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Ethanol Blending Policy in India: Demand and Supply Issues

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Abstract

In the year 2008, the Government of India announced its National Policy on biofuels, mandating a phase-wise implementation of the programme of ethanol blending with petrol in various states. This study examines demand and supply aspects of the ethanol blending policy (EBP) of the Government of India. In the last two years, the demand from the industrial sector could not be fully met domestically and was met by imports. The study examines the main sectors using ethanol. The preparedness of the automobile industry is a major factor in the successful implementation of this policy. In this context the issue of compatibility of vehicles to different levels of ethanol blending is also analyzed.

***JEL Classification**: Q16, Q28, Q4.*
***Keywords**: Biofuels, Ethanol, Energy, Energy Policy*

Executive Summary

India is one of the fastest growing economies of the world, with its gross domestic product (GDP) growing at an average annual rate of over seven per cent since 2004. Energy inputs are a critical component of national economic activity. However, since it is believed that the conventional sources of energy will be exhausted in few decades; biofuels are being increasingly seen as potential alternatives to the liquid fossil fuels. In this context, ethanol is being seen as a promising renewable fuel for transportation purposes for the near future.

In the year 2008, the Government of India announced its National Policy on biofuels, mandating a phase-wise implementation of the programme of ethanol blending with petrol in various states. This study examines demand and supply aspects of the ethanol blending policy (EBP) of the Government of India.

In India, ethanol production is mainly done using sugarcane as feedstock. For successful implementation of the EBP in the country, a steady supply of sugarcane (or sugarcane juice) as feedstock is required. However, sugarcane production in a bumper crop year just about meets the requirement of all the sectors. In other years, there is a shortfall due to which the EBP has not been successfully implemented till now. In the past few years, there was a large unmet demand for ethanol from the industrial sector that was met by imports.

The existing vehicular fleet in the country is compatible with the 5 per cent ethanol-blended petrol. Sufficient lead time would have to be given to the automobile industry to make appropriate engine and other modifications to make vehicles compatible with higher levels of blended fuel.

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Abbreviations

ADE	Additional Duty of Excise
ARAI	Automobile Research Association of India
BIS	Bureau of Indian Standards
CAGR	Compound Annual Growth Rate
CIF	Cost Insurance Freight
CII	Confederation of Indian Industry
CO_2	Carbon Dioxide
CST	Central Sales Tax
DBT	Department of Biotechnology
EBP	Ethanol Blending Programme
EGoM	Empowered Group of Ministers
ESMAP	Energy Sector Management Assistance Programme
FAO	Food and Agriculture Organisation
FDZ	Free Delivery Zone
FFV	Flex Fuel Vehicle
FOB	Free On Board
FRP	Fair and Remunerative Price
GDP	Gross Domestic Product
GAIL	Gas Authority of India Limited
GoI	Government of India
ICC	Indian Chemical Council
IEA	International Energy Agency
ISMA	Indian Sugar Mills Association
J&K	Jammu and Kashmir
MEG	Monoethylene Glycol
MoPNG	Ministry of Petroleum and Natural Gas
MoCF	Ministry of Chemicals and Fertilisers
MODVAT	Modified Value Added Tax
MPP	Minimum Purchase Price
MTBE	Methyl Tertiary-Butyl Ether
NBCC	National Biofuel Co-ordination Committee
OMCs	Oil Marketing Companies
PetroFed	Petroleum Federation of India
PTA	Purified Terephthalic Acid
R&D	Research and Development
RPO	Retail Pump Outlet
SAP	State Advised Price
SMP	Statutory Minimum Price
SIAM	Society for Indian Automobile Manufacturers

STAI	Sugar Technologists' Association of India
UNCTAD	United Nations Conference on Trade and Development
UP	Uttar Pradesh
USD	US Dollars
USDA	United States Department of Agriculture
USDA FAS	USDA Foreign Agriculture Service
UK	United Kingdom
VAM	Vinyl Acetate Monomer

Units of Measurement

Kcal/g	Kilo Calories per Gram
Kg	Kilograms
KJ	Kilo Joules
KLD	Kilo Litres per Day
Kmh	Kilometre hour
KWh	Kilo Watt hours
MJ	Mega Joules
MT	Million Tonnes

Ethanol Blending Policy in India: demand and supply issues

Saon Ray, Smita Miglani and Amrita Goldar

1. Introduction

The increase in consumption of fossil fuels as economies grow and the nearing depletion of such fuels has prompted a search for their alternatives worldwide. Biofuels have emerged as a substitute for fuel oil, especially for oil-importing countries and serve a multitude of purposes. The most important advantage of these fuels is that they are renewable, and are being seen as sustainable sources of energy. Some studies have also pointed out that biofuels help reduce environmental emissions,[1] apart from addressing the problem of the rising import cost of fuel oil.

Among liquid fuels, there are mainly two types of biofuel: alcohols (ethanol and butanol) and diesel substitutes (such as biodiesel and hydro-treated vegetable oils). They can be used either individually as fuels or for blending in petrol or diesel. While biodiesel is mainly manufactured by transesterification of vegetable oil, ethanol is produced from starch contained in crops such as corn and sorghum or through fermentation of sugarcane, molasses, and sugar-beet. In India, ethanol production is mainly done using sugarcane as feedstock.

Transport has been identified as a major polluting sector and hence the use of biofuels is important in view of the tightening of emission norms. It is argued that blending ethanol with petrol[2,3] and diesel will reduce import dependence on crude oil, saving on foreign exchange outflows to that extent. However, energy security can be addressed only if the supply of ethanol available to industry is adequate. This study examines the demand and supply of ethanol in India. We discuss the National Policy on Biofuels in the next section.

2. The National Policy on Biofuels

The Ministry of Petroleum and Natural Gas (MoPNG) issued a notification in September 2002 for mandatory blending of 5 per cent ethanol in nine major sugar-

[1] This is of special importance for India because the economy is facing substantial pressure from the United Nations Framework Convention on Climate Change (UNFCCC) to limit its carbon footprint. Thus, there is pressure on India to look for alternative and environmentally benign sources that can fulfil its energy requirements in a sustainable manner.

