 (GoI, 2012). Given the limited domestic energy resources, escalating crude oil prices, and growth in domestic consumption of petroleum products, India's oil import bill has inflated considerably (see figure 1). In the near future the imports are slated to rise further with no major breakthrough in domestic oil production and the phenomenal rise in vehicular population, as evident from the domestic sales that has rapidly grown from 9.6 million vehicles in 2008 to over 17 million vehicles in 2013. India's energy policy has primarily focused on providing energy security to sustain high economic growth rate. The "energy security" is broadly interpreted as adequate, clean and efficient supply of energy for the input requirements of various producing sectors and the basic needs of households, along with insurance against the risk of a disruption in supply or volatility of prices (GoI, 2006). Oil being the dominant fuel in the world, like any other net oil-importing developing country, India's energy insecurity is centred on the uncertainty surrounding oil prices and its supply. Since oil, like any other fossil fuel, is non-renewable, India faces increasingly difficult challenges in ensuring energy security.

Among all end-uses, the scope for fuel substitution is highly restricted in the transport sector, which is a very vital one because of its role in ensuring the mobility of goods and people. The vehicular population is growing at 8-10 percent annually in India, with two-wheelers constituting 72 percent of the total registered motor vehicles. Among the various petroleum products, diesel meets an estimated 73 percent of fuel demand from transport sector. Figure 1 shows the increasing trend of high speed diesel consumption in India. With growing concerns of vehicular exhaust being one of the major causes of global environmental pollution, the global community is seeking non-petroleum-based alternative fuels, along with more advanced energy technologies, to increase energy use efficiency. Thus, there has been a worldwide search for alternative renewable fuels to mitigate the problem of energy insecurity and India has been exploring the feasibility of developing biofuels that can reduce the dependence on petroleum products for transport.

The use of a biotic resource, however, may involve some change in the land use pattern if it is derived from a cultivated crop, as is in the case of bioethanol and biodiesel, from sugar cane and oilseeds respectively. Since changes in land use may threaten the security of food or other agrarian supplies, this paper focuses on assessing the profitability and competitiveness of jatropha cultivation for biodiesel production and sweet sorghum cultivation for bioethanol production. Given the close linkages between land use pattern and rural livelihoods, the paper also looks at the implications of jatropha cultivation on rural livelihood options.

