POLICY BRIEF #77

FOOD VS FUEL: RECALIBRATING INDIA'S ETHANOL BLENDING STRATEGY

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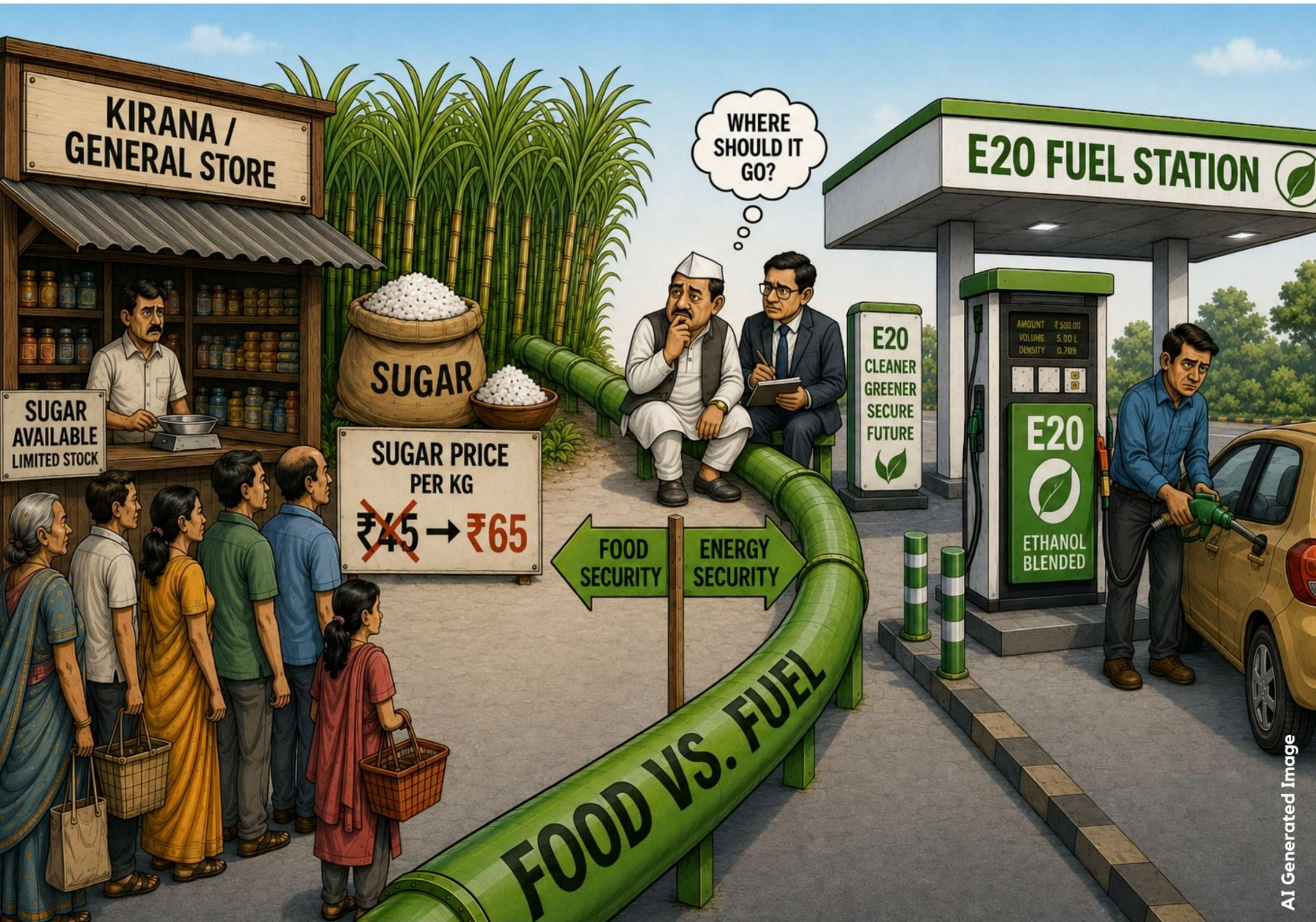

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Abstract

India has rapidly expanded its Ethanol Blended Petrol (EBP) Programme, which promotes blending of ethanol in petrol. The ethanol is produced from agricultural commodities such as sugarcane, maize and surplus rice. The programme aims to reduce dependence on imported fossil fuels and increase the use of domestically produced renewable fuel. The Government had a target of E20 i.e., petrol should contain up to 20 per cent ethanol by volume. India achieved this target in the Ethanol Supply Year (ESY) (November to October) 2025–26, five years ahead of the original schedule. During 2019–20 to 2025–26, ethanol supplied to oil marketing companies increased from 1.73 billion litres (173.03 crore litres) to a projected 12 billion litres (1,200 crore litres). This represents a CAGR of about 38 per cent over six years. In contrast, production of the agricultural commodities like sugarcane, maize and rice, used to produce ethanol grew much slowly. During the same period maize production grew at 11.4 per cent CAGR, rice at 4.4 and sugarcane at 5.1 per cent. This widening gap in growth of ethanol demand for blending and the supply of feedstock to meet that demand is creating a growing food-versus-fuel trade-off. The trade-off is already evident in the sugar market. Where a low opening stocks and lower production have coincided with a 44 per cent rise in modal retail sugar prices, from ₹45 per kg in July to ₹65 per kg by 29 August.

The brief examines whether the benefits of replacing petrol with ethanol justify the economic, energy and environmental costs of producing the agricultural feedstocks required for E20. The brief compares India's experience with that of the United States and Brazil. It reviews existing evidence on the energy and environmental performance of ethanol, and examines how different feedstocks are priced. The findings suggest that current assessments and procurement prices do not adequately capture the full economic and environmental cost of producing ethanol. In particular, subsidised fertiliser, electricity used for irrigation, water use and the opportunity cost of diverting food and feed commodities are largely absent from existing assessments. For example, the Food Corporation of India (FCI) procured rice supplied to ethanol distilleries are priced at ₹2,320 per quintal which is substantially below its estimated economic cost of ₹4,173 per quintal in 2025-26.

The brief therefore argues for a more adaptive and market-oriented approach to the ethanol blending policy. It recommends using sugar imports as an immediate buffer during shortages; limiting FCI rice largely to genuine surplus stocks while moving its pricing closer to at least the acquisition cost; making feedstock allocation responsive to agricultural conditions; greater openness to feedstock and ethanol imports. Most importantly, it calls for an India-specific well-to-tank assessment of sugarcane, maize and rice. A study that incorporates their full energy, environmental and economic costs, including implicit subsidies. Reforming distortionary input subsidies and allowing ethanol producers greater flexibility to choose feedstocks based on their true market costs could improve efficiency. In the longer term, second-generation ethanol from agricultural residues and other non-food biomass offers a way to expand ethanol use without intensifying the competition between food and fuel.