[2] For blending in petrol, ethanol should be anhydrous, with a concentration above 99.5 per cent in proportion. Water content, including denaturants and other impurities, is less than 0.5 per cent. Another form is hydrous ethanol, which is used neat, i.e., without addition of petrol, in vehicles designed specifically for its use.

[3] Ethanol blended with petrol is also known as gasohol.

producing states and four union territories from 2003.[4] In 2003, the Report of the Committee on Development of Biofuel, under the auspices of the Planning Commission, recommended a phase-wise implementation programme to blend biofuels with petrol and diesel. However, due to a supply shortage from 2004 to 2005, the ethanol-blending mandate was made optional in October 2004, but it resumed in twenty states in October 2006.[5] In October 2007, the Government of India made it mandatory to blend 5 per cent ethanol in petrol across the country, with the exception of J&K, the Northeast and island territories. In 2008, the Government of India announced its National Biofuel Policy, mandating a phase-wise implementation of the programme of ethanol blending in petrol in various states. The blending level of bio-ethanol[6] at 5 per cent with petrol was made mandatory from October 2008, leading to a target of 20 per cent blending of bio-ethanol by 2017.[7] This was taken up by the oil marketing companies (OMCs) in twenty states and four union territories.

The new biofuel policy was approved by the Union Cabinet in December 2009. In view of the multiplicity of departments and agencies, it was felt imperative to provide a high-level co-ordination and policy guidance/review of biofuel development, promotion and utilisation. For this purpose, the policy proposed to set up a National Biofuel Co-ordination Committee (NBCC), headed by the Prime Minister. Ministers from the concerned ministries were proposed to be members of this Committee. The role and active participation of the states was considered crucial in the planning and implementation of the biofuel programme. The policy also proposed that the minimum purchase price (MPP) for bio-ethanol should be based on the actual cost of production and import price of bio-ethanol. The price of ethanol would be determined by the Biofuel Steering Committee[8] and decided by the NBCC and, in the event of diesel or

[4] In order to study the financial and operational aspects of blending 5 per cent ethanol with petrol as allowed in the specifications of the Bureau of Indian Standards (BIS) for petrol, the government launched three pilot projects: two in Maharashtra and one in Uttar Pradesh (UP) during April-June 2001. Apart from these pilot projects, R&D studies were also undertaken simultaneously to establish whether it was safe to blend ethanol up to 5 per cent with petrol in vehicles. Discussions were held with concerned agencies, including the governments of major sugar-producing states. The Society for Indian Automobile Manufacturers (SIAM) had confirmed its acceptance for the use of 5 per cent ethanol-doped petrol in vehicles and state governments of major sugar-producing states and representatives of sugar and distillery industries confirmed the availability/capacity to produce ethanol.

[5] Maharashtra, Gujarat, Goa, UP, Haryana, Punjab, Karnataka, Andhra Pradesh., Tamil Nadu, Uttaranchal, Delhi, Himachal Pradesh, Madhya Pradesh, Chhattisgarh, Kerala, Rajasthan, West Bengal, Orissa, Bihar, and Jharkhand and four Union Territories (Chandigarh, Puducherry, Dadra & Nagar Haveli, Daman & Diu). An amending notification was issued in September 2006 to cover the entire country under 5 per cent EBP (except the north-eastern states, Jammu and Kashmir (J&K), Andaman and Nicobar Islands and Lakshadweep) with effect from November 2006.

[6] In the Government of India policy documents, reference is often made to 'bio-ethanol'. The broad definition of this term is basically the same as for 'ethanol' in this paper.

[7] The National Bio-fuel Policy proposed an indicative target of 20 per cent blending for both biodiesel and bio-ethanol by the year 2017. While the targets for biodiesel are in the nature of recommendations, ethanol blending was made mandatory from October 2008. The MoPNG decided to defer the proposed 10 per cent blending of ethanol, which was expected to start from October 2008.

[8] In March 2010, the government constituted an Empowered Group of Ministers (EGoM) to reconcile inter-ministerial differences on the EBP and to recommend an ethanol price that is affordable by all

petrol prices falling below the MPP for bio-diesel and bio-ethanol, OMCs would be duly compensated by the government. Biofuel imports would be permitted to the extent necessary and decided by the NBCC under the policy. Additionally, it was mentioned that bio-ethanol already enjoys a concessional excise duty of 16 per cent and bio-diesel is exempt from excise duty.[9] Duties and taxes would be levied on imports to ensure that indigenously produced biofuels are not more expensive than imported biofuels.

The objective of the National Biofuel Policy has been to encourage domestic production of ethanol and further the Ethanol Blending Programme (EBP) in the country. The Indian approach to bio-fuels is based on non-food feedstock to deliberately avoid a possible conflict between food and fuel. However, the implementation of the 5 per cent EBP throughout the country has in reality remained pending due to problems such as ethanol shortages, the variable taxation structure of state governments and certain regulatory restrictions. We examine the issues related to demand and supply of ethanol in the following sections.

3. Demand for and Supply of Ethanol in India

There are three main uses of ethanol in India. Of the total available ethanol, the maximum – about 45 per cent – is used to produce potable liquor, about 40 per cent is used in the alcohol-based chemical industry (as a solvent in synthesis of other organic chemicals) and the rest is used for blending with petrol and other purposes.[10] The demand for ethanol has been continually increasing on account of the growth of user industries and use of ethanol as a fuel in the country. However, the production and availability of ethanol has largely lagged behind. India is the fourth largest producer of ethanol in the world after Brazil, the United States of America (USA) and China, producing approximately 2000 million litres of ethanol,[11] mainly by fermentation of sugarcane molasses.[12] Ethanol is made by fermentation of sugars: enzymes from yeast change simple sugars into ethanol and carbon dioxide. Potable ethanol and more than half of industrial ethanol is made by this process (see Annexure 1).

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stakeholders. In July 2010, the EGoM affirmed its stand on fixing a price of Rs.27/litre for ethanol (as against a price of Rs. 21.50 per litre during 2006-09), to be applied on the produce that oil companies procure from sugar mills for blending with petrol.

