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A Review of National Biofuel Policy in India: A Critique- Need for Promotion of Alternative Feedstocks

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ABSTRACT

The last one to two decades have seen several countries stipulating a mandatory requirement of 5-10% blending of biofuels with petrol and diesel. The mandatory blending has triggered a rapid growth in the biofuel sector. Several governments have put in place biofuel policies that have a bearing right from the production of biofuels crops at the farm to their conversion into transport-grade biofuels to be utilised for blending purpose. This paper highlights the salient features of India's biofuel policy and discusses how it influences the economic viability of ethanol production and its commercialisation in the country. The Government of India provides a wide range of policy incentives to promote biofuels as an alternative energy source. The policy challenges affecting biofuel development are discussed under the framework adapted from the Global Subsidies Initiative of Steenblik (2007) showing the existing policies and distortions along the biofuel supply chain to promote alternate feedstocks. For long-term sustainability of ethanol production for blending mandates, this paper explores the options to augment bioethanol production using alternative feedstocks like sweet sorghum that is grown in the drylands and policy support required for its promotion, which will benefit all the stakeholders of the bioethanol supply chain in the long run.

Keywords: National biofuel policy, Energy demand, Policy challenges, Sweet sorghum

1. INTRODUCTION

Energy is a critical input for economic growth and sustainable development in both developed and developing countries. Globally, the energy requirement for the transportation sector is met from fossil fuels that are non-renewable and contribute to atmospheric pollution. However, the sharp rise in crude oil prices from US$20 a barrel in 2002 to almost US$100 (even touching $140 before stabilising at around $80) forced nations to seriously look for alternative energy sources that are renewable and non-polluting. This trend of rising oil prices is expected to continue in the face of their shrinking supplies and rising demand. Second, growing concerns over human-induced climate change, as evidenced by rising temperatures and environmental pollution, is further driving the impetus for non-polluting energy sources. One such source is ethanol from plant biomass/grain and biodiesel from processing edible and non-edible vegetable oils.

The last one to two decades have seen several countries stipulating a mandatory requirement of 5-10% blending of biofuels with petrol and diesel. The mandatory blending has triggered a rapid growth in the biofuel sector in the last decade. By 2007-2008, world biofuel production had touched 62.2 billion tons (t), of which around 88% was in the form of ethanol. The two largest ethanol producers, Brazil and the United States, account for almost 87% of its total production. Biodiesel production, which accounts for a smaller proportion of liquid biofuels, increased from 0.01 million t in 1991 to 9.0 million t by 2008. The European Union (EU) produces over 60% of the global share with a significantly smaller contribution coming from the USA (17%).

The chief raw materials for bioethanol production are sugarcane in Brazil, corn in USA, corn and wheat in China, and molasses in India. In the case of biodiesel, the main feedstocks are vegetable oils from rapeseed mustard, soybean, sunflower and palm oil. However, the biofuel industry is still at a nascent stage requiring Government

support in terms of lower taxes and other infant industry incentives. Since raw materials for biofuels originate from the farm sector, ensuring appropriate incentives for farmers to grow biofuel crops without compromising on food security is critical. Several nations, like USA, Brazil, the Philippines, China, EU, have in place biofuel policies that have a bearing right from the production of biofuel crops at the farm to their conversion into transport-grade biofuels at the distillery to be utilised for blending purpose.

This paper highlights the salient features of India's biofuel policy particularly bioethanol and discusses how it influences the sustainability and commercialisation of ethanol production in the country. In India, molasses (by-product derived during sugar production) is the main raw material for ethanol production to meet the mandated blending requirements. The paper addresses the long-term sustainability of ethanol production from molasses for blending mandates. Finally, the paper explores the viability of using alternative feedstocks like sweet sorghum that is grown in the drylands for bioethanol production and policy options for its promotion.

2. ENERGY DEMAND IN INDIA

India's energy demand is primarily met through non-renewable energy sources, such as coal, natural gas, and oil, which will continue to play a dominant role in the country's energy scenario in the next few decades. The highest demand for energy comes from industry followed by transportation sector, which consumed about 16.9% (36.5 m of oil equivalent) of the total energy (217 million t) in 2005-2006[1]. Within the transportation sector the consumption of motor spirit (gasoline) grew by 6.64%, from 7.01 million t in 2001-2002 to 11.26 million t in 2008-2009 and that of high speed diesel by 4.1%, from 36.55 million t to 51.67 million t, respectively [2]. This growth will only escalate over the next several years since India's vehicular population is expected to grow by 10-12% per annum. Hence, securing a long-term supply of energy sources and prioritising development will ensure the country's future energy requirement. Currently, the country is looking for alternative energy options from biofuels to meet the energy demand for the transportation sector. To promote biofuels as an alternative energy source, Government of India stipulated mandatory blending requirements of gasoline with biofuels along with various policy incentives. The policies are designed to facilitate and bring about optimal development and utilisation of indigenous biomass feedstocks for biofuel production.

3. BIOFUEL POLICY IN INDIA

In 1948, the Power Alcohol Act heralded India's recognition of blending petrol with ethanol. The main objective was to utilise ethanol from molasses to blend with petrol with the aim of bringing down the price of sugar, trim wastage of molasses and reduce dependence on petrol imports. Subsequently, the Act was repealed in 2000, and in January 2003, the Government of India launched the Ethanol Blended Petrol Programme (EBPP) in nine States and four Union Territories promoting the use of ethanol for blending with gasoline and the use of biodiesel derived from non-edible oils for blending with diesel (5% blending). In April 2003, the National Mission on Biodiesel launched by the Government of India identified *Jatropha curcas* as the most suitable tree-borne oilseed for biodiesel production.

