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India's biofuels production programme: need for prioritizing the alternative options*

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ABSTRACT

The Government of India launched National Biofuel Mission in 2003, primarily with a view to explore the potential of biofuels as a cleaner source of energy and to partially offset the growing burden of crude oil import bills. This paper analyzed the economic viability and long-term sustainability of bioethanol production from sugarcane molasses and commercial feasibility of biodiesel produced from tree-borne oilseeds like jatropha. Based on the analysis the paper indicated that given the slow growth in area and yield of sugarcane on the one hand and rising demand for sugar, potable and industrial demand of ethanol on the other, it is highly unlikely that the blending targets of ethanol with petrol would be met as planned by the Government. To ensure long-term sustainability and economic viability of bioethanol production, it is imperative to diversify the feed-stock basket by including more crops like sweet sorghum and tropical sugar beet and encourage research on industrial production of second generation biofuels. The commercial feasibility of jatropha-based biodiesel largely depends on development of a proper supply chain by augmenting marketing of jatropha seeds, upgrading processing infrastructure and up-scaling biodiesel distribution.

Key words: Bioenergy, Biofuels, Economic viability, Supply chain, Sustainability

In the recent past, lot of emphasis has been given world over on bioenergy as a possible long-term and sustainable alternative for fossil fuel-based energy. The growing dependence on fossil fuels for powering its transport sector, resulting in mounting fuel bills, is the key reason for India to embrace biofuel production on its own. Moreover, this can be viewed as a natural response to a global hue and cry over increased emissions from fossil fuels, hastening the process of climate change. Presently, the country is testing its options for a partial switch over to biofuels as a means of energy. In general, bioethanol produced from sugar or starch derived from grains/biomass and biodiesel obtained from the processing of edible and non-edible vegetable oils are used as fuel in automobiles. It is well established that biofuels offer a number of environmental, social and economic advantages. The use of biofules may lead to reduction in vehicular pollution and greenhouse gas emissions as it is established that the emission of Sulphur Dioxide (SO_2), particulate matter and Carbon Monoxide (CO) etc. are less from biofuels (Subramanian e*t al*. 2005). The economic and social benefits arising out of the development of biofuel sector through increased income and employment opportunities for the rural communities is also highlighted (UNCTAD 2006, Rajgopal 2008). The greening of wastelands and regeneration of degraded forest lands through cultivation of biofuel crops is another added advantage (Mandal and Mithra 2004).

In India, bioethanol is primarily produced by fermentation of sugarcane molasses, a bye-product in the manufacture of sugar from sugarcane. Apart from being a fuel, it is used as a major raw material in the beverage sector. It also has various industrial and other uses. In 2009, India produced around 1073 million litres of ethanol (USDA 2010) of which around 100 million litres was blended with petrol to be used in automobiles as fuel. The Ethanol Blended Petrol Programme (EBPP) launched by the Government of India (GoI) in January 2003 made it mandatory to blend petrol with 5% of ethanol with immediate effect across the country (except Jammu and Kashmir, north-eastern states and Island territories). The National Biofuel Policy released in December 2009 by the Ministry of New and Renewable

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Energy (MoNRE) envisages a target of complete blending of 5% ethanol by 2011–12 and then gradually raise it to 10% by 2016–17 and to 20% after 2017.

Biodiesel in India is mostly produced from the oils extracted from the seeds of jatropha and pongamia. Even though biodiesel can be more effectively produced from other oilseed crops like rapeseed and mustard, oilpalm, soybean, sunflower etc., India deliberately opted for jatropha and pongamia. This is because, the availability of edible oil is scarce and the country already depends on huge quantity of imported oils for edible purposes. Moreover, both these species are proved to be low intensive in inputs and they can be effectively raised in marginal and low fertile lands (Altenburg *et al.* 2008). It is argued that if encouraged in the wastelands with community participation, these crops can create income and employment opportunities for landless people, besides helping in greening of these lands (Shinoj *et al.* 2010). In any case, biodiesel sector in India is still in the take off stage even though similar blending targets as that of bioethanol are applicable to biodiesel too.

In this backdrop, the present study attempts to analyze the different aspects of India's biofuel production programme with the aid of secondary data collected from various sources and tries to suggest the suitable courses of action for treading forward.

