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Biofuels in India: Future Challenges

P. Shinoj, S.S. Raju, Ramesh Chand, Praduman Kumar and Siwa Msangi

Introduction

Biofuels are globally considered sustainable and eco-friendly source of energy to enhance national energy security and decrease dependence on imported fossil fuels. During the past one decade, Government of India (GoI) has initiated several measures to augment production and use of biofuels. The National Biofuel Mission launched in 2003 is the frontrunner of such efforts in the country. The 'National Policy on Biofuels' released in 2009, foresees biofuels as a potential means to stimulate rural development and generate employment opportunities, as well as aspires to reap environmental and economic benefits arising out of their large-scale use. The Policy aims at mainstreaming biofuels by setting an indicative target of their blending up to 20 per cent with petrol and diesel in the transport sector by the year 2017 (GoI, 2009). It is categorically mentioned in the Policy that the program is to be carried out based solely on the non-food feedstocks that are raised on degraded or wastelands not suitable for agriculture, thus avoiding a possible conflict between food security and fuel security. Bioethanol produced from the sugar cane molasses and biodiesel produced from the non-edible oilseed crops like jatropha and pongamia are currently being promoted for commercial use. Though very well conceived in its scope and aims, India's national biofuel program faces considerable challenges in its implementation. This brief presents the current status, discusses the future prospects and examines the critical constraints and impediments in the path of development of this program. It also offers suggestions and alternative policy options so as to enable the program achieve its objectives.

Food *versus* Fuel Debate

One major reason why biofuels have attracted so much attention in recent years among the analysts, commentators and observers, of global food policy is their direct connection with food and feed availability and subsequent influence on market prices. The recent data suggest that a significant amount of food grains is being diverted for biofuel production by many leading producers in the world. For instance, nearly one-fourth of the total corn produced in the US was used for biofuel production during 2007-08 as against 11.9 per cent five years back (Chand, 2008). In addition to cereals, oilseed crops like rapeseed, soybean and sunflower are also being diverted for the same purpose. The European Union (EU) used nearly 4.7 million tonnes of rapeseed oil for biodiesel production that constitutes around 64 per cent of their total output of rapeseed oil in the year 2007-08. In terms of area, nearly 47.8 million hectares of arable land was set apart for growing biofuel feedstock in 2006-07, that is nearly 3.4 per cent of the total arable land available for cultivation in the world (Trostle, 2008). Because of these reasons, the growth in biofuels production is believed to be one of the major contributors to the rising food prices in the international markets.

In concurrence with the official biofuel policy, India produces biofuels only from non-edible feed stocks. Molasses, a major feed stock for bioethanol production, is a by-product of the sugarcane industry that produces edible sugar. Limited amounts of bioethanol are also produced through direct conversion of sugar cane juice and from other sources like sweet sorghum, tropical sugar beet, cassava, etc. but with no implications for food security. Biodiesel is mainly produced from non-edible oilseed crops like jatropha and pongamia, edible oil wastage and animal fats. Currently, jatropha, the major feed stock for biodiesel in India, occupies only around 0.5 million hectares of low-quality 'wastelands' across the country, of which 65-70 per cent are new plantations of under-three years. The Planning Commission Report on Development of Biofuels (GoI, 2003) has earmarked an estimated area of 13.4 million hectares of marginal / wasteland that is suited to growing of jatropha and can cater to large-scale planting so as to meet the blending targets. Similarly, the Department of Land Resources under the Ministry of Rural Development, GoI, has estimated that around 25 million hectares of fallow land is available in the country that can be diverted for growing of feed stock crops, including jatropha. Given these facts, currently there is no apprehension about a threat to food security in India from the commercial biofuel blending programs as opposed to the case with other major biofuel producing countries.