Due to shortage in ethanol production[1] during 2004-2005, the blending mandate was made optional in October 2004, and resumed in October 2006 in 20 States and 7 Union territories in the second phase of EBPP. These ad-hoc policy changes continued until 2009 when the Government of India came out with a comprehensive biofuel policy. This comprehensive National Policy on Biofuels was formulated by the Ministry of New and Renewable Energy (MNRE) and cleared by the Government of India in December 2009, calling for blending at least 20% biofuels with diesel and petrol by 2017.

3.1. National Policy on Biofuels: An Overview

3.1.1. Salient features

- An indicative target of 20% blending of biofuels both for biodiesel and bioethanol by 2017.

[1]Shortage in ethanol production was mainly caused by a shortage in molasses production driven by shortages in cane production.

- Biodiesel production to be encouraged from non-edible oilseeds on waste, degraded and marginal lands.
- A Minimum Support Price (MSP) to be announced for farmers producing non-edible oilseeds used to produce biodiesel.
- Financial incentives for new and second generation biofuels, including a National Biofuel Fund.
- Biodiesel and bioethanol likely to be brought under the ambit of "declared goods" by the Government to ensure the unrestricted movement of biofuels within and outside the states.
- Setting up a National Biofuel Coordination Committee under the Prime Minister for a broader policy perspective.
- Setting up a Biofuel Steering Committee under the Cabinet Secretary to oversee policy implementation.

Several ministries are currently involved in the promotion, developing and policy making for the biofuel sector.

- The MNRE is the overall policymaker, promoting the development of biofuels and research and technology development for its production.
- The Ministry of Petroleum and Natural Gas has the responsibility of marketing biofuels and developing and implementing a pricing and procurement policy.
- The Ministry of Agriculture's role is that of promoting research and development for the production of biofuel feedstock crops.
- The Ministry of Rural Development is specially tasked to do the promotion, especially of Jatropha plantations in wastelands.
- The Ministry of Science and Technology supports research in biofuel crops, specifically in the area of biotechnology.

In view of the multiple departments and agencies involved, a National Biofuel Coordination Committee headed by the Prime Minister has been set up to provide high-level co-ordination and policy guidance/review on different aspects of biofuel development, promotion and utilisation.

3.2. Policy Challenges Affecting Biofuel Development

Biofuel policies have important implications for the development of the energy sector. The profitability of biofuel production is significantly influenced by biofuel policies affecting multiple sectors, which include agriculture, research, industry and trade. Identifying relevant policies and quantifying their impacts on specific cases is difficult, because of the variety of policy instruments (taxes, subsidies, price support, etc.) and the way they are applied[3].

For example, subsidies can affect the sector at different stages[4]. The various points in the biofuel supply chain where direct and indirect policy measures can support the sector are interrelated, and assigning policies to one category or another may be somewhat artificial in practice[3]. Figure 1, adapted from the Global Subsidies Initiative of Steenblik[4], is used as a background to discuss the biofuel policy in India, its implications and distortions at various stages of the biofuel supply chain in production, commercialisation and sustenance in promotion of biofuel sector.

3.3. Blending Mandates

Imposing quantitative targets in the form of blending mandates is the key driver in the development and growth of the biofuel industry. The blending mandate of 5% ethanol with gasoline in 9 states of India in 2003 was enhanced to include 20 states in 2006. In 2010, the National Policy on Biofuels (NPB) approved a target 20% blending with biofuels (both biodiesel and bioethanol) by 2017.

In India, the main raw material for ethanol production is molasses, a by-product derived during sugar production. Supply of sugarcane and the production of molasses are dependent on sugar cycles. During 2006 and 2007, due