BIOFUELS: LESSONS FROM THE GLOBAL EXPERIENCE

The global experience in biofuel expansion has not been very inspiring. In an urge to shift to greener sources of energy rapidly, most of the major biofuel producing countries resorted to staple food crops for production of bioenergy. It is estimated that, out of the total ethanol produced in the globe currently, around 60% come from cereals and the rest from sugarcane, both of which are important food crops. Table 1 shows the extent of diversion of foodgrains for biofuel production by the countries like United States, European Union, Canada, China etc. in the recent years. In 2008, around 95 million tonnes of corn was diverted for biofuel production, which is around 12% of total global corn production. Of this, United States alone used 80%. Similarly, Canada and China meets most of their ethanol requirement from corn and wheat alone. More importantly, the use of cereals for biofuels is expected to increase at a rate of 10% annually during 2006–07 to 2016–17, while the cereal production itself would grow only at a rate of 1.4% indicating a squeeze in availability of foodgrains for human consumption (Chand 2009). Biodiesel is mostly produced from soybean, rapeseed and mustard which are also important food crops.

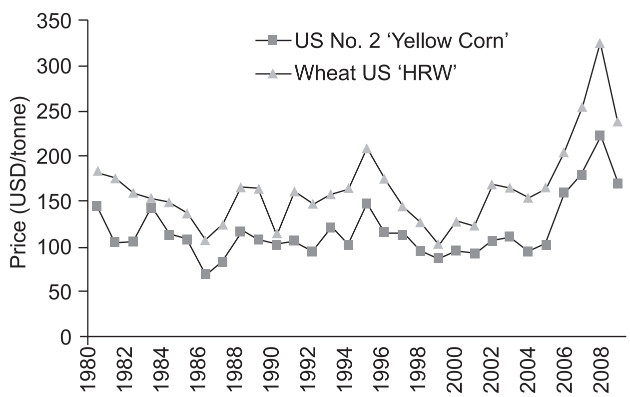
Table 1 Utilization of cereals for ethanol production (2005–06 to 2008–09)

	2005–06	2006–07	2007–08[1]	2008–09[2]
	Million tonnes			
USA				
All	41.3	54.5	76.8	101.7
Corn	40.7	53.8	76.2	100.4
Sorghum	0.6	0.7	0.6	1.3
EU 27	3.2	3.4	2.9	5.2
Canada	0.7	1.5	1.8	2.5
China	9.5	11.0	11.5	12.0
Other countries	1.1	1.4	1.9	2.4
Total	55.8	71.8	94.9	123.8

[1] Estimate; [2]projection

Source: von Braun (2008)

The diversion of food crops for energy production was one of the major contributing factors towards a drastic rise in food prices in international market, leading to widespread chaos (von Braun 2008). In a very short span of time, the world witnessed unprecedented levels of food riots due to price spikes in major foodgrains. The price of US 'Hard Red Winter' wheat rose to ever time high at US $ 326/tonne while that of US No. 2 'Yellow Corn' went as high as US $ 223/ tonne in 2008 (Fig 1). The ripples of price rise of these staples got reflected in the domestic markets of almost all countries including that of India.



Source: The World Bank 2009

Fig 1 Historic trends in nominal prices of US 'HRW' wheat and US No.2 'Yellow Corn'

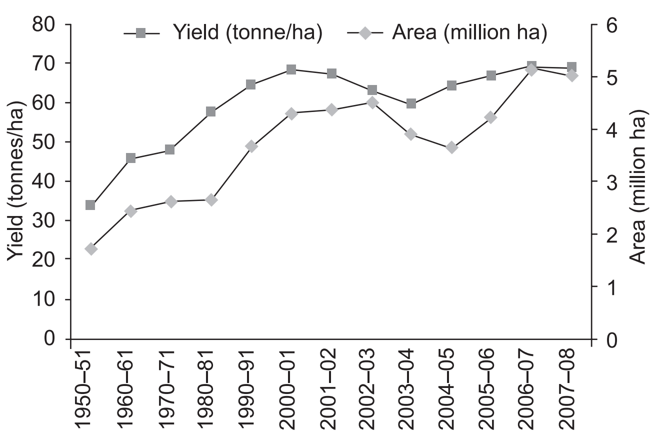
A study by IFPRI (Rosegrant 2008) compared the increase in prices during the period 2000–2007 with that of historic rates of growth and came with an estimate that, around 30% of increase in the weighed average of grain prices is caused by increased biofuel demand. The scenario analysis based on actual plans of biofuel expansion of countries using IFPRI's IMPACT model also cautions that the prices would further rise by 18% in case of oilseeds and by 26% of corn by 2020.