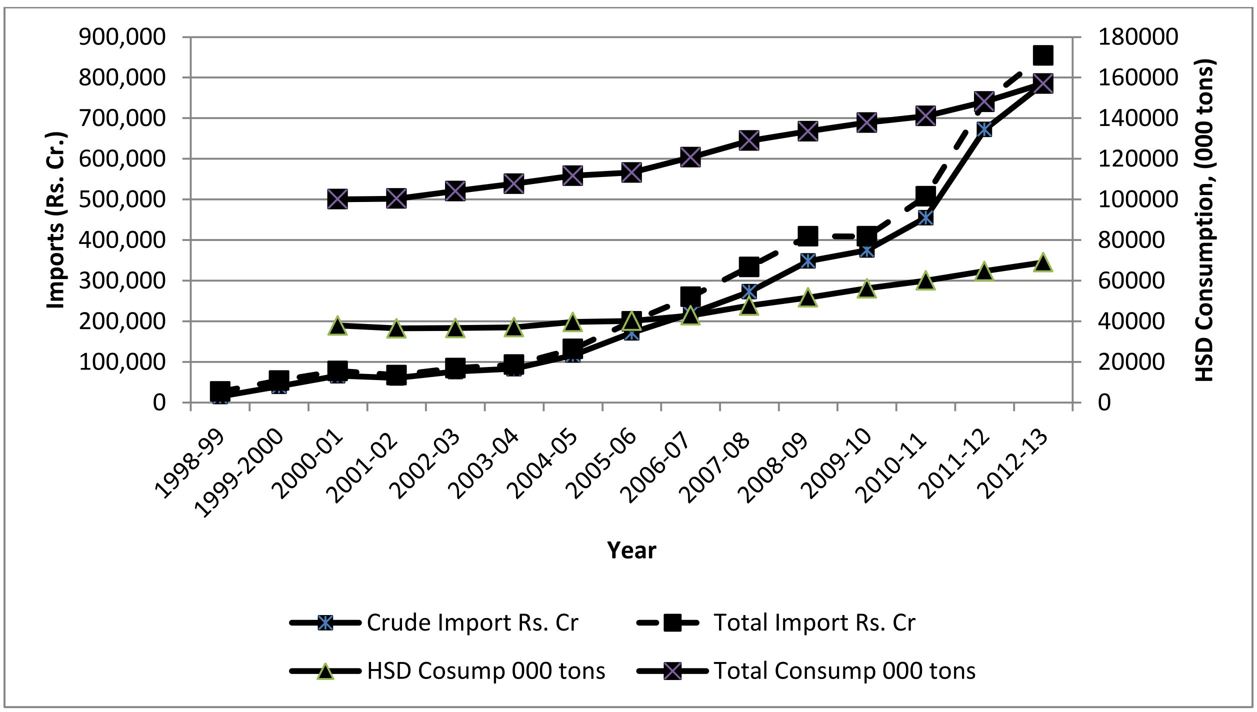

Figure 1. Petroleum Production Consumption and Import Dependence in India

2.0 India's Biofuel Policy Context

India's biofuel policy regime is influenced broadly by: (a) energy security concerns – ever increasing energy demand necessitates search for renewable energy alternatives given India's limited fossil fuel reserves; (b) environmental concerns – growing local pollution and climate change concerns make it imperative to search for environmentally friendly alternatives; (c) wasteland utilization – biofuel feedstock cultivation could bring wastelands and other unproductive lands for effective utilization; and (d) enhance rural livelihood options. The National Policy on Biofuels adopted in 2009 envisaged strengthening India's energy security by encouraging use of renewable energy resources to supplement transport fuels. The policy aimed at achieving 20 percent blending of transport fuels petrol and diesel with bioethanol and bio-diesel by 2017. The policy emphasized use of degraded land and waste land not suitable for agriculture to raise biofuel feedstock to avoid food versus fuel dilemma. In addition to setting-up of a National Biofuel Fund for providing financial incentives, including subsidies and grants for new and second generation biofuel feedstock, the policy also advocated establishing minimum support price mechanism to ensure fair price for biofuel feedstock growers.

Though the National Policy on Biofuels attempted to stay clear of food versus fuel dilemma, a number of studies have cautioned against zealous promotion of biofuels. Fischer et al. (2008) argue that an additional 140 to 150 million people may be at the risk of hunger by 2020 due to biofuel expansion in India and other South Asian countries. The authors further observe that even though the second generation biofuels may reduce adverse impacts on food security, the indirect impact of biofuels on food security through adverse influence on biodiversity could be considerably high. Msangi and Rosegrant (2011) argue that biofuel expansion will result in substantive increase in market prices and hence lead to food security concerns. They further argue that the South Asian countries, including India, may have to increase their crop yields by an additional 1 percent per year up to 2030 to overcome stress induced by the biofuel expansion.

The feasibility analysis of meeting blending targets outlined in the National Biofuel Policy raises important issues regarding land availability in case of biodiesel production, and the need for identifying alternative feedstock in case of bioethanol production. Based on the Integrated Energy Policy projections, India's high speed diesel (HSD) requirement would reach

190 million tons by 2031-32. Twenty percent blending target outlined in the National Biofuel Policy 2009 translates to biodiesel demand of about 38 million tons by 2031-32. With a yield of around 3.75 tons per ha, cultivating jatropha in 33.2 million hectares of land would meet the biodiesel demand. Singhal and Sengupta (2012) show that about 37.38 million hectares of wasteland suitable for jatropha cultivation in available in India. However, as discussed further in the fourth section below, the wasteland is not strictly wasteland with significant rural population dependent on miscellaneous tree growth supported by such lands. Also, the overall area under foodgrains has remained static in India over past decade or so. In such context use of wasteland for fuel purposes remains debatable. This acquires further important in the context of South Asian Enigma of stagnant per-capita food consumption (compared to North Africa and West Asia) despite impressive growth registered in terms of per-capita income.

The bioethanol blending target set by the policy will need additional production capacity and hence more bioethanol production plants, as well, require more sugar cane cultivation, if molasses is used as primary feedstock. In the case of bioethanol production, molasses may have to be diverted from other uses such as the alcohol or pharmaceutical industries. The availability of molasses to meet blending mandates depends on cane and sugar production that are cyclical in nature. Lower molasses availability will put pressure on molasses prices and availability of molasses for ethanol production. Owing to the cyclical nature of sugarcane production in the country, the processing industry experience periodic market glut of sugarcane and molasses impacting prices. For example, the molasses prices in the last decade have fluctuated between Rs 1000 and Rs 5000 per ton (Shinoj et al., 2011). Additionally, ethanol produced has many other alternative uses such as potable alcohol, and the chemical and pharmaceutical industry. During the constrained ethanol supply periods, the utilization tends to be more towards potable and industrial uses due to inability of the Oil Marketing Companies to procure the required amount of fuel ethanol bending at prevailing market prices (Shinoj et al., 2011). Import of ethanol for fuel usage is currently restricted through policy and even if made free, would cost the exchequer very dearly, as the international markets for ethanol are already very tight due to demand from other biofuel-consuming countries. Given the scenario of 10% blending requirement, the growing demand for alcohol from the potable and chemical sector (growing at 3-4% per annum) and the highest available alcohol from molasses pegged at 2.3 billion liters, there will be a shortage of alcohol for blending (Basavaraj et al., 2012).

If molasses alone has to meet the entire requirement of 10% blending, an area covering approximately 10.5 million ha with 736.5 million tons of sugarcane has to be cultivated (around 20–23% in excess of what is required for meeting the corresponding sugar demand) which translates into doubling of both area and production. Presently, the country lacks both technology and infrastructure required to implement this. Further, it is not possible to increase the area under sugarcane beyond certain limit given that sugarcane is highly water intensive with a requirement of 20,000–30,000 cubic metre per ha per crop. Increasing the area under sugarcane will be at the cost of diverting land from other staple food crops (Shinoj et al., 2011). Hence, ethanol production has to be augmented from alternative feedstocks. One such alternative is sweet sorghum which is both resource saving and sustainable.