Acknowledgement

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List of Abbreviations

2G	Second-generation (ethanol produced from lignocellulosic biomass)
AA	Advance Authorisation
ANA	Agência Nacional de Águas e Saneamento Básico (National Water and Basic Sanitation Agency), Brazil
BCD	Basic Customs Duty
BE	Budget Estimate
BS-VI	Bharat Stage VI (vehicle emission standard)
CACP	Commission for Agricultural Costs and Prices
CAGR	Compound Annual Growth Rate
CIF	Cost, Insurance and Freight
DES	Directorate of Economics and Statistics, Department of Agriculture and Farmers' Welfare
DFPD	Department of Food and Public Distribution
DGFT	Directorate General of Foreign Trade
DoCA	Department of Consumer Affairs
E10 / E15 / E20 / E30	Petrol blended with 10, 15, 20 or 30 per cent ethanol by volume
EBP	Ethanol Blended Petrol (Programme)
EPE	Empresa de Pesquisa Energética (Energy Research Office), Brazil
ESY	Ethanol Supply Year (1st November to 31st October)
FAO	Food and Agriculture Organization of the United Nations
FCI	Food Corporation of India
GM	Genetically Modified

GREET	Greenhouse gases, Regulated Emissions and Energy use in Technologies (lifecycle model, Argonne National Laboratory)
GST	Goods and Services Tax
ITC	International Trade Centre
JEC	JRC–EUCAR–CONCAWE research collaboration (Well-to-Wheels methodology)
LCA	Life Cycle Assessment
MJ	Megajoule
MMT	Million Metric Tonnes
NITI Aayog	National Institution for Transforming India
OECD	Organisation for Economic Co-operation and Development
OMC	Oil Marketing Company
OMSS(D)	Open Market Sale Scheme (Domestic)
PIB	Press Information Bureau
RE	Revised Estimate
SION	Standard Input Output Norms
TE	Triennium Ending
TRQ	Tariff Rate Quota
TTW	Tank-to-Wheel
UPA	United Progressive Alliance
US / USA	United States of America
USDA	United States Department of Agriculture
WTT	Well-to-Tank
WTW	Well-to-Wheel

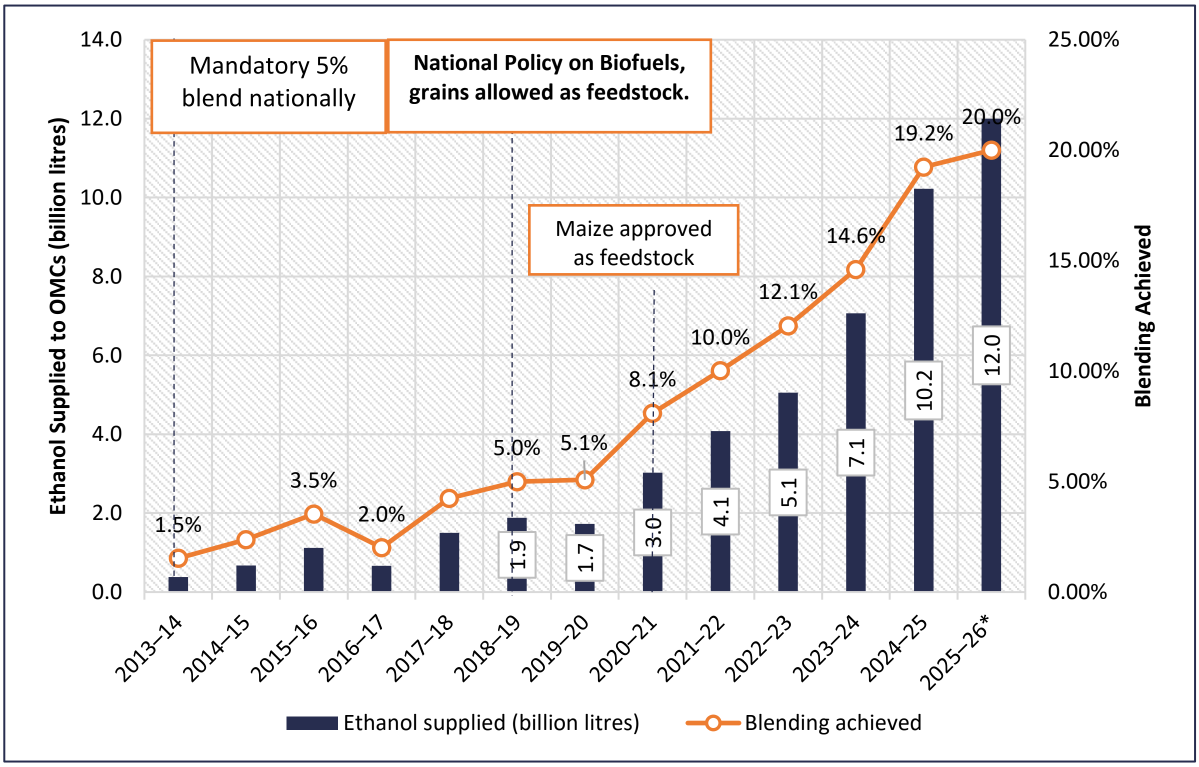
Food vs Fuel: Recalibrating India's Ethanol Blending Strategy

Ashok Gulati and Tanmoy Adhikary

1. Background

India has made remarkable progress in ethanol blending over the past six years (since 2019-20), although the programme's origins go back to more than two decades. In 2001, oil marketing companies (OMCs) launched three pilot projects for marketing ethanol-blended petrol, with the objective of reducing dependence on fossil fuels and promoting a renewable domestic fuel. Following the positive experience from these pilots, the Government decided in September 2002 to launch the Ethanol Blended Petrol (EBP) Programme from January 2003, initially targeting 5 per cent ethanol blending in nine States and four Union Territories. The first phase covered Uttar Pradesh, Maharashtra, Goa, Punjab, Haryana, Gujarat, Karnataka and parts of Andhra Pradesh and Tamil Nadu, along with Chandigarh, Dadra & Nagar Haveli and Uttarakhand. The programme was subsequently extended in November 2006 to 20 States and four Union Territories.

