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Maize for Bio-Ethanol: Potential and Opportunities

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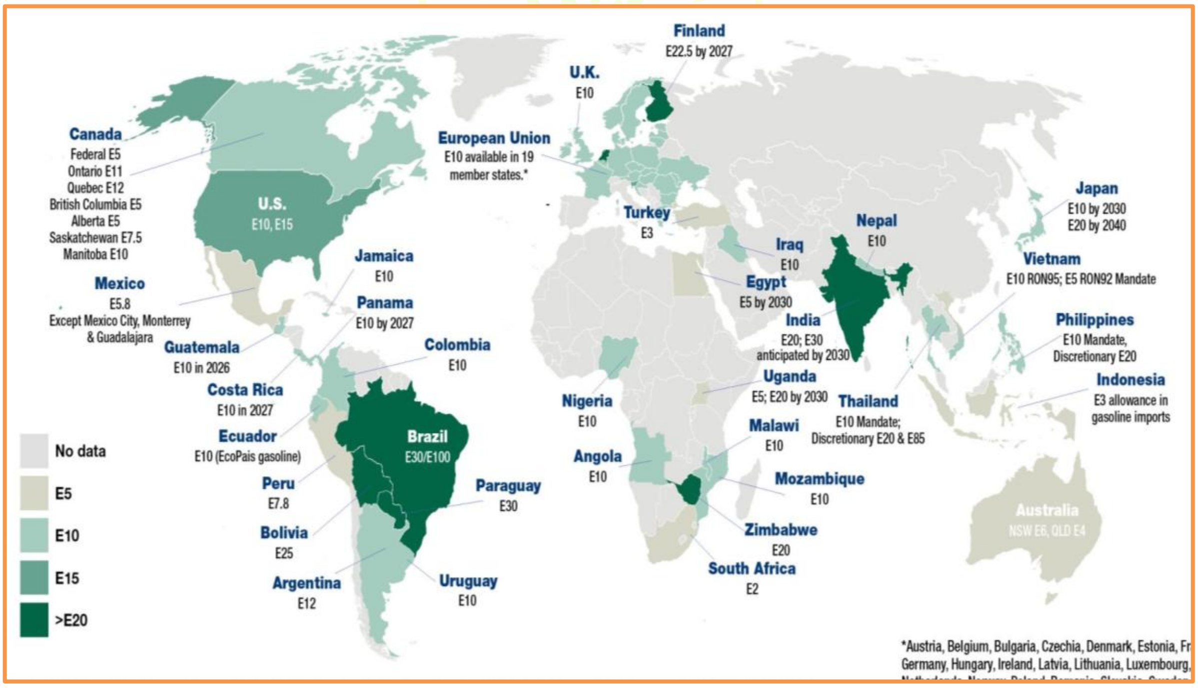
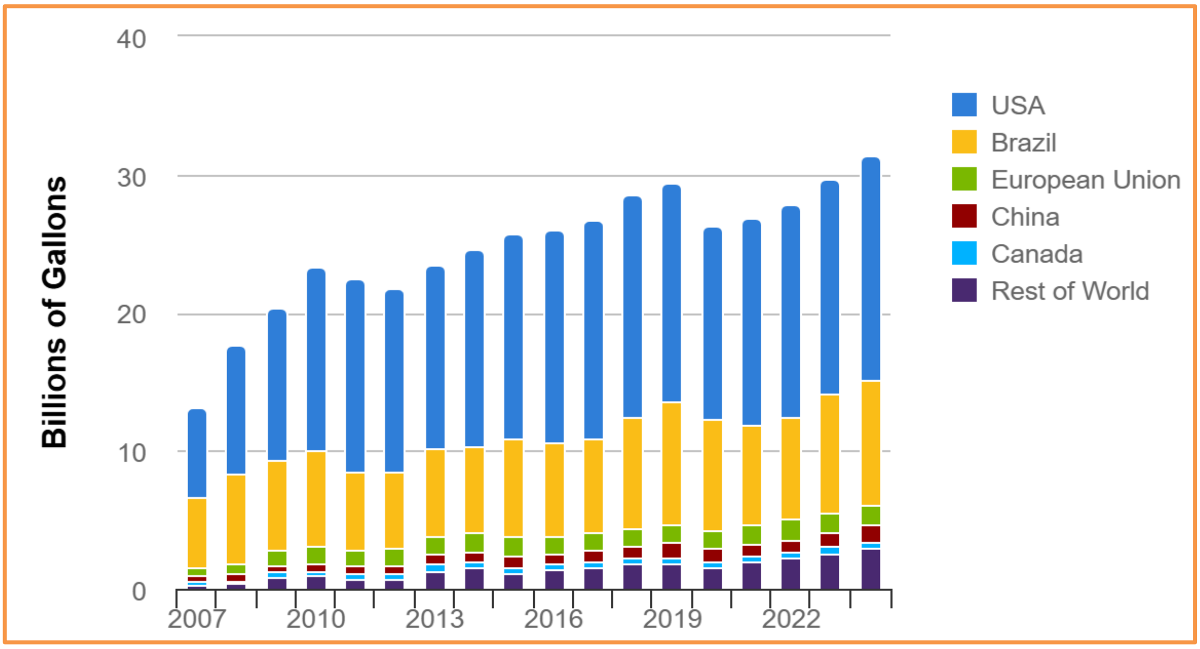
As global energy demands shift toward sustainable alternatives, maize (corn) has emerged as a pivotal feedstock for bioethanol, a renewable biofuel that reduces greenhouse gas emissions and dependence on fossil fuels. Globally, ethanol production reached ~100+ billion litres in recent years with the United States and Brazil producing the lion's share (corn-based in the US; sugarcane in Brazil). Maize is attractive because of high starch content, relatively mature conversion technology, and useful co-products (DDGS) that support feed markets. India is actively expanding bioethanol blending targets (E20/E25 → E30 mandate moving national policy to E20/E25), and maize is emerging as an important complementary feed stock alongside sugarcane and surplus rice.

