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Growth Patterns And Regional Concentration Of Sugar Industries In India

Dayananda Huded, Research Scholar, Rani Channamma University, Belagavi
Dr. Mallikarjun M. Maradi, Research Guide, Rani Channamma University, Belagavi

Abstract:
The sugar industry in India plays a crucial role in the agricultural economy. It contributes significantly to jobs, rural development, and export earnings. This study looks at the growth of the Indian sugar sector from 2014-15 to 2023-24. It focuses on important indicators like the distribution of sugar mills, installed capacity, production and consumption trends, average sugar recovery rates, and cane crushing volumes. Using secondary data from official sources such as the Directorate of Sugar and the Indian Sugar Mills Association, the analysis shows strong growth in production capacity and output. This growth is supported by helpful government policies and increased sugarcane farming. However, challenges remain. These include fluctuating recovery rates, uneven distribution of mills across regions, and imbalances between supply and demand. Descriptive and analytical methods, backed by SPSS for statistical insights, reveal a compound annual growth rate (CAGR) of about 4.5% in sugar production, while consumption grows at a CAGR of 3.5%. The findings highlight the sector's resilience despite climate changes and policy shifts. They recommend better technology for higher recovery and sustainable practices. This decade-long perspective offers useful insights for policymakers, industry stakeholders, and researchers to encourage balanced growth and reduce vulnerabilities in the sugar value chain.

Keywords: Sugar Industry, Growth Trajectory, Production and Consumption Trends.

Introduction

India, as the world's largest producer and second-largest consumer of sugar, depends heavily on its sugar industry to support over 50 million sugarcane farmers and provide jobs for millions more. The industry generates significant foreign exchange through exports and contributes to bio-energy projects through ethanol blending. Over the last decade, from 2014-15 to 2023-24, the sector has undergone major changes, including policy reforms like the Fair and Remunerative Price (FRP) mechanism and shifts towards by-products such as ethanol and cogeneration. These changes have increased production from 23.6 million metric tons (MMT) in 2014-15 to an estimated 34 MMT in 2023-24. This growth is influenced by climate factors, new technologies, and market needs. However, challenges like cane arrears, low recovery rates, and uneven mill infrastructure still affect overall performance.

This study looks into the complex growth of the sugar industry, examining structural and operational aspects to identify patterns and challenges. By focusing on sector distributions and trends over time, it aims to provide a detailed overview of how the industry has shifted from facing surplus issues to becoming a global leader. The analysis is especially relevant with the government's goal of reaching 20% ethanol blending by 2025, which could change the sector's future and sustainability.

Literature Review

The Indian sugar industry has been thoroughly examined by local researchers, focusing on economic, policy, and farming aspects. **Gangwar et al. (2014)** looked at the social and economic effects of sugarcane production and diversification. They pointed out that while the sector helps rural communities, it struggles with water shortages and inconsistent policies. Their policy paper stresses the importance of integrated farming practices to improve productivity. **Malik and Priya (2020)** used growth modeling methods to forecast trends in sugarcane area, production, and productivity. They analyzed time-series data and predicted a 3-4% yearly increase, attributing it to hybrid varieties and better irrigation. Their study in Sugar Tech highlights the importance of econometric models in shaping policies. **Munagala and Shastri (2021)** examined different designs for integrated sugar industry complexes. They compared public-private models to find ways to improve efficiency. Their research, published in Industrial & Engineering Chemistry Research, suggests that co-generation and ethanol units could increase profits by 15-20%. **Paulraj and Nandakumar (2019)** reviewed policies that affect the Indian sugar industry. They criticized export quotas and subsidies for creating market distortions. In International Journal of Agriculture Sciences, they support market-linked pricing to help stabilize farmer incomes. **Thangarasu and Praveena (2010)** assessed the financial health of sugar mills. Their findings showed profit differences across states due to how well mills use their capacity. Their analysis, in Indian Journal of Agricultural Marketing, calls for financial restructuring to manage high debt levels. **Rao (2018)** estimated factors behind growth and instability in sugarcane production, focusing on southern states. He highlighted yield variability as a major issue. His article in Indian Journal of Sugarcane Technology recommends developing climate-resilient varieties. **Sheetal and Kumar (2019)** explored growth strategies, linking policy changes to a rise in output after 2018. In Journal of Asia Business Studies, they stress the need to diversify into ethanol for sustainable growth. **Srivastava et al. (2015)** studied soil amendments to improve sugarcane quality in subtropical India. They connected higher recovery rates to the use of organic inputs. Their research in Sugar Tech offers agronomic suggestions for boosting yields.