Figure 1: Evolution of Ethanol Blending Programme in India



Source: (DFPD, 2026)

Despite these early policy interventions, the programme progressed slowly for more than a decade. Blending remained at only around 1.5 per cent in 2013–14 (**Figure 1**), reflecting persistent constraints in feedstock availability and flexibility, limited inter-state movement, taxation and inadequate ethanol supply. The UPA government at that time also did not pursue the programme as a strong, mandatory nationwide mandate during this period, partly reflecting concerns over food inflation and the diversion of agricultural commodities towards fuel. The policy framework was strengthened in January 2013, when the Government mandated 5 per cent blending nationally. However, the National Policy on Biofuels, 2018 marked a more fundamental shift by broadening the eligible feedstock base beyond conventional sugarcane-based ethanol to include maize and surplus food grains, while also creating a stronger framework for investment in ethanol-production capacity. At the same time, ethanol production was allowed from B-heavy molasses and directly from sugarcane juice/syrup. This was important for sugar availability because, relative to the C-heavy route, B-heavy diversion reduces sugar production by about 20 per cent while increasing ethanol availability by about 100 per cent, whereas direct diversion of sugarcane juice reduces sugar production by about 100 per cent while increasing ethanol availability by about 600 per cent. (PIB, 2018) Although maize was included in the broader 2018 feedstock framework, its operational use under the EBP programme was subsequently authorised in 2020, along with surplus FCI rice. The subsequent Roadmap for Ethanol Blending in India 2020–25, prepared by NITI Aayog, provided the basis for accelerating capacity creation and advancing the 20 per cent blending target from 2030 to ESY 2025–26. (NITI Aayog, 2021)

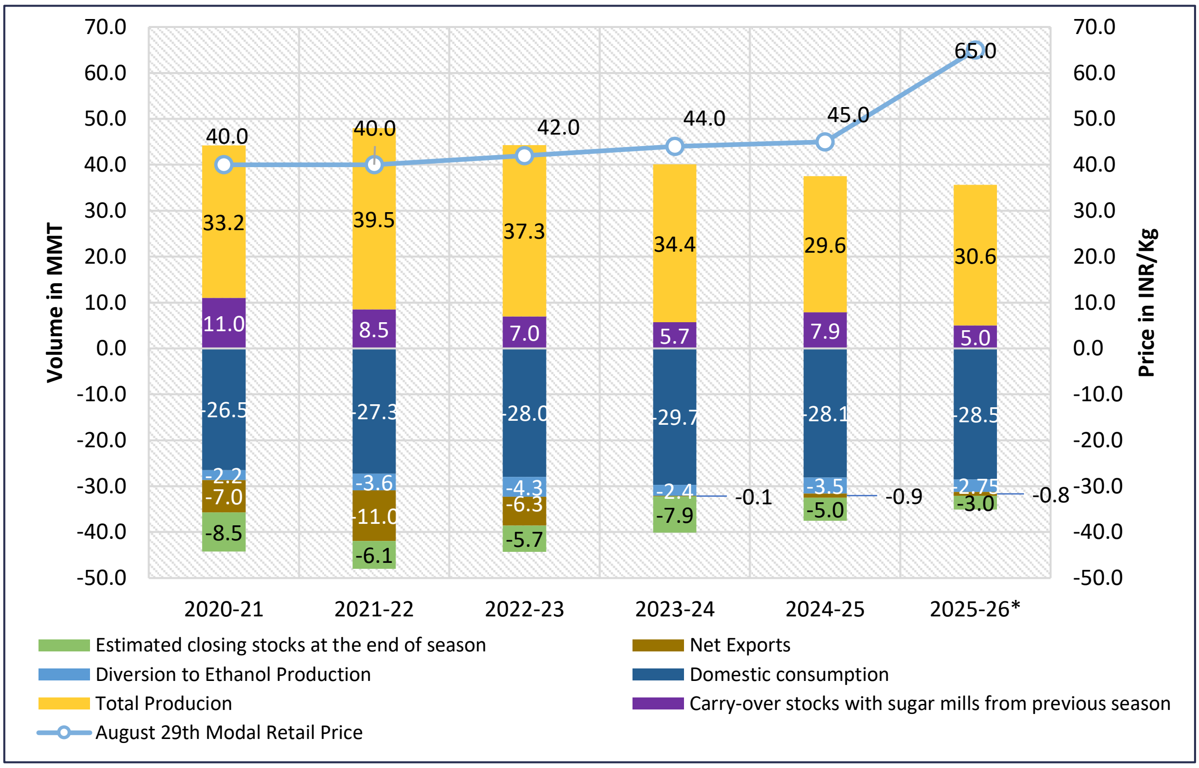
The transformation since then has been remarkable. Ethanol supplied to OMCs for blending increased from 1.73 billion litres (173.03 crore litres) in ESY 2019–20, when blending was 5.08 per cent, to more than 12 billion litres (1,200 crore litres, projected) in ESY 2025–26, when India achieved the 20 per cent blending target. This represents a CAGR of approximately 38 per cent over six years compared to 19 percent in the previous period (2006-07 to 2019-20). The rapid expansion of more than a six-fold increase in the volume of ethanol demanded by the petrol market in just six years has caught two sectors off guard. One is the automobile sector with concerns around compatibility of older vehicles, lower mileage and higher depreciation. Other one is the agricultural sector which faces a broader challenge: meeting the rapidly rising demand for sugar, maize and rice as fuel feedstocks while continuing to meet their existing food and feed requirements.

This acceleration in ethanol production has been much faster than the growth of the agricultural feedstocks on which the programme depends. Using the latest comparable crop-year data, maize production increased from 28.8 million metric tonnes (MMT) in 2019–20 to 55.1 MMT in 2025-26, a CAGR of about 11.4 per cent; rice production increased from 118.87 MMT to 154.02 MMT, or about 4.4 per cent annually; and sugarcane production increased from 370.5 MMT to around 500.1 MMT, implying a CAGR of about 5.1 per cent.

The divergence is therefore substantial: ethanol supply has expanded at roughly 38 per cent annually, compared with significantly lower annual growth in the production of its principal agricultural feedstocks in the same period. This has been made possible partly through a rapid change in the composition of feedstocks particularly the growing use of maize and other grains but it also means that the ethanol programme is increasingly drawing on commodities that have competing uses in the food and feed economy.

This is where the Food-versus-Fuel question becomes relevant. The issue is not whether ethanol should be part of India's energy mix; the progress achieved under the EBP programme demonstrates that it can be. The concern is whether the pace and structure of expansion are consistent with the growth of the agricultural resource base from which the ethanol is produced. Today's pressure is visible in sugar (**Figure 2**), where a combination of low opening stocks, lower production and continuing diversion to ethanol has coincided with a sharp 44 percent rise in prices within one month. Tomorrow, the same pressure could emerge in maize, with implications for poultry and livestock feed and, consequently, for the prices of eggs, meat and milk; or in rice, where diversion of grain to fuel raises a different set of food-security, fiscal and water-use questions. The recent sugar episode therefore provides an opportunity to examine a broader policy issue: how should India reconcile its rapidly expanding ethanol programme with the competing demands placed on the country's limited agricultural resources?