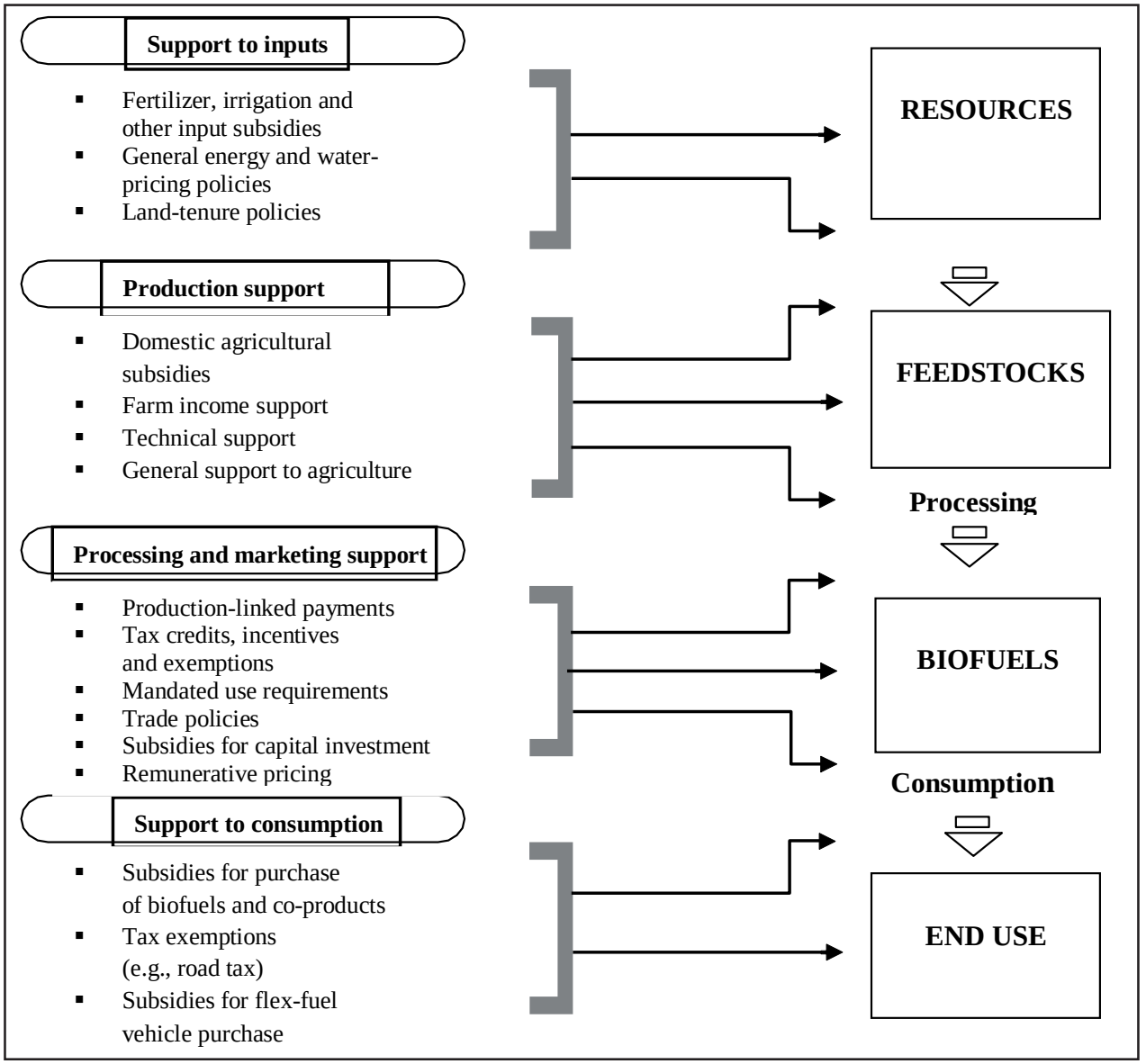

Figure 1: A framework adapted from the Global Subsidies Initiative of Steenblik (2007) showing the policy support required along the biofuel supply chain.

to excess supply of cane and molasses, prices were depressed. The mandated blending targets were probably based on the surplus ethanol available during a good sugarcane production year. The price of molasses has been fluctuating considerably over the years from Rs 50/t to Rs 6,000/t ($1.1 to $133.3) between 2003 and 2008. Additionally, there is competition from the potable and chemical industries for the alcohol from molasses. During a normal year, cane converted into sugar generates enough molasses to produce alcohol that can meet the needs of potable and chemical sectors (30-40% each) with another 20-30% surplus alcohol available for conversion into ethanol and related products. During 2009, the total supply of ethanol was 2.4 million t was sufficient to meet total demanded of 1.80 million t from all three sectors (@ 5% blending target for ethanol). Despite this, the ethanol blending target could not be met due to inability of the Oil Marketing Companies (OMCs) to procure the required amount of fuel ethanol at prevailing market prices that are lower than alcohol prices for different uses. Another estimate by the Indian Chemical Council finds that even at 5% blending there would be a deficit of 1,140 million liters in 2010-2011, which would grow to 2,400 million liters by 2014-2015 assuming constant production of molasses and alcohol (Table 1). A study by Shijoj *et al*.[5] finds that as per the 20% blending target set by the

government by 2016-2017, the fuel ethanol demand would be 1.93 million t and total demand (ethanol + alcohol) would be as high as 3.52 million t.

Table 1: Projected demand and supply of alcohol in India

Alcohol requirement (million liters)	2010-11	2011-12	2012-13	2013-14	2014-15
Potable sector	1,450	1,550	1,660	1,780	1,900
Industrial sector	1,050	1,100	1,160	1,210	1,280
5% Blending	1,040	1,090	1,150	1,200	1,260
Total alcohol required	3,540	3,740	3,970	4,190	4,440
Highest expected alcohol availability (million liters)	2,400	2,400	2,400	2,400	2,400
Deficit (million liters)	(1,140)	(1,340)	(1,570)	(1,790)	(2,040)

Source: Indian Chemical Council, 2010
Note: On the basis of past trends, the growth rates are assumed to be 5% for the industrial sector, 7% for the potable sector and 5% for blending.

The question that arises is how blending requirement of bioethanol at 5%, 10%, 20% blending mandates could be met? Could ethanol production from molasses be boosted or there is a need to promote alternative feed stocks that would help meet the targets. The biofuel policy can address this by prioritising feedstock-targeted blending mandates that will give a boost to alternative feedstocks besides molasses and make them viable for ethanol production.

3.4. Input Support (Subsidies)

The justification for providing policy support to any new sector is based on its ability to overcome the initial costs of technological innovation and market development required to make the sector competitive. This is the "infant industry" argument for providing subsidies. However, providing subsidies for a sector that cannot ultimately achieve economic viability is not sustainable and may only serve the purpose of transferring wealth from one group to another while imposing costs on the economy as a whole[3].