Present Status of Biofuel Production and Utilization

Currently, India's biofuel production accounts for only 1 per cent of its global production. India has about 320 distilleries with the production capacity of over 3.50 billion litres of alcohol every year. In the year 2008, the country produced nearly 2.15 billion litres of ethanol, of which an estimated 280 million litres of ethanol were blended with petrol. As ethanol has many alternative uses such as in the potable liquor and in chemical and pharmaceutical industries, its availability for blending with petrol is highly dependant on the prevailing market prices which determine its viability for the Oil Marketing Companies (OMCs) for its use as a fuel. Because of the cyclical nature of sugar cane production and consequent shortfalls in molasses availability, the government has not been able to meet its mandated blending target of 5 per cent[1] so far. In April 2010, the government decided to raise the minimum purchase price (MPP) of ethanol to Rs. 27.00 per litre from the previous level of Rs. 21.50 per litre so as to increase its availability for blending. With the increased price and the expected surplus production of sugar cane in 2010-11, the government hopes to meet the targets this year.

Large-scale blending of biodiesel with conventional diesel has not yet started in India. Around 20 biodiesel plants annually produce 140- 300 million litres of biodiesel which is mostly utilized by the informal sector locally for irrigation and electricity generation and by the automobile and transportation companies for running their experimental projects (USDA, 2010). The National Biodiesel Mission launched by the Planning Commission has focused on expansion of jatropha area in two phases. The first phase which was the demonstration phase, was taken up during 2003-2007 and included several micro-missions on jatropha covering promotion of its large-scale plantations in forests and wastelands, procurement of seed and oil extraction, transesterification, blending and trade and technological research and development. The second phase of expansion targets to make the program self-sustainable by producing enough biodiesel to meet the 20 per cent blending target (NCAER, 2007). To ensure a fair price to the jatropha farmers, various state governments have offered a minimum purchase price (MPP) for jatropha seeds. The MPP is announced for biodiesel also, the present rate being Rs 26.50 per litre for biodiesel. In addition, some subsidy programs and tax concessions/ exemptions are also part of the government's efforts to boost the production of feed stocks for biofuels. Several public institutions like National Oilseeds and Vegetable Oils Development Board (NOVOD) under the Ministry of Agriculture, Government of India, state biofuel boards, state agricultural universities and non-state actors like non-governmental organizations (NGOs), self-help groups (SHGs), co-operative societies, etc. are also actively supporting the biofuel program in various capacities.

Challenges before Biofuel Industry

The major challenges before biofuel industry are discussed separately for bioethanol and biodiesel.

Bioethanol

With rising per capita income, urbanization, infrastructural development and the resultant increase in vehicular density, the demand for petrol in India is galloping – the rate of growth in demand has been 8.5 per cent for petrol, 3.0 per cent for ethanol for industrial and other uses and 3.3 per cent for ethanol for potable use during the five-year period 2004-05 to 2008-09. These growth rates are expected to continue over the next several years. With the government planning to bring into effect 20 per cent blending of petrol with bioethanol by 2017, it is important to anticipate the demand for ethanol for it, so that necessary measures could be undertaken to achieve the targets. Keeping this in view, the demand for ethanol as fuel and for other alternative uses was projected using the growth rate for the period 2004-05 to 2008-09 (Table 1). It was found that the fuel ethanol demand during 2011-12 for 5 per cent, 10 per cent and 20 per cent blending would be 0.72 Mt, 1.44 Mt and 2.87 Mt, respectively (925 million litres, 1840

[1] The Government of India has made 5 per cent blending of ethanol with petrol mandatory since 2003 across 9 states and 5 union territories. In 2006, this was extended to 20 states and 8 union territories. The blending mandate is to be raised to 10 per cent from 2011 and further to 20 per cent by the year 2017, as per the official Policy.

Table 1. Projected ethanol demand for various uses in India

(million tonnes)

Year	Petrol demand	Fuel ethanol demand			Potable ethanol demand	Industrial and other uses ethanol demand	Total ethanol demand		
		5 %	10 %	20 %			5 %	10 %	20 %
2008-09	11.25	0.56	1.13	2.25	0.65	0.60	1.81	2.38	3.50
2011-12	14.37	0.72	1.44	2.87	0.71	0.65	2.08	2.80	4.23
2016-17	21.61	1.08	2.16	4.32	0.84	0.76	2.68	3.76	5.92
2020-21	29.94	1.50	2.99	5.99	0.96	0.85	3.31	4.80	7.80

million litres and 3680 million litres, respectively)[2]. The corresponding total ethanol demand after accounting for potable, industrial and other uses would be 2.08 Mt, 2.80 Mt and 4.23 Mt, respectively. In the year 2016-17, when blending at 20 per cent is to be commenced, the total ethanol requirement would be 5.92 Mt which is equivalent to 6704 million litres[3].

