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The Architecture of Growth: Drivers of India's Ethanol Expansion

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Abstract

This paper examines the factors behind the sharp increase in ethanol production in India over the past decade. As ethanol blending has become a central element of India's energy and agricultural strategy, it explores what has driven this rapid expansion. The issue is significant due to its implications for energy security, agricultural surplus management, environmental sustainability and economic stability in an oil-import-dependent economy. Five key factors associated with this growth are identified: the long-term policy vision of the Indian government, the availability of agricultural surplus, volatility in agricultural and fuel prices, the proven technical and economic feasibility of ethanol and the impact of global geopolitical disruptions such as the Russia–Ukraine conflict, with a focus on observed trends rather than predetermined conclusions.

Keywords: Ethanol blending in India, sugarcane, crude oil

Introduction

Over the past decade, India has witnessed a significant and sustained increase in ethanol production. This has positioned ethanol blending as a central component of the country's energy and agricultural strategy. Ethanol, a biofuel primarily derived from sugarcane and food grains, is blended with petrol to reduce fossil fuel dependence, lower emissions and support rural incomes. India's ethanol production capacity rose from around 300 crore litres in 2014 to over 1,800 crore litres by 2023, while the national blending rate increased from about 1.5% to over 12% in the same period (The Economic Times, 2025). This rise was economically significant because a higher ethanol blending rate reduces India's dependence on imported crude oil, saving foreign exchange and improving the current account balance. Additionally, it encourages domestic biofuel industries and generates employment. So, it raises a critical question: what factors have driven the sharp increase in ethanol production in India?

The relevance of this question extends beyond energy policy alone. Ethanol sits at the intersection of fuel security, agricultural management, environmental sustainability and macroeconomic stability. For a country that imports more than 80% of its crude oil requirements, domestically produced ethanol represents both an economic and strategic alternative. At the same time, ethanol production has emerged as a tool to address persistent challenges within Indian agriculture, particularly surplus production and price instability.

This paper explores five key causes that appear to have contributed to the rise in ethanol production. In section 1, it examines the long-term vision of the Indian government, reflected in blending targets, policy continuity and institutional support. In section 2, it considers the role of agricultural surplus, especially in sugarcane and food grains, and how ethanol has been positioned as an outlet for excess production. In section 3, it looks at price volatility in both global crude oil markets, which has shaped policy incentives and producer behavior. In section 4, the paper observes the importance of ethanol's proven technical and economic feasibility, supported by existing infrastructure and industry experience. Finally in section 5, it considers the influence of the Russia–Ukraine conflict, which intensified concerns around energy security and import dependence.

After a careful analysis of all these factors, the study finds that India's rapid expansion of ethanol production is driven by a convergence of policy, economic and external factors rather than a single cause. Strong and consistent government vision after 2014 created policy certainty and investment confidence. Ethanol emerged as an effective outlet for agricultural surplus, especially sugarcane, while global oil price volatility and the Russia–Ukraine conflict reinforced energy security concerns. Proven technical feasibility further enabled large-scale adoption.

Literature Review

The rise in ethanol production in India has been extensively discussed in academic research, government-linked policy studies and sectoral analyses, largely within the broader contexts of energy security, agricultural stability and economic reform (Roy et al., 2021; CSTEP, 2023). Although ethanol blending was formally introduced in the early 2000s, most studies agree that production levels remained modest and inconsistent for over a decade due to policy uncertainty and weak institutional support (Feasibility Analysis for Ethanol Blended Fuel in India, 2017). The literature suggests that the sharp increase observed in recent years reflects a convergence of institutional, economic and external factors rather than a sudden or isolated policy shift (Roy et al., 2021).

Several studies emphasize the importance of political stability and policy continuity in shaping ethanol outcomes. Prior to the mid-2010s, ethanol policies were characterized by frequent revisions, inconsistent enforcement and uncertain procurement mechanisms, which discouraged long-term investment in distillery capacity (CSTEP, 2023). Research focusing on the post-2014 period highlights how clearer policy direction, assured offtake arrangements and administered pricing reduced uncertainty for producers and improved investor confidence (Roy et al., 2021). These institutional reforms laid the foundation for sustained expansion, particularly once blending targets began to be implemented more rigorously after 2018 (Ethanol Fuel Blending Program in India, 2024).