Most inputs like fertilizer, pesticides and electricity to pump irrigation water for crop production are subsidised in India. The quantum of subsidy for a crop varies based on the inputs utilised for its production. Currently, molasses, a by-product of sugarcane, is the chief raw material for ethanol production. The inputs utilised in cane production are highly subsidised through seed subsidy, purchase of implements and tools and electricity to pump irrigation water apart from fertilizer and pesticides subsidy. The subsidies provided for cane production indirectly accrue to molasses used in production of ethanol.

3.5. Output Support

Besides production support, output support for the purchase of biofuels is also critical. The National Biofuels Policy proposes an MSP mechanism for *Jatropha* whose seed is used to produce biodiesel. For sugarcane, the existing statutory minimum price provides effective protection to growers. The policy specifically targets ethanol production from the currently available sugarcane molasses. In the case of biodiesel, the policy proposes that the Minimum Purchase Price (MPP) be linked to the prevailing retail price of diesel, while for bioethanol it is based on the actual cost of production and import price of bioethanol. The demand for alcohol at higher prices from the chemical and potable sectors dictates the pricing of ethanol, while at the same time constraining supply to the biofuel industry. The experience so far indicates that the OMCs are unable to procure ethanol at the prevailing rate for effecting blending mandates as the sugar industries get better price and assured demand from beverage and pharmaceutical industries[5].

3.6. Processing and Marketing Support

OMCs in 20 states and 4 Union Territories have been assigned the task of blending 5% ethanol with gasoline. The sugar industry has been permitted to produce and process ethanol from sugarcane juice to augment production to meet blending requirements. Other than molasses and sugarcane, the policy does not specify in concrete terms processing of alternative feedstocks for bioethanol. Alternative feedstocks like sweet sorghum and sugar beet are mentioned in the policy but there is no concrete road map suggested for their promotion.

3.7. Distribution and Marketing of Biofuels

OMCs have been responsible for the storage, distribution and marketing of biofuels in India. India's biofuel policy exempts the biofuel sector from central taxes and duties. Although biodiesel is exempt from excise duty, bioethanol enjoys a concessional excise duty of 16%. Custom and excise duty concessions are also provided on plant and machinery for the production of biodiesel and bioethanol. While these policies do promote the biofuel sector, those promoting production of feedstock to fully realise the benefits provided on the processing front need to be highlighted, since production and processing are interdependent. Though the policy mentions about exemption of central taxes and duties on biofuels, various forms of taxes like sales tax, license fee, permit fee and import taxes still exist hindering the growth and development of the biofuel industry. The policy provides no additional incentives for blenders and retailers of biofuel unlike in several other countries.

3.8. Subsidies in Other Countries

Several countries are subsidising or mandating investments in infrastructure for biofuel storage, transportation and use, most of it directed towards ethanol, which normally requires major investments in equipment. Such support is often justified on the grounds that greater use of ethanol and expansion of the market for it will not occur until sufficient distribution infrastructure and sales points are in place[3]. For example, in the United States, the American Jobs Creation Act of 2004 introduced the Volumetric Ethanol Excise Tax Credit (VEETC), a tax credit of 51 cents per gallon of ethanol for blenders and retailers. The VEETC was expanded to include biodiesel in 2005. The EU rural development policy provides grants as capital costs for setting up biomass production plants.

Though such sops are mentioned in the policy of India to promote the biofuel industry, they have not been implemented at ground level. OMCs in India have well-established infrastructure and manpower. Given the available resources and the expertise of OMCs, options to set up biofuel-processing plants can be explored. The capital costs involved could be subsidised by the Government in the initial phase. Also, the production centres can cater to both bioethanol and biodiesel needs, and also aid in developing the biofuel industry to benefit all stakeholders. This could be done on pilot basis since more information is required for upscaling and outscaling.

3.9. Consumption Support

The biofuel policy's thrust is primarily on the supply side, even though demand side factors also play a major role in promoting biofuels. For example, many countries actively promote flex-fuel vehicles designed to use a higher percentage blend of ethanol with petrol than ordinary vehicles through reduced registration fees and road tax exemptions. Similarly, support is provided for the purchase of biofuels, co-products and flex-fuel vehicles.

Under section 52 of the Motor Vehicles Act in India, an existing vehicle engine can be converted to use biofuels and accordingly, engine manufacturers need to suitably modify the engines to ensure compatibility with biofuels. Demand for such vehicles and consequently biofuels can be stimulated by providing exemption of road tax and reduced registration fee for vehicles running on blended fuels. Incentives similar to the ones approved by MNRE for the dissemination and promotion of battery-operated vehicles (BOVs) will also help in augmenting the biofuel industry.

3.10. Financial and Fiscal Incentives

Apex financial institutions like the National Bank for Agriculture and Rural Development, Indian Renewable Energy Development Agency and Small Scale Industries Development of India have refinancing provisions to set up biodiesel plantations, oil expelling/extraction units and infrastructure for storage and distribution. The lending towards these sectors would be classified as priority sector lending. The policy states consideration of subsidies and grants upon merit for new and second generation feedstocks; advanced technologies and conversion processes; and production units based on new and second generation feedstocks. Similar emphasis explicitly mentioned for bioethanol would specially benefit the ethanol industry.