Figure 2: Sugar Balance Sheet of India



Data sources: 2020–21 to 2024–25: (DFPD, 2025-26)*; 2025–26: Sugar production, diversion to ethanol and domestic consumption from* (PIB, 2026)*; net exports up to July 2026 from* (DGFT, 2026)*. Closing stock for 2025–26 is estimated based on the above data and are presented as of 31 August 2026. Price data:* (DoCA, 2026) *. It may be noted that our estimate of the production figure for 2025-26 is likely to be lower than 30.6 MMT, somewhere around 28MMT. That means further pressure on sugar prices and even lower closing stocks.*

Note: *The 2025–26 figures are therefore provisional/estimated as of 31 August 2026, rather than final sugar-season figures.*

In the figure: *The positive left-hand axis shows total sugar availability in each sugar season, while the negative left-hand axis shows the disbursement of sugar under different heads i.e. domestic consumption, net exports, diversion to ethanol and closing stocks. The positive right-hand axis shows the modal retail sugar price (₹/kg) as on 29th August of corresponding years.*

This question is particularly important because ethanol policy does not operate independently of agriculture. The Government influences the procurement and pricing of ethanol, determines the feedstocks eligible for the EBP programme, supports production capacity and, in the case of sugar and food grains, also influences the price and allocation of the underlying commodities. The central policy challenge is consequently not to choose between food and fuel in absolute terms, but a need for 360-degree evaluation of which feedstocks should be prioritised, under what conditions, and at what economic and environmental cost.

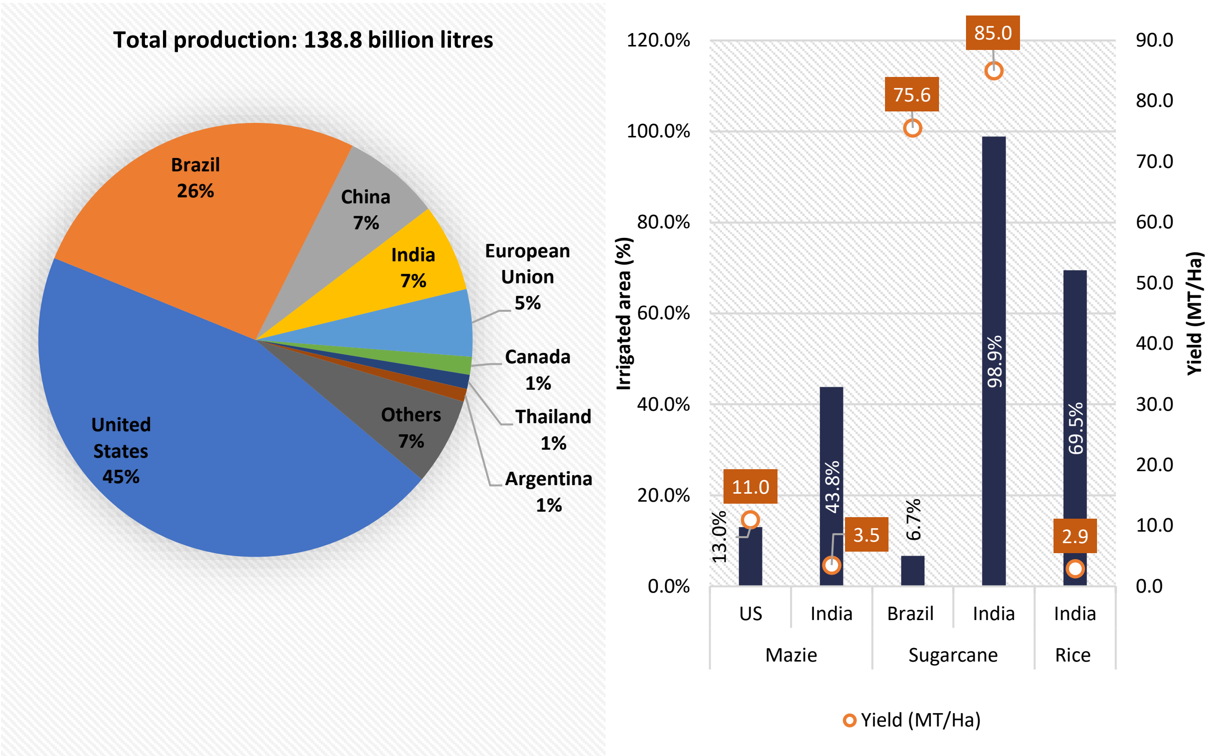
The remainder of this brief examines this question through three lenses. First, it compares India's experience with the United States and Brazil, where ethanol has developed around very different agricultural systems. Second, it reviews the available evidence on the net energy and lifecycle environmental performance of ethanol and identifies the gaps in India's current evidence base. Third, it compares the economic, fiscal and resource costs of sugarcane, maize and FCI rice as ethanol feedstocks before considering the policy choices available for sustaining E20 without unnecessarily intensifying the food-versus-fuel trade-off.

2. Global Scenario

Globally, ethanol has become an important link between agriculture and transport fuel, with production rising from 103.7 billion litres in 2010 to 144.4 billion litres in 2025, implying a CAGR of about 2.2 per cent. The major producers being the US with a production of 62.5 billion litres (45 per cent of global production) and Brazil 36.4 billion litres (26 per cent) in TE 2025. Followed by China and India both at 7 percent market share. (Figure 3) (OECD-FAO, 2026).

The two major hubs USA and Brazil, however, have evolved around very different feedstocks. The United States is overwhelmingly corn-based, with 98.8 per cent of ethanol production in 2025 coming from corn and the remainder from sorghum. The country's ethanol programme dates back to the oil shocks of the 1970s, when blending was promoted to reduce petroleum dependence, and was subsequently strengthened through the Renewable Fuel Standard. Ethanol's share in US motor fuel increased gradually, from just 0.08 per cent in 1981 to 4.75 per cent in 2007 and around 10 per cent by 2019. (USDA, 2026) Unlike India, the US also continues to provide consumers with a choice between conventional and flex-fuel vehicles and fuels.