Another recurring theme in research papers is India's vulnerability to fluctuations in global energy markets. Studies analyzing the period from 2010 onwards note that heavy dependence on imported crude oil exposed the Indian economy to price volatility and external geopolitical shocks (Singh et al., 2025). Ethanol blending is frequently framed as a strategic domestic alternative capable of partially reducing this exposure and enhancing energy security (CSTEP, 2023). As global oil prices remained unstable through

the late 2010s and were further disrupted by geopolitical conflicts, the economic rationale for expanding domestic biofuel production gained increased policy relevance (Singh et al., 2025).

The literature also highlights the broader macroeconomic implications of ethanol blending. Modelling-based studies suggest that substituting imported fossil fuels with domestically produced ethanol reduces foreign exchange outflows, improves the balance of payments and generates employment in rural areas (Ethanol Fuel Blending Program in India, 2024). These economic benefits are often cited as key justifications for sustained public investment and strong policy backing as ethanol production scaled up during the late 2010s (Roy et al., 2021).

A substantial body of work further links ethanol expansion to structural challenges within Indian agriculture, particularly the sugar sector. Studies document persistent overproduction, volatile sugar prices and delayed payments to farmers as recurring problems prior to increased ethanol diversion (Voora et al., 2023). Redirecting surplus sugarcane and molasses towards ethanol production is therefore viewed as a stabilizing mechanism that absorbed excess supply and improved liquidity within the sector (Viable Feedstock Options and Technological Challenges for Ethanol Production in India). However, several authors caution that while ethanol diversion can ease short-term price instability, it does not fully resolve long-term concerns related to environmental sustainability, water stress and regional imbalances in crop cultivation (Voora et al., 2023; Food vs Fuel Debate, 2008).

Despite extensive analysis, significant gaps remain in the existing literature. Most studies examine individual drivers such as policy reform, energy security or agricultural surplus in isolation, resulting in fragmented explanations for ethanol growth (Roy et al., 2021). Limited attention is given to how these drivers interact across different phases or how earlier constraints gradually evolved into later enablers. Additionally, much of the research relies heavily on secondary data and modelling approaches, with relatively little empirical evidence from regional or farm-level perspectives (CSTEP, 2023). There is also a lack of structured, time-based analysis linking policy evolution, economic pressures, agricultural dynamics and geopolitical developments. This paper seeks to address these gaps by integrating these elements within a clear chronological framework, offering a more comprehensive explanation of the increase in ethanol production in India.

Major Factors

1. Vision of Government

The change in government in 2014 marked a notable shift in how India approached long-standing challenges related to energy security and agricultural sustainability. While earlier governments had acknowledged the potential of ethanol blending, implementation remained weak and episodic. The Ethanol Blended Petrol (EBP) programme existed on paper for over a decade before 2014 but suffered from inconsistent execution, poor coordination between ministries, and the absence of a clear long-term commitment (Planning Commission of India, 2013; Ministry of Petroleum and Natural Gas [MoPNG], 2014). As a result, ethanol blending barely crossed about 1.5% by 2013–14, reflecting limited production

capacity and low confidence among farmers and industry stakeholders regarding policy continuity (MoPNG, 2015).

Upon assuming office in 2014, the National Democratic Alliance, under the leadership of Narendra Modi, brought a broader and more coherent developmental vision. Its election manifesto placed strong emphasis on energy security, reducing import dependence, and revitalizing agriculture. Nitin Gadkari, as Union Minister for Road Transport and Highways, played a significant role in promoting ethanol blending through sustained public advocacy and policy support (Press Information Bureau [PIB], 2021). This macro-level vision proved critical, as ethanol was no longer viewed merely as an auxiliary fuel but as part of a larger national strategy. Fuel diversification was explicitly linked with farmer welfare, rural income stability, and environmental responsibility, moving ethanol from the periphery to the center of energy planning (NITI Aayog, 2021).

Equally important was the shift in governance style after 2014. The leadership emphasized time-bound execution, inter-ministerial coordination, and measurable outcomes. Clear political signaling conveyed continuity and seriousness of intent, reducing uncertainty for private investors and agricultural stakeholders who had previously faced frequent policy reversals and delays. In contrast to the fragmented pre-2014 approach, the post-2014 vision provided clarity, direction, and credibility, creating institutional confidence and administrative momentum that later enabled the rapid scaling up of ethanol production and blending (NITI Aayog, 2021).