3.0 Biofuel Feedstock Cultivation – Competitiveness Analysis

For the purpose to assessing whether the cultivation of biofuel feedstock would become competitive for other food and non-food crops being cultivated in a region the following approach:

a) Biofuel feedstock price that is competitive to a principal crop is referred as the price level at which the per hectare ground rent earnings from the biofuel feedstock – if sown on the same piece of land – will be equal to the earnings from the principal crop it is to replace.

b) Using the competing biofuel feedstock price, one can estimate the critical bioethanol/biodiesel price which is the minimum price of biofuel for which returns to a farmer are just sufficient to cover the opportunity cost of diverting land from cultivating a principal crop to biofuel feedstock cultivation.

c) Using the energy parity of bioethanol and petrol, and biodiesel and HSD, one can further estimate the critical petrol and HSD prices.

d) Comparison of the computed critical petrol and HSD prices with the domestic storage point prices reveal whether the food/non-food crops could be threatened by the biofuel feedstock cultivation.

It is important to acknowledge here that cultivation of biofuel feedstock also crucially depends, among other things, on agro-climatic conditions and soil quality. The approach adopted here does not account for such bio-physical suitability assessment of biofuel feedstock cultivation. For the purpose of implementing the above outlined approach the following determinants of agricultural land use reported in the cost of cultivation data are utilized:

a) Paid out costs (A2): - It is a sum total of all actual expenses (in cash and kind) incurred by a farmer in production and rent paid for leased in land.
b) Profit margin: It is a measure of earnings accruing to a farmer per Rupee of expenditure incurred by him/her in farm operations. It is defined as the ratio of Gross Value of Output to Paid out cost.
c) Ground rent: It is defined as the difference between Gross Value of Output for a crop and Cost C1 incurred by a farmer. Cost C1 is a sum total of all actual expenses (in cash and kind) incurred by the farmer in production, interest on value of owned fixed capital assets (excluding land) and imputed value of family labour.

Competitiveness of jatropha and sweet sorghum are assessed using the approach outlined above. The cost of cultivation data across various crops in all major states of India for the years 2004-05, 2007-08 and 2010-11 is utilized for this purpose. The competitiveness of jatropha and sweet sorghum has been assessed against, (a) cereals – rice, wheat, jowar, bajra, maize, ragi and barley; (b) pulses – gram, urad, and moong; (c) oilseeds – groundnut, rapeseed, soybean, sunflower, and sesamum; (d) fibres – cotton and jute; and (e) other crops including sugar cane, onion etc. Analysis is confined to 19 major states of India, namely, Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.

Cost of Cultivation Data for Biofuel Feedstock

Paramathma et al. (2004) and Goswami et al. (2011) provided some estimates of cost of cultivation of jatropha. Jatropha being a plantation crop, its comparison with other annul crops poses slight conceptual difficulty. Taking a specific life time for the jatropha plant and interest rate for present value calculations, the paid out costs and revenue over life time of the plant are converted to their annual cost equivalents. For the purpose of the calculations the life time is taken here as 14 years and the interest rate is considered as 12.5 percent. Based on data provided in Paramathma et al. (2004) and Goswami et al. (2011) the equivalent annual cost of jatropha cultivation per hectare is estimated to be in the range of Rs. 17000 to Rs. 20000. With the seed priced at Rs. 9 per kg, the equivalent annual revenue per hectare from jatropha cultivation is estimated to be in the range of Rs. 65000 to Rs. 70000. Thus the ground rent per hectare ranges between Rs. 48000 and Rs. 50000. The profitability ratio correspondingly would range between 3.5 and 4.0.

Sweet sorghum is similar to grain sorghum but possesses sugar-rich stalks, with higher juice content. Because of its rapid growth, high sugar accumulation, high biomass production potential and wider adapt ability, sweet sorghum can be grown in different agro-climatic conditions. The sugar content in the juice extracted from sweet sorghum varies from 16-23% Brix. It has good potential for jaggery and syrup production besides ethanol. The grain can be used as food and the bagasse after extraction of juice from stalks is an excellent livestock feed. In view of the potential benefits of sweet sorghum as a feedstock for bioethanol production, a pilot value chain model of sweet sorghum as a food-feed-fodderfuel was tested in Andhra Pradesh, India, to augment incomes of farmers while developing a sustainable sweet sorghum–ethanol value chain under ICRISAT-NAIP (ICAR) Sweet Sorghum Value Chain Project by linking sweet sorghum farmers to ethanol industry.

The source of farm input data was the farmers cultivating sweet sorghum under the project and data were collected for the crop years 2008-09, 2009-10 and 2010-11 from Ibrahimbad village in Medak district of Andhra Pradesh. The data collected was analyzed for various costs, gross and net returns and input-output ratios of the crops. The costs of cultivation that were covered include both paid-out costs and imputed costs. Paid-out costs included hired labor (human, animal and machinery); expenses on material inputs such as seed, fertilizer, manure, pesticides and irrigation; and rent paid for leased in land. Since some of the inputs used in the production process came from family sources, the value of these inputs was imputed. The method of imputing these costs was on the basis of the prevailing market rates for labor and materials and postharvest prices of the main product and by-product. However, in calculating the net returns to crop cultivation only cost concept A1 was considered, i.e, the value of paid-out costs such as hired labor and expenses on materials while the imputed cost of family labor was not included. All the costs and returns were based on the actual area reported by the farmers.