[9] To promote ethanol usage for blending with petrol, the excise duty levied on manufactured ethanol was exempt from excise duty in the next processing stage. No other central taxes and duties were proposed to be levied on bio-diesel and bio-ethanol. Customs and excise duty concessions would be provided on plant and machinery for the production of bio-diesel or bio-ethanol, as well as for all engines run on biofuels, if these are not manufactured indigenously.

[10] Ethanol is also used as a feedstock to make ethers, also called Ethyl Tertiary-Butyl Ether (ETBE), an oxygenate with high-blending octane used in petrol. ETBE contains about 45 per cent ethanol.

[11] Bharadwaj et al. (2007)

[12] It is also utilised as cattle feed and in foundries as a binder. In surplus years, it is exported out of the country.

However, the amount of ethanol currently produced in India is not sufficient to meet domestic demand. In the year 2008-09, there was a huge unmet demand from the industrial sector, which was met by imports.

3.1 Demand for Ethanol

Data on ethanol production and consumption in India is published by many sources. Among these are the Indian Sugar Mills Association (ISMA), the U.S. Department of Agriculture (USDA), and the Indian Chemical Council (ICC). The estimates from these various sources vary considerably. One reason is that the year in question varies, e.g. the sugar year used by ISMA is from October to September, and the alcohol year used by ICC is from December to November. Estimates provided by USDA are for calendar year and those provided by the Planning Commission are for financial year April to March. Monthly data is not available to make comparisons across different sources.

Table 1 shows ethanol production and consumption figures from various sources. From this table we note that while the ICC data shows the widest deficit of ethanol, the least deficit is shown by data from ISMA. The data reported by the USDA show variability that is similar to the ISMA data: both report a surplus in 2006, 2007, and 2008, while showing a deficit in 2004 and 2005. Data estimates by the ICC present a slightly different picture. According to these, there has been a deficit of ethanol not only in 2003–04 but in all subsequent years (not shown by ISMA or USDA). In the final analysis however, we note that there is a huge deficit in the domestic supply of ethanol reported by each of the sources, though the amount of this deficit varies. It is noteworthy that ethanol production is beset with a cyclical pattern shown by sugarcane production, with three–four years of bumper harvests followed by relatively poor crops over a similar period.

Table 1: Ethanol production and consumption in India (million litres)

Ethanol Production	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
ISMA (in sugar year)*	1240	1925	2950	2715	1560	–
ICC (in alcohol year) #	980	1590	2100	2200	1300	1680
USDA FAS	1199	1300	1,898	2,398	2,150	1073
Ethanol Consumption						
ISMA (in sugar year)*	1410	1550	1700	1840	2010	–
ICC (in alcohol year) #	1470	1740	2120	2280	1650	2870
USDA FAS	1430	1479	1639	1750	1940	1780
Surplus Ethanol						
ISMA (in sugar year)*	(–170)	(375)	(1250)	(875)	(–450)	–
ICC (in alcohol year) #	(–490)	(–150)	(–20)	(–80)	(–350)	(–1190)
USDA FAS	–231	–179	259	648	210	(–707)
Imports						
ICC (in alcohol year) #	490	150	20	80	350	–
USDA FAS	–	–	29	15	70	280

Exports						
USDA FAS	–	–	24	14	3	3

Source: ISMA, Yearbook 2008–09 (Vol. I, pp. 438–39); USDA Foreign Agricultural Service (2010); and ICC data Note: (a) The estimates for 2007–08 and 2008–09 given by ISMA are provisional
**The sugar year is from October–September; #The alcohol year is from December–November.*

In the year 2003, the Report of the Committee on Development of Biofuels was published by the Planning Commission of India. It gave projections of demand and supply of ethanol for India for the end of each five-year plan (shown in Table 2). This report shows the break-up of production and consumption of ethanol in terms of molasses and cane. Data from different sources shows that as of 2010, the actual production of ethanol in India has not kept pace with the demand.

Table 2: Projected Demand and Supply of Ethanol (million litres)

Year	Ethanol production			Ethanol utilisation			Ethanol Blending Requirement for Transport Sector		Petrol Demand
	Molasses	*Cane*	*Total*	*Industry*	*Potable*	*Balance*			
2001–02	1775	0	1775	600	648	527	**5%**	448.03	8,960.52
							10%	896.05	
							20%	1,792.10	
2006–07	2300	1485	3785	711	765	2309	**5%**	638.14	12,762.72
							10%	1,276.27	
							20%	2,552.54	
2011–12	2300	1485	3785	844	887	2054	**5%**	814.30	16,286.09
							10%	1,628.61	
							20%	3,257.22	
2016–17	2300	1485	3785	1003	1028	1754	**5%**	1,039.27	20,785.36
							10%	2,078.54	
							20%	4,157.07	

Source: Planning Commission (2003).

Note: Figures for petrol demand in million litres are calculated on an assumption of ethanol density of 0.789g/ml. Planning Commission (2003) also gives ethanol demand estimates, assuming an ethanol density of 0.85g/ml.

Table 3 provides an overview of the demand for ethanol in India by the transport sector at the 5 percent level of blending. It shows that, if an annual growth rate of 3.5 per cent for alcohol-based chemical industry and 3 per cent for potable alcohol industry is assumed,[13] the total ethanol consumption demand for all sectors combined amounts to

[13] These growth rates were assumed by the Planning Commission (2003).

approximately 3,020 million litres in 2011–12.[14] This includes the Planning Commission's (2003) demand estimate of 814.30 million litres of ethanol for EBP. This is likely to rise if the blending mandate is extended to 10 per cent and subsequently to 20 per cent.

Table 3: Ethanol Consumption Demand by 2011–12 (million litres)

Use	Planning Commission (2003) estimate		SIAM estimate	
	ICC estimates	*USDA FAS estimates*	*ICC estimates*	*USDA FAS estimates*
Chemical Industry (growth @3.5% p.a.)	1071.23	750	1071.23	750
Potable Industry (growth @3% p.a.)	1135.16	1010	1135.16	1010
EBP	814.30	814.30	1517	1517
Total	3020.69	2574.30	3723.39	3277

Source: Authors' estimates.
Note: Approximately 814.3 millon litres is the ethanol consumption demand estimated by Planning Commission (2003), whereas 1517 million litres is the demand estimated by SIAM.