2. Agricultural Surplus

A core insight of agricultural economics is that increases in output do not automatically translate into higher farm incomes. According to basic demand–supply theory, when the supply of a commodity rises sharply while demand remains relatively inelastic, market prices fall. Since most agricultural commodities exhibit low price elasticity of demand, even modest increases in supply can lead to disproportionate declines in prices. Consequently, farmers often experience a fall in total revenue despite producing more.

This paradox of higher output coinciding with lower income is a recurring feature of agrarian economies. In India, this dynamic has produced a persistent cycle of price instability. Periods of high production, often driven by favorable monsoons, technological improvements or policy incentives, result in excess supply. Prices then collapse, reducing farmer incomes and triggering distress. In response, farmers either demand higher administered prices or increase production further to compensate for lost income, which once again exacerbates oversupply. This self-reinforcing loop creates chronic volatility and undermines income stability.

The sugarcane sector illustrates this problem with particular clarity. Sugarcane cultivation in India has consistently outpaced domestic consumption of sugar. The crop's long gestation period and limited flexibility once planted make rapid supply adjustments difficult. When production exceeds demand, sugar prices fall, inventories accumulate and sugar mills face liquidity constraints. These constraints frequently lead to delayed payments to farmers, intensifying rural distress despite record output levels (RBI, 2021; NITI Aayog, 2021). Thus, the problem is not one of insufficient production, but of insufficient demand

absorption. In this context, ethanol blending emerged as a mechanism to ease demand-side constraints by channeling surplus sugarcane into fuel markets, helping mitigate price volatility and income instability. Hence, the government increasingly shifted its approach from price-based support mechanisms toward demand-side interventions. Rather than attempting to restrict production or rely solely on export incentives and subsidies, policymakers sought to create an alternative, stable outlet for surplus agricultural produce. Ethanol production emerged as a particularly suitable channel, especially for sugarcane and its by-products (Government of India, 2018).

A pivotal step in this direction was the National Policy on Biofuels, 2018 (NPB-2018). For the first time, ethanol production was embedded within a comprehensive national framework that explicitly linked agriculture with energy markets. Crucially, the policy broadened the range of permissible feedstocks beyond conventional C-heavy molasses to include B-heavy molasses, sugarcane juice, sugar syrup, damaged foodgrains, maize and other surplus crops (Ministry of Petroleum and Natural Gas [MoPNG], 2018). By allowing sugarcane juice and intermediate molasses to be diverted directly to ethanol, the policy enabled surplus cane to bypass sugar production during years of excess supply, thereby preventing market gluts and downward pressure on sugar prices. In effect, ethanol was transformed into a demand-side stabilizer for the sugarcane sector (NITI Aayog, 2021).

However, feedstock flexibility alone was insufficient without adequate processing capacity. To address this constraint, the government introduced multiple financial assistance schemes between 2018 and 2020 aimed specifically at sugar mills and distilleries. Through subsidized loans and capital support for setting up or expanding ethanol distillation capacity, mills were enabled to rapidly augment capacity within existing facilities (Department of Food and Public Distribution [DFPD], 2020). This intervention allowed surplus cane to be absorbed domestically rather than resulting in unsold inventories or delayed farmer payments.

Equally important was the creation of price and offtake certainty through a formal procurement mechanism. From 2020 onwards, the government fixed ex-distillery prices for ethanol based on different feedstocks. By guaranteeing procurement by Oil Marketing Companies at pre-announced prices, the state reduced market risk for mills and ensured predictable revenue streams (MoPNG, 2021). Moreover, differentiated pricing of sugarcane, by providing Fair Remunerative Price (FRP) to farmers, incentivized the diversion of surplus sugarcane toward ethanol during surplus years. FRP even motivated farmers to take up sugarcane cultivation, as is evident from the table and graph below which provides FRP over the years.