Yields were calculated based on the measured area that was found to be less in most cases compared to the actual area reported by the farmers. For the purpose of this analysis actual area reported by farmers was considered along with the data corresponding to 2010-11. Based on Reddy et al. (2013), the cost of sweet sorghum cultivation excluding family labour is taken as Rs. 9496 per hectare. Including family labour and materials, the cost of production is estimated to be around Rs. 12414. Table 1 reports the profitability ratio and ground rents associated with sweet sorghum cultivation under various assumptions about the price of sweet sorghum stalk.

Table 1: Paid-out Cost, Profit Margin and Ground Rent Earnings: Sweet Sorghum Cultivation

Price of Sweet Sorghum Stalk in (Rs/tonne)	Paid-out cost (Rs. Per hectare)	Profitability Ratio	Ground Rent (Rs/hectare)
600	12414	1.484	6018
700	12414	1.6	7818
800	12414	1.774	9618
1200	12414	2.35	16818

Critical HSD Price Range

Using the equivalent annual cost of jatropha cultivation and the ground rent of a crop that jatropha could potentially replace, the critical biodiesel price is estimated. The bio-refinery cost of producing biodiesel from raw jatropha oil is taken as Rs. 9.50 per kg of biodiesel (Singhal and Sengupta, 2012). Taking into account the energy content of biodiesel and HSD, the critical HSD price is also estimated. Table 2 reports the estimated critical HSD prices for the years 2004-05, 2007-08 and 2010-11 for several food and non-food crops.

Table 2: Critical HSD Price Range (in Rs. Per litre)

	2004-05		2007-08		2010-11	
Crop	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
Paddy	20.47	13.15	24.36	13.25	25.61	11.21
Wheat	17.56	12.65	21.95	12.53	21.77	11.97
Maize	15.54	12.64	16.40	13.24	21.93	12.38
Jowar	13.81	13.02	14.64	12.82	16.41	12.12
Bajra	13.74	13.37	14.51	13.51	14.47	13.32
Ragi	13.92	12.55	17.13	11.88	16.38	10.73
Barley	15.53	11.22	18.05	13.74	16.80	13.74
Gram	16.23	13.74	19.19	13.74	20.80	13.74
Tur	16.40	13.64	13.74	13.74	13.74	13.74
Groundnut	15.53	12.81	17.84	13.74	20.32	13.74
Rapeseed & Mustard	17.23	12.91	23.29	13.74	22.15	13.36
Soybean	15.24	13.74	17.12	13.74	18.05	13.74
Sesamum	15.68	13.63	15.95	13.74	16.56	13.74
Sunflower	14.30	13.74	15.84	13.74	15.39	13.74
Cotton	18.37	12.39	21.21	13.74	32.20	13.74
Jute	13.94	13.26	15.53	13.71	23.09	13.74
Sugarcane	28.67	13.74	28.09	13.74	48.13	13.74

The storage point price of HSD in April 2013, for instance, was Rs. 38.05 per litre. In comparison, the critical HSD prices across almost all crops (with the exception of sugarcane in 2010-11) for the three time periods considered are lower. This suggests that jatropha could compete with all food crops. However two caveats must be noted – first, the crucial HSD prices are probably under-estimates due to high yield predictions considered in Paramathma et al. (2004); second the crop cultivation may not entirely depend on cost considerations and as mentioned above agro-climatic conditions and soil quality matter significantly.

Aggregating the data across the states the coefficient of variation of critical biodiesel price of each state across different crops that jatropha could compete in that state is calculated. A lower coefficient of variation makes food and other agricultural products vulnerable to a competitive threat from energy crop cultivation Table 3 reports the estimated coefficient variation values across 19 states for the three years.

Table 3: State-wise Coefficient of Variation (CV) of Critical Biodiesel Prices

State	2004-05		2007-08		2010-11	
	Avg Critical Biodiesel Price	**CV**	**Avg Critical Biodiesel Price**	**CV**	**Avg Critical Biodiesel Price**	**CV**
AP	14.8	15.6	15.9	15.2	18.3	34.6
Assam	12.5	1.3	13.1	3.8	13.2	6.6
Bihar	14.0	6.7	15.5	6.4	16.7	18.3
Chhatisgarh	13.2	3.8	14.8	11.8	14.3	8.7
Gujarat	14.4	7.9	16.5	16.7	18.1	29.9
Haryana	16.4	26.4	17.6	19.9	21.0	33.7
HP	12.7	1.2	12.8	3.2	13.5	8.7
Jharkhand	12.7	7.8	13.2	12.2	12.8	19.7
Karnataka	14.6	31.3	15.2	21.5	17.0	54.5
Maharashtra	13.8	25.0	13.6	9.6	15.6	38.5
MP	13.4	8.9	14.6	12.0	16.4	20.7
Orissa	12.9	1.1	13.4	4.1	15.2	15.4
Punjab	16.8	10.8	20.6	10.0	23.0	11.8
Rajasthan	13.9	10.1	14.9	14.0	15.9	31.2
TN	14.1	19.8	15.7	25.9	18.2	44.5
UP	14.3	16.2	15.7	15.7	17.0	26.4
Uttarkhand	13.9	27.4	16.7	24.5	23.8	42.2
WB	13.4	9.1	14.0	4.5	15.9	20.8

The estimates show that states such as Orissa, Himachal Pradesh, and Assam are particularly vulnerable as the coefficient of variation is consistently lower than that of other states.

