The Social Science Review A Multidisciplinary Journal. July-August, 2026. Vol. 4. Issue 4. 52-59
Published by: Pather Dabi Educational Trust, (Regn No: IV-1402-00064/2023), Under Govt. of West Bengal, India

The Social Science Review
A Multidisciplinary Journal
ISSN: 2584-0789
(Open-Access, Peer-Reviewed, Refereed, Bi-Monthly, International e-Journal)
Homepage: www.tssreview.in

DECARBONIZING TRANSPORT SECTOR OF INDIA: POLICY & ITS IMPLICATIONS

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RESEARCH ARTICLE

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DOI:
https://doi.org/10.70096/tssr.260404009

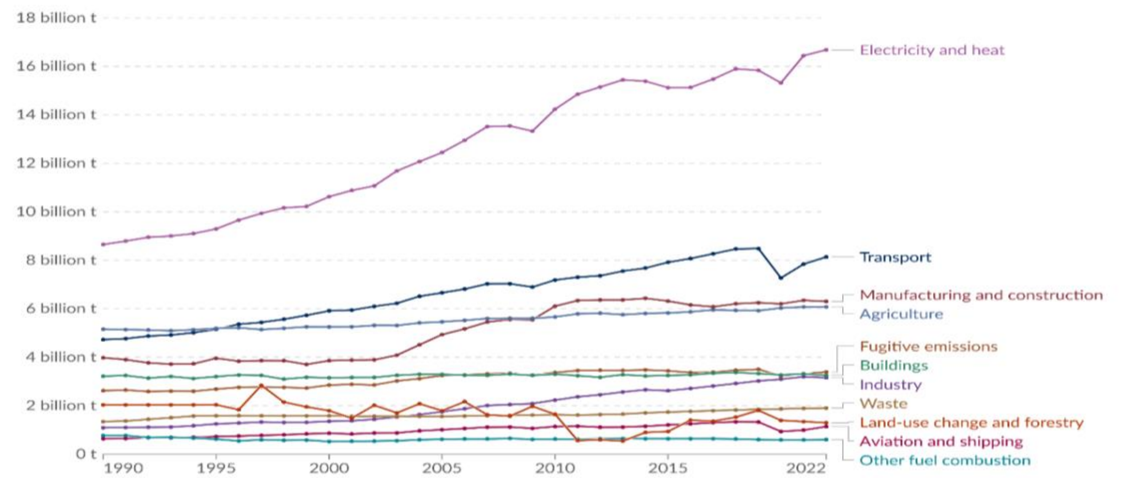
Abstract
India has been pursuing Ethanol Blending Programme as a part of its decarbonization strategy since 2003. Initially production of sugarcane-based ethanol was emphasised. But considering the ecological effects of over emphasizing the sugarcane as primary feedstock of ethanol production, later on government emphasised on the development of new feedstock for producing biofuel. Maize has been emerging as a major feedstock for ethanol production in due course of time. Maize is a multi-purpose commodity in Indian economy. About 60% of maize goes to animal-feed industry. Considering the rapidly growing poultry and dairy sector of the Indian economy the increasing demand for maize from the ethanol industry is encouraging competition between the ethanol distilleries and feed industry for the limited supply of maize. India was net exporter of maize till 2023-24 and the country had become net importer of maize for the first time in 2024-25. This paper intends to evaluate the present status of the decarbonization strategy of India and an attempt has been made to evaluate the impact of ethanol blending programme, a sustainable strategy for climate change initiative on the food and fodder security of India.

Keywords: *Greenhouse gases, Decarbonization, Sustainable climate action, Ethanol blending programme*

Introduction

One of the most challenging problems that we are facing in the 21st century is the adverse effects of climate changes. There is no denial of the fact that because of this problem our very existence in this planet is now at stake. Though the International communities took the matter seriously, global response to this challenge is not encouraging till date. United Nation raised a wake-up call by initiating a coordinated efforts with the formation of United Nations Framework Convention on Climate Change (UNFCCC). Under this framework, conferences known as Conference of Parties (COP) held at Kyoto (1997) and Paris (2015) are the two most important conferences in the sense that they set bindings and voluntary targets for emission reductions. Figure 1 shows that the greenhouse gases emission across the different sectors of the world during the period 1990-2022. Emission from electricity and heat tops the list. Transportation is second most emitter of greenhouse gases.