However, data from ISMA shows that ethanol production has grown at a compound annual CAGR of about 3.3 per cent between 1992-93 and 2008-09. If production is assumed to grow at this rate, total ethanol production in India will be around 2,022 million litres by 2016–17. This is just about half the ethanol requirement of transport sector at 20 per cent blending by 2016–17 and only 67 per cent of projected ethanol demand by 2011-12. Hence, there would be a large unmet demand for ethanol in the country. Moreover, it must also be noted that only modest rates of growth for chemical and potable industries have been assumed here.[15] A more robust growth in these sectors will mean an even greater shortage of ethanol.

3.2 Supply of ethanol

Ethanol is primarily produced using sugarcane molasses, a by-product of sugar manufacturing in India. Three factors primarily determine sugarcane production in India: area under sugarcane production, sugarcane yield per hectare, and the proportion of sugarcane output that is crushed by sugar factories. The area under sugarcane production in India has increased nearly 2.5 times since 1950–51 (Pohit et al., 2009) (reaching about 5.04 million hectares in 2007–08). However, it has tended to stagnate in the recent past (Table 4). There has also been considerable variation in the area under

[14] ISMA does not provide the break-up of the consumption of ethanol and hence the amount available for petrol blending in the country. If the estimates of ethanol use in petrol from other sources are added to these figures since 2005-06, the total would be higher.
[15] The authors were informed of the 10 per cent growth rate of the potable alcohol sector and the 5 per cent growth rate of the alcohol-based chemical industry during stakeholder consultation meetings.

sugarcane production over time. Cultivation of this crop tends to follow a cyclical pattern of output (with three–four years of bumper harvests followed by relatively poor crops over a similar period subsequently). Farmers shift to other crops partly because of this, and also because other crops can be grown more profitably or within a shorter time span compared to sugarcane.

Table 4: Area under production, production and yield of sugarcane in India

Year	Area (million hectares)	Production (million tonnes)	Yield (tonnes/hectare)
1985–86	2.85	170.65	59.9
1995–96	4.14	282.94	68.4
2000–01	4.32	296.00	68.6
2001–02	4.41	297.21	67.4
2002–03	4.52	287.38	63.6
2003–04	3.94	233.90	59.4
2004–05	3.66	237.09	64.8
2005–06	4.20	281.17	65.6
2006–07	5.15	355.52	69.0
2007–08	5.04	340.56	67.5
2008–09 (P)	4.40	271.20	61.7

Source: Indian Sugar Millis Association, Indian Sugar Year Book 2008–09 Vol.1, pp. 18; Handbook of Sugar Statistics October 2009, pp. 1. Note: (P):– Provisional estimates

The main feedstock for producing ethanol in the country is molasses, a by-product of sugar manufacture. Annexure 2 shows the production trend data of molasses in India published by the ISMA. The sugarcane production in 2008-09 was 271.2 million tonnes (ISMA). In India's case, industry sources reveal that ethanol production in India has been taking place almost entirely through the final 'C' grade molasses[16] (i.e. a litre ethanol can be extracted from 0.004 tonnes of molasses).[17] As reported by ISMA, the ethanol production was 1,560 million tonnes in 2008-09. However, using the ethanol demand estimate of 3723 million litres (see Table 3) and making assumptions about industry growth rates, a grand total of approximately 545 million tonnes sugarcane is estimated to be required for consumption in India by 2011-12 (with the mandated 5 percent blending for transport). This is much higher than approximately 355 and 340 million tonnes of sugarcane produced in 2006-07 and 2007-08, which were recorded as the bumper crop years.[18]

[16] 'C' grade molasses is the last category of molasses syrup remaining after repeatedly boiling sugarcane juice of which the maximum possible crystallisable sugar has been extracted. Grade 'B' molasses has comparatively higher percentage of fermentable sugar left and grade 'A' the highest percentage of these categories.

[17] Pohit et al. (2009). The ISMA publications assume an average yield of 240 litres alcohol per tonne of molasses.

[18] The above estimations of sugarcane demand were made assuming that ethanol production is done using only 'C' heavy molasses feedstock in India. This estimate would get lowered if we assume some proportion of ethanol being sourced from 'A' and 'B' molasses and/or directly from cane juice as well.

3.3 Ways to augment sugar production and availability of ethanol

A major problem in this regard is that in India, sugar production in general follows a 5-7 year cycle i.e. production increases over a 3-4 year period, reaches a high, which in turn, results in lower sugar prices. As a result of lower sugar price realisations of sugar mills, the sugarcane arrears to farmers increase. This results in lower sugarcane production for the next 2-3 years. Due to lower sugar production, the prices shoot up resulting in increased area under sugarcane cultivation during the next season, following which there is usually a glut again. It is a systemic problem which needs to be resolved through targeted policy regulations.

Yearly fluctuations in output, along with varying market estimates of demand for sugar, make the scenario for policy and business planning purposes uncertain. When sugar prices are low, millers' margins are squeezed and they are not able to earn enough to recover their costs of converting cane to sugar.[19] In many parts of India, the sugarcane industry faces severe financial problems. When factories are financially constrained, they take delivery of cane but postpone payments to farmers, forcing them into a debt trap. Farmers in India switch between cane and other crops more frequently than in countries such as Brazil: due to uncertainties regarding payments from millers and the high investment requirements for the crop.[20]

The integration of production and milling up to the ethanol production stage, if implemented on a large scale, could ensure an efficient production set-up. This is another measure that needs to be considered to ensure a sustained supply of ethanol at reasonable prices (as shown in Table 8). Between 2003 and 2010, the supply of ethanol lagged behind the demand for it, partly because ethanol in India is produced from molasses rather than directly from sugarcane.[21] In this context, Pohit *et al*. (2009) have pointed out that allowing the direct use of sugarcane for ethanol manufacture can provide sufficient availability of ethanol. India also needs large investments to augment crushing capacity.

Another option is considering the use of alternative feedstock such as sweet sorghum or sugar beet, as is done in Europe. However, the technologies available today for breaking down cellulosic materials into sugar are expensive, and the cost of harvesting and transporting cellulosic feedstock to ethanol plants can also be high (ESMAP, 2005). Advances in biotechnology could enable cost-effective saccharification, fermentation and commercialisation of the readily available cellulosic material.