Critical Ethanol Blended Petrol

The sweet sorghum stalk price that is competitive to a principal crop would refer to the price level at which the per hectare GR earnings from Sweet Sorghum, if sown on the same piece of land, will be equal to the earnings from the principal crop it is to replace. The competing sweet sorghum price vis-à-vis every principal crop in a state is to be estimated as covering the opportunity cost of cultivating sweet sorghum, replacing a specific crop. Such an opportunity cost-based price would be derived from the cost of cultivation (Cost C1) of sweet sorghum plus the GR of the crop replaced in the state concerned. The competing GVO for sweet sorghum (in Rupees per hectare) against *i*th principal crop in *j*th state would thus be equal to the Cost C1 of cultivating sweet sorghum plus GR (or opportunity cost of land use) from the *i*th principal crop in *j*th state. Using the above estimated competing GVO for Sweet Sorghum, along with the yield of bio-ethanol syrup per tonne of stalk will provide the competing sweet sorghum stalk price range in per kg terms. The estimated crop-wise stalk price value will thus be sufficient to cover the opportunity cost of diverting the agricultural land for sweet sorghum cultivation.

Further, the equivalent value in per litre term of estimated value of one kg of salk corresponding to a specific crop and the bio-refinery cost of converting raw syrup into bio-ethanol taken together gives an estimate of the critical bio-ethanol price that would induce a reallocation of resources in agriculture. The bio-refinery cost of producing bio-ethanol from straw (excluding the cost of raw material) is estimated to be Rs 22 per litre (Reddy et al., 2013). The critical bioethanol price calculated is the minimum price of bioethanol for which returns to a farmer are just sufficient to cover the opportunity cost of diverting land from cultivating a principal crop to sweet sorghum cultivation.

A farmer will be induced to divert his land for sweet sorghum cultivation if the ex-refinery gate price of bioethanol exceeds the critical price level. On the basis of the GR earnings for principal crops and a range of stalk prices, the median competing stalk price for each principal crop is calculated (see Table 4). The critical bioethanol price for a particular agricultural crop is estimated taking into account the competing sweet sorghum stalk price corresponding to that crop and the bio-refinery cost of producing bioethanol from raw sweet sorghum oil. The suitable use of low energy-consumption integrated technology for ethanol production from sweet sorghum shall yield 91.9 kg of ethanol for a tonne input of sweet sorghum stalk (Li et al., 2013). This yield of ethanol in kg per hectare is used to get the competing price of Sweet Sorghum in Rs./kg. Adding the cost of raw material and the bio refinery cost (taken as Rs. 22 per litre as mentioned above) gives an estimate of the value of one kg of bioethanol. Using the conversion factor of one kg of sweet sorghum stalk will yield to 1.26 litres of syrup, the price bioethanol in rupees per litre is estimated. On an energy parity basis, the corresponding critical EBP price is estimated. The calorific values of one litre of commercial ethanol and one litre of bioethanol are taken respectively as 5074 kilocalories and 5042 kilocalories.

It must be emphasized here that the choice of the crop sown depends on the agriculture season, whether it is the rabi or kharif season. As a result farmer may grow more than one crop in an agricultural year. Similarly, some of the varieties of sweet sorghum have a short gestation period of 3~4 months, and hence the farmers can adopt the crop rotation method in order to maximize their benefits. But, for estimating the GR earnings for principal crops we have assumed that farmers cultivate only one principal crop a year.

Table 4: Critical Ethanol Blended Petrol Price Range: 2010-11

Crops	Competing SS Price Range	Median Compet-ing SS Price	Critical Bio-ethanol Price Range	Median Critical Bio-Ethanol Price	Critical EBP Price Range	Median EBP Price
Paddy	2.10 - 32.95	13.97	23.67 - 48.15	33.09	23.82 - 48.45	33.30
Wheat	3.71- 24.72	16.46	24.95 - 41.62	35.06	25.11 - 41.89	35.29
Maize	4.61- 25.06	8.28	25.66- 41.89	28.57	25.82- 42.16	28.75
Jowar	4.04- 13.27	6.63	25.21- 32.53	27.26	25.37-32.74	27.43
Bajra	6.61 - 9.08	7.20	27.25- 29.21	27.72	27.42 - 29.39	27.82
Ragi	1.77 - 13.16	6.18	23.40- 32.45	26.91	23.55 - 32.65	27.08
Barley	13.81 - 14.08	13.95	32.96- 33.18	33.07	33.17 - 33.39	33.28
Gram	8.87- 22.64	13.01	29.04- 39.97	32.32	29.22 - 40.22	32.53
Urad	11.22 - 15.87	12.81	30.91- 34.59	32.23	31.10- 34.81	32.43
Moong	10.44 - 13.08	10.44	30.28- 32.38	30.28	30.47- 32.58	30.47
Groundnut	8.48 - 21.61	16.34	28.73- 39.15	34.97	28.91 - 39.40	35.19
R&M	6.70- 25.54	20.38	27.32- 42.27	38.17	27.49 - 42.54	38.41
Soyabean	9.15- 16.75	11.04	29.26- 35.29	30.76	29.44 - 35.51	30.96
Sesamum	8.31- 13.55	12.49	28.59- 32.75	31.91	28.78 - 32.96	32.12
Sunflower	8.91- 11.05	9.73	29.07- 30.77	29.72	29.25 - 30.97	29.91