Rathod and Goudar's (2019) study of Karnataka's sugar industry shows a clear performance gap. Private mills usually have higher operational efficiency than cooperative ones. This difference is due to better management practices and more capital investment in the private sector. **Chintamani R. & Joshi P.K. (2020)** looks at how recent government policy reforms have affected the financial health of sugar mills in India. It finds that measures such as the Ethanol Blended Petrol (EBP) Programme and the minimum selling price (MSP) for sugar have been important for improving their profitability and viability. The study concludes that ongoing policy support and diversification into value-added products like ethanol are vital for ensuring the long-term financial stability of sugar mills.

Significance of the Study

This research has significant effects on those involved in the sugar industry. For policymakers, it provides recommendations based on data to improve FRP mechanisms and support fairness in mill infrastructure. Industry players can use trend analyses for smart investments in growing capacity and diversifying by-products. Academics and farmers gain from the statistical modeling of production and consumption, which encourages new ideas in high-recovery varieties. In the end, the study aids national goals of food security, rural empowerment, and green energy shifts, making the sugar sector a key part of inclusive growth.

Need for the Study

The Indian sugar industry, despite its importance, faces structural inefficiencies and outside pressures that require a focused ten-year analysis. Changing global prices, climate-related yield variations, and policy changes like ethanol mandates have increased the need to look at growth patterns. Current studies often focus on specific aspects, leaving a gap in comprehensive, time-series evaluations of key metrics such as mill distribution and recovery rates. This study fills that gap by combining ten years of data. It offers

evidence-based insights into sustainability and competitiveness, which are crucial for informed policymaking as India aims to become a $5 trillion economy.

Objectives of the Study

1. To examine the sector-wise distribution of existing sugar mills and installed capacity in India.
2. To analyse the growth and trends in sugar production and consumption.
3. To identify the sustainability challenges for Indian sugar Industries.

Research Methodology

This study uses a descriptive and analytical research design to examine the growth of the Indian sugar industry. We gathered secondary data from reliable sources like the Annual Reports of the Directorate of Sugar (Ministry of Consumer Affairs), Indian Sugar Mills Association (ISMA) bulletins, and chinimandi web portal reports, covering the years 2014-15 to 2023-24. The dataset includes numbers on mill distribution, capacity, production, consumption, recovery rates, and cane crushing. We performed the analysis with SPSS software for basic descriptive statistics, such as means, standard deviations, CAGR calculations, and trend visualizations, like line graphs for time patterns. No primary data collection was done, which ensured our insights were based on verified historical records.

Scope of the Study

The study looks at a detailed analysis over ten years, from 2014-15 to 2023-24, of the Indian sugar industry. It focuses on important operational and structural aspects. The study examines how 534 sugar mills are distributed across sectors: public (2.4%), cooperative (39.9%), and private (57.7%). It notes that most mills are in Maharashtra and Uttar Pradesh. The analysis includes the installed crushing capacity, which totals 10.5 million tonnes per day, with private mills making up 52.4%. Production trends show an increase from 23.6 million metric tonnes (MMT) to 34 MMT, while consumption grew from 24 MMT to 31 MMT. The average sugar recovery rate is 10.2%. Cane crushing volumes rose from 272 MMT to 353 MMT. The study looks at these figures to highlight trends in efficiency and sustainability. This scope offers a complete view of the industry's growth and operations.