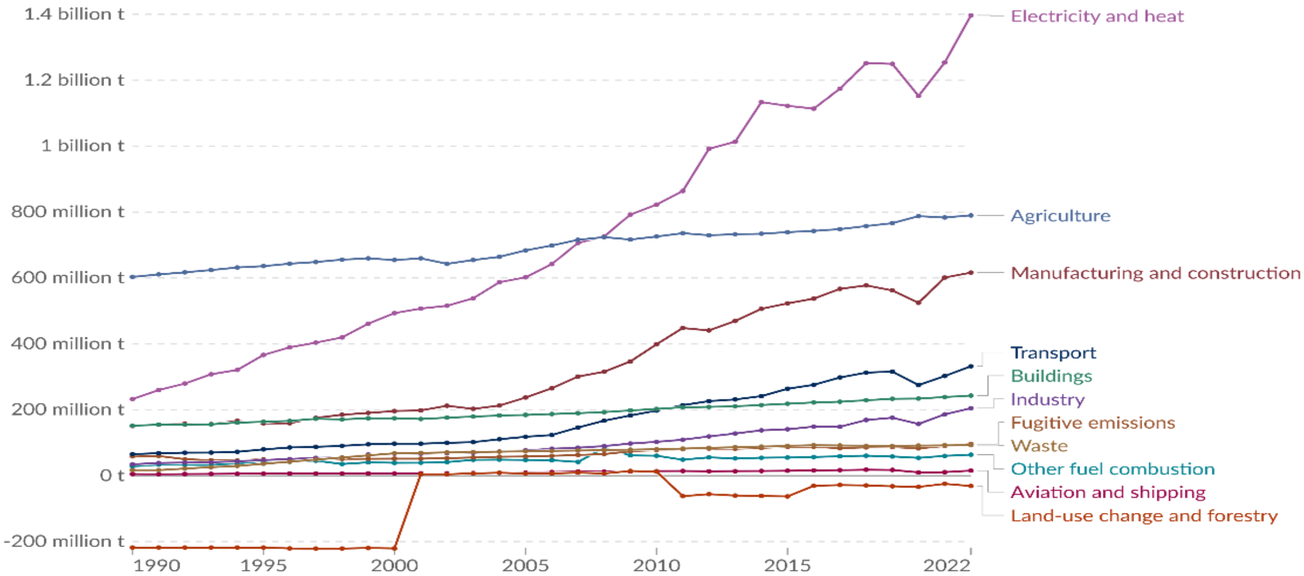
Figure 1: Greenhouse gas emissions by sector (World) (1990-2022) (Tonnes of carbon dioxide equivalents)



Source: Our World in Data

In India greenhouse gas emission by sector is shown figure 2. Emission from electricity and heat emit most and second is agricultural sector. This is not surprising that agriculture stands at second position since India has world's largest population of cattle. As of 2023 it accounts to 33% of the world's cattle population. Ruminant animals during the process of digestion of food in their rumen release methane via burping.

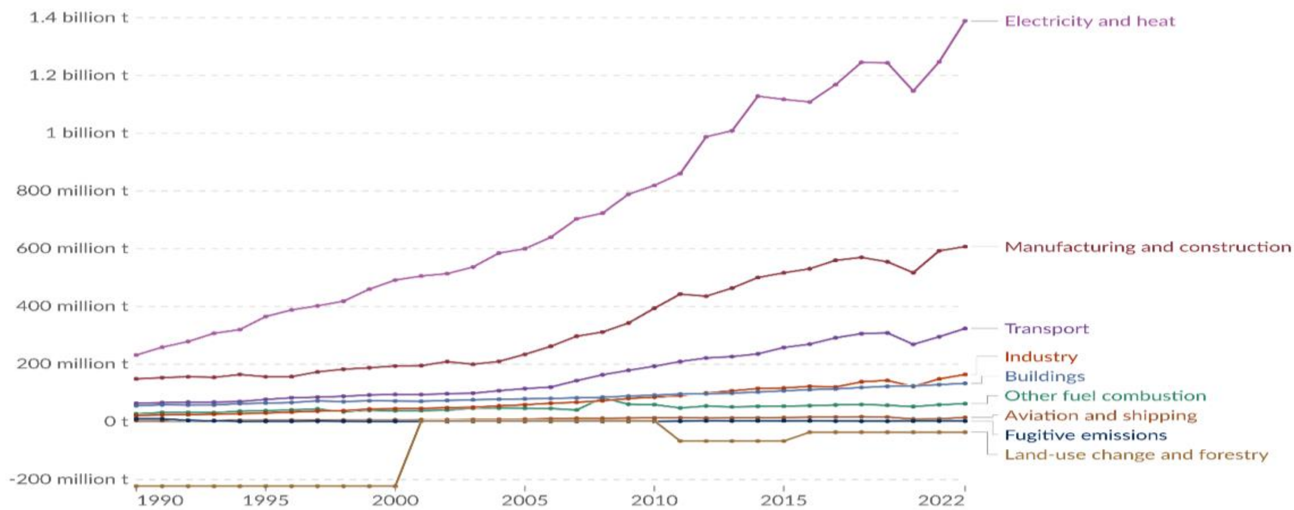
Figure 2: Greenhouse gas emissions by sector (India) (1990-2022) (Tonnes of carbon dioxide equivalents)