Years	FRP (in rupees)
2016-2017	230
2017-2018	255
2018-2019	275
2019-2020	275
2020-2021	285
2021-2022	290

2022-2023	305
2023-2024	315
2024-2025	340
2025-2026	355

Table 1. Sugar Season wise FRP Announced by Central Government

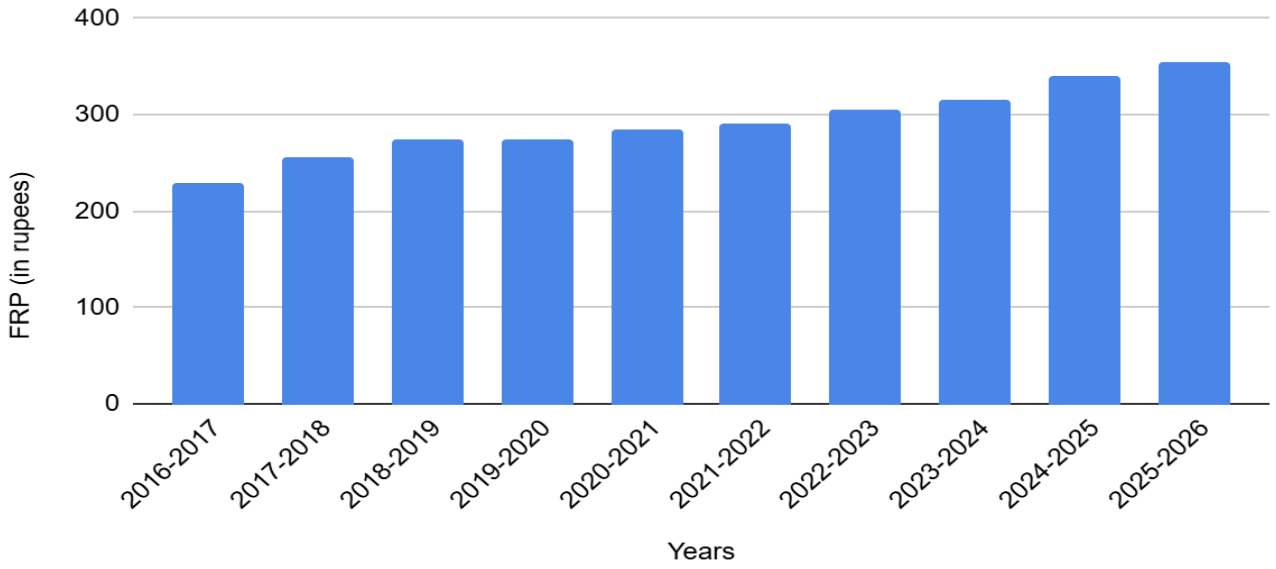

Figure 1. Sugar Season wise FRP Announced by Central Government

Source: Department of Food & Public Distribution, Ministry of Consumer Affairs, Food & Public Distribution, Government of India. (n.d.). Sugar policy. Government of India.

In addition to sugarcane, surplus accumulation in foodgrains was addressed through policy decisions allowing the use of excess and damaged rice, broken rice and maize for ethanol production. Approved by the National Biofuel Coordination Committee, this measure provided an outlet for excess public stocks and reduced storage and fiscal burdens (Press Information Bureau [PIB], 2020). Together, these measures marked a departure from ad hoc price controls toward a structured demand-creation strategy. Ethanol production thus emerged not merely as an energy initiative, but as a structural solution to long-standing price instability in India's agricultural markets, particularly in the sugarcane sector.

Below are a table and graph providing data on the production, consumption and surplus levels of sugar in the country. It suggests that since major policy changes in 2018, there has been a fall in closing stock of sugar. This implies that sugar was successfully employed in various other activities, ethanol production being the major one.

Years	Total available supply	Total consumption (including exports)	Closing stock (Surplus)
2010-11	293.74	233.69	60.5
2011-12	321.96	255.95	66.01
2012-13	324.17	231.19	92.98
2013-14	337.92	263.18	74.74
2014-15	357.84	267.04	90.80
2015-16	342.05	264.53	77.52
2016-17	284.83	246.07	38.76
2017-18	365.74	258.54	107.20
2018-19	438.82	293	145.82
2019-20	419.90	312.5	107.40
2020-21	419.32	334.91	84
2021-22	442	379	63
2022-23	392	341	52
2023-24	372	293	79
2024-25	341	302	39