[19] To recover the cost of production, the final price of sugar should be higher than the sum of conversion and production cost.

[20] Annexure 3 shows the area under production, produce and yield of sugarcane for selected countries between 1999 and 2002.

[21] Pohit *et al*. (2009).

3.4 Imports of ethanol

The other way to enhance ethanol supply in the country is to increase imports from abroad. Some argue that given so many constraints, India can only meet its needs from imports from surplus countries such as Brazil as has been done in the past. This is a viable way out as long as it remains cost effective to do so. Among foreign markets, Brazil which mostly makes ethanol directly from cane, exports substantial quantities after taking care of its domestic requirements (which have also been rising over time). Statistics on ethanol imports shown in Table 5 are compiled by the Ministry of Commerce.[22]

Table 5: India's Ethanol Imports (million litres) (Fiscal Year April–March)

Year	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Quantity	0.33	23.65	4.83	7.65	0.05	0.13	19.82	7.38	313.53	310.77	39.24	5.04	71.54	278.96

Source: http://commerce.nic.in/

In May 2009, the Planning Commission advised the government to consider providing incentives to encourage companies to acquire sugarcane plantations abroad, especially in countries such as Brazil. India's leading sugar refiner and ethanol producer, Shree Renuka Sugars,[23] has a long-standing presence in Brazil and is now counted among the top five sugar producers there. In the year 2010, it acquired a 50.34 per cent controlling stake in Equipav SA AA, the Brazilian sugar and ethanol-producing company.[24] This follows the 100 per cent acquisition of another Brazilian firm, Vale do Ivai, in 2009.[25]

Another option worth exploring is collaboration with Brazil and other prospective international suppliers of ethanol in the areas of R&D, and cross-border investments. Initiatives along similar lines should be encouraged as they can secure raw material supplies to meet the growing demand for sugar and ethanol in India, besides promoting technology transfers between the companies.[26]

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[22] The data compiled by the Ministry of Commerce includes imports of industrial ethanol as well. However, the break-up between industrial and bio-ethanol is not available.

[23] Shree Renuka Sugars has a 21 per cent market share in India's fuel ethanol market and accounts for 20 per cent of India's international sugar trade.

[24] Equipav AA has mills with a yearly cumulative cane-crushing capacity of 10.5 million tonnes and a mega sugarcane plantation facility in Sao Paulo state of Brazil. It also owns a bagasse-based power co-generation capacity pegged at 203 MW.

[25] Vale do Ivai is a Brazilian producer of sugar and ethanol with a yearly cane-crushing capacity of 3.1 million tonnes from its two mills.

[26] http://www.livemint.com/2010/02/21232754/Shree-Renuka-clinches-deal-wit.html

4. Sectors using ethanol

Traditionally, the ethanol produced in the country was used primarily for potable purposes. However, the alcohol-based chemical industry was set up in the country as a way to use molasses (which is a waste by-product) that the sugar industry was finding difficulty in disposing off. This entailed the production of chemicals such as acetic acid, acetic anhydride, ethyl acetate, acetone, MEG, etc. that provide feedstock for a variety of industries such as synthetic fibres, pesticides, pharmaceuticals, paints, dye and adhesives. Ethanol produced in the country easily met the consumption requirements of these two industries until around the year 2002 when ethanol also started being used for blending with petrol in some major cities of the country. Though the blending proportion of ethanol was just about 5 per cent, margins tightened over the years as the policy gradually covered the other Indian states. Currently, of the 325 distilleries in India, ethanol produced is utilised in a ratio of about 50-52 per cent for potable use, 36-38 per cent for industrial use and 12-14 per cent for blending in petrol and other uses. The following sub-sections discuss the consumption in each of these segments along with the issues involved therein.

4.1 The Potable Alcohol Industry in India

The India potable alcohol market can be classified into 'country-made liquor' and 'Indian-Made Foreign Liquor' (IMFL) which account for the bulk of alcohol utilisation in the country.[27] The potable alcohol industry is estimated at a market value of approximately Rs. 300 billion and has been growing at the rate of 7–10 per cent per annum over the past few years. However, the exact shares of country liquor and IMFL manufacturing are unknown since production of the former category still thrives illegally in many areas, making it difficult to arrive at a correct estimate.

The potable alcohol produced in India is primarily made from sugarcane molasses and not from grain as in many other countries. Due to the increasing uncertainties involved in molasses availability (and the resultant increase in its prices) the industry is gradually accepting the option of grain-based alcohol.[28] However, molasses still accounts for most domestically produced potable alcohol in the country. Apart from feedstock constraints, the growth of the industry is impeded by a high tax/duty structure; potable beverages are heavily taxed at various stages of production and distribution.

[27] A third category of liquor consumed by the populace is known as 'Bottled in Origin' (BIO) products but these are mainly imported from abroad.

[28] Since grain prices have remained quite stable compared to sugarcane-based molasses, cost of production using grain feedstock remains quite predictable for alcohol producers. But in general, it is more expensive to use grains unless molasses prices are very high. Thus, establishing dual substrate facilities gives distilleries flexibility to switch between molasses and grains according to price changes.

The process of manufacturing IMFL (such as whisky, rum, and brandy) includes a secondary distillation of the fermented mixture of grains and molasses that yields extra neutral alcohol (ENA) with 94.6 per cent alcohol content which is reduced in strength, blended with other products (including water) and flavoured to obtain IMFL. The IMFLs are usually of 42.8 per cent v/v ethanol content. In the past few years, significant growth has been achieved in the production of quality spirits and the industry is now exporting these products. In terms of market players, the IMFL industry is highly consolidated with a few companies holding significant shares in the market. The production centres for IMFL are mostly located in the sugar-producing states of Maharashtra, UP, Karnataka, and Tamil Nadu and some in Haryana and Punjab. Regulation and taxation of the sector is under the jurisdiction of the state governments and is large source of revenue for the states.[29]

With the implementation of the ethanol-blending programme of the government, ethanol availability to the potable alcohol industry is likely to get affected unless its supply is increased. Increased demand for ethanol has also resulted in the increased price of molasses in past few years.