All the above mentioned facts and figures are sufficient to believe that expansion of biofuel sector at the expense of food production has a gross negative effect on the global food availability and would further aggravate the situation if continued unrestricted. However, in India, both molasses-based ethanol production and jatropha and pongamia-based biodiesel production do not have any direct bearing on food security. The Indian biofuel programme seems to be affected by a different set of constraints which are discussed in the next section.

INDIA'S CHALLENGES

Economic viability of biofuel production

India's ethanol programme depends to a larger extent on the economic viability of molasses-ethanol conversion. The supply of molasses in turn depends on the sugarcane production in the country. Sugarcane has a potentially important place in the Indian agricultural scene. It is characterized by occasional ups and downs in terms of area and production due to a variety of reasons. Owing to the cyclical nature of sugarcane production in the country, the farmers and the processing industry experience periodic market shortages as well as glut of sugarcane, sugar and molasses impacting prices and farm income. The area under sugarcane in 2007–08 was 5.04 million ha producing around 340 million tonnes of sugarcane. As shown in Fig 2, although the area under sugarcane has increased by three times since 1950–51, in the recent years the growth in area is minimal with some inter-year fluctuations and yield more or less stagnant.



Source: GoI 2008

Fig 2 Trends in area and yield of sugarcane (1950–51 to 2007–08)

The spells of shortage in sugarcane production lead to reduced availability of molasses, leading to steep rise in its prices. The inadequacy of molasses also forces most of the distilleries to utilize less than their actual plant capacity. The molasses prices have fluctuated substantially and ranged between ₹ 1 000 and ₹ 5 000 during the last decade. This has a serious bearing on the viability of molasses based ethanol. The cost of production of ethanol as per the report of the Planning Commission (GoI 2003) was ₹ 9.74/litre assuming a molasses price of ₹ 1 000/ton. Based on this the Government has fixed a minimum purchase price of ₹ 21.50/litre of ethanol in 2006 (MoNRE 2009), the price at which the sugar industry also agreed then to sell to Oil Marketing Companies (OMCs). However, cost of production exceeded the minimum purchase price when the molasses price shot up to ₹ 5 000 and even more. The experience so far indicates that the OMCs are unable to procure ethanol at the prevailing rate for effecting 5% blending as the sugar industries get better price and assured demand from beverage and pharmaceutical industries. Even though the government revised the purchase price to ₹ 27/litre, in April 2010, blending of ethanol obtained at this rate would prove uneconomical as the cost of petrol sans taxes is around ₹ 23 a litre, presently.

As in the case of molasses-based ethanol, there are concerns about the economic viability of biodiesel produced from jatropha and other tree-borne oilseeds too. The cost of production of biodiesel depends substantially on the cost at which the seeds are procured and the economies of scale at which the processing plants are operating. A recent study by Shinoj *et al*. 2010 demonstrated that per liter cost of production of biodiesel can range between ₹ 19 and ₹ 40 depending on the various micro-environments under which the processing plants are operated. Since the biodiesel industry is yet in the development stage, it would require far more institutional, infrastructural and technological reforms before the biodiesel industry becomes economically viable.

THE PROBLEM OF SUSTAINABILITY OF SUGARCANE-BASED ETHANOL

There are arguments in favour of bioethanol that it would become economical in a scenario of higher crude oil prices, like the recent (July 2008) high to the tune of US $ 147/barrel. However, even in such a scenario, it would be difficult to meet the mandated ethanol blending requirement. The base year (2008–09) demand for 5% blending was worked out to be 0.56 million tonnes of ethanol, whereas the actual blending of fuel ethanol in 2009 was only 0.08 million tonnes (100 million litres). Even though the total supply of ethanol (2.4 million tonnes in 2009) was sufficient to meet total amount demanded (1.80 million tonnes), the utilization was more towards potable and industrial uses due to inability of the OMCs to procure the required amount of fuel ethanol at prevailing market prices. Further, the projections show that the demand for total ethanol would reach around 2.05 million tonnes by 2011–12 and to around 2.55 million tonnes by 2016–17. As per the actual target of the Government to effect 10% blending by 2016–17, the fuel ethanol demand would be 1.93 million tonnes and total demand would be as high as 3.52 million tonnes (Table 2).