Source: Our World in Data

Though the emissions of GHG from the transport industry stands at fourth position, in terms of carbon dioxide emission globally, it secured third position in India (Figure 3). With the increase in per capita income of the people of India, need for transportation of both passengers and freight witnessed an unprecedented increase during the last two decades and consequently emission of carbon dioxide from this sector has increased a lot. As of 2020, 368.2 million tons of CO_2 has been released into the air by the transport industry and emission from road sector accounts for 90 % of all CO_2 emissions (Jain & Rankavat, 2023). In this backdrop India's commitment to UNFCCC at COP 26 held in Glasgow to achieve net zero emission by 2070 is very important. Energy intensive transport sector has already been in the phase of decarbonizing efforts by the Government of India since 1982 with creation of a separate ministry named as Ministry of Non-Conventional Energy Sources (MNES) (later renamed as Ministry of New and Renewable Energy (MNRE) with focus on promoting of renewable energy. But it got impetus when India pledged to reduce carbon emissions intensity of GDP by 33–35% by 2030 (from 2005 levels).

Figure 3: Carbon dioxide (CO2) emissions by sector (India) (1990-2022) (Tonnes)



Source: Our World in Data

Objective of the study

This paper intends to evaluate the present status of the decarbonization strategy of India and an attempt has been made to evaluate the impact of ethanol blending programme, a sustainable strategy for climate change initiative on the food and fodder security of India.

Database and Methodology

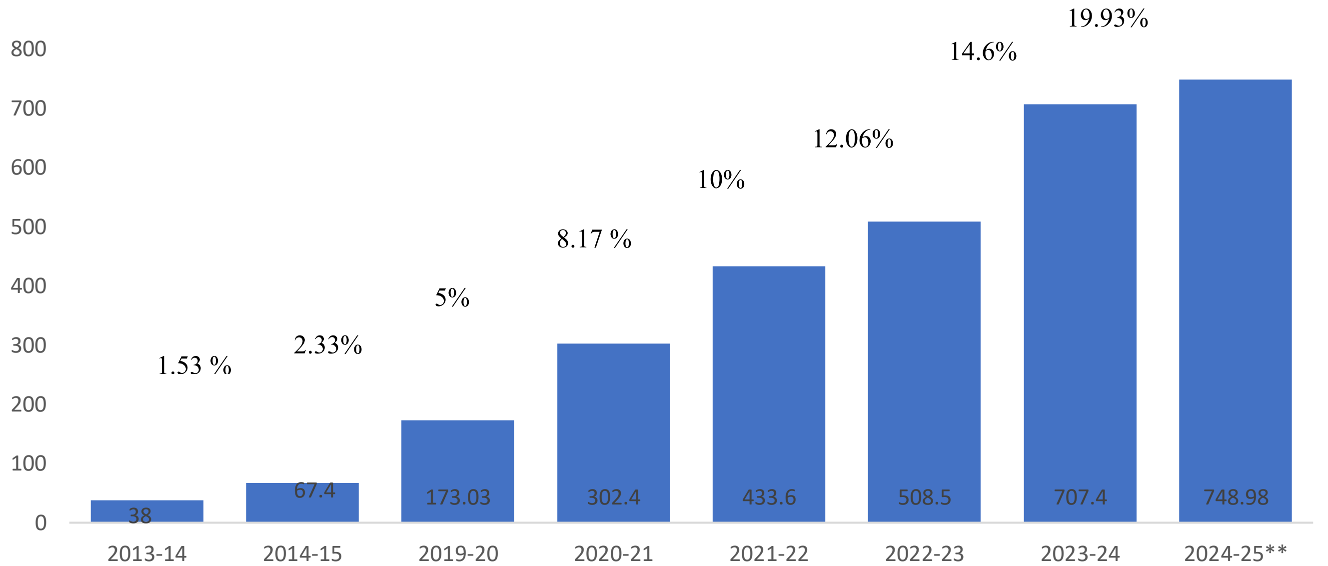
This paper is based on the secondary sources of data collected from Our World in Data; Ministry of Consumers affairs, Food & Public Distribution, GoI; Ministry of Petroleum & Natural Gas, GoI; Economic Survey (2023-2024); Directorate General of Commercial Intelligence and Statistic (DGCIS), GoI; Commission for Agricultural Costs and Prices (CACP); Department of Animal Husbandry & Dairying (DAHD), Department of Fisheries (DoF). This study is based on descriptive analysis.