4.2 The Chemical Alcohol-based Industry in India

The Working Group on the Chemical Industry for the 11th Plan (2007–2012) estimates the size of the alcohol-based chemical industry to be Rs. 4500 crore with 20 major units engaged in the manufacture of chemicals. The alcohol-based industry is, therefore, a very important constituent of the organic chemicals sector and the entire Indian chemicals industry in general. The report also calculates that the industrial chemical sector accounts for approximately 53 per cent[30] of domestic ethanol consumption (999.3 million litres) with three companies accounting for the lion's share (62 per cent) of this. The sheer magnitude of consumption of ethanol by the sector makes it the second largest consumer of ethanol in the country, behind the potable sector.

Estimates of ethanol consumption made by the alcohol-based chemical industry and the Planning Commission differ. A comparison of chemical industry estimates with estimates from the Planning Commission's "Report of the Committee on the Development of Biofuels" shows that the chemical industry estimates are much higher. The Planning Commission estimates consumption by the chemical industry to be 711 million litres in 2006-07. The report also states that by the end of the 12th Five-Year Plan, i.e., 2016–17, demand for ethanol by the sector would increase to 1003 million litres (assuming 3.5 per cent growth in ethanol consumption for chemical use). Actual consumption data provided by the chemical industry show that the level of ethanol consumption is much higher. Table 7 shows that that the chemical sector consumed 1,014 million litres of ethanol in 2006-07. However, the figures show that the

[29] The sector is also subject to government licensing and constraints on imports from abroad.
[30] Industry estimates show the number to be lower - at around 40 per cent.

consumption by this sector has been falling since then. The growth of the industry is critically dependant on adequate ethanol availability.

Table 6: Alcohol Consumption (December–November) (in lakh litres)

	2006–07	2007–08	2008–09	2009–10 (Aug'10)	2009–10 Expected	2010–11 Expected
Industry Total	10147	9607	5356	4404	6248	6740

Source: ICC
Note: Alcohol consumption growth rate by the chemical industry for 2010–11 is assumed to be 8%.

The growth in ethanol consumption is primarily driven by production requirements for alcohol-based chemicals such as acetic acid and ethyl acetate that are, in turn, used in other industrial products as well as feedstock.[31] Although many of these chemicals can be produced using petrochemicals, Nguyen *et al.* (2010), who compare these two processes based on their production cost, environmental impact and safety, point out that the bio-ethanol-based process is less expensive and has lower carbon dioxide emissions than the fossil-based process, though it poses greater safety hazards.

With rapid economic growth, the demand for these chemicals is set to rise further. Given the constraints of ensuring a rapid enough increase in ethanol production, it is apparent that the country will have to depend on imports either of ethanol or of alcohol-based chemicals from international markets.

4.3 Ethanol in India's Automobile Sector

The Government of India's policy mandating 5 per cent ethanol blending in petrol is currently being implemented in the country. An indicative target of minimum 20 per cent ethanol-blended petrol across the country has been set for the year 2017. The preparedness of the automobile industry is a major factor in the successful implementation of this policy, given the fact that petrol-run vehicles account for the majority of vehicles registered in India.[32]

The Planning Commission (2003) gives an account of the advantages of ethanol blending in conventional petrol *vis-à-vis* other substitutes such as methanol. [33, 34, 35]

[31] While many of these chemicals have industrial uses, a large number are also used as feedstock to produce other derivative chemicals. For example, acetic acid is used to generate both vinyl acetate monomer (VAM) as well as purified terephthalic acid (PTA).
[32] For instance, SIAM estimates provide an indicative figure that on average, 66-68 per cent of annual sales of passenger vehicles in India in the past three years were petrol-run vehicles.
[33] It is cheaper to manufacture hydrous ethanol as it does not require purifying ethanol to remove residual water.
[34] The disadvantages of ethanol-blended petrol are that it vaporises more readily and could aggravate ozone pollution in warm weather. Due to its moisture content, it can damage rubber seals/diaphragms if present in a high concentration (an inhibitor additive can be used to counter corrosion).

Ethanol's vapour pressure is lower than that of petrol, resulting in lower evaporative emissions while its flammability is also much lower than that of petrol, reducing the risk of vehicles catching fire.[36] In addition, there is no gum formation associated with ethanol, and anti-oxidants and detergent additives are not required. Other advantages of ethanol are that it improves the octane number,[37] has a higher volumetric efficiency leading to increased power and has advantages of wider flammability limits and higher flame velocity (Planning Commission, 2003).[38] Although the calorific value of ethanol is lower than that of petrol, it is still preferred because of its higher efficiency due to its higher oxygen content.[39] This is also the reason for its use as a 100 per cent fuel in Brazil.

Test results of conventional vehicles for ethanol compatibility reveal that the existing vehicular fleet in India is mostly compatible with 5 per cent ethanol-blended petrol with almost no serious environmental implications. A blending of less than 10 per cent has a few disadvantages, which are not serious, and there is no need to modify the engine. Blends above 15 per cent ethanol, however, require engine modifications.[40]

Internationally it has been shown that low ethanol-petrol blends (5–10 per cent ethanol) can fuel petrol vehicles with little if any engine modification during production (IEA,

[35] Addition of oxygenates in conventional fuels such as petrol enables it to burn more fully and thus increases its fuel efficiency. Methyl Tertiary-Butyl Ether (MTBE) ethanol are the most accepted fuel oxygenates because of their high oxygen content. MTBE, used as an octane enhancer in fuels, is manufactured by combining methanol and isobutene. Methanol (wood alcohol) is derived from natural gas, while isobutene is from crude oil/ natural gas. Although it has high oxygen content and other desirable properties, methanol often encounters solubility problems in petrol. Thus, ethanol is preferred over MTBE and methanol.

[36] A disadvantage of ethanol (relative to MTBE) is that it has a greater tendency to absorb water/moisture. Other disadvantages over petrol such as (i) lower energy content (thus requiring a larger fuel tank), (ii) higher aldehyde emissions, (iii) corrosiveness, affecting metallic parts, (iv) higher latent heat of vapourisation of ethanol causing starting problems (affecting engine performance and drivability), and (v) higher evaporation losses due to higher vapour pressure.