As it would be interesting to know the future requirement of sugarcane area and production to meet the alternate ethanol blending requirements, an exercise was undertaken to work out the sugarcane area and production needed to meet the various demands of ethanol for the period 2008–09 through 2011–12 and 2016–17. The fuel ethanol demands were worked out at both 5% and 10% blending and the

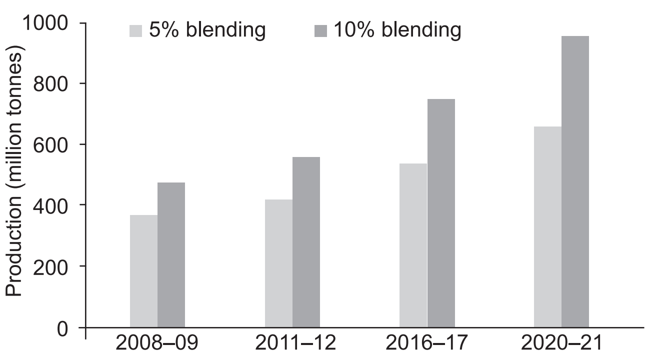
Table 2 Projected ethanol demand in India for various uses (million tonnes)

Year	Petrol demand	Fuel ethanol demand		Ethanol for industrial and other uses	Potable demand	Total ethanol demand	
		5%	10%			5%	10%
2008–09 (base year)	11.25	0.56	1.13	0.60	0.65	1.80	2.37
2011–12	14.37	0.72	1.44	0.65	0.71	2.08	2.80
2016–17	21.61	1.08	2.16	0.76	0.84	2.68	3.76
2020–21	29.94	1.50	2.99	0.85	0.96	3.31	4.80

Note: The compound annual growth rates for the last five years ending with 2008–09 for petrol demand (8.5%), ethanol demand for industrial and other uses (3%) and potable use (3.3%) were used for trend projections.

Source: Authors' calculation

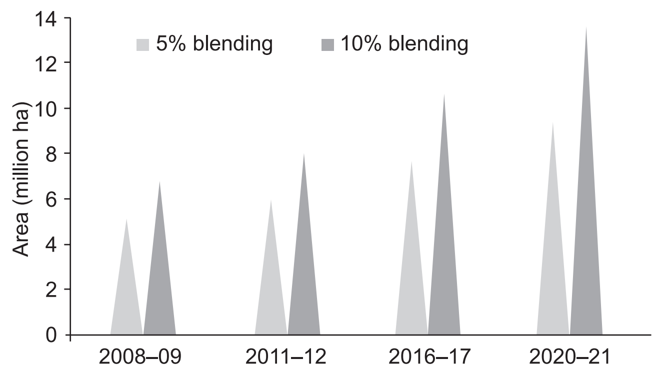
corresponding estimates of area and production are given separately. The analysis was carried out under the following assumptions: (i) all the ethanol would be produced from molasses, (ii) recovery of molasses from sugarcane: 4%, (iii) recovery of ethanol from molasses: 25%, (iv) molasses utilization pattern: 85% for ethanol production and rest for other uses, (v) average yield of sugarcane: 70 tonnes/ha, and (vi) sugarcane utilization pattern: 60% for sugar and ethanol production and rest for *khandsari*, jaggeri, seed, feed and other uses.



Source: Authors' calculation

Fig 3. Projected sugarcane production requirement to meet ethanol blending targets

The scenario analysis suggests that around 408.4 million tonnes, 524.6 million tonnes and 648.4 million tonnes of sugarcane would be required to be produced during 2011–12, 2016–17 and 2020–21, respectively to meet the combined demand for 5% blending, potable and industrial demand, and demand for sugar and associated products[2] (Fig 3).The corresponding sugarcane area required would be 5.8 million ha, 7.5 million ha and 9.3 million ha, respectively (Fig 4). However, if the Government is targeting to bring into effect 10% blending by the year 2016–17 as planned in the National Biofuel Policy, an approximate production of 736.5 million tonnes of sugarcane and an area coverage of 10.5 million ha would be required (around 20–23% in excess of what required for meeting the corresponding sugar demand). This means,



Source: Authors' calculation

Fig 4 Projected sugarcane area requirement to meet ethanol blending targets

both production and area under sugarcane need to be more than doubled to achieve 10% blending. An alternative to improve the efficiency of ethanol recovery is converting sugarcane juice directly to ethanol, a method which is six times more efficient than ethanol production from molasses. However, presently, the country lacks both technology and infrastructure required to implement this. Another major hurdle is that, diversion of sugarcane for direct ethanol production would be at the cost of reduction in sugar production. The demand for sugar is increasing at an average annual rate of 4.2% for the last ten years. The current demand for sugar in India is 23.3 million tonnes, highest in the world. However, it is highly unsustainable to extend the sugarcane area beyond a limit, given the fact that sugarcane is a crop that is highly water intensive with a water requirement of 20 000–30 000 m^3/ha/crop. Therefore, it is high time to think about alternate sources of both sugar and ethanol, which is both resource saving and sustainable.