Growth Trajectory

Table 1 Exhibits State & Sector-wise Distribution of Existing Sugar Mills in India as on 2024-25

Sl. No.	State	Private Sector	Public Sector	Co-op. Sector	Total	% Holding
1	Bihar	9	-	-	9	1.69
2	U.P.	92	3	23	118	22.10
3	Uttarakhand	3	2	3	8	1.50
4	Punjab	7	-	9	16	3.00
5	Haryana	3	-	11	14	2.62
6	Andhra Pradesh	4	-	1	5	0.94
7	Telangana	7	-	-	7	1.31
8	Tamil Nadu	15	2	13	30	5.62
9	Maharastra	113	-	97	210	39.33
10	Gujarat	2	-	14	16	3.00
11	Madhya Pradesh	17	-	2	19	3.56
12	Kerala	-	-	-	-	0
13	Rajastan	-	1	-	1	0.19
14	Karnataka	60	1	14	75	14.04
15	Pondicherry	-	-	-	-	0
16	Goa	-	-	-	-	0

17	Chhattisgarh	-	-	4	4	0.75
18	Dadar Nagar & Haveli	-	-	-	-	0
19	Others	1	-	1	2	0.37
	Total	333	9	192	534	100.00

Source: Annual Report, Directorate of Sugar, 2024-25

The table shows the distribution of 534 sugar mills in India for 2024-25 by sector. The private sector leads with 333 mills, making up 62.4% of the total. Cooperatives come next with 192 mills at 35.9%, while the public sector has only 9 mills at 1.7%. This pattern indicates that the industry is mainly driven by private and cooperative sectors. Maharashtra has the highest concentration with 210 mills, which includes 113 private and 97 cooperative mills. Uttar Pradesh follows with 118 mills, primarily private at 92. Karnataka has 75 mills, also dominated by private mills at 60. These three states account for 75.47% of all mills, showing a large regional focus. The lack of mills in states like Kerala, Pondicherry, and Goa highlights logistical and environmental issues. This suggests a need for expansion strategies to improve regional balance and strengthen the supply chain in the sugar industry.

Table 2: Indicates the Sector wise Distribution of Installed Capacity. (in Lakh Tonnes)

Sl. No.	State	Public Sector	Private Sector	Coop. Sector	Total	% Holding
1	Andhra Pradesh	-	21	13	34	4.44
2	Assam	--	--	3	3	0.39
3	Bihar	16	12	--	28	3.66
4	Chhattisgarh	--	--	4	4	0.52
5	Dadar & Nagar Haveli	-	-	1	1	0.13
6	Goa	-	-	1	1	0.13
7	Gujarat	--	4	23	27	3.53
8	Haryana	--	4	12	16	2.09
9	Karnataka	3	71	17	91	11.90
10	Kerala	--		2	2	0.26
11	Madhya Pradesh	3	22	5	30	3.92
12	Maharashtra	--	126	136	262	34.25
13	Nagaland	1	--	--	1	0.13
14	Odisha	--	5	3	8	1.05
15	Pondicherry	--	1	1	2	0.26
16	Punjab	--	9	15	24	3.14
17	Rajasthan	1	1	1	3	0.39
18	TN & Pondicherry	3	27	16	46	6.01
19	Telangana	-	10	1	11	1.44
20	Uttar Pradesh	7	124	28	159	20.78
21	Uttarakhand	2	4	4	10	1.31
22	West Bengal	1	1		2	0.26
	All India	37	442	286	765	100.00

Source: Annual Report, ISMA, 2024-25

The table shows the distribution of installed sugar mill capacity in India for 2024-25, totaling 765 lakh tonnes (76.5 million tonnes). The private sector leads with 442 lakh tonnes (57.8%). This is followed by cooperatives at 286 lakh tonnes (37.4%) and the public sector, which has a small share of 37 lakh tonnes (4.8%). This highlights the dominance of private and cooperative sectors in improving milling efficiency. Maharashtra has the highest capacity at 262 lakh tonnes (34.25%). This is divided between private mills