Table 2. Production and Consumption of Sugar

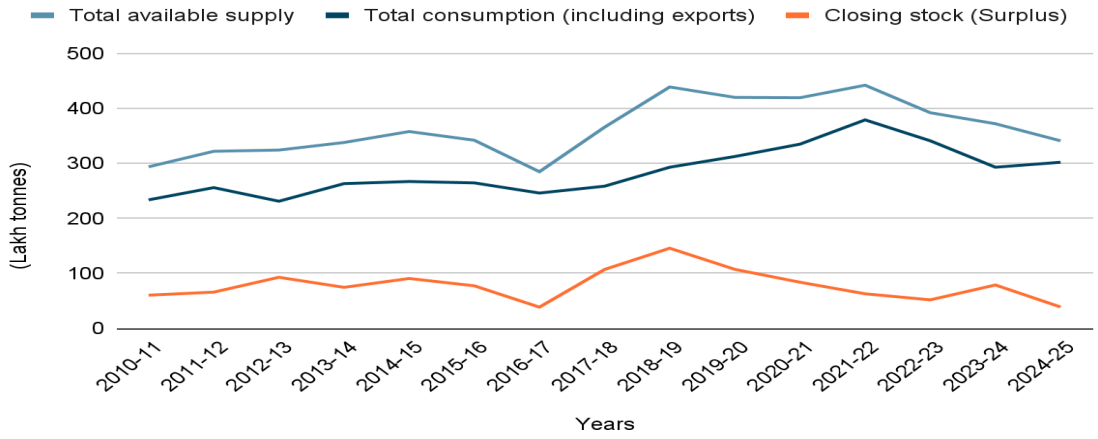

Figure 2. Production and Consumption of Sugar

Source: ChiniMandi. (n.d.). Balance sheet of sugar.

3. Global Oil Prices

Global crude oil prices have historically been characterized by high volatility, driven by geopolitical tensions, supply disruptions, cartel behavior and demand shocks. For an economy like India, which imports more than 80 percent of its crude oil requirements, such volatility has profound macroeconomic

implications (Ministry of Petroleum and Natural Gas [MoPNG], 2023). Between 2010 and 2025, as shown by the table and graph below, India experienced repeated episodes of sharp oil price fluctuations—from the high-price regime of the early 2010s, to the collapse during 2014–16, followed by renewed unpredictability during the post-pandemic recovery and the Russia–Ukraine conflict. These fluctuations exposed India's structural vulnerability to external energy shocks and highlighted the need for alternatives to imported fossil fuels (Reserve Bank of India [RBI], 2022).

Year	Average oil price
2025-12-31	$64.27
2024-12-31	$75.82
2023-12-31	$77.70
2022-12-31	$94.25
2021-12-31	$68.23
2020-12-31	$38.58
2019-12-31	$57.31
2018-12-31	$64.58
2017-12-31	$51.86
2016-12-31	$44.22
2015-12-31	$49.19
2014-12-31	$91.56
2013-12-31	$97.57
2012-12-31	$94.03
2011-12-31	$96.79
2010-12-31	$79.95

Table 3. Average Oil Prices

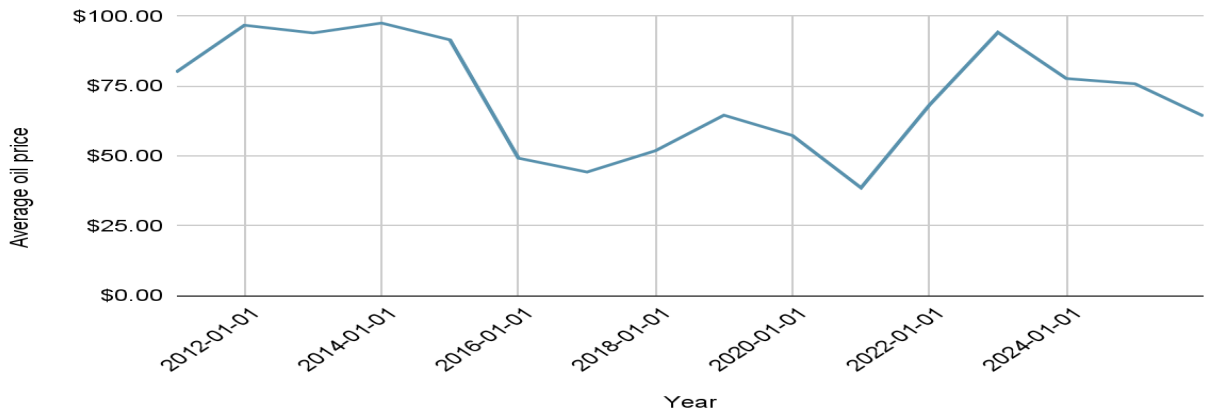

Figure 3. Average Oil Prices

Source: Macrotrends LLC. (n.d.). Crude oil prices (1946–2026)

At the macroeconomic level, rising global oil prices directly worsen the current account balance. Since crude oil is one of India's largest import items, an increase in prices leads to a higher import bill even if import volumes remain unchanged. This widens the current account deficit (CAD), increasing dependence on foreign capital inflows to finance external imbalances. Persistent or sudden widening of the CAD can undermine investor confidence, exert pressure on the exchange rate and increase external vulnerability (RBI, 2021).