3.11. Research and Development

The policy's major thrust is innovation, R&D and demonstration. It focuses on R&D efforts in processing and production technologies and maximising efficiencies and utilisation of by-products along the biofuel value chain. Demonstration projects are to be set up for biodiesel and bioethanol production, focusing on conversion technologies through Public-Private Partnership (PPP). Grants are to be provided to academic institutions, research organisations, specialised centres and industry for promising R&D and demonstration projects.

3.12. Institutional Mechanisms

Among the institutional policies that promote the biofuel industry are international cooperation through technical cooperation in production, conversion and utilisation; trade in biofuels; state participation in planning and implementing biofuel programmes; and capacity building for dissemination and creating awareness.

Though a policy on biofuels is in place to promote biofuels at various stages of the supply chain, the government's initiatives on their production and commercialisation have not taken off as anticipated to meet the energy demand both for ethanol and biodiesel.

4. SUSTAINING BIOETHANOL PRODUCTION TO MEET BLENDING MANDATES

NPB mentions about level playing field necessary for accelerated development and utilisation of biofuels vis-a-vis direct and indirect subsidies to fossil fuels and distortions in energy pricing. To augment availability of ethanol and reduce the oversupply of sugar, the NPB permits sugar industry to produce ethanol directly from sugarcane juice. The policy implies further concessions to sugarcane growers and processors who are already benefitting from the input subsidy. Sugarcane has the advantage of having massive infrastructure already established for it and favourable government policy support since earlier years. This has led to policy makers tailoring policies favouring ethanol production from sugarcane and molasses. However, this is counterintuitive to the policy recommendation of using degraded and less fertile land for biofuel production. This lopsided policy that implies concessions for ethanol production through sugarcane could have a detrimental effect on resource allocation in the agriculture sector.

However, considering the demand for sugar in India, it is highly unlikely that sugarcane juice will be used for ethanol production in India. The analysis conducted by Raju *et al*.[6] has shown that 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 per ha per crop.

Due to the lopsided policy along with non-availability, economic viability and sustainability of ethanol from molasses the viability of blending mandates the EBPP has not been successfully implemented. This necessitates options to augment bioethanol production to meet the blending mandates through policy support for alternative feedstocks. One such alternative feedstock that has been pilot tested in recent years is sweet sorghum. Though the policy document mentions feedstocks like sweet sorghum, sugar beet etc., for ethanol production, neither have these crops been given due prominence in the policy nor has a clear roadmap been specified for their

Table 2: Comparison between sugarcane, sweet sorghum and sugar beet as feedstocks for ethanol production

Crop	Cost of cultivation (USD ha^{-1})	Crop duration (months)	Fertilizer requirement (N-P-K kg ha^{-1})	Water requirement (m^3)	Ethanol productivity (liters ha^{-1})	Av. stalk yield (t ha^{-1})	Per day productivity (kg ha^{-1})
Sweet sorghum	435 over two crops	4	80-50-40	8,000 over two crops	4,000 $year^{-1}$ over two crops[a]	50	416.67
Sugarcane	1,079 $crop^{-1}$	12-16	250 to 400-125-125	36,000 $crop^{-1}$	6,500 $crop^{-1}$[b]	75	205.47
Sugarcane molasses	-	-	-	-	850 $year^{-1}$[c]	-	-
Sugar beet		5-6	120-60-60[d]	8,000-10,000[e]	6,000-6,400[f]	75-80	500-444

Source: Reddy *et al*.[9]; [a]50 t ha^{-1} millable stalk per crop @ 40 l t^{-1}; [b]85-90 t ha^{-1} millable cane per crop @ 75 l t^{-1}; [c] 3.4 t ha^{-1} @ 250 l t^{-1} ; [d]Sweet sorghum stalk @ US$ 12.2 t^{-1} ; [e]Sugarcane molasses @ US$ 39 t^{-1}. Source (d,e): Dayakar Rao *et al*.[10]
[f]**Source**: Shinoj *et al*.[5] 75-80 t ha^{-1} of sugar beet @ 80 l t^{-1}.

commercialisation and utilisation. Policy support mechanism to promote alternative feedstocks will benefit all the stakeholders of the bioethanol supply chain in the long run while meeting the mandated requirements.

5. SWEET SORGHUM AS AN ALTERNATE SOURCE OF BIOETHANOL PRODUCTION

Sweet sorghum stalk has been found to be a potential source of raw material for commercial ethanol production. Sweet sorghum does not compromise on food, feed or fodder production when used for energy production, thereby meeting the biofuel programme's vision without compromising on food security[2].

Cultivation of sweet sorghum involves the judicious use of scarce resources like irrigation water and other inputs (sweet sorghum uses less than a third of the inputs used by sugarcane, such as water, electricity and fertilizers) making it a promising alternative feedstock[7,8]. Sweet sorghum scores favourably on all the parameters compared to alternative feedstocks. Additionally, the pollution levels in sweet sorghum-based ethanol production has 25% of the biological oxygen dissolved, i.e., 19,500 mg l^{-1}, and lower chemical oxygen dissolved, i.e., 38,640 mg l^{-1}, compared to molasses-based ethanol production (as per pilot study conducted by Vasantdada Sugar Institute (VSI), Pune, India). Hence, besides molasses there is a need for clear guidelines to promote alternative feedstocks like sweet sorghum for bioethanol production.