India's Decarbonization strategy

Transport industry consists of roadways, waterways, airways and railways. India is striving to achieve net zero emission nation by adopting various decarbonization strategies. Since transport industry assumes an important role as an emitter of CO_2, government adopted national biofuel policy in early 2000s aiming at blending ethanol with petrol in a phased manner. Blending ethanol with petrol results in better combustion efficiency and helps to emit lower carbon emission into the air. A study on life cycle emissions of ethanol by NITI Aayog revealed that sugarcane and maize based ethanol helped to reduce greenhouse gases by 65% and 50% respectively than those of petrol (Ministry of Petroleum & Natural Gas)[1].

Figure 4 shows the quantity of ethanol supplied to Oil Marketing Companies (OMC) for blending with petrol in different Ethanol Supply Years (ESY). Ethanol supplies to OMC was 38 crore litres in 2013-14 and it rose to 748.98 crore litres in 2024-25 (as on 31.07.2025) registering 1871 % increase in supply. Starting from blending with petrol at 1.53 % in 2013-14, gradually it was taken to 19.93% in 2024-25. With this success government became so enthusiastic that it has advanced the target of 20 % blending in petrol by 5 years from 2030 to 2025.

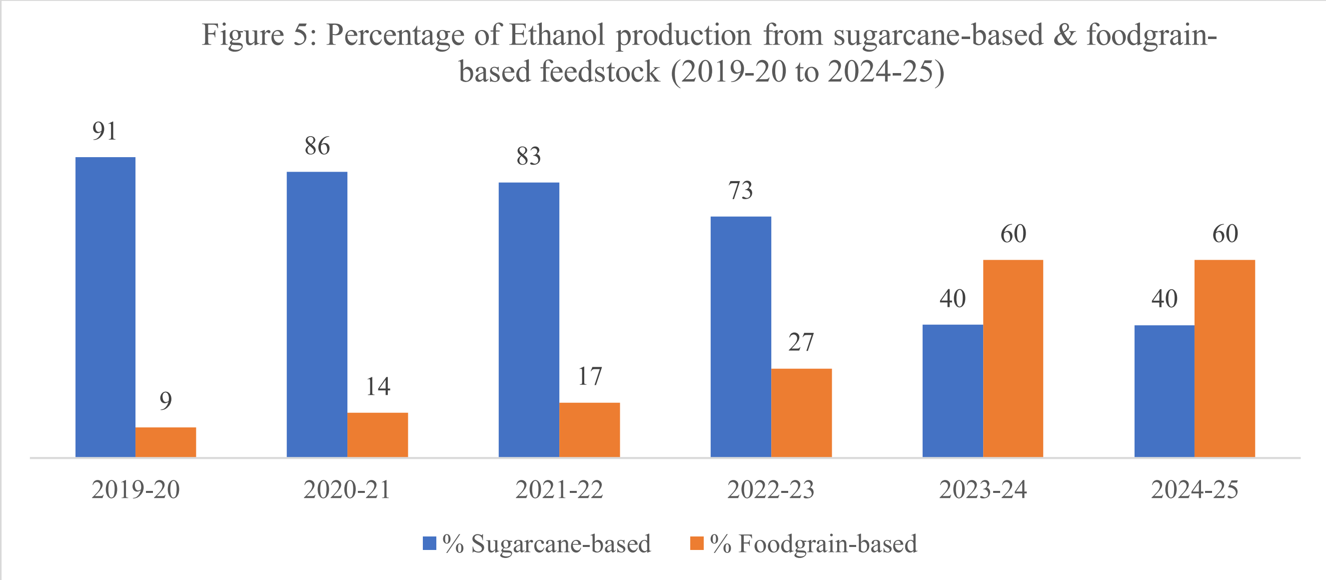
Figure 4: Ethanol supplied to OMC (Crore Litres) & blending percentage with petrol during the EYS*
2013-14 to 2024-25