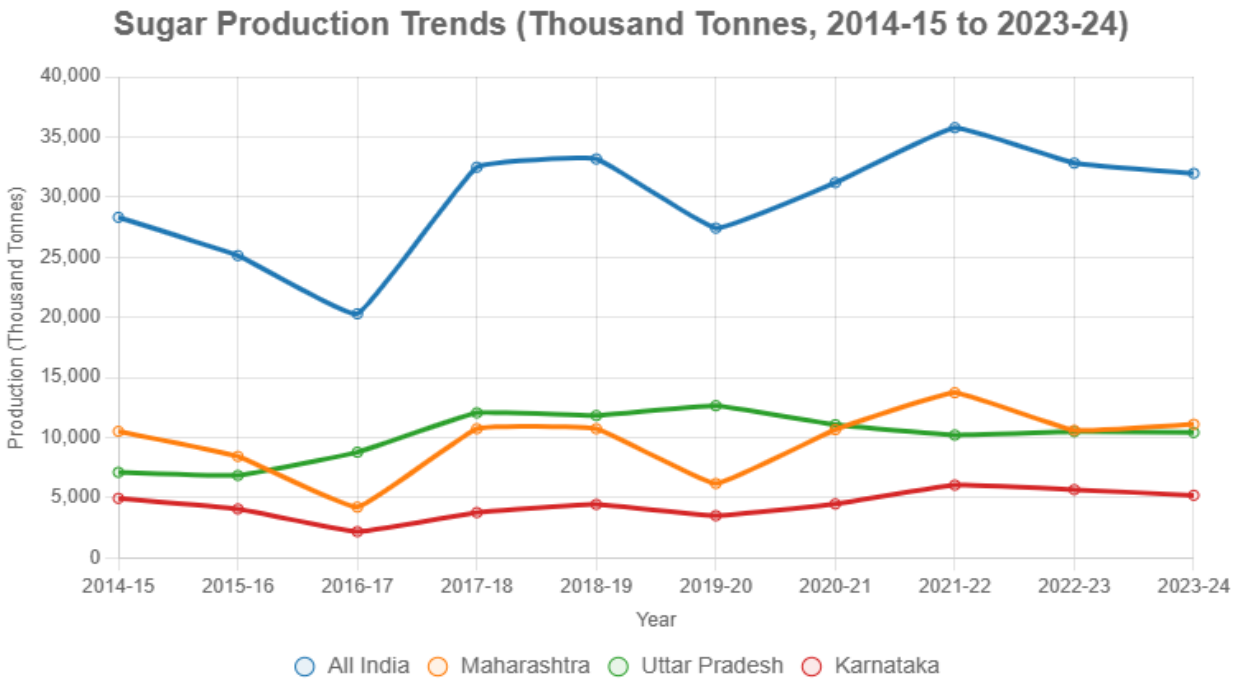
(126 lakh tonnes) and cooperatives (136 lakh tonnes). Next is Uttar Pradesh with 159 lakh tonnes (20.78%), mostly from private mills (124 lakh tonnes). Karnataka follows with 91 lakh tonnes (11.90%), led by private mills (71 lakh tonnes). These three states make up 66.93% of the national capacity. This shows a significant regional concentration, which boosts production but could create supply chain issues. States like Nagaland, Assam, and West Bengal contribute very little (0.13-0.39%), indicating the need for targeted investments to ensure a fair distribution of capacity.

Growth and Trends in Sugar Production and Consumption during the Last Decade.

Table 3: State wise Sugar Production in India during Last 10 Years. (in 000 Tonnes)

States	2023-24	2022-23	2021- 22	2020-21	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15
All India	31964	32815	35760	31192	27411	33162	32479	20285	25125	28310
Maharashtra	11096	10590	13720	10650	6169	10720	10723	4203	8424	10506
Uttar Pradesh	10414	10484	10199	11059	12638	11821	12048	8773	6840	7101
Karnataka	5189	5657	6038	4467	3494	4430	3754	2165	4049	4935
Tamil Nadu	1073	1482	1247	878	788	955	712	1067	1367	1250
Gujarat	928	998	1208	1047	932	1123	1105	885	1168	1153
Haryana	608	748	715	761	743	702	844	668	539	576
Bihar	689	627	457	475	728	841	716	526	503	526
Punjab	593	657	596	547	538	787	824	692*	671	537
M.P. & C.G.	680	596	653	536	460	563	550	406	398	450
A.P. & Telangana	157	188	210	199	285	508	466	385	551	564
Uttarakhand	311	491	453	416	458	401	419	346	273	325
Telangana	184	263	228	123	139	257	269	116	278	322
Others	29	26	29	25	30	39	36	39	49	48
Rajasthan	12	8	7	9	9	11	7	10	5	6
Kerala & Goa	0	0	0	0	0	4	6	4	10	11

Source: Annual Report, Directorate of Sugar, from 2014-15 to 2023-24



The table shows sugar production by state in India from 2014-15 to 2023-24. National output varied between 20,285 thousand tonnes in 2016-17 and 35,760 thousand tonnes in 2021-22. This reflects an unstable trend with a slight decline (CAGR -1.34%). Maharashtra, Uttar Pradesh, and Karnataka are the top producers, making up about 60-70% of total production. Maharashtra reached its highest at 13,720