Field surveys conducted ICRISAT in Ibrahimbad, Medak district, Andhra Pradesh in 2008 under the National Agricultural Innovation Project (NAIP) revealed that the cost of inputs (fertilizer and imputed cost of irrigation) in the cultivation of sugarcane was Rs 6,691/ha compared to Rs 1,948/ha for sweet sorghum. The cultivation of sugarcane requires higher amounts of scarce resources such as irrigation water and fertilizers, which are highly subsidised. Sugarcane requires nearly 160-180 ha cm of irrigation water, while sweet sorghum is cultivated under rain-fed conditions. Additionally, crop-wise estimates of input subsidies during 2001-2002 (Table 3) show that sugarcane had the highest input subsidy of Rs 6,099/ha, while sorghum had the lowest. The difference in irrigation subsidy alone provided to sugarcane was Rs 1,444/ha relative to sorghum.

6. TWEAKING POLICIES TO SUPPORT ALTERNATE FEEDSTOCKS

6.1. Economics of Sweet Sorghum Cultivation and Processing

As mentioned earlier, the justification for providing policy support to any new sector is based on its ability to

[2]The grain can be harvested for food, and bagasse left after extraction of juice from the stalk is an excellent feed for livestock.

Table 3: Crop-wise distribution of input subsidies per hectare in India (2000-2001)

Crop	% fertilizer subsidy to total subsidy	% electricity and canal subsidy to total subsidy	Subsidy/ha of crop area (Rupees)
Paddy	31.43	31.01	3,587
Sugarcane	5.51	4.95	6,099
Sorghum	3.55	1.01	839
Maize	2.64	1.87	1,634
Total (billion rupees)	138.0	366.40	-

Source: Acharya and Jogi[11]

overcome the initial costs of technological innovation and market development required to make the sector competitive. This is the "infant industry" argument for providing support.

Data on cost of cultivation for sweet sorghum collected over a period of 3 years by ICRISAT across various locations under the project on Value Chain Model for Bio-ethanol Production in India, funded by NAIP, ICAR, Government of India, shows that sweet sorghum stalk yields have varied between 14 and 18 t per hectare. With buy back price of sweet sorghum stalk at Rs. 700-1,000 per t sweet sorghum cultivation is competitive with other dryland crops in Medak district of Andhra Pradesh (Table 4). Across clusters in Western Maharashtra also sweet sorghum was found to be profitable with competing crops like sorghum intercropped with pigeon pea and sole sorghum. However, it becomes less competitive when compared to commercial crops like cotton and soybean in Maharashtra clusters. The high opportunity cost of land for cultivation forces the distillery to pay higher prices for sweet sorghum cultivation (if fertile lands used for cultivation of cotton and soybean has to be replaced to cultivate sweet sorghum).

Sweet sorghum is economically the next best alternative for ethanol production after molasses (Table 5) when the feedstock is priced at Rs. 800 per t of stalk. However, feedstock and ethanol pricing have a bearing on the viability of ethanol production from all available feedstocks.

On the processing side, economic viability assessment was carried out by the authors using the data from a distillery crushing sweet sorghum for ethanol production. The distillery that had buy-back arrangement with farmers for cultivation of sweet sorghum was paying Rs. 1,200-1,300 ($24-26) per ton of stalk to farmers, since they had to be compensated for loss in returns for cultivation of crops like cotton and soybean. With feedstock price fixed at Rs. 1,200-1,300/ton of stalk and subsequent processing costs incurred by the distillery, ethanol has to be priced at Rs. 36 per liter from the existing administered Rs. 27 per liter to make the distillery viable.

Several scenarios were developed by varying feedstock price, ethanol price and ethanol recovery rate by performing sensitivity analysis. The sensitivity analysis performed, helped to estimate the break-even points and ethanol pricing scenarios for sweet sorghum value chain.

Table 4: Benefit cost ratio of sweet sorghum cultivation with competing crops in Ibrahimbad location of Andhra Pradesh

Crop name	Benefit-cost ratio		
	2008	2009[1]	2010[1]
Sweet sorghum	1.55	0.96	0.81
Maize - pigeon pea	1.30	NA	0.97
Sorghum - pigeon pea	1.37	0.97	0.59

Note: [1]Low returns from crops during 2009 and 2010 was due to adverse climatic conditions.

Table 5: Relative economics of ethanol production from different feedstocks in India

Parameter	Sweet sorghum	Sugarcane molasses	Sugarcane juice	Grains (pearl millet and broken rice)
Cost of raw material (Rs./t)	800[1]	3,000-5,000[2]	1,200[3]	7,000[3]
Cost of processing (Rs./t)	384	1,890	490	2,400
Total cost of ethanol production (Rs/t)	1,184	4,890-6,890	1,690	9,400
Output of ethanol (liters)	45	270	70	400
Value of ethanol (Rs./t)	1,215	5,805	1,505	8,600
Net returns (Rs./t)	31	915-1,085	185	800
Cost of feedstock (Rs./liter)	17.77	11.11-18.51	17.14	17.5
Cost/liter of ethanol (Rs.)	26.31	18.11-25.51	24.14	23.5
Profit/liter of ethanol (Rs.)	0.68	3.39-4.01	-2.64	-2

Source: Authors's calculation based on the data collected from ICRISAT project on sweet sorghum for ethanol production funded by NAIP-ICAR.