Figure 3: Major Ethanol Producing countries in TE 2025 & Irrigated area, yield comparison with major ethanol producing countries



Source: (OECD-FAO, 2026); (USDA, 2026) (ANA, 2026) (DES, 2026)

The pace of feedstock diversion is particularly revealing. It took the US roughly 26 (1981-2007) years to divert 30.9 per cent of its corn production to fuel ethanol (USDA, 2026), whereas India moved from virtually zero to around 30.2 per cent of maize production being used for fuel ethanol between 2020–21 and 2024–25, a period of only five years (2026). This rapid expansion has occurred despite a substantial productivity gap: maize yields are around 3.5 tonnes per hectare in India, compared with about 11 tonnes per hectare in the US. Although maize is less water-intensive than sugarcane and rice, 43.8 per cent of India's maize area is irrigated, compared with about 13 per cent in the US. This is increasingly important as maize accounted for 35.96 per cent of India's ethanol production in ESY 2025–26. (PIB, 2026)

Brazil presents a different model. Its ethanol industry remains predominantly sugarcane-based, but maize has emerged as an important supplementary feedstock. In 2025, Brazil produced approximately 28.7 billion litres of sugarcane ethanol and 9.45 billion litres of ethanol from maize and other biomass, taking total production to around 38.2 billion litres. This implies a roughly 75:25 split between sugarcane and maize/other biomass. (EPE, 2026)

The resource-use comparison is equally important. In the United States, the 2023 USDA Irrigation and Water Management Survey records 11.64 million irrigated acres (4.7 million hectares) of corn for grain or seed. Against total harvested corn area of roughly 86–87 million acres (34.8 to 35.2 million hectares) only around 13–14 per cent of US corn area is irrigated, leaving the vast majority rainfed. (USDA, 2026) India is considerably more irrigation-dependent: about 43.8 per cent of maize area was irrigated in 2024–25, equivalent to roughly 5.3 million hectares out of 12.1 million hectares. (DES, 2026)

The contrast is even sharper for sugarcane. In Brazil, around 29.1 per cent of sugarcane area is under fertigation using wastewater, mainly vinasse, while another 6.7 per cent receives irrigation using freshwater or a combination of freshwater and reused water. These categories should not be mechanically added because the systems may overlap, but they indicate that a substantial majority of Brazilian sugarcane is rainfed. (ANA, 2026) In India, almost the entire sugarcane area in the major producing states is irrigated, with major producing states reporting irrigation coverage of close to 100 per cent.

These differences in feedstock, productivity and irrigation dependence are important because the environmental performance of ethanol is shaped not only by how much ethanol a crop can produce, but also by the resources required to produce that crop. The US has built its ethanol industry around a high-productivity, predominantly rainfed maize system that is GM crop, while Brazil combines a largely rainfed sugarcane system with a rapidly expanding maize pathway. India, in contrast, is expanding both sugarcane- and grain-based ethanol on a more irrigation-dependent and relatively lower-productivity agricultural base, which is also non-GM. This raises a more fundamental question for India: does the energy and emissions saved by replacing petrol with ethanol justify the energy, water and other resources (e.g., highly subsidised fertilisers in India) required to produce the feedstock and convert it into fuel? The next section examines this question through the available evidence on the net energy and lifecycle environmental performance of ethanol.

3. Net Energy Balance

The case for ethanol blending rests on the expectation that replacing a portion of petrol with a renewable fuel can reduce fossil-fuel consumption and greenhouse-gas emissions. However, these benefits cannot be assessed solely at the vehicle tailpipe. Ethanol itself requires energy and other resources to produce: crops have to be cultivated, fertilisers and irrigation may be used, feedstock must be transported, and ethanol has to be processed and distilled before it reaches the fuel system. A meaningful assessment must therefore consider the entire fuel life cycle from feedstock production to processing, transportation, blending and final combustion.

The established approach internationally is well-to-wheel (WTW) analysis, which combines the well-to-tank (WTT) and tank-to-wheel (TTW) stages. WTT captures the energy use and emissions associated with producing and supplying the fuel, while TTW captures its use in the vehicle. Broader life-cycle assessment (LCA) can extend this boundary further to include impacts such as land use, water depletion, acidification, particulate matter and human toxicity. The GREET model, developed by Argonne National Laboratory in Illinois, USA, is one of the most widely used frameworks for this purpose. It disaggregates fuel pathways into agricultural production, fertiliser and other inputs, feedstock transportation, fuel conversion, energy use, fuel distribution and vehicle operation, while also allowing treatment of co-products. The European Commission's JEC Well-to-Wheels methodology similarly provides a standardised framework for comparing the energy and greenhouse-gas performance of alternative transport fuels and distinguishes WTW analysis from broader LCA. (Argonne National Laboratory, 2026); (European Commission, 2026)

These distinctions are particularly important for India because the environmental performance of ethanol can vary substantially with the feedstock and production system. An ethanol pathway that performs well at the distillery level may have a considerably different lifecycle footprint once cultivation, irrigation, fertiliser use, transport and co-products are incorporated. Equally, a comparison based only on tailpipe emissions would overlook the energy and environmental costs incurred before the fuel reaches the vehicle.

The Indian evidence base, however, remains relatively limited and fragmented. One of the earlier comprehensive assessments, by Soam et al., examined fuel ethanol produced from sugarcane molasses in northern and western India and showed that the estimated lifecycle performance is highly sensitive to how energy use and emissions are allocated between ethanol and its co-products. Their estimated net energy ratio ranged from 0.38 to 3.39 in northern India and from 0.48 to 4.23 in western India, depending on the allocation method. The study also reported substantial variation in greenhouse-gas outcomes across methodologies. This wide range illustrates an important methodological point: there is no single net-energy value for ethanol independent of system boundaries, assumptions and treatment of co-products. (Soam, Kumar, Gupta, Sharma, & Tuli, 2015)

More recent work has adopted the GREET framework for Indian conditions. A 2024 study based on field-level data from Gayatri Sugars in Telangana used GREET to assess the energy and environmental performance of sugarcane-molasses ethanol across cultivation, transportation and processing. It reported an energy-yield ratio of 15.795 MJ/MJ, while identifying sugarcane cultivation and transportation as significant contributors to the carbon footprint. The study also found that alternative cane-trash management practices significantly affect emissions, with mulching performing substantially better than burning. These findings reinforce the importance of looking beyond the distillery gate when evaluating the sustainability of ethanol. (Uppalapati, et al., 2024)

The most directly relevant recent evidence for India's blending programme is a 2025 cradle-to-grave LCA of E10, E20 and E30. The study models sugarcane-molasses ethanol in an Indian context using openLCA, with regional sugarcane data from Punjab and Haryana, and evaluates the complete fuel pathway through combustion in a BS-VI spark-ignition passenger vehicle. It finds that increasing the ethanol share reduces greenhouse-gas emissions, fossil-fuel depletion and particulate-matter formation relative to conventional petrol. At the same time, sugarcane cultivation increases land and water-related impacts and agrochemical use contributes to other environmental burdens. The study therefore finds a favourable overall environmental balance for the mid-level blends, including E20, but also demonstrates that the benefits come with resource-use trade-offs. (Harde & Ojha, 2025)

The existing evidence therefore provides support for the environmental case for ethanol, but it does not provide a sufficient basis for judging India's entire E20 programme. The principal limitation is that the most detailed India-specific studies remain concentrated around sugarcane-based ethanol or individual production facilities. The recent E20 study is an important step forward, but it does not compare the competing feedstocks that are now central to India's ethanol programme.