It is quite clear from the above analysis that to attain 20 per cent blending target without compromising on the industrial, potable and other requirements, India has to either increase its ethanol production nearly 3-times of the present levels or go for massive imports of ethanol. There are several constraints in increasing ethanol production to such levels, given the fact that sugar cane yield in the country has been stagnant at around 60-65 tonnes per hectare for the past several years. It also does not appear feasible to increase area under sugar cane as this will be at the cost of diverting land from other staple food crops. Sugar cane being a crop that consumes about 20,000-30,000 cubic metres of water per hectare per crop, over-exploitation of the groundwater for energy production would not be a sustainable option. Production of ethanol directly from sugarcane juice, a more efficient method, would constrain sugar production for the food market. Moreover, even occasional shortage of molasses bids up the cost of ethanol production, making its blending with petrol an uneconomical proposition. 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.

Biodiesel

As in the case of petrol, the demand for diesel has also been increasing at the rate of 7.5 per cent per annum since 2004-05. Demand projections for diesel suggest that nearly 3.21 million tonnes of biodiesel would be required for 5 per cent blending by the year 2011-12 (Table 2).

To bring this into effect, assuming that jatropha would be the major feedstock for biodiesel (i.e., 80 % of the requirement would be met from jatropha) with an average seed yield[4] of 2.5 t/ha and 30 per cent biodiesel recovery rate, the area required under the crop has been worked out to be 3.42 million hectares. An estimated area of 26.25 million hectares would be required under jatropha to meet 20 per cent blending target by the year 2020-21, if the yield and oil content of jatropha remains the same and that no new superior feedstocks are

Table 2. Projections of biodiesel demand and corresponding jatropha area required for meeting the blending targets in India

(Area in million ha, Demand in million tonnes)

Year	Diesel demand	At 5 % blending		At 10 % blending		At 20% blending	
		Biodiesel demand	Jatropha area	Biodiesel demand	Jatropha area	Biodiesel demand	Jatropha area
2011-12	64.19	3.21	3.42	6.42	6.85	12.84	13.69
2016-17	92.15	4.61	4.91	9.21	9.83	18.43	19.66
2020-21	123.06	6.15	6.56	12.31	13.13	24.61	26.25

Note: The compound annual growth rate during the five years ending 2008-09 for diesel demand (7.5 %) was used for trend projections.

[2] Our estimates for petrol demand were found comparable with those of Petroleum Planning and Analysis Cell (PPAC), Ministry of Petroleum and Natural Gases, GoI (Latest PPAC estimate of petrol demand for 2020-21 is 25.4 Mt).

[3] 1 metric tonne of ethanol is equivalent to 1267 litres (Density of ethanol is 0.789 g/mL)

[4] The NCAP survey conducted at Rajasthan, Chhattisgarh and Uttarakhand suggests that the average yield of jatropha under normal management practices in farmers' field ranges between 2.0 and 2.9 t/ha. See Shinoj *et al.*, (2010) for more details.

introduced. So far in the country, only around 0.5 million hectares land has been put under jatropha cultivation and the government has not initiated purchasing of biodiesel through the designated purchase centres even though an MPP of Rs 26.50 per litre was announced a few years ago.

There are several reasons behind the slow progress of India's national biofuels program towards its stated goals. The jatropha production program was started rather in haste without any planned varietal improvement program preceding it. In almost every state where it was implemented, conventional low-yielding cultivars were used for new plantings of feedstocks. Because of this reason, the producers are not comfortable with the yields of the crop, especially under low management conditions[5], as indicated by the field studies. Moreover, the longer gestation period (3-4 years) of jatropha also discourages the farmers in places where state support is not readily available. However, a financial assessment based on discounted measures[6] on long-term investment on jatropha cultivation has suggested promising prospects. The estimates of net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR) on jatropha investment (Table 3) were found to be encouraging and suggest that with some initial support, jatropha cultivation could be made profitable in farmers' field. The relatively higher estimates for the state of Chhattisgarh could be attributed to lower cost of jatropha production and its higher yields in the state.