Oil price volatility also affects India's foreign exchange reserves. Higher import payments require greater outflows of foreign currency, particularly US dollars, reducing reserve buffers or forcing greater borrowing. A depreciating rupee further compounds the problem by making imports more expensive, creating a feedback loop between oil prices, exchange rate depreciation and external imbalances (International Monetary Fund [IMF], 2022).

Inflation represents another critical transmission channel. Petroleum products directly enter the consumption basket and indirectly affect prices through transportation, logistics, fertilizers and manufacturing inputs. Rising crude prices therefore fuel cost-push inflation, eroding household purchasing power and raising production costs for firms. Governments are often compelled to absorb part of the shock through fiscal interventions such as subsidies or tax reductions, shifting the burden either to consumers through higher prices or to public finances through constrained spending (RBI, 2022).

These macroeconomic stresses were repeatedly evident during periods of global oil price spikes. While short-term measures such as excise duty adjustments or strategic petroleum reserve releases provided temporary relief, they did not address the fundamental problem of import dependence. This context created a strong economic rationale for pursuing domestic energy substitutes capable of reducing exposure to global oil markets (NITI Aayog, 2021).

Ethanol blending emerged as a strategically important response to this vulnerability. By partially substituting imported crude oil with domestically produced ethanol, India reduced foreign exchange outflows while simultaneously supporting its agricultural sector. Over time, ethanol came to be framed not merely as a renewable fuel, but as a macroeconomic stabilizer (MoPNG, 2023).

The outcomes of this approach are visible in aggregate terms. Between Ethanol Supply Year (ESY) 2014–15 and ESY 2024–25 (up to July 2025), ethanol blending by public sector Oil Marketing Companies resulted in foreign exchange savings exceeding ₹1,44,087 crore, while substituting approximately 245 lakh metric tonnes of crude oil (Press Information Bureau [PIB], 2025). These figures underline the macroeconomic significance of ethanol as an import-substitution strategy.

Beyond external balances, ethanol expansion also altered the distribution of energy expenditure within the economy. Funds that would otherwise have been transferred abroad for crude oil imports were redirected domestically, primarily to farmers and agro-processing industries. At an ethanol blending level of 20 percent, annual payments to farmers could reach ₹40,000 crore, while foreign exchange savings could be around ₹43,000 crore, strengthening rural demand and reducing leakages from the domestic economy (NITI Aayog, 2021).

This macroeconomic rationale was clearly articulated in the Roadmap for Ethanol Blending in India (2020–25) prepared by NITI Aayog in coordination with the Ministry of Petroleum and Natural Gas. The roadmap explicitly linked higher blending levels with reductions in crude oil imports and foreign exchange outflows, positioning ethanol as a measurable instrument for moderating current account pressures during periods of elevated oil prices (NITI Aayog, 2021).

The government's decision to advance the E20 blending target from 2030 to the Ethanol Supply Year 2025–26 further reflected this urgency. This acceleration followed renewed global energy disruptions during the post-pandemic period and the Russia–Ukraine conflict (discussed in detail in section 5), underscoring ethanol's role as a buffer against external energy shocks rather than a distant environmental objective (MoPNG, 2023).

Taken together, these measures transformed ethanol into a macroeconomic risk-management instrument. By reducing crude oil imports, conserving foreign exchange and dampening inflationary pressures, ethanol blending directly addressed the vulnerabilities exposed by volatile global oil markets (RBI, 2022; NITI Aayog, 2021).

4. Proven Feasibility of Blending

In addition to pressures arising from global oil price volatility, the expansion of ethanol production in India was significantly influenced by the demonstrated success of ethanol blending in other countries. International experience showed that ethanol blending was not merely a theoretical alternative but a technically feasible and economically sustainable fuel strategy. Observing successful implementation abroad helped reduce uncertainty among Indian policymakers and strengthened confidence in scaling up domestic ethanol programmes (International Energy Agency [IEA], 2019).