This limitation has become increasingly important as the feedstock structure of Indian ethanol has changed. In ESY 2025–26, maize accounted for 35.96 per cent of ethanol production, while FCI rice accounted for 24.64 per cent. (PIB, 2026) The environmental performance of E20 can therefore no longer be inferred primarily from studies of sugarcane-molasses ethanol.

India requires a national, feedstock-specific WTW/LCA assessment of E20 that reflects the actual composition of the country's ethanol supply. Such an assessment should compare sugarcane, maize and FCI rice, and eventually second-generation feedstocks, under a common system boundary. It should incorporate regional differences in crop yields and cultivation practices; irrigation and fertiliser use; farm energy requirements; feedstock transportation; distillery energy consumption; electricity sources; treatment of co-products; and the characteristics of India's vehicle fleet and petrol consumption. Moreover, none of the existing studies have really calculated the true economic cost of producing ethanol in the Indian context. It is important to do so as power for pumping irrigation water and fertilisers are highly subsidised. Each one at a national level cost more than Rs 2 lakh crores. And it is well known that rice and sugarcane are water guzzling crops and highly irrigated indicating lot of use of subsidised power. They are also highly fertiliser intensive, which again is highly subsidised. In case of FCI rice, the economic cost in 2026 hovers around Rs 44/kg, but it is being given to ethanol plants at Rs 23.2/kg. If 5 MMT of FCI rice is used by ethanol plants, it means a loss of Rs 10,000 crores to the exchequer, which is hidden in food subsidy bill of the country. All these need to be adjusted, if we want to do a robust analysis of physical and economic conversion of maize, rice and sugar into ethanol.

The distinction between micro-level and macro-level evidence is critical. Data from an individual distillery can provide valuable information about conversion efficiency and plant-level energy use. Similarly, vehicle experiments can establish the impact of E20 on fuel economy and tailpipe emissions. But neither can establish the environmental performance of the national E20 programme, where millions of vehicles with varying compatibility consume fuel supplied through an ethanol industry drawing on a changing mix of sugarcane, maize, rice and other feedstocks. A country level assessment would need to combine these individual components and determine the aggregate consequences of the programme.

The objective, therefore, should not be to classify E20 as either environmentally beneficial or harmful in the abstract. The available evidence already suggests that the environmental outcome depends materially on the production pathway and system boundary used for the assessment. An E20 blend produced from one feedstock under one set of agricultural and processing conditions cannot automatically be assumed to have the same lifecycle performance as E20 produced from another.

For India, the relevant policy question is consequently more specific: how much fossil energy and greenhouse-gas emissions does E20 save, and what water, land and other resource costs (e.g., fertilisers and power) are incurred in producing the ethanol required to deliver those savings? Answering this question requires moving from individual pathway studies to a comprehensive, India-specific assessment covering the country's actual feedstock portfolio. Until such an assessment is undertaken, the evidence for the environmental benefits of E20 remains stronger at the level of individual feedstock and production pathways than at the level of the national E20 programme as a whole.

4. Comparative Economic Viability of Different Feedstocks

The environmental implications of ethanol are only one part of the Food-versus-Fuel debate. The other is its economic cost. India's ethanol procurement framework provides different prices for different feedstocks, reflecting differences in conversion costs and feedstock economics. Sugarcane-based ethanol can be produced at different stages of sugar processing, with each route having a different ethanol yield and opportunity cost. C-heavy molasses is the final by-product left after maximum sugar recovery and yields roughly 220–235 litres of ethanol per tonne of molasses; B-heavy molasses is produced at an earlier stage, before complete sugar crystallisation, and yields about 300–310 litres per tonne of molasses. Ethanol can also be produced directly from sugarcane juice or syrup, before sugar is extracted, yielding roughly 70–75 litres per tonne of cane (PIB, 2018). The procurement prices differ because these routes involve different feedstock availability, ethanol yields and, crucially, different opportunity costs of the sugar foregone: diverting C-heavy molasses has the lowest opportunity cost, while using B-heavy molasses or directly diverting cane juice/sugar involves progressively greater sacrifice of sugar production. This is reflected in the administered prices, with ESY 2025–26 rates of ₹57.97/litre for C-heavy molasses, ₹60.73 for B-heavy molasses and ₹65.61 for sugarcane juice/sugar/syrup. (PIB, 2026).

However, these procurement prices should not be treated as measures of the underlying economic cost of ethanol. A procurement price represents the return received by the producer, whereas an economic-cost assessment must account for the resources used to produce the feedstock, the cost of processing it into ethanol, government support embedded at different stages of production, and the opportunity cost of alternative uses of the feedstock. This distinction is particularly important when comparing feedstocks that operate under very different policy regimes.

Table 1: Feedstock-wise administered ethanol procurement price, ESY 2021-22 to 2025-26

Feed Stock	2021-22	2022-23	2023-24	2024-25	2025-26 (Provisional)
C – Molasses	46.66	49.41	56.28 (Incentive of 6.87)	57.97	57.97
B – Molasses	59.08	60.73	60.73	60.73	60.73
Sugarcane Juice/Sugar/Syrup	63.45	65.61	65.61	65.61	65.61
Damaged Food Grains	52.92	64.0	64	64	64
FCI Rice	56.87	58.5	58.5	58.5	60.32
Maize	52.92	66.07	71.86 (Incentive of 5.79)	71.86	71.86

Source: (PIB, 2026). Incentives are included where applicable.

Sugarcane-based ethanol: the opportunity cost of sugar

The economics of sugarcane-based ethanol are fundamentally different from those of grain-based pathways because the same cane can ultimately support either sugar or ethanol production. In years of surplus sugar, diverting cane or sugar towards ethanol can be economically beneficial by reducing excess inventories, releasing working capital and improving the liquidity of sugar mills. This can also strengthen mills' ability to meet their payments to sugarcane farmers. (PIB, 2026)

The economic impact changes when the sugar balance tightens. When stocks are low and sugar prices are rising, diverting additional cane or sugar towards ethanol carries a larger opportunity cost because the sugar foregone has greater value in the domestic market. The appropriate comparison is therefore not simply the procurement price of ethanol against its conversion cost, but the value created through ethanol relative to the value of the sugar that could have been produced from the same feedstock.

This distinction is particularly important during a supply-constrained year. A policy that is appropriate when sugar stocks are in surplus need not remain appropriate when the domestic market is facing a shortage. The opportunity cost of sugar diversion should therefore be incorporated explicitly into any assessment of the economic efficiency of sugarcane-based ethanol.