Sources: Ministry of Consumers affairs, Food & Public Distribution, GoI, Ministry of Petroleum & Natural Gas, GoI (Different years)* EYS means Ethanol Supply Year starting from November to October next year **As on 31.07. 2025

1. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2155558

At the beginning of this Ethanol Blending Programme (EBP), production of biofuel was started from sugarcane molasses. Later other sources of feedstocks have been explored. Figure 5 shows the amount of sugarcane-based and foodgrain-based feedstocks used for the production of ethanol in different years.



Source: Ministry of Consumers affairs, Food & Public Distribution, GoI. (Different years)

Initially the share of sugarcane-based feedstock used for ethanol production was higher. About 91% of total production of ethanol came from sugarcane-based feedstock and rest 9% was from foodgrain-based feedstock in 2019-20. India is the second largest producer of sugarcane after the Brazil. Organic composition of sugarcane made it an enviable source of ethanol production. Ambitious Ethanol Blending Programme (EBP) of Government of India pushed the demand for sugarcane production upward over the years. Production of sugarcane increased from 325 million tonnes in 2011-12 to 490.5 million tonnes in 2022-23, thus registering 36% increase in production (Economic Survey 2023-24, statistical Appendix p 37). But excessive sugarcane production has some ecological effects. Sugarcane production requires huge usage of water and it becomes more difficult in times of bad monsoon when scarcity of water is evident. During this time dependence on ground water becomes necessary. One estimate was that sugarcane field requires 20 megalitres of water/hectare (Shrivastava et al., 2011). Increase in the area under sugarcane has an effect on the decrease in groundwater table also (Sharma, 2016).

Table 1: Water requirement of Maize, rice & sugarcane

Crop	Water Requirement (mm)	Water Requirement (m^3/ha)
Maize	500	5000
Rice (Paddy)	1250	12500
Sugarcane	2200	22000

Source: Economic Survey (2023-2024)

Since the excessive sugarcane production may have adverse effects on ecology in future, government in its amendment of Biofuel policy 2018 in 2022 allowed broken rice, surplus rice with FCI and maize to be used as feedstocks for ethanol production while continuing support to produce ethanol from sugarcane. After the amendment of biofuel policy 2018, ethanol production from foodgrain-based feedstock got impetus. It started to rise and in the year 2024-25 it contributed 60% of the total ethanol production (Figure 5). This resulted diversification of feedstocks in the supply chain which might have long run effects on crop-pattern and availability of animal feeds. Table 1 shows total ethanol production from different feedstocks during the period 2019-2025.

Table 2: Total ethanol production from different feedstock (Crore litres)

Feedstock	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25*
Molasses(C-heavy)	74.12	38.9	10.06	5.6	57.56	10.94
Molasses(B-heavy)	68.14	183	249.43	235.3	148.81	88.92
Sugarcane syrup	14.83	39	80.26	128.4	63.9	156.06
Damaged food grains	15.94	39	22.59	31.9	115.62	48.6
FCI Rice	0	2.2	45.75	73.7	0.13	66.44
Maize	0	0	0	31.5	286.47	266.45
Total	173.03	302.4	408.09	506.4	672.49	637.41

Source: Ministry of Consumers affairs, Food & Public Distribution, GoI. (Different years)