Global landscape: who produces ethanol and why maize matters



Global bioethanol blending policies map (Source: grains.org/bioethanol)

Global liquid biofuel production (dominated by ethanol) exceeded 100 billion litres recently; the United States and Brazil together account for about 80% of global ethanol output. The U.S. ethanol industry is almost entirely corn-based and benefits from mature dry-grind processing, integrated co-product markets (distillers dried grains with solubles-DDGS), and supportive fuel-blending policy. (https://afdc.energy.gov/data)



Global ethanol production by country or region (Source: https://afdc.energy.gov/data)

Corn has high starch concentration (easily hydrolysable to fermentable sugars) and high yield per hectare in many regions; technologies (dry-grind/wet-milling) are well optimised, and co-products (DDGS, syrup, oil) provide valuable revenue streams that improve plant economics. Technology maturity and strong domestic feed markets are the main reasons corn dominates ethanol world wide. (Assaf, J.C. *et. al*., 2024)

Maize is now an important complementary feed stock because it:

A. Has rising production (~10–11 million ha area in recent years),

B. Requires less water than rice in comparable productivity scenarios,

C. Can be sourced from surplus or commercial maize production areas. State policy changes (e.g., Maharashtra allowing sugar mills/distilleries to use maize/broken rice) broaden the raw material base and enable year-round operations.

Production Process

Maize bioethanol involves dry or wet milling to extract starch, followed by saccharification, fermentation (using yeast), and distillation. Ethanol yield is about 400-450 liters per tonne of maize. Advanced technologies like enzyme optimization enhances efficiency. However, as a matter of sustainability, maize ethanol reduces GHG emissions by 40-60% vs. gasoline, but concerns include land use and water intensity.

Dry-milling: Whole grain is ground, liquefied (α-amylase), saccharified (glucoamylase), fermented (yeast), distilled and dehydrated. Simple plant layout, lower capital cost per tonne of grain processed. Produces ethanol + DDGS (high-value animal feed).

Wet-milling: Grain fractionation into starch, germ (oil), fiber and protein; starch is fermented to ethanol, other fractions sold to food, feed and industrial markets. Higher capital cost but yields diversified co-products (starch for food, corn oil, gluten feed). Wet-milling is less common (smaller global share) but useful when multiple high-value co-products are needed.