FCI rice: a low private price does not necessarily imply a low economic cost

FCI rice presents a different set of economic considerations because the price paid by an ethanol producer does not necessarily reflect the true cost incurred by the public procurement system. For ESY 2025–26, the administered procurement price for ethanol produced from FCI rice is ₹60.32 per litre. At the same time, the share of FCI rice in ethanol production increased sharply, from just 0.02 per cent in ESY 2023–24 to 24.64 per cent in ESY 2025–26, reflecting the increased availability of surplus FCI stocks after meeting food-security requirements. (PIB, 2026)

The economics of the underlying feedstock, however, need to be considered separately from the ethanol procurement price. FCI's average acquisition cost of rice was ₹3,889.46 per quintal in 2025–26, based on revised estimates, while rice supplied to ethanol distilleries under OMSS(D) was priced at ₹2,250 per quintal between June and October 2025 and ₹2,320 per quintal from November 2025. Thus, for the latter part of the year, distilleries paid about 40 per cent less than FCI's average acquisition cost. (The economic cost of FCI is marginally even higher). The same Rajya Sabha reply records that 6.35 MMT of rice was supplied to ethanol plants between June 2025 and June 2026, with a total value of ₹14,596.78 crore.

The distinction becomes even more important when considering the broader economic cost of rice. FCI estimates the economic cost of rice at ₹4,391.1 per quintal for 2026-27 (Budget Estimate (BE)) (FCI, 2026). This comprises the pooled cost of grain, procurement incidentals and distribution costs. Thus, the administered price to ethanol distilleries is substantially below not only FCI's average acquisition cost but also the broader economic cost of rice.

Table 2: FCI Rice Cost

Measure	2025–26 (₹/Quintal)
OMSS(D) price to ethanol distilleries	2,320.00
FCI average acquisition cost (RE)	3,889.46
FCI economic cost (BE)	4,173.30
Difference: acquisition cost – distillery price	1,569.46
Difference: economic cost – distillery price	1,853.30

Source: (PIB, 2026); (FCI, 2026)

Maize: a growing feedstock, but with important resource and market trade-offs

Maize occupies a distinct position in India’s ethanol economy, as it competes directly with food, feed and industrial uses in a relatively open market. Its lower water requirement than sugarcane and rice does not, by itself, establish it as a more sustainable feedstock. Around 43.8 per cent of India’s maize area is irrigated, compared with about 13 per cent in the US, while yields remain substantially lower at around 3.5 tonnes per hectare versus 11 tonnes per hectare. With maize accounting for 35.96 per cent of ethanol production in ESY 2025–26, these resource and productivity constraints become increasingly relevant.

The ₹71.86 per litre procurement price for maize-based ethanol is also not a measure of its full economic cost or efficiency. A meaningful assessment would need to account for feedstock prices, processing and energy requirements, co-product credits, water and other resource use, existing agricultural support and subsidies, especially on power for irrigation and on fertilisers consumed by these feedstocks, and the opportunity cost of maize in food and feed markets. Although maize generally requires less water than sugarcane and rice, its environmental and economic advantage cannot be inferred from this single parameter. An India-specific well-to-tank or well-to-wheel assessment covering the actual feedstock mix and associated implicit resource costs is therefore necessary to determine the net energy, environmental and economic implications of expanding maize-based ethanol. Authors are not aware of a single study that has done all these adjustments in the Indian case of ethanol blending.

5. Way Forward

The objective should not be to abandon E20, but to make the programme more responsive to changing agricultural conditions. The ethanol market has already reached considerable scale: OMCs procured 6.79 billion litres (679.04 crore litres) in ESY 2023–24, 10.33 billion litres (1,033.31 crore litres) in 2024–25 and 7.05 billion litres (705.43 crore litres) up to June 2026, with corresponding expenditure of about ₹48,757 crore, ₹73,996 crore and ₹49,577 crore, respectively, including GST and transportation. (Rajya Sabha, 2026) The scale of these commitments makes a return to a purely experimental programme neither feasible nor desirable. What is needed is a flexible feedstock strategy that can maintain E20 without placing excessive pressure on food markets when agricultural supplies tighten.

Sugar imports should provide the immediate supply buffer

India has maintained a 100 per cent basic customs duty on both raw and refined sugar since 2018. While such protection is immaterial to domestic prices during periods of surplus, it limits the ability of the domestic market to respond to a supply shortfall. The Government has now permitted 1 MMT of duty-free raw sugar imports under a TRQ until 31 October 2026, alongside a one-time mechanism to bring eligible quantities imported earlier under the Advance Authorisation route into the TRQ system. (DGFT, 2026)

Given the scale of the emerging supply gap, a stronger temporary response would be to reduce the duty on both raw and refined sugar to say around 10 per cent and allow 3–4 MMT to enter the domestic market, with the measure reviewed as production and stocks recover. Allowing both forms of sugar would provide greater flexibility than restricting imports to raw sugar and would allow the market to determine the most efficient form of supply. This immediate measure is to tame the sharp rise in sugar prices as well as to moderate inflationary expectations during the coming festive season.

The Advance Authorisation system also highlights an inconsistency in the present trade regime. Under SION E52, raw sugar can be imported duty-free against an obligation to refine it into white sugar and export the finished product. Although appropriate as an export-promotion instrument, the arrangement means that, during a domestic shortage, Indian refining capacity can process imported raw sugar for overseas markets without increasing domestic availability. The May 2026 export restriction retained an exception for exports under Advance Authorisation. The 20 August 2026 DGFT intervention partially addresses this anomaly by permitting eligible AA quantities to be converted once into the TRQ regime for domestic sale. (DGFT, 2026) A broad, temporary tariff reduction would nevertheless be a simpler and more transparent mechanism for augmenting domestic supply.

Ethanol feedstock allocation should respond to the sugar balance

E20 should not imply a fixed allocation of feedstocks. When sugar production is in surplus, diversion towards ethanol can reduce excess stocks and improve the financial position of sugar mills. When stocks are tight, however, the opportunity cost of diverting sugar rises. The feedstock mix should therefore respond to the availability of sugar rather than remain unchanged across agricultural cycles.

A practical approach would be to link sugar diversion to a minimum stock-to-consumption buffer. Once stocks fall below this threshold, sugar-based ethanol procurement could be reduced progressively, with the displaced ethanol requirement met through other feedstocks.

The analysis could compare the current diversion level of about 9 per cent with lower diversion scenarios and estimate the amount of sugar released to the domestic market in each case. This would provide a quantitative basis for determining how much sugar could be conserved without materially disrupting the E20 target.

FCI rice should remain a residual feedstock

FCI rice can continue to play a role when government stocks are genuinely surplus to food-security requirements, but it should not become a structural pillar of the ethanol programme. The concern is not that rice should never be used for fuel; rather, its apparent affordability to distilleries does not necessarily represent its full economic cost.