[37] Ethanol has a high octane number and, when used as a blending fuel with petrol, has a low tendency to create knocking in spark ignition engines. Oxygen in its molecule allows low-temperature combustion with reduced carbon dioxide emissions. Thus, ethanol offers a more complete combustion of the fuel mixture, which partly offsets its less desirable property of 'lower energy content per litre'. Ethanol-petrol blending is more practical because ethanol can increase the octane rating of the fuel without adding to pollution.

[38] As an alternative fuel for automotive petrol, ethanol is commonly used as an oxygenate to improve the combustion and emission quality of petrol since it has a higher octane number than petrol. This allows a more efficient combustion of fuel, and less emission of unburnt hydrocarbons and particulate matter.

[39] The performance parameters of ethanol blends with petrol have also been estimated by the Planning Commission (2003). Theoretically, when petrol is blended with oxygenates, it is expected to decrease the energy content of petrol, leading to decreased mileage. Blending up to 10 per cent ethanol reduces fuel economy only by between 1 and 3 per cent on highways, which is not significant.

[40] These relate to modifications to prevent the corrosion of metal parts, using compatible elastomers for oil seals and rubber components, and providing a larger orifice for more flow of fuel through the carburettor/ injector, retarding ignition timing and increasing the compression ratio to offset the lower cetane number of ethanol.

2007). This has also been proved in Brazil and the US during the past two decades.[41] Today, auto manufacturers in Brazil produce vehicles that are specially modified to run on a higher percentage of ethanol.[42] The main mechanical differences between ethanol and petrol vehicles lie in engine calibration and the fuel management system.[43] The success in using ethanol as a fuel in Brazil, [44] the US and the EU offers a large experience that can be usefully tapped by countries such as India to develop their own infrastructure for EBP. A vehicular fleet with Flex Fuel Vehicles (FFV) will be essential to run a successful long-term ethanol programme as India plans to mandate 20 per cent of ethanol blending in petrol by 2017. FFV technology as adopted in Brazil is now sufficiently well-developed to allow the gradual introduction of biofuels in any country.

In India, apart from the scarcity of ethanol at an affordable price, multiple taxes on denatured ethanol that complicate inter-state movement, unclear licensing and procurement rules, non-standardised blending methodology; and non-compatibility of existing handling, storage, dispensing and retail distribution systems with ten percent blended petrol are other areas of concern (SIAM, 2008). There is a need to establish separate dispensing outlets with labelling at petrol-pumps and in-line (injection) blending instead of splash blending[45] (using control-systems to control water absorption in fuel).[46] The automobile industry needs sufficient lead time to make appropriate engine and other modifications so that vehicles are compatible with higher levels of blended fuel. Ethanol has lower energy content than petrol, and thus ethanol-blended petrol has a lower calorific value than standard petrol. Consumers would therefore need larger fuel tanks, and other design modifications would have to be made to vehicles if a higher level of blended fuel is used.

[41] Prompted by the increase in oil prices in the 1970s, Brazil introduced a programme to produce ethanol for use in automobiles in order to reduce oil imports. Today, ethanol provides roughly 40 per cent of transportation fuels in the nation, more than in any other country in the world.

[42] In 2001, the Brazilian government provided tax preferences for the purchase of new flex-fuel cars (14 per cent sales tax, compared to a 16 per cent sales tax on petrol-only vehicles) (Sandalow, 2006). By February 2006, Flex Fuel Vehicles (FFVs) represented 70 per cent of new car sales in Brazil. International experience (Brazil and the US) shows the overall compatibility of new vehicles with E10.

[43] FFVs are not required until E10, since only a few modifications in plastics in vehicles are required. For material compatibility, it is recommended that components that come in contact with the fuel, such as piston rings, engine blocks and valve seals, be made of ethanol-compatible materials.

[44] The high growth of FFVs in Brazil during the past few years is the result of the ability of auto companies to rapidly scale up production and the instant acceptance of such cars by consumers. Ethanol-compliant vehicles come with special computerised systems that monitor the ethanol-petrol ratio of the fuel, optimise performance and adjust the emission control devices. Besides neat ethanol, all motor petrol sold in Brazil contains 20–25 per cent ethanol.

[45] With in-line blending, ethanol is metred into petrol as it travels through a pipe. In splash blending, ethanol is added directly to a tanker or a delivery truck along with the base petrol.

[46] Splash blending is considered to be less accurate than in-line blending as it is generally not open to on-site blend testing. There is also a risk of inaccurate blend ratios if the delivery truck has not travelled far enough to provide adequate mixing.

5. Policy Recommendations and Conclusion

The study examines the domestic demand and supply situation of ethanol in context of 'Ethanol Blending Programme' in India. The ethanol blending programme was launched in India in 2002. The blending of bio-ethanol at 5 per cent with petrol was made mandatory from October 2008 and was to be taken up by the oil marketing companies in 20 states and four union territories. The Indian approach to biofuels is based on non-food feedstock to deliberately avoid a possible conflict between food and fuel. However, the implementation of this policy has not had much success. This was mainly due to the shortage of ethanol. For successful implementation of EBP in India, a steady supply of sugarcane (or sugarcane juice) as feedstock at affordable price *vis-à-vis* petrol is required.

The estimated total sugarcane requirement in India by 2011–12 is more than the production of sugarcane in bumper years (approximately 355 and 340 million tonnes during 2006–07 and 2007–08 respectively). Achieving an increase in area under sugarcane cultivation is difficult because it is a highly water-intensive crop and largely irrigated crop in India. But improvements in the productivity and yield of sugarcane and in the recovery of sugar may bear fruit.

In May 2009, the Planning Commission of India advised the government to consider providing incentives to companies to acquire sugarcane plantations abroad, to bring ethanol into the country. Other options include collaboration with Brazil and other prospective international suppliers of ethanol in areas of R&D and cross border investment. These measures along with other steps to augment the domestic availability of ethanol, like the integration of the production and milling of sugarcane to the ethanol production stage can alleviate some bottlenecks.