Table 3. Financial measures for assessing the feasibility of investment in jatropha cultivation in three states of India

State	NPV (Rs)	BCR	IRR (%)
Rajasthan	47310	1.47	25
Chhattisgarh	100265	10.18	85
Uttarakhand	48743	1.81	45

Note: The economic life-span of jatropha was assumed to be 20 years; A 10 per cent discount rate was used for the calculations.

The jatropha seed distribution channels are currently underdeveloped as sufficient numbers of processing industries are not operating. Even though, several private companies have ventured into jatropha cultivation and biodiesel production, their involvement is still very low. There are no specific markets for jatropha seed supply and hence the middlemen play a major role in taking the seeds to the processing centres and this inflates the marketing margin. The processing industry suffers from low backward integration with the seed market and forward integration with biodiesel distribution channels. The distribution channels are almost non-existent as most of the biofuel produced is used either by the producing companies for self-use or by certain transport companies on a trial basis. Unless large-scale use of biodiesel commences or a demand pull from mandatory blending of biodiesel comes, these channels would remain under-developed. Further, the cost of biodiesel depends substantially on the cost of seeds and the economy of scale at which the processing plant is operating. The NCAP study on processing industries

Table 4. Cost of production of biodiesel in Rajasthan and Chhattisgarh - A comparison

Inputs	RSMML plant		CBDA plant	
	Quantity/day	Value (Rs)	Quantity/day	Value (Rs)
Jatropha seeds	1 tonne	12000	10 tonnes	65000
Labour	4 man days	1000	11 man days	2920
Chemicals		680		7140
Electricity	25 units	250	250 units	2500
Interest on fixed capital	@10 %	650	@10 %	6800
Depreciation on fixed assets#	@4 %	710	@4 %	4440
Incidentals		350		6500
a. Total cost		15640		95300
b. Revenue from by-products		5580		44024
Net cost incurred (a-b)		10060		51276
Net cost/kg of biodiesel		40.24		18.78

Notes: The recovery of biodiesel from RSMML plant: 250 kg/tonne of seeds; CBDA plant: 273 kg/tonne of seeds;
4 per cent depreciation on fixed assets and 10 per cent on machinery were used for the calculations.
Source: NCAP Field Survey on Biofuels

[5] The yield can be as low as 500 kg/ha if no initial irrigation and fertilizer application are provided.
[6] Assumed that the parity between the seed prices and cost of inputs would remain the same as of today, throughout the economic lifespan of jatropha.

from Rajasthan [Rajasthan State Mines and Mineral Ltd. (RSMML) plant) and Chhattisgarh (Chhattisgarh Biofuel Development Authority (CBDA) plant] amply suggests that the cost of production of biodiesel can vary from Rs 19/kg to Rs 40 / kg (Table 4), depending upon various economic conditions under which they are operated. Major factors responsible for higher cost of production at RSMML plant include higher seed cost, higher transaction cost due to involvement of middlemen, under-utilization of labour and other staff in the processing plant, higher wage rates, lower biodiesel recovery, etc (Shinoj *et al.*, 2010).