HURDLES IN DEVELOPING THE BIODIESEL SUPPLY CHAIN

Unlike ethanol, commercial production of biodiesel in India has not yet took off. There are various problems associated with development of biodiesel supply chain in

Table 3 Area required for Jatropha plantations for meeting the biodiesel blending targets

Jatropha seed yield (tonnes/ ha)	Biodiesel yield (tonnes/ ha)	Jatropha area (million ha) required for blending at			
		5%		10%	
		2011–12	2016–17	2011–12	2016–17
1	0.31	10.99	13.71	21.94	27.42
2	0.61	5.49	6.86	10.97	13.71
3	0.92	3.66	4.57	7.31	9.14
4	1.22	2.75	3.43	5.49	6.86
5	1.53	2.20	2.74	4.39	5.48

Source: Authors' calculation

the country. The first and the foremost is the uncertainty regarding the availability of land for cultivation of jatropha and other tree-borne oilseed crops. The present strategy of the Central Government is to utilize wastelands for biodiesel plantations so as not to affect the food security of the country.

The Planning Commission, Government of India (GoI 2003), identified 13.4 million ha of land for cultivation of *Jatropha* c*urcas*. However, even with lots of efforts from various stakeholders, only around 0.5 million ha is put under jatropha cultivation so far (USDA 2010, Gopinathan and Sudhakaran 2009). Various issues like confusion over transfer of ownership of community and government wastelands, lack of good quality planting materials, low confidence in farmers on the profitability from jatropha, lack of an integrated approach for promoting cultivation etc. are hindering the expansion of area under jatropha cultivation. As per the area calculations given in Table 3, under a probable level of average biodiesel yield of 0.61 tons/ha, around 5.49 million ha of land under jatropha is required to effect 5% blending by 2011–12, ten times more than that of current area. In whichever way, it seems quite unlikely to achieve the targeted blending within the stipulated time period.

Another important constraint in the way of biodiesel expansion is the inadequacy of infrastructure, services and marketing system for developing biodiesel supply chain. A whole lot of supporting services like processing, marketing, financing, institutional and governance arrangements etc. need to be simultaneously developed for ensuring the success of large-scale biofuel production programme. The roles played by various stakeholders like private sector, non-governmental organizations, public agencies etc. also need to be clearly defined.

TACKLING THE CHALLENGES: NEED TO EXPLORE ALTERNATE SOURCES

The concerns regarding the feedstock availability, economic viability and sustainability of molasses-based ethanol necessitated the search for alternate feed stocks to produce ethanol. Sweet sorghum has been found to be one such potential source of raw material for commercial ethanol production due to various advantages. Sweet sorghum is similar to grain sorghum, have rapid growth, wider adaptability and high biomass producing ability with sugar-rich stalks, and is suitable for seed propagation and mechanized crop production (Reddy *et al*. 2005). The presence of reducing sugars in this crop prevents crystallization and results in high fermentation efficiency of around 90% (Ratnavathi *et al.* 2004). The growing period (four months) and water requirement (8000 m^3 over two crops) of sweet sorghum are four times lower than that of sugarcane (Table 4). Moreover, the ethanol yield from two crops of sweet sorghum per year (2 800 litres/ha) is greater than that obtained from molasses in a year (700–800 litres/ ha). At the present rates of feedstock cost, the per litre cost of production of sweet sorghum-based ethanol (₹ 17–19) is considerably lower than that of molasses based ethanol (₹ 24–32 litre). The pro-poor dimension and commercial feasibility of sweet sorghum based ethanol production has already been demonstrated by International Crop Research Institute for Semi Arid Tropics (ICRISAT) through its BioPower and Agri-Business Incubator (ABI) Initiatives. However, the potentiality of sweet sorghum seems to have not percolated widely among policy-makers. Adequate extension efforts, coupled with repeated field trials and industrial trials all over the country are required to sensitize the farmers and distillers to enable large-scale adoption (Dayakar Rao *et al*. 2004).