A DBT–CII (2010) study on estimation of net energy and carbon balance of bio-ethanol across its value chain concludes a net positive energy balance resulting in overall reduction of carbon emissions; life-cycle studies in the field are still ongoing. The lower calorific value of EBP has implications for material, design and performance compatibilities of vehicular fleet. As the discussion on the tests of automobiles revealed, the regulated emissions of carbon dioxide, nitrogen oxide and hydrocarbons increased using ten percent blending with mileage accumulation on all test vehicle categories. Thus, while the blending up to five percent does not have any serious implications, the subsequent step up to ten and twenty percent will have to be done with caution.

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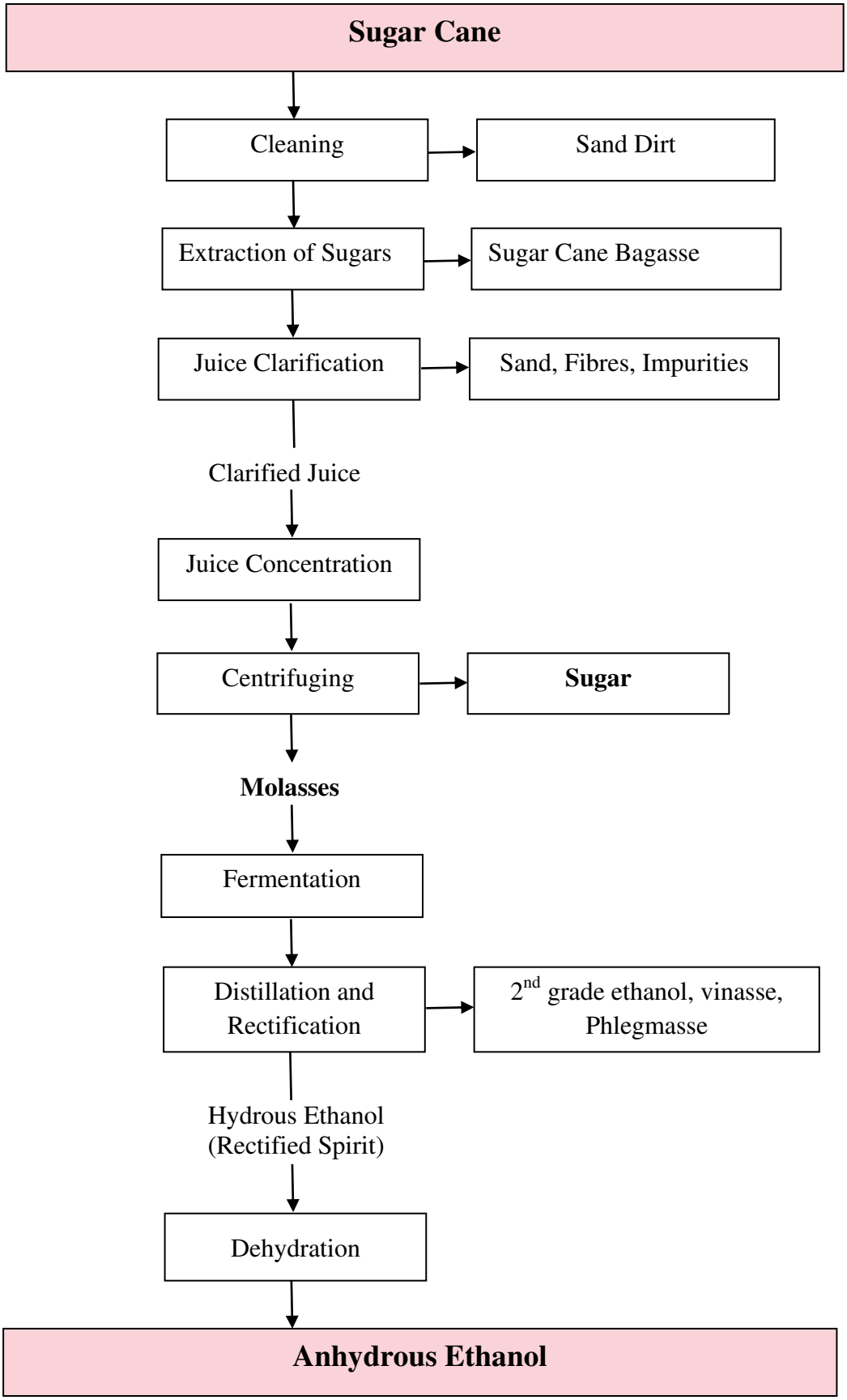
Annexure 1: Flow Diagram of the Ethanol Production Process



Annexure 2: By-Products of Sugar Industry (million tonnes)

Year	Molasses Production	Molasses utilised for alcohol production at 95 per cent
1992–93	4.35	4.13
2001–02	8.07	7.66
2006–07	13.11	12.45
2007–08 (P)	11.31	10.75
2008–09 (P)	6.5	6.17

Source: Indian Sugar Mills Association, Yearbook 2008–09, Vol. 1, p. 438–39.
Note: (a) In reality, about 80 to 90 per cent of molasses is used for ethanol production in India every year (also mentioned in Section 3).
(b) The term 'alcohol' in the table can refer to 'ethanol' here.

Annexure 3: Area, Production and Yield of Sugarcane for Selected Countries

Country	Area, Production and Yield of Sugarcane for Selected Countries (1999–2002) (Area : ' 000 Hectare; Production : ' 000 Tonne; Yield : Kg/Hectare)											
	1999			*2000*			*2001*			*2002*		
	Area	*Production*	*Yield*	*Area*	*Production*	*Yield*	*Area*	*Production*	*Yield*	*Area*	*Production*	*Yield*
Bangladesh	165F	6951	42127	174F	6951F	39948	169	6742	39921	163	6502	39890
Brazil	4860	333314	68579	4812	324668	67470	5023	339136	67510	5062	360556	71228
India	**4150**	**282250**	**68012**	**4200**	**315100**	**75024**	**4050**	**286000**	**70617**	**4100**	**279000**	**68049**
Pakistan	1056F	53104F	50279	923F	51210	55483	850F	49070	57729	1000	48042	48042
Philippines	358*	26287F	55914	1010	46333	45883	961	43606	45385	390*	25835	66244
U.S.A	401	32406	80787	420	32973	78570	417	31571	75799	415	32597	78547

*Source: Ministry of Agriculture, Government. of India as extracted from http://www.indiastat.com Note: F: FAO Estimate; *: Unofficial figure.*

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