[1]When the feedstock is priced at Rs. 800, it becomes profitable to produce ethanol from sweet sorghum without accounting for capital costs and valuing by-products. However, the cost of feedstock has varied in the range of Rs.700-1,000/t; [2]The molasses prices have ranged between Rs. 3,000 and 5,000/t during the last few years and, hence, the profitability of molasses ethanol production is highly sensitive to fluctuating molasses prices; [3]The data on other feedstocks cost are for the year 2009. The prices of feedstock (sugarcane and grains) have increased in the recent years.

6.3. Policy Support for Sweet Sorghum

The area under cultivation of alternative feedstocks for ethanol production is low due to the reasons mentioned (higher feedstock prices, assured buy-back arrangement for farmers and low ethanol prices). The NPB proposes MSP mechanism for biodiesel crops, while it does not specify any MSP for bioethanol-producing crops like sweet sorghum and sugarbeet.

In the current market context, policy support for the production of a biofuel crop primarily depends on mutual/ simultaneous co-existence of producers and processors to promote alternate feedstocks. For growers, it is the relative profitability of bioethanol crops vis-a-vis competing crops and assured buy-back at pre-determined prices are important factors determining allocation of land for these crops. While for industry, the raw material's conversion efficiency, its continuous supply for at least 5-6 months in a year, the economics of establishing multi-feedstock production units and the purchase price of ethanol by oil companies are critical factors. For industries producing ethanol from alternative feedstock, policy support should be in the form of a MPP to ensure at least a break-even price of ethanol production.

Provision of assistance to farmers cultivating sweet sorghum justifying the support on the arguments of augmenting bioethanol production under rainfed conditions will help the farmers to meet both their food and fodder requirements.

Policies favouring ethanol production from feedstock such as sweet sorghum by capping a third of the 5-10% requirement in the initial years will serve as an incentive to tap alternative sources.

Additionally, conversion of any form of sugars to alcohol requires special permissions and licensing (opinions based on the visits to industries by ICRISAT scientists). Barriers for licensing and permissions for conversion of multiple feedstocks to ethanol deters industry from processing as the industry cannot sustain on single feedstock to run on optimal capacity and profitability licensing and permissions has to be made easy for establishment and operationalisation of multi-feedstock units that can operate for longer periods in a year to augment the ethanol production using different feedstock.

Options can be explored with sugar industry to integrate crushing of sweet sorghum during lean periods of sugarcane crushing. Viability gap funding as undertaken for infrastructure projects in PPP mode can also be explored for financial assistance for private sector for production of ethanol from alternate feedstocks like sweet sorghum. The policy support in the form of "infant industry sops" during the initial years or a one-time capital assistance for industries crushing alternate feedstocks for ethanol production will help in boosting bioethanol production.

Sweet sorghum is a newly introduced promising crop for the production of bioethanol. Research is on to develop promising cultivars for higher yield and juice content. So are pilot projects linking farmers to the bioethanol industry. Hence, funding support for ongoing research on sweet sorghum and its promotion are critical. Identifying institutional mechanisms through PPPs and funding support by national and international funding agencies to promote such biofuel crops will go a long way in promoting alternative feedstocks.

6.4. Economic Viability and Cost of Subsidy

Various studies across countries have calculated the point at which ethanol from various feedstocks would be competitive with fossil fuels and policy incentives and interventions to be provided for promotion of bioethanol. In Indian context, there are arguments in favour of bioethanol that it would become economical in a scenario of higher crude oil prices, high to the tune of US $ 147/barrel (July 2008). The analysis conducted by Shinoj *et al*.[5] on the sustainability of sugarcane-based ethanol has shown that even in such a scenario, it would be difficult to meet the mandated ethanol blending requirement.

To determine the break-even points of production of ethanol from sweet sorghum in the Indian context, the Tyner and Taheripour[12] framework of determining break-even points of ethanol production from maize as feedstock relative to crude oil is replicated by the authors. The analysis is done taking into account the current prices and conversion technology of the feedstock that could form the basis for price and policy incentives to promote biofuels from alternative feedstocks.

The break-even price analysis shows that with a conversion rate at 4.5% of ethanol from sweet sorghum, the feedstock price should be Rs 800/ton of stalk when the price of crude is at US$ 85 per barrel.

Currently, sweet sorghum growers are paid Rs 700-1,300/t ($14-26) of stalk by ethanol processors. The difference between break-even price and the market price (Rs. 1,200-1,300/ton as the opportunity cost of cultivation) of sweet sorghum will help in determining the quantum of loss incurred by ethanol processors in producing ethanol from sweet sorghum. In other words, given the price of crude oil, ethanol producers can make profits even though the price of sweet sorghum increases, if the difference between the break-even price and market price of sweet sorghum is compensated by support from government.

6.4.1. Cost of Subsidy

An estimate is made by the authors on the magnitude of support required if alternate feedstocks like sweet sorghum are prioritised and promoted with enabling environment in India and taking into consideration the land required for its cultivation and ethanol production for blending mandates. Based on projections by the Planning Commission, 1.97 billion liters of bioethanol at the rate of 10% blending would be required by 2017. Currently, the entire blending requirement by OMCs has to come from sugarcane molasses. Given the unsustainable scenario of ethanol production from molasses (shortage of molasses due to cyclical nature of sugarcane production, fluctuating prices of molasses, inability of OMCs to procure ethanol at the prevailing market rate and better price and assured demand for potable and industrial uses), ethanol could be produced from alternate feedstocks like sweet sorghum.