In 2025–26, FCI's average acquisition cost of rice was about ₹3,889 per quintal, while rice was supplied to ethanol distilleries at ₹2,320 per quintal during the later part of the year. FCI’s estimate of economic cost is ₹4,391 per quintal (2026-27 budget estimate). The government says that it should not be treated as a direct subsidy to ethanol producers, as it is broken and damaged rice. But the reality cannot be denied that the price faced by the distillery is substantially below the cost borne by the public procurement system, including that of broken rice. (FCI, 2026)

The wider economic comparison should also account for the substantial public support associated with paddy cultivation through fertiliser, electricity and irrigation, as well as the resource and environmental costs of intensive paddy production. FCI rice is therefore best treated as a temporary outlet for large surplus stocks rather than as a permanently subsidised source of fuel feedstock.

Rejuvenate the future markets

The longer-term solution should not be to replace one administered feedstock regime with another, but to rejuvenate market mechanisms across sugar, agricultural feedstocks and ethanol. Greater flexibility in imports can help domestic markets respond to temporary shortages, while allowing prices to reflect underlying supply conditions and opportunity costs. This principle should apply not only to sugar, but also to maize and other ethanol feedstocks, where excessive demand for fuel can otherwise be transmitted into food and feed prices. Import policies should therefore be made more responsive, with temporary tariff adjustments or other market-opening measures used when domestic supplies are inadequate rather than relying predominantly on administrative controls.

The same principle should extend to the ethanol market. Greater scope for imports during periods of domestic shortage could provide a safety valve for the EBP and reduce pressure to divert food and feed crops simply to maintain a fixed blending rate. A more open and responsive market for ethanol would also make the cost of maintaining E20 more transparent by allowing domestic ethanol to compete with imported supplies where economically feasible. Over time, a combination of flexible import policy, less distortionary feedstock markets and greater price responsiveness would allow the ethanol programme to adjust to agricultural cycles without repeatedly creating food-versus-fuel pressures.

Assess the true economic and energy cost of each feedstock

The choice of ethanol feedstock should ultimately be guided by its full economic and energy cost, rather than by administered procurement prices or any single resource-use indicator. An India-specific well-to-tank (WTT) net energy balance should therefore be undertaken for sugarcane, maize and FCI rice, incorporating farm-level inputs such as fertiliser, electricity for irrigation and other energy use, along with processing, transport and conversion requirements. The assessment should also account for implicit subsidies and the opportunity cost of land, water and alternative uses of the feedstock. While maize currently appears to have a lower water and electricity footprint than sugarcane and rice on some indicators, this parameter alone cannot establish its overall superiority without such a comprehensive comparison.

The broader policy objective should also be to reform input subsidy regimes rather than optimise ethanol production around distorted prices. Gradually replacing input subsidies on electricity, fertiliser and other farm inputs with targeted income support would allow market prices to better reflect the underlying economic cost of production. Ethanol plants could then be given greater flexibility to choose among feedstocks based on their relative market prices, availability and energy efficiency, rather than having the feedstock mix determined primarily through administered incentives.

Imported ethanol should remain a contingency option

A domestic feedstock shortfall should not automatically force India to choose between higher agricultural commodity prices and a lower blending rate. Imported ethanol could provide an additional safety valve.

The trade data indicate a 2025–26 CIF price of about ₹60.24/litre for imported denatured ethanol. After the applicable 5 per cent BCD and Social Welfare Surcharge, the value rises to about ₹63.55/litre before GST and transportation. Against this, domestic administered procurement prices range from ₹57.97 to ₹ 71.86/litre ex-mill, depending on feedstock.

The comparison does not establish that imports would always be cheaper. Freight, port handling, storage and international price movements would affect the final landed cost, and import policy currently restricts fuel-ethanol imports. It does, however, indicate that imported ethanol is within a potentially relevant cost range and could be used selectively when domestic feedstock availability becomes temporarily constrained or is highly expensive.

E20 should have a temporary flexibility mechanism

The final safeguard should be flexibility in the blending rate itself. The 20 per cent target can remain the long-term objective, while a temporary reduction to E15 could be considered in years when domestic ethanol availability becomes insufficient or the cost of maintaining E20 becomes disproportionately high in terms of food and/or feed prices.

The choice between maintaining E20, importing ethanol and temporarily reducing blending should ultimately depend on their relative economic costs under prevailing conditions. Such a mechanism would allow the programme to respond to temporary agricultural shocks without compromising the longer-term objective.

Taken together, these measures point towards a more adaptive EBP framework. Sugar-based ethanol can remain important when sugar supplies are abundant, but sugar diversion should be moderated when stocks become tight. Maize should absorb a larger share of ethanol demand as its productivity and market supply improve, while FCI rice should remain largely a residual outlet for genuine surplus stocks but the pricing of rice should be raised to at least its acquisition costs. The current system of highly subsidised price of FCI broken rice to ethanol plants smells of either a big favour to them or high irrationality, which is being driven by overflowing stocks of rice with FCI. Sugar imports can provide an immediate food-market buffer, while imported ethanol or a temporary reduction in blending can provide a corresponding fuel-market safety valve. This approach would allow India to pursue E20 without treating the blending target as independent of the availability and opportunity cost of the agricultural resources on which it ultimately depends.

6. Moving Beyond Food-Based Ethanol

A long-term expansion of ethanol cannot depend indefinitely on food and feed crops. As blending rises beyond E20, the quantity of agricultural feedstock required will increase correspondingly, potentially intensifying competition for land, water and food and feed supplies. This makes the development of second-generation (2G) ethanol from lignocellulosic biomass an important component of India's longer-term strategy.

The United States provides a relevant example through research on switchgrass (*Panicum virgatum*), a perennial warm-season grass that can be used for cellulosic ethanol without directly diverting grain from food and feed markets. Studies of native warm-season grasses have reported positive net-energy outcomes for switchgrass, although the results depend on biomass yield, cultivation practices, collection and transportation requirements and conversion efficiency. (Illukpitiya, K.C.Reddyb, & Bansal, 2017) The attraction of such feedstocks is therefore not simply their energy potential, but their ability to separate ethanol production from conventional food crops.

India has substantial quantities of agricultural residues and other lignocellulosic biomass that could eventually support 2G ethanol. However, theoretical biomass availability does not translate automatically into an economically viable feedstock. Collection and aggregation across dispersed farms, storage, transportation, pre-treatment, enzymatic hydrolysis, conversion efficiency and the capital cost of biorefineries remain significant constraints.

2G ethanol should therefore be viewed as a medium- to long-term pathway, rather than an immediate replacement for conventional feedstocks. In the near term, India can improve the efficiency of E20 by shifting towards feedstocks with lower food and resource trade-offs, particularly high productivity maize (GM), while investing in technologies that can progressively expand the use of agricultural residues and dedicated lignocellulosic crops. Over time, moving from food crops towards crop residues and advanced cellulosic feedstocks would reduce the structural tension between food and fuel and provide a more sustainable basis for further expansion of ethanol blending.

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