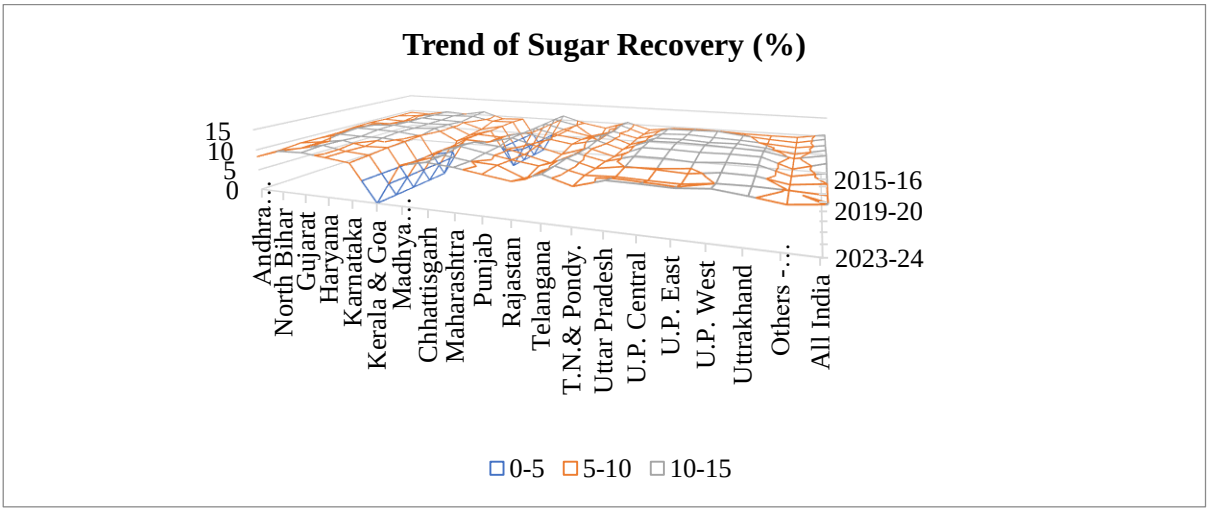
thousand tonnes in 2021-22 but fell to 6,169 thousand tonnes in 2019-20 due to drought. Uttar Pradesh remained relatively steady, peaking at 12,638 thousand tonnes in 2019-20. Karnataka had a low of 2,165 thousand tonnes in 2016-17. Tamil Nadu and Andhra Pradesh & Telangana experienced sharp declines. Their production dropped from 1,367 and 564 thousand tonnes in 2014-15 to 1,073 and 157 thousand tonnes in 2023-24, respectively. Smaller states like Kerala & Goa stopped production entirely by 2019-20, showing regional differences and environmental challenges.

Table 4 Indicates the State wise Average Recovery of Sugar in India during Last 10 Years.

(in %)

States	2023-24	2022-23	2021-22	2020-21	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15
Andhra Pradesh	8.32	8.39	8.88	8.85	8.96	9.4	9.53	9.37	9.35	9.38
North Bihar	10.18	9.46	9.66	10.36	10.79	10.39	9.58	9.21	9.77	9.18
Gujarat	10.37	10.7	10.52	10.22	10.75	10.82	10.55	10.58	10.38	10.34
Haryana	9.72	9.7	9.47	10.26	10.58	10.36	10.39	10.34	10.52	9.94
Karnataka	9.01	9.27	9.65	9.8	9.94	10.73	10.6	10.19	10.74	11.06
Kerala & Goa	-	-	-	-	-	7.58	7.92	8.38	9.6	9.19
Madhya Pradesh	9.57	9.06	9.41	9.38	9.89	9.93	9.63	9.7	9.78	9.48
Chhattisgarh	10.86	10.89	11.55	11.09	9.68	9.64	-	-	-	-
Maharashtra	10.32	10.02	10.38	10.5	11.28	11.27	11.24	11.25	11.33	11.29
Punjab	9.38	9.7	9.29	9.02	9.59	10.14	9.78	9.78	10.06	9.42
Rajastan	8.48	7.11	8.43	7.42	8.03	9.18	9.02	8.55	5.88	8.31
Telangana	10.65	10.66	10.77	10.33	10.22	10.65	10.84	10.38	10.85	10.51
T.N.& Pondy.	8.72	9.23	9.02	8.97	8.54	8.8	8.64	8.92	8.74	8.67
Uttar Pradesh	10.61	9.54	10.04	10.78	11.29	11.46	10.84	10.61	10.61	9.54
U.P. Central	10.54	9.35	9.92	10.81	11.36	11.6	10.99	10.89	10.72	9.7
U.P. East	10.36	9.24	9.63	10.45	11.17	11.49	10.64	10.55	10.9	9.57
U.P. West	10.92	10.03	10.48	10.97	11.31	11.25	10.82	10.31	10.16	9.31
Uttrakhand	10.18	10.14	10.38	10.99	11.2	10.97	10.24	9.85	9.61	9.24
Others - Assam, Nagaland & West Bengal	9.28	9.97	9.2	9.11	8.97	9.75	9.24	9.36	9.24	9.26
All India	**10.05**	**9.67**	**10**	**10.4**	**10.8**	**11**	**10.7**	**10.4**	**10.6**	**10.4**