Nigerseed	0.00- 0.00	9.30	22.00- 22.00	29.38	22.14 - 22.14	29.57
Safflower	8.43 - 11.89	10.16	28.69- 31.44	30.06	28.87 - 31.64	30.25
Cotton	24.98 - 47.07	30.28	41.83- 59.36	46.03	42.09 - 59.74	46.33
Jute	7.97 - 27.54	14.12	28.32- 43.86	33.20	28.50 - 44.14	33.41
Sugarcane	42.73 - 66.09	59.43	55.91- 74.45	69.77	56.27 - 74.93	69.61
Potato	27.44 - 66.00	40.07	43.78-74.38	53.80	44.05 - 74.85	54.14
Arhar	10.55 - 23.54	13.79	30.38- 40.68	32.94	30.57 - 40.94	33.15
Lentil	10.67 - 20.61	15.65	30.47- 38.36	34.42	30.66 - 38.60	34.64
Peas	10.09 - 12.67	11.38	30.01- 32.05	31.03	30.20 - 32.26	31.23
Onion	26.3- 117	32.45	42.9- 114.9	47.76	43.2 -115.7	48.06

The Refinery Transfer Price (RTP) on landed cost basis for unblended petrol is fixed at Rs 46.46 per litre on May 2014, while the 2013 price was pegged at Rs 44.12 on account of rising demand and fluctuations in crude oil prices in the international market. In comparison to ex-refinery unblended petrol price levels, the estimated critical blended-petrol prices are on a lower side. Except the four crops - sugar cane, cotton potato and onion, the highest estimated median critical EBP price is Rs38.41 per litre for R&M cultivation and the lowest median price is Rs 27.08 per litre for ragi cultivation. Thu, potentially sweet sorghum cultivation could compete with many crops.

To promote the use of EBP as a transport fuel across states, the EGoM has fixed the interim refinery gate price of ethanol at Rs.27 per litre for the oil marketing companies. Excluding for sugarcane, the highest estimated median critical bioethanol price is Rs. 53.80 for potato and the lowest Rs26.91 per litre for ragi cultivation. In comparison with the prevailing government fixed price of Rs27 per litre, the imputed critical prices of bio-ethanol or EBP are higher than the regulated price, hence, except the cereals, other agro products are not vulnerable to competitive threat from sweet sorghum cultivation as alternative feedstock for bio-ethanol. Ragi and Jowar, with lowest critical bio-ethanol price, are at the margin, hence, are likely to be vulnerable, however, as mentioned earlier, the choice of the crop cultivation depends on the climatic conditions and as well, incentives available to farmers.

With the given uncertainty over the availability of low-cost crude oil reserves in the near future and the rising trend in the crude oil prices & petroleum products such as unblended petrol, these low estimates of critical bio-ethanol and EBP prices are of great significance. With the petroleum-based fuels becoming expensive, the customers will have incentive to switch their choices to the substitutes, creating demand for bio-based fuels. With the given fluctuations in the foreign currency exchange rates and volatility in the international crude oil prices, the OMCs will have incentive to look for alternative fuel sources to maintain profitability. This eventually lead to rise in demand for bio-ethanol, and given the increasing cost of sweet sorghum cultivation, is likely to put pressure on the bio-ethanol procurement Price, creating a likely scenario for Government to open up the bio-fuel industry to be acted upon by market forces. Only with the rise in the bio-ethanol procurement prices, farmers of food crops may find sweet sorghum cultivation more profitable, thus have an incentive to switch to energy crops, posing a threat to food security. However, whether the government would like to allow the OMCs to retain the higher margin or whether it would prefer the margin to be passed on to Sweet Sorghum farmers through higher support prices are issues that it needs to look into. In the alternative scenario, if the present policy regime prevails, it would thus be difficult for the industry to take-off under the current scenario of ethanol price, feedstock price and conversion rate (feedstock to ethanol conversion).

Across crops state-wise critical EBP prices are analyzed to estimate the coefficient of variation to assess the vulnerability of specific states to competitive threat from sweet sorghum cultivation (see Table 5). Note that, CV for kerala could not be estimated as paddy is the only crop considered for that state based on the cost of cultivation data. In states such as Assam, Chatisgarh, Orissa, and Jarkhand the CV values are very low which implies that there is a greater threat to the cultivation of food crops as farmers are more attracted to the cultivation of the sweet sorghum. Additionally, in similar lines with the earlier vulnerability analysis based on critical EBP Prices, here as well one can see that cereals, particularly paddy cultivated in all the four above mentioned states is found to be vulnerable. For remaining of the states, though farmers shall be persuaded to cultivate sweet sorghum in interest of biofuel feedstock, the estimated high CV implies that sweet sorghum as a cultivation crop is not a threat to the principal crops cultivated in these states.