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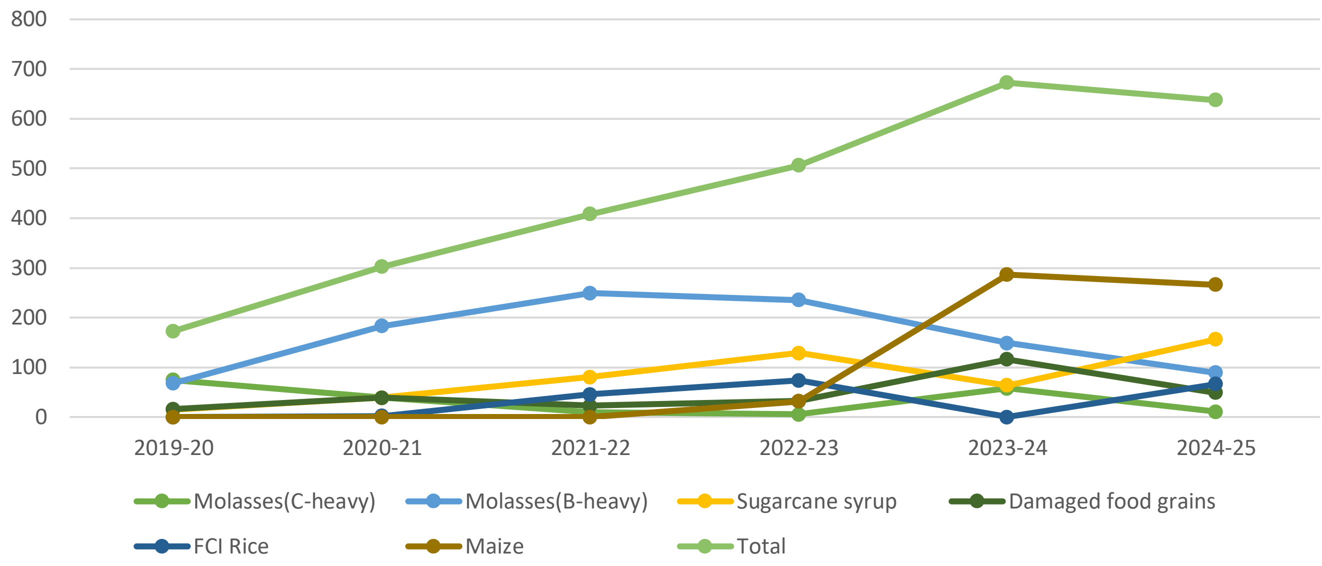
Table 2 reveals that among the foodgrain-feedstocks, maize-based ethanol production has been increasing steadily since 2022-23. In terms of water requirement/ hectare sugarcane and paddy need more water than that of maize (Table 1).

*As on 30.06.2025

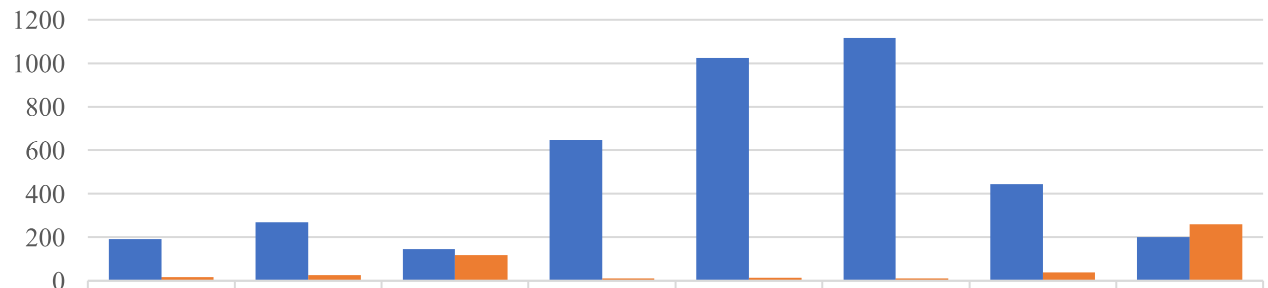
Figure 6: Total ethanol production from different feedstock (Crore litres)



Source: Ministry of Consumers affairs, Food & Public Distribution, GoI (Different years)

Considering huge requirement of water/ha for the production of sugar and paddy, increased demand for ethanol to be made by maize was a good option by the government. India ranks fifth in terms of maize production. India was net exporter of maize till 2023-24. But due to the increased demand for ethanol production, the country had become net importer of maize for the first time in 2024-25. One important usage of maize is as animal feedstock. In India about 60% of maize is used as poultry-feed. Government became so enthusiastic to carry forward the ethanol-blending percentage beyond 20%. Since maize is most cost effective, environmentally viable option for the production of ethanol, it is high time to explore what challenges and opportunities this particular crop is facing presently.