Tropical sugar beet is another potential feedstock found suitable for ethanol production, even though the scope of commercial exploitation has not so far been widely tested in India. However, the field trials conducted by Tamil Nadu Agricultural University (TNAU) have shown that tropical sugarbeet can be successfully cultivated in India at large scale. Sugarbeet is a crop of 5–6 months duration and it grows well in sandy loam. The ability of this crop to thrive well in saline and alkaline soils is of special significance. Ethanol can be directly produced from sugar beet juice at an average recovery rate of 80–90 litres of ethanol/tonne of sugarbeet. At this rate, the ethanol yield from sugarbeet (6 000–6 400 litre/ha) is far higher than sugarcane molasses and sweet sorghum, and can be realized at a very low cost of production (₹ 12–14/litre) (Table 4). Above all, by shifting from sugarcane to sugarbeet, around 10 000–20 000 m^3 of water/ crop can be saved. Sugarbeet can also be explored as a source of sugar in addition to ethanol as it contains greater sugar content.

Concurrently, the country has to look for improved technology and management practices to maximize the efficiency from the existing feedstocks. Lower plant capacity, use of batch process technology, inefficient byproduct and effluent management practices etc. are major technological constraints faced by the industry currently. Long-term technological targets like biotechnological applications to increase the sugar content of crops, commercial use of

Table 4 Comparison between sugarcane, sweet sorghum and sugarbeet as feed stocks for ethanol production

Particular	Sugarcane	Sweet sorghum	Sugarbeet
Sugar content (%)	11–12	10–14	12–15
Ethanol yield (l/ha)	700–800 (1) (from molasses)	1400(2)	6 000–6 400(3)
Cost of ethanol production (₹/l)	24–32(4)	17–19(5)	12–14(6)
Crop duration (months)	12–16	4	5–6
Water requirement (m^3/ha/crop)	20 000–30,000	4 000	8 000–10 000
Fertilizer requirement (NPK kg/ha)	250: 125: 125	80: 50: 40	120: 60: 60

Notes:

(1) 2.8 to 3.4 tonnes/ha of molasses @ 250 l/tonne. Direct conversion of sugarcane juice to ethanol can yield around 4 800–6 000 litres/ha.

(2) Two crops of sweet sorghum can be taken per year. Yield of millable stalk@ 35 tonnes/ha/crop and ethanol yield @ 40 l/tonne (Reddy *et al.* 2005)

(3) 75–80 tonnes/ha of sugarbeet @ 80 l/tonne

(4) *Source:* Revised based on Dayakar Rao *et al*. (2004). Cost molasses range between 3 000 and 5 000/tonne

(5) *Source:* ICRISAT (2009). Cost of sweet sorghum stalk @ ₹ 600/tonne

(6) *Source:* Revised based on TNAU (2009). Cost of sugarbeet @ ₹ 700/tonne

microbes and membranes etc. should also be devised (Raju *et al*. 2009). Research has shown that, ligno-cellulosic biomass sources like bagasse, cereal crop residues, forest thinnings, saw dust, paper etc. can also serve as excellent feed stocks for bioethanol production. However, the commercial feasibility and viability of such feed stocks are yet to be ascertained. Therefore, a shift in focus of research towards developing second generation biofuels and adequate investments to support it is the need of the hour. The Government should also take efforts to reflect the changing priorities in its policies.

The global debate over diversion of food crops for biofuel production is largely inapplicable to Indian biofuel programme, as the country gives considerable emphasis on using only non-edible feedstocks for bioenergy production. However, there is widespread concern over the long-term sustainability, economic viability and commercial feasibility of the programme in its present shape. The findings of the study reinforce that ethanol production focused over sugarcane molasses as a primary feedstock is neither economically viable nor sustainable with the available technologies. It also raises strong apprehension over the overall readiness of the various stakeholders involved in the biodiesel supply chain. It is therefore, imperative to prioritize the various options available so that the efforts are not only directed towards making it sustainable and economically viable, but also pro-poor and resource saving. If promoted, sweet sorghum-based ethanol may prove a better option, which would be pro-poor in marginal and rainfed areas and so is the case with tropical sugarbeet. Therefore, selection of the best feedstocks with long-term prospects should be one important course of action; but simultaneous thrust on improving the existing technology for greater efficiency is also central to success. Both Government policies and private entrepreneurial efforts hence need to be fine-tuned and directed to this effect.

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