Since, in the short run it would not be possible to bring a larger area under its cultivation and also because of the research and extension efforts required to make it a viable option for blending, it is assumed that only 5% of the total ethanol required for blending would come from sweet sorghum during 2012 and this would go up to 20% by 2020. Based on these assumptions, annual requirement of bioethanol from sweet sorghum, and land requirement

for sweet sorghum during 2012-2014, 2015-2019 and 2020 have been projected at 5%, 10% and 20% of the total ethanol requirement, respectively.

Based on these annual projections, the cumulative area that would need to be brought under sweet sorghum cultivation by 2020 would be 0.5 million ha, a small proportion of the total area presently under cultivation in *kharif* (rainy season) sorghum alone (around 3.5 million ha). The area under *kharif* sorghum in the state of Maharashtra is close to 1.2 million ha. Here we assume that initially sweet sorghum would replace *kharif* sorghum since both crops grow under similar conditions and the grain from sweet sorghum crop would compensate for the loss in sorghum grain.

It is expected that the on-farm sweet sorghum stalk productivity of 20 t/ha increase to 30 t/ha between now and 2020 with improved cultivars, better management practices and increased awareness of farmers on sweet sorghum cultivation. With increased productivity, a larger area could be brought under sweet sorghum cultivation, and hence ethanol available for blending from sweet sorghum stalk as raw material would also increase.

The estimated break-even price of sweet sorghum for ethanol production is Rs. 1,200/ton (including the cost of processing) at 4.5% recovery when crude is priced at $85 a barrel. Based on the estimated breakeven, if a support of Rs. 1,200/ha (one-third of what is provided for crops like paddy and sugarcane) is provided for processors, the total economic cost of subsidies for sweet sorghum production would amount to Rs. 105 million to Rs. 605 million (US$ 2.33 to 13.35 million) by 2020 based on area required for sweet sorghum cultivation (Table 6). Comparing the amount of subsidies provided to water-intensive crops like sugarcane and paddy in India, which account for an average of Rs. 3,000-4,000/ha, and the subsidies provided in the United States and EU for biofuel production, the estimated quantum of support for sweet sorghum is modest.

Table 6: Projection of ethanol requirement in India by 2020 and land and subsidy requirements to meet 20% of the demand from sweet sorghum

Year	Ethanol requirement for blending (billion liters)	Ethanol requirement from sweet sorghum (billion liters)	Area required for cultivation of sweet sorghum (@ 20 t/ha productivity; million hectares)	Subsidy required (million rupees)
2006	1.20	-	-	-
2007	1.26	-	-	-
2008	1.31	-	-	-
2009	1.37	-	-	-
2010	1.44	-	-	-
2011	1.50	-	-	-
2012	1.57	0.079	0.087	105
2013	1.64	0.082	0.091	110
2014	1.72	0.086	0.096	115
2015	1.80	0.180	0.200	240
2016	1.88	0.188	0.209	251
2017	1.97	0.197	0.219	262
2018	2.06	0.206	0.229	274
2019	2.15	0.215	0.239	287
2020	2.25	0.450	0.500	601

6.5. CONCLUSIONS

While the policy framework to promote the biofuel sector in India is very encouraging, experience has shown that the Government's initiatives have not translated into results on the production and commercialisation fronts to meet the country's energy demand, calling for a re-examination of the policy from various stages of the biofuel supply chain. This paper highlights the key features of the biofuel programme in India, and critically examines them to meet the mandated ethanol blending programme stipulated by the Government of India.

The focus of the policy is on ethanol production from molasses that is plagued by price volatility combined with demand for molasses-based alcohol from the potable and chemical industries. Its production is dependent on sugar production and, hence, volatility in sugar production also affects molasses availability. This is already evident as the viability of blending mandates is at stake as the EBPP has not been successfully implemented across the country owing to non-availability of ethanol for blending on a continuous basis.

The policy is thus sugarcane centric, which is counter intuitive to the policy recommendation of using degraded and less fertile land for biofuel production. Sugarcane is a big beneficiary of subsidies on fertilizer, pesticides and electricity for pumping irrigation water for crop production in India. The policy document not only favours production of ethanol from sugarcane through molasses but also recommends sugarcane juice as another option. While mention is made of other feedstocks like sweet sorghum, sugar beet etc., in the policy document for ethanol production, due prominence and clear road map are not specified. In view of the above, prioritisation of alternative feedstocks to fulfill targeted blending mandates is called for. Policies favouring alternative feedstock such as sweet sorghum by capping a third of the 5-10% requirement will serve as an incentive to promote alternative feedstocks. A small subsidy in the initial years will go a long way in promoting alternative feedstocks, which can supplement ethanol production for blending requirements.

The major thrust of the biofuel policy is primarily on supply side. However, the demand side factors like provisions for consumption support also play a significant role in promotion of biofuels. Promotion of flex-fuel vehicles designed to use higher percentage blends of ethanol as in case of Brazil is a classic example. Similarly, reduction in registration fees and road tax exemptions for vehicles running on biofuels are provided by many countries. Policy sops of such kind and incentives similar to the ones announced and approved by the MNRE for dissemination and promotion of BOVs will also help in promoting and sustaining the biofuel industry. Such sops should be provided only in the initial years (5-10) until the industry is able to sustain on its own.

It is hoped that modifications in the existing NBP favouring bioethanol production from alternate feedstocks like sweet sorghum besides molasses will benefit all the stakeholders in the biofuels supply chain and will quicken the pace of biofuel production in the country to meet the blending mandates.

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