Table 5: State-wise Coefficient of Variation (CV) of Critical EPB Price: 2010-11

S.no	States	No. of Crops	Average Critical EBP Price	CV
1	Andhra Pradesh	13	29.28	46.05
2	Assam	3	28.87	5.51
3	Bihar	8	31.99	43.03
4	Chatisgarh	5	30.96	7.43
5	Gujarat	10	28.02	54.72
6	Haryana	7	20.08	97.47
7	Himachal Pradesh	4	22.03	67.15
8	Jharkhand	4	29.74	16.76
9	Karnataka	14	23.64	55.65
11	Madhya Pradesh	12	30	33.79
12	Maharashtra	16	29.6	31.9
13	Orissa	9	32.7	12.35
14	Punjab	3	31.3	88.07
15	Rajasthan	12	28.9	34.67
16	Tamil Nadu	10	25.5	54.16
17	Uttar Pradesh	13	28.2	45.43
18	Uttarakhand	3	25.1	86.6
19	West Bengal	7	22.7	68.83

4.0 Biofuel Feedstock Cultivation – Implications for Livelihoods

As highlighted in Section 2 above, the National Biofuel Policy emphasized use of wastelands and unproductive lands for the cultivation of biofuel feedstock, especially the feedstock for biodiesel generation. Considering the promotion of jatropha cultivation, this section highlights its implications for rural livelihoods. The discussion presented here is based on field survey conducted in six districts of Tamil Nadu, India. The southern state of Tamil Nadu had started promotion of jatropha cultivation way back in 2002, ahead of the launch of National Biofuel Mission in 2003. The state had also established a Centre of Excellence in biofuels at Tamil Nadu Agricultural University to promote research and facilitate effective dissemination of knowledge to the farmers. With around 20000 ha under jatropha cultivation, Tamil Nadu was the third largest cultivator of biofuel feedstock in 2008. During the period 2007-2012, the Tamil Nadu Government aimed to bring 100000 ha under jatropha cultivation in the state. The state government promotion program involved provision of 50 percent subsidy on seedling and inputs on cultivation practices. The jatropha cultivation was mainly envisaged through contract farming, mostly on unproductive and wastelands.

During December 2013 and January 2014 a field survey was carried out in six districts of Tamil Nadu to assess the present status of jatropha cultivation in Tamil Nadu. The six districts covered are – Kancheepuram, Coimbatore, Thiruvannamalai, Villupuram, Tirunelveli, and Viruthunagar. The field study indicated that barring a few isolated cases, the jatropha cultivation has significantly declined in the recent years. The main reasons for declined interest in jatropha cultivation include: (a) significantly lower realized yields on the fields compared to what have been achieved in the research plots; (b) substantially high irrigation requirements for achieving good yields – which again differed from what has been shown on research plots. High initial investment requirements favoured larger land holders compared to small and marginal land holders. This in turn undermined the very objective of the Biofuel Policy.

The Tamil Nadu governments' initiatives for jatropha promotion cast shadow on the notion of 'wasteland', especially because at the village level the wastelands are often common property resources utilized by multiple stakeholders. The land targeted for jatropha cultivation is largely occupied by prosopis – which in turn was historically promoted by several earlier governments as a means of providing alternative livelihood opportunity for the rural households. Prosopis is used as feedstock in small industries in rural areas and it provides significant employment opportunity for landless poor (for cutting etc.). In comparison to prosopis, jatropha cultivation with very less employment opportunities became less attractive. On its part, the Government agencies viewed jatropha cultivation similar to other tree planting programs. As a result the value chain has not developed and the cultivation targets remained elusive.

In sum, ambiguous definition of wasteland and inadequate understanding of use of wastelands has led to concerns regarding feasibility of achieving biodiesel production targets. It has also compromised the livelihood options of rural population. At all India level, with only 0.5 million hectares under jatropha cultivation, a mere 0.01 percent of total biodiesel required for 5 percent blending is achievable from the existing jatropha production. Reaching higher levels of production (and blending targets) requires resolving uncertainty regarding transfer of ownership of community and government owned lands and developing the value-chain of jatropha production.

5.0 Conclusions

For a variety of reasons, the need for finding alternative energy sources to meet justifiably growing energy demands in India is real and urgent. While jatropha remains as the main feedstock for biodiesel production, sweet sorghum could be considered as alternative feedstock for bioethanol production. The analysis presented in this paper suggests that from a competitive perspective both jatropha and sweet sorghum could pose threat to food crops. However, choice of crops for cultivation will depend on variety of other factors including climatic and soil condition which have not been incorporated in the analysis presented here.

For India, it has been estimated that by dedicating 33 mha of degraded lands at a woody biomass productivity of 4 tonnes per ha per year, 100 TWh of electricity could be produced annually, meeting most of the rural electricity needs as well as providing carbon mitigation benefit of 40 MtC annually. Actual availability of land for biofuel cultivation however would depend on a number of factors including climatic and soil conditions, access to infrastructure such as roads and electricity, as well as the ownership of the land. The available information about wasteland suitability for oilseed plantations is sketchy and a proper wasteland mapping exercise should precede any major biodiesel development program in India (Gunatilake, 2011).