Advanced and hybrid routes: The production of 2G / cellulosic ethanol uses maize stover/biomass (or dedicated energy crops) after pretreatment and enzymatic hydrolysis. Still cost-intensive, but offers better land-use efficiency and lower food-vs-fuel conflict if residues are sustainably collected. Research and pilot plants are advancing globally. (Kaur, G. *et. al*., 2025)

Economics and co-product value

The economics of grain ethanol rests heavily on (i) feed stock cost, (ii) ethanol price, and (iii) value of co-products such as DDGS and corn oil. In established markets, DDGS constitutes a large implicit subsidy by replacing higher-cost feed. In India, co-product markets are nascent compared with the U.S.; thus, economic viability depends on local feed demand, logistics, and policy (procurement prices, ethanol purchase price from OMCs). Policy support (blending mandates, procurement pricing) has been critical to make ethanol plants bankable in India. (Assaf, J.C. *et. al*., 2024).

Food vs. fuel: trade-offs

Food security concerns arise when grains are diverted from food/feed to fuel. The global debate intensified during price spikes, and many countries use flexible feedstock mixes or target surplus/low-value grain and byproducts (broken rice, culls). India's pragmatic approach has included using surplus rice and enabling grain usage when stocks are abundant, as seen in recent large allocations of rice to ethanol production (Reuters report, 2025). Blending targets, procurement pricing, use of low-value broken grains, and a move toward 2G/bagasse/stover feedstocks help manage trade-offs. India's Roadmap for Ethanol Blending (2020–25) explicitly emphasises maize as a lower-water foodgrain alternative and 2G feedstocks for long-term scale-up.

Indian context - policy, feedstock availability and recent developments

India has aggressively scaled ethanol blending. The Ethanol Blended Petrol (EBP) programme targets 20% (E20) and beyond. Recent reports show blending averaged 19.05% by July 2025, nearing E20 (20% by 2025-26) with policy pushes to expand feedstock base. The government's E20 mandate and incentives have driven rapid capacity addition. (Press Information Bureau, 2024-25 progress)

Year	Maize ethanol (MT)	Blending achieved (%)	Maize Area (M ha)
2022	1	~10	~8.3
2024	6+	11.7	9.2
2025	11	19-20	Projected 10+
2030	18-20	30	12-14

Technical and supply-chain challenges in India

- Seasonality & logistics: Maize harvest seasonality and storage losses require drying, storage and transport infrastructure; investments in collection centres and silos are needed.
- Feed vs feed markets: To replicate U.S. economics, India needs strong DDGS/feed markets (ruminant poultry sectors) to absorb co-products — this is growing but fragmented.
- Plant scale and financing: Dry-grind plants need adequate scale and reliable feedstock supply; dual-feed (sugar+grain) flexibility improves utilization. Recent policy allowing dual feed helps.

Sustainability & best practices (how to make maize ethanol "sustainable")

- Use surplus/low-value grains (broken rice, culls) rather than prime food grains where possible. India has already done this with rice to some extent. (Reuters report, 2025)
- Co-locate distilleries with feed/animal farms to ensure DDGS uptake and reduce transport emissions.
- Adopt precision farming and maize hybrids with higher starch yields per ha to increase productivity and reduce per-litre emissions.
- Recover and use process heat (e.g., cogeneration with bagasse or biogas) to reduce fossil energy use in plants.
- Scale up 2G technologies (maize stover, bagasse, rice straw) to reduce food vs fuel conflict and improve lifecycle GHG reductions. (Kaur, G. *et. al*., 2025)

Research priorities & role of plant breeding

To maximise maize's suitability as ethanol feedstock, research should focus on:

- ✓ High-starch, high-starch-yield hybrids: increase fermentable sugar per ha.
- ✓ Low-moisture and fast-drying lines to reduce post-harvest drying energy.
- ✓ Dual-purpose lines: maintain grain quality for feed/food while optimising starch for ethanol.

- ✓ <u>Breeding for residue quality:</u> stover composition favourable for 2G processing (higher cellulose/hemicellulose, lower lignin) to improve saccharification.
- ✓ <u>Integration of on-farm practices</u>: increase harvest index and reduce losses; precision nutrient/water management lowers per-L ethanol emissions (Assaf, J.C. *et. al*., 2024).

Conclusion

Maize is a technically and economically proven feedstock for fuel ethanol at scale and presents a pragmatic complementary feedstock for India's ethanol blending ambitions. Careful policy design, co-product market development, investment in storage/logistics, breeding for starch-yield traits, and an accelerated transition to 2G technologies will determine whether maize can sustainably power India's ethanol goals without jeopardising food security. With appropriate safeguards and integrated planning, maize can help India meet blending targets while supporting farm incomes and reducing fossil fuel imports.

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