Figure 7: Maize Export & Import (India)
(US $ Million)



	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Export	190.67	269.44	144.42	645.49	1023.46	1116.94	443.64	202.12
Import	15.84	25.79	117.48	10.93	14.18	11.06	38.68	259.81

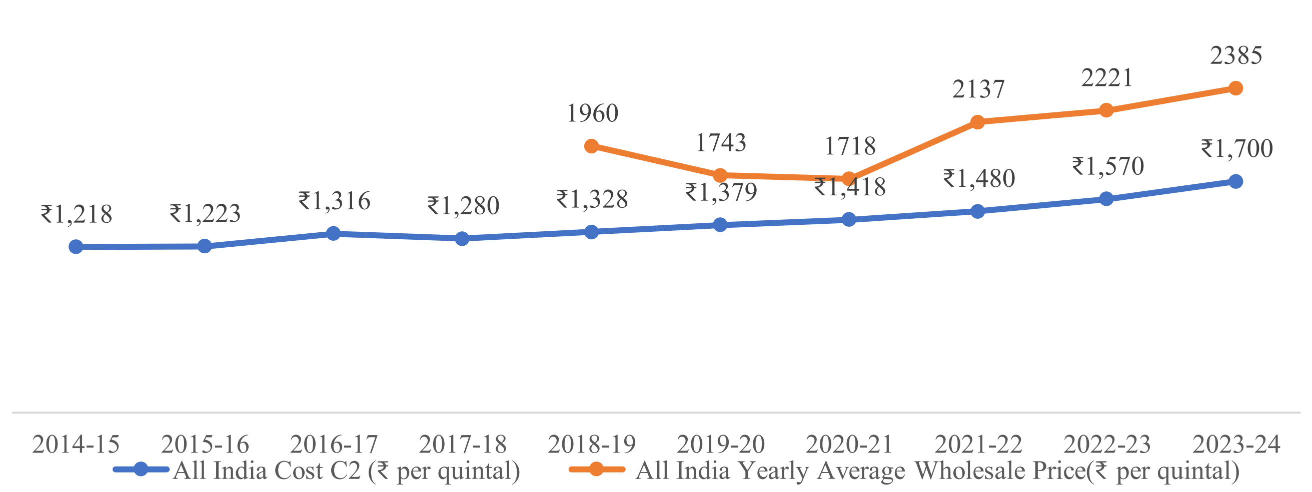
■ Export ■ Import

Source: Ministry of Commerce & Industry, GoI

Challenges ahead of maize-based ethanol production

The assured ethanol price policy of the government of India is helping in bringing more area under the maize cultivation. Record corn production amounting to 42.28 million metric tonnes (MMT) from 12 million hectare achieved during the agricultural year 2024-25 (Ministry of Agriculture and Farmers' Welfare, Advance Estimates 2024-25). In spite of higher ex-mill price offered by the government under the ethanol price policy, maize production has been witnessing a gradual increase in its cost of production. The cost of production of maize per quintal was Rs. 1218 in 2014-15 and it increased to Rs. 1700 per quintal in 2023-24. Ex-mill price has increased to Rs. 2385 per quintal in 2023-24 from Rs. 1218 in 2014-15. Therefore, the difference between Ex-mill price and cost of production per kilogram stands at Rs. 6.85 (=Rs. 23.85- Rs. 17) in 2023-24, which made maize cultivation less attractive to the farmers.

Figure 8: Cost of Production (C2)[1] & Wholesale Price of Maize (₹ per quintal)



Sources: Commission for Agricultural Costs and Prices (CACP) (Different years); Agricultural Prices of India (2024), Agricultural Marketing Division, GoI

1. **C2** — A2+FL plus imputed rental/economic cost of owned land and interest on fixed capita, where A2 includes all paid out cost, FL means imputed family labour.