Ethanol production from sugarcane offers significant potential to substitute for fossil fuel. However, area under sugarcane needs to be stepped up substantially to meet the increasing ethanol demand under different scenarios of ethanol blending with petrol. Schaldach et al. (2011) estimated that the area for sugarcane production in India increases by 46% (5% blending scenario), 79% (10% blending) and 144% (20% blending) under various blending scenarios. Expansion in sugarcane area is at the expense of the extent of natural land, which correspondingly decreases by 45%, 47% and 51%. However, adoption of yield increasing technologies such as drip-fertigation has huge potential to increase the existing yield levels of sugarcane and hence area expansion could be minimized if these technologies are adequately supported through public policy.

There are also apprehensions that prolonged dependence on first generation crops for biofuels will result in increased risk of deforestation with associated consequences of substantial greenhouse gas emissions and loss of biodiversity. Thus extensive monitoring of deforestation and other land use changes is essential.

REFERENCES

Belum VS Reddy, Ashok Kumar A, Ravinder Reddy Ch, Parthasarathy Rao P and Patil JV(Eds.) (2013), 'Developing a Sweet Sorghum Ethanol Value Chain'. International Crops Research Institute for the Semi-Arid Tropics(ICRISAT).

G Basavaraj, P Parthasarathy Rao, Ch Ravinder Reddy, A Ashok Kumar, P Srinivasa Rao and BVS Reddy (2012), 'A Review of the National Biofuel Policy in India: A critique of the Need to Promote Alternative Feedstocks', International Crops Research Institute for the Semi-Arid Tropics(ICRISAT).

G Basavaraj, P Parthasarathy Rao, Kaushik Basu, Ch Ravinder Reddy, A Ashok Kumar, P Srinivasa Rao and BVS Reddy (2012). 'Assessing Viability of Bio-ethanol Production from Sweet Sorghum', Working Paper Series no. 30, RP – Markets, Institutions and Policies, International Crops Research Institute for the Semi-Arid Tropics.

GOI (2003): 'Report of the Committee on Development of Biofuels', Planning Commission, Government of India.

GOI (2005): 'Wastelands Atlas of India', Department of Land Resources, Ministry of Rural development, Government of India.

GOI (2006): 'Integrated Energy Policy', Report of the Expert Committee, Planning commission, Government of India.

GOI (2009): 'National Policy on Biofuels', Ministry of New and Renewable Energy, Government of India.

GOI (2010a): 'The working Group Report on Road Transport for the Eleventh Five Year Plan', Planning commission of India.

GOI (2010b): 'Estimates of Cost of cultivation /Production& Related Data', Directorate of Economics & Statistics, Government of India.

GOI (2013): 'Twelfth Five Year Plan (2012–2017)',Volume I, Planning commission of India.

GOI(2012): 'Basic Statistics on Indian Petroleum and Natural Gas', Ministry of Petroleum and Natural Gas, government of India.

Gunatilake, H. (2011), 'India: Study on Cross-sectoral Implications of Biofuel Production and Use', Final Report of TA 7250-IND Submitted to the Department of Economic Affairs, Ministry of Finance, Asian Development Bank, Manila, The Philippines.

IOCL (2014), 'Annexure Price Buildup of Petrol at Delhi effective 01-05-14', www.iocl.com/Products/PriceBuildup/Price_buildup_of_MS.pdf

Jihong Li, Shizhong Li, Bing Han, Menghui Yu, Guangming Li, and Yan Jiang (2013), 'A novel cost-effective technology to convert sucrose and homocelluloses in sweet sorghumStalks into ethanol', Biotechnology for Biofuels 2013, 6:174.

Msangi, S. and M. Rosegrant (2011), 'World Agriculture in a Dynamically Changing Environment: IFPRI's Long-term Outlook for Food and Agriculture', in P. Conforti (ed.), *Looking Ahead in World Food and Agriculture: Perspectives to 2050*, Agricultural

Development Economics Division, Economic and Social Development Department, Food and Agricultural Organization, Rome.

Robin Singhal and Ramprasad SenGupta (2012), 'Energy Security and Biofuel, implications for land use and Food Security', Economics & Political Weekly, Vol XLVII No 40.

Saon Ray, Amrita Goldar and Smita Miglani (2011), 'Ethanol Blending Policy: Supply and Demand Issues', Indian Council for Research on International Economic Relations.

Saon Ray, Amrita Goldar and Smita Miglani (2011), 'Ethanol Blending Policy: Issues Related to Pricing', Indian Council for Research on International Economic Relations.

Schaldach R., J.A. Priess and J. Alcamo (2011), 'Simulating the Impact of Biofuel Development on Country-wide Land-use Change in India', *Biomass and Bioenergy*, 35, 2401-2410.

Sen, Abhijit and M S Bhatia (2004), 'State of the Indian Farmer: A Millennium Study Cost of Cultivation and Farm Income', NewDelhi: Academic Foundation, Vol 14.

Shinoj, P., S.S.Raju, Ramesh Chand, P K Joshi, Praduman Kumar and Siwa Msangi (2012), 'Biofuels in India: Potential, Policy and Emerging Paradigms', NationalCentre for Agricultural Economics and Policy Research