Brazil's ethanol programme served as the most influential reference point for India. Initiated in the 1970s in response to oil shocks, Brazil's programme integrated ethanol deeply into the national fuel system. With blending levels reaching E25–E27 and widespread adoption of flex-fuel vehicles, Brazil demonstrated that high ethanol blends could be sustained without adverse impacts on vehicle performance or fuel efficiency.

The relevance of Brazil's experience was particularly strong for India due to similarities in sugarcane-based agriculture, rural employment dependence and vulnerability to oil imports. Brazil's experience showed that ethanol could simultaneously enhance energy security, stabilize farm incomes and reduce environmental costs, reinforcing India's belief that ethanol blending could be successfully scaled domestically (Goldemberg et al., 2014; IEA, 2020).

Figure 4. Corn Only Ethanol Plant in Brazil

Source: Schroeder, K. (2022, May 22). Corn ethanol boom in Brazil. Ethanol Producer Magazine

The United States offered another critical example, particularly in addressing concerns related to vehicle compatibility and fuel quality. Under the Renewable Fuel Standard (RFS), ethanol blending became a nationwide norm, with E10 universally adopted and higher blends permitted for compatible vehicles. The U.S. experience highlighted the importance of regulatory clarity, scientific testing and phased implementation in ensuring smooth integration of ethanol into fuel markets. For India, this helped alleviate resistance from automobile manufacturers and oil marketing companies by demonstrating that technical challenges associated with blending could be resolved through standardization and gradual targets (U.S. Energy Information Administration [EIA], 2021).

Experiences from developing economies such as Thailand further reinforced ethanol's feasibility in contexts comparable to India. Thailand successfully implemented multiple blending levels while using ethanol policy as a tool to absorb surplus agricultural output, particularly sugarcane. This was highly relevant for India, where recurring sugar surpluses often lead to financial stress for mills and delayed payments to farmers. Thailand's example demonstrated that ethanol blending could function as an agricultural stabilization mechanism in addition to being an energy policy (Food and Agriculture Organization [FAO], 2018).

Figure 5. Sustainable Mobility: Ethanol Talk Seminar by Thailand and Brazil

Source: Sugar Asia Magazine. (2020, April 25). Thailand driven ethanol with Brazil for global sustainability

A key lesson drawn from global success was the importance of feedstock flexibility. While Brazil and the United States relied primarily on single dominant crops, India recognized that it could not fully replicate these models due to its distinct agricultural structure, land constraints, water scarcity and food security concerns. Instead, India diversified its ethanol feedstocks to include molasses, sugarcane juice, damaged foodgrains, surplus rice and maize. This approach reflected learning from international experience while carefully adapting policies to domestic agricultural and food security conditions (NITI Aayog, 2021). Rather than replicating foreign models, India customized them to suit its economic and agrarian realities. Collectively, these international experiences shifted India's approach from cautious experimentation to policy-driven expansion. Early ethanol programmes in India faced challenges such as irregular supply, pricing disputes and logistical bottlenecks. However, global evidence indicated that these were transitional challenges rather than structural constraints (IEA, 2019).

In conclusion, the success of ethanol blending in countries such as Brazil, the United States and Thailand provided India with evidence-based validation rather than mere inspiration. These experiences demonstrated that ethanol blending could be implemented at scale when supported by coherent policy frameworks, institutional coordination and regulatory clarity. Proven international feasibility thus emerged as a critical factor accelerating ethanol production and blending in India (NITI Aayog, 2021).

5. Russia-Ukraine Conflict

The Russia–Ukraine conflict significantly strengthened India's ethanol strategy by exposing the geopolitical risks associated with dependence on imported fossil fuels. Unlike routine market fluctuations, the conflict demonstrated how international sanctions, supply disruptions and geopolitical tensions can

rapidly destabilize energy access and prices. This heightened risk perception reinforced the strategic need for domestically produced alternatives such as ethanol.

For India, the conflict highlighted the importance of energy autonomy rather than mere price management. Ethanol blending gained prominence as a reliable domestic option capable of reducing exposure to external shocks and insulating the economy from geopolitical uncertainties. As a result, ethanol production was increasingly framed within a broader narrative of national resilience and strategic energy security (NITI Aayog, 2022; Reserve Bank of India [RBI], 2022).