Since Indian economy is growing in terms of GDP and middleclass population constitutes a major chunk of the population, demand for animal protein have also been rising. This has been reflected in the steady increase in the demand for animal protein. Table 3 shows growth rates of production of some selected foods. Fisheries sector has been witnessing 9.86 % Compound Annual Growth Rate (CAGR) during the period 2014-15 to 2021-22 and egg production registered 7.35 % CAGR during the period 2014-15 to 2022-23. All these sectors have been heavily dependent on the supply of maize for the growth of fodder industry. In India a major portion of the maize is used for animal and fish feed industry. About 63% of the maize goes to cater animal-feeds industry and poultry-feeds accounts for 47% of the maize consumption (Ministry of Food Processing Industries). If government continues ethanol production by relying heavily on maize as feed-stock, it may create shortage of feedstocks for animal and consequently cost of production of such protein-based food may rise. This may not only effect consumption of the people due to the possible fluctuations in the retail prices of these protein-rich food items but it may also have severe repercussions on live and livelihood of the people engaged in these sectors. Therefore, until and unless the production of maize is raised within the country it will not be a viable option to depend heavily on maize as feed-stock for ethanol production to implement EBP more aggressively as govt has already initiated.

Table 3: Growth rates of production of some selected foods

Sector	Metric	Growth Rate	Period/Year
Egg Production	Annual Growth Rate (AGR)	3.18%	2023-24 over 2022-23
	Compound Annual Growth Rate (CAGR)	7.35%	2014-15 to 2022-23
Meat Production	Annual Growth Rate (AGR)	4.95%	2023-24 over 2022-23
	Compound Annual Growth Rate (CAGR)	4.84%	2014-15 to 2022-23

Poultry Meat GVA	Annual Growth Rate (AGR)	5.27%	2021-22 over 2020-21
	Compound Annual Growth Rate (CAGR)	9.86%	2014-15 to 2021-22
Fisheries Sector	Annual Average Growth Rate	8.61%	2014-15 to 2021-22

Sources: Department of Animal Husbandry & Dairying (DAHD); Department of Fisheries (DoF),GoI

Conclusion

Ethanol production is increasing dependent on maize. Though this crop needs less water compared to other foodgrain feedstocks, this may have adverse effects on food and animal-feed industry. Maize is a multi-purpose commodity in Indian economy. About 60% of maize goes to animal-feed industry. Considering the rapidly growing poultry and dairy sector of the Indian economy the increasing demand for maize from the ethanol industry encouraging competition between the ethanol distilleries and feed industry for the limited supply of maize. National policy on biofuel 2018 as amended in 2022 emphasised on the development of new feedstock for producing biofuel. Using the surplus rice and wheat straw in ethanol production can be viable option. This will help the economy in other way. Every year stubble burning has become a regular incident in western parts of the country especially in Punjab, Haryana and western region of Uttar Pradesh. As soon as the crop- harvesting is over in this region, farmers become hurry to prepare the field for the next crop. So, they start burning the loose straw that are left in the field. This leads to release of huge greenhouse gases into the air as well as brings loss to the nutritional health of the soil. Various studies revealed that uncontrolled stubble burning leads to emission of GHGs like carbon dioxide, sulphur dioxide, nitrous oxide, ammonia, methene etc (Awasthi et al., 2011; Jain et al., 2014). India is the second largest producer of crop. It generates nearly 600-700 MMT of residues every year and of which about 16 % is burned on farm (Vinay Trivedi, 2020). There are extensive research works that support that a considerable amount of bio-energy can be produced from straw or stubble (Jain et al., 2014; Ravindra et al., 2019). Some studies found that second generation bio-ethanol can be produced from crop residues (Becerra-Pérez et al., 2022; Molaverdi et al., 2022; Reijnders, 2008) Currently India is producing merely 3 crore litres of 2G Ethanol from rice straw which is .004 % of the total production during EYS 2024-25. Therefore, this has to be scaled up considering its huge potential. Therefore, if this crop residues are diverted to the ethanol production in large scale it will boost the production of ethanol as well as help environment to be less polluted.

Due to rapid urbanization in India, a large volume of Municipal Solid Waste (MSW) has been generated across the cities of India throughout the year. There are scientific evidences that ethanol production from Bio-degradable MSW is technically and scientifically feasible (Kalogo et al., 2007; Li & Khraisheh, 2008; Thapa et al., 2019). A study revealed MSW-ethanol is efficient in terms of low GHG emission compared to corn-based ethanol reducing GHG 58 % than that of corn-based (Kalogo et al., 2007). But ethanol production from MSW has not been started in India till now. This opportunity must be explored as early as possible and government must encourage entrepreneurs in this direction.

Acknowledgment: No
Author's Contribution: *Dr. Tushar Kanti Pal:* Literature Review, Data Collection, Methodology, Analysis, Drafting, Referencing
Funding: No
Declaration: The author has given consent for the publication.
Competing Interest: No

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