Addressing the Constraints and Moving Forward

For building a sustainable and viable biofuel industry in the country, it is high time to look for alternative options that would not only help meet the immediate targets but also pay dividends in the long-run. In the case of bioethanol industry, the country needs improved technology and management practices that would bring down costs. Lower plant capacity, use of batch-process technology, inefficient by-product and effluent management practices, etc. are considered as major technological constraints. Several ethanol plants in the country are operating below their full production capacity which leads to diseconomies of scale and needs interventions. Long-term technological targets like application of biotechnology to increase sugar content in sugar cane, commercial use of membranes and microbes for enhancing ethanol recovery from molasses, etc. can also be thought of. Another option is to complement ethanol production using alternative feedstocks like sweet sorghum, tropical sugar beet, etc. that can yield higher ethanol at lower costs as compared to molasses-based production[7]. Sweet sorghum is a rapidly growing crop with wider adaptability and higher biomass producing ability and thrives well in dry tracts. Several studies (Rao and Bantilan, 2007; Reddy et al., 2005) have established the suitability of sweet sorghum for commercial ethanol production. Sugar beet grows well in the saline and alkaline soils that are not suited to other food crops. It has low crop duration, higher sugar content, higher ethanol yield and requires less irrigation and fertilizer as compared to sugar cane (TNAU, 2009). Exploiting such advantages of these alternative crops without compromising food production is a challenge that needs urgent attention. Focusing research efforts on commercial production of ethanol from second-generation feedstocks like bagasse, crop residues of cereals, forest thinnings, saw-dust, waste paper, etc. is equally important in ensuring the long-term environmental sustainability and benefits of biofuels (Raju *et al.,* 2009).

In spite of several promotional measures by both states and centre, it is apparent that a self-sustaining atmosphere for the development of a stable feedstock production system and biodiesel supply chain has not been created so far. The area coverage under feedstocks and the institutional and infrastructural framework to support the program have been sub-optimal. In this context, favourable policies like ensuring initial government support in the form of subsidized inputs, technical assistance, buy-back arrangements and minimum support prices in the marginal areas, enhancing community participation in cultivation, extending land titles to landless farmers and tribal people in forest areas for jatropha cultivation, etc. would have catalytic effect. Other beneficial initiatives include: a centrally coordinated research program on varietal improvement of jatropha and other feedstock germplasm that replaces the current piecemeal approach; conscientious selection of geographical locations for planting the feedstock crops for ensuring environmental suitability and preventing use of fertile lands for their cultivation; encouraging private sector involvement in growing the feedstock crops and setting-up of processing and marketing infrastructure; area-wise critical assessment that precedes investing in processing infrastructure so as to fully utilize the economies of scale in processing; and state intervention in creating marketing and institutional infrastructure for jatropha seed and biodiesel supply chain. Therefore, adopting a holistic approach for simultaneously developing production, processing and marketing systems with specific thrust on the above-mentioned initiatives could prove instrumental in ensuring the success of the program.

Conclusions

The importance of developing a strong biofuel industry to tackle the challenges of energy security and fuel self-sufficiency has been widely acknowledged in India. Even though the food versus fuel debate is quite relevant at the global level, it is largely irrelevant to the Indian biofuel production program due to the country's policy decision not to use any edible feedstock for bio-energy production. The National Biofuel Policy has been designed to harness the various environmental, social and economic benefits arising out of large-scale development of biofuels in the country. However, the success of the program would largely depend on the readiness of the stakeholders and the government machinery to tackle the challenges that the program may face from time to time. It has become apparent that bioethanol production solely based on sugar cane molasses is neither economically viable nor

[7] See Shinoj *et al.,* (2011) for a comparison on resource requirement as well as cost estimates of alternative feed stocks.

sustainable in the long-run. Similarly, the jatropha based biodiesel production program is bogged down with several obstacles like slow progress in planting, sub-optimal processing and marketing infrastructure, under-developed distribution channel, etc. While favourable government policies, vigorous participation of local community and private entrepreneurs can sustain the program in the short-term, it is equally important to have a sound long-term strategy at our disposal. The current course is not likely to be adequate in the long-run, given the present choice of feedstocks, status of technology and available policy. Substantial research thrust on development of second and third generation feedstocks is crucial to address the future bio-energy needs of the country.

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P. Shinoj, S.S. Raju, and Ramesh Chand are Scientist, Principal Scientist and Director, respectively at National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi; Praduman Kumar is Consultant to the biofuel project and Siwa Msangi, Senior Research Fellow, International Food Policy Research Institute (IFPRI), Washington D C. Correspondence email: pshinoj@ncap.res.in; raju@ncap.res.in

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P. B. No 11305, Dev Prakash Shastri Marg, Pusa, New Delhi – 110 012, India.
Phones: 91-11-25847628, 25848731 Fax: 91-11-25842684 E-mail: director@ncap.res.in
http: //www.ncap.res.in