The conflict also accelerated policy urgency. In the post-conflict period, long-term diversification of energy sources received stronger political and institutional backing. A major reinforcement of this commitment came with the advancement of the E20 (20% ethanol blending) target from 2030 to 2025–26, formally operationalized in 2023 with the phased rollout of E20 petrol across multiple states. This accelerated timeline signaled a clear shift from gradual transition to time-bound structural transformation of the fuel market (Ministry of Petroleum and Natural Gas [MoPNG], 2023). Rather than postponing commitments amid uncertainty, India maintained momentum on blending targets and capacity expansion, signaling confidence in ethanol as a structural energy solution.

Additionally, geopolitical instability reinforced the importance of policy continuity. Sustained government support, assured procurement mechanisms and clearly articulated blending roadmaps helped reassure investors and ethanol producers, contributing to steady expansion of production capacity despite global uncertainty (NITI Aayog, 2021; MoPNG, 2023).

Overall, the Russia–Ukraine conflict acted as a catalyst that elevated ethanol from a complementary fuel option to a strategic instrument for reducing India's vulnerability to geopolitical energy disruptions and enhancing long-term energy security.

Issues in Ethanol Blending

India's ambitious push toward a 20% ethanol blending target (E20) by 2025-26 is a cornerstone of its energy and environmental strategy. However, the sector faces significant economic and logistical hurdles, with pricing emerging as one of the most significant concerns. While early assessments, including a NITI Aayog report prepared in 2020–21, suggested that ethanol was cheaper than petrol and could reduce fuel costs, this situation has reversed over time (NITI Aayog, 2021). The procurement price of ethanol has increased substantially, eroding the expected cost advantage of ethanol-blended petrol. As of 31 July 2025, the weighted average procurement cost of ethanol for ESY 2024–25 stands at ₹71.32 per litre, inclusive of transportation and GST, which is now higher than the cost of refined petrol (Ministry of Petroleum and Natural Gas [MoPNG], 2025).

Another major issue is vehicle compatibility, particularly with higher blends such as E20. A large share of India's existing vehicle fleet, especially older two-wheelers and passenger vehicles, is not fully designed for higher ethanol concentrations. Also, ethanol has a lower energy density (30-34% less than petrol) which leads to a 3-7% drop in fuel efficiency (Patil, 2025). This raises risks related to engine wear

and increases maintenance costs, potentially slowing consumer acceptance of higher blends (NITI Aayog, 2021).

Water scarcity also poses a serious challenge to the sustainability of ethanol production. Sugarcane-based ethanol, which constitutes a major share of India's supply, is highly water-intensive. In water-stressed regions, expanded ethanol production can exacerbate groundwater depletion and strain local ecosystems, raising concerns about long-term environmental viability (NITI Aayog, 2021).

Finally, supply chain and infrastructure gaps continue to limit efficient blending. Regional imbalances in feedstock availability, inadequate storage and blending infrastructure and logistical bottlenecks affect consistent ethanol supply across states. Despite these challenges, oil marketing companies have continued with the blending mandate due to its contributions to energy security, farmer income diversification and emissions reduction (MoPNG, 2025).

Conclusion

This study demonstrates that the expansion of ethanol blending in India represents a coordinated structural transformation rather than a single-sector reform. Energy security concerns, agricultural surplus management and industrial policy have converged to create a multi-dimensional strategy in which ethanol functions simultaneously as an energy buffer, a macroeconomic stabilizer and a rural support mechanism. The programme's success thus far reflects the state's capacity to align incentives across sectors and reduce vulnerability to external shocks.

However, this convergence also creates new trade-offs. Rising production costs, uncertainties in ethanol pricing relative to petrol, feedstock constraints and uneven infrastructure development raise concerns about long-term sustainability. The assumption that ethanol remains consistently cheaper than petrol has weakened, making continued expansion without reform potentially fiscally burdensome.
Future research should focus on the long-term economic and environmental impacts of higher blending levels. Region-specific studies on feedstock efficiency, water usage and land-use changes would strengthen sustainability assessments. Further evaluation of second-generation biofuels could help reduce pressure on food crops.

From a policy perspective, emphasis should shift towards diversification and efficiency. Investment in advanced biofuel technologies, flexible pricing mechanisms and integrated planning across energy, agriculture and water policy will be essential to ensure that ethanol blending remains both viable and responsible in the long run.

In conclusion, the increase in ethanol blending in India is not the result of a single factor but a carefully constructed response to multiple national challenges. While the progress achieved so far is substantial, the success of the programme in the long run will depend on adaptive policy design, technological innovation and continued evaluation of its broader economic and environmental impacts.

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