Source: Annual Report, Directorate of Sugar, from 2014-15 to 2023-24



Southern states, including Karnataka, have experienced declines, showing a mean of 10.1% and a CAGR of -2.25%. Tamil Nadu and Puducherry are around 8-9%, while Andhra Pradesh has fallen from 9.38% to 8.32%. Gujarat remains steady at about 10.2% to 10.8%. Emerging regions like Chhattisgarh, which started reporting in 2018-19, have reached recovery rates as high as 11.55%. After 2018-19, Kerala and Goa stopped reporting recovery, highlighting regional differences. The overall variability, with a standard deviation of 0.4%, emphasizes the need for technology improvements in areas with low recovery rates.

Table 5 Exhibits State wise Cane Crushed in India during Last 10 Years. (000 tonnes)

States	2023-24	2022-23	2021-22	2020-21	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15
Andhra Pradesh	1891	2242	2366	2246	3182	5546	5408	4885	4116	5894
North Bihar	6761	6629	4731	4580	6750	2723	8091	7479	5711	5147
Gujarat	8954	9328	11491	10245	8666	11295	10381	10476	8368	11245
Haryana	6255	7707	7545	7415	7022	2648	6774	8124	6454	5120
Karnataka	57563	61035	62561	45578	35165	23977	41270	35427	21252	37714
Kerala & Goa	0	0	0	0	0	101	53	74	47	101
Madhya Pradesh & Chhattishgarh	6964	6393	6728	5590	4675	963	5710	5716	4185	4074
Maharashtra	107531	105680	132231	101443	54710	61390	95154	95360	37346	74383
Punjab	6328	6772	6419	6067	5612	2112	7754	8421	6760	6671
Rajastan	142	117	79	120	108	48	116	77	119	89
Telangana	1724	2464	2116	1192	1363		2415	2483	1116	2558
T.N.& Pondy.	12308	16054	13816	9785	9221	14553	10854	8240	11970	15654
Uttar Pradesh	98168	109932	101626	102636	111938	56733	103167	111190	82716	64479
U.P. Central	37279	45538	42236	41656	43933	20103	39595	44531	31471	24491
U.P. East	29301	29153	25189	25657	32144	17123	32219	33437	24874	20462
U.P. West	31588	35241	34201	35323	35861	19507	31353	33222	26368	19526
Uttrakhand	3058	4841	4364	3781	4090	3175	3652	4091	3506	2837
Others - Assam, Orissa, Nagaland and West Bengal	311	258	322	274	335	284	401	384	412	526
All India	**317958**	**339452**	**356395**	**300952**	**252837**	**185548**	**301200**	**302427**	**194078**	**236492**

Source: Annual Report, Directorate of Sugar, from 2014-15 to 2023-24

The table shows cane crushing figures for each state in India from 2014-15 to 2023-24. National totals increased from 236,492 thousand tonnes to 317,958 thousand tonnes, with a compound annual growth rate (CAGR) of 3.35%. The peak occurred in 2021-22, reaching 356,395 thousand tonnes, driven by good monsoons and increased cultivation. Maharashtra, the leading state, grew from 74,383 to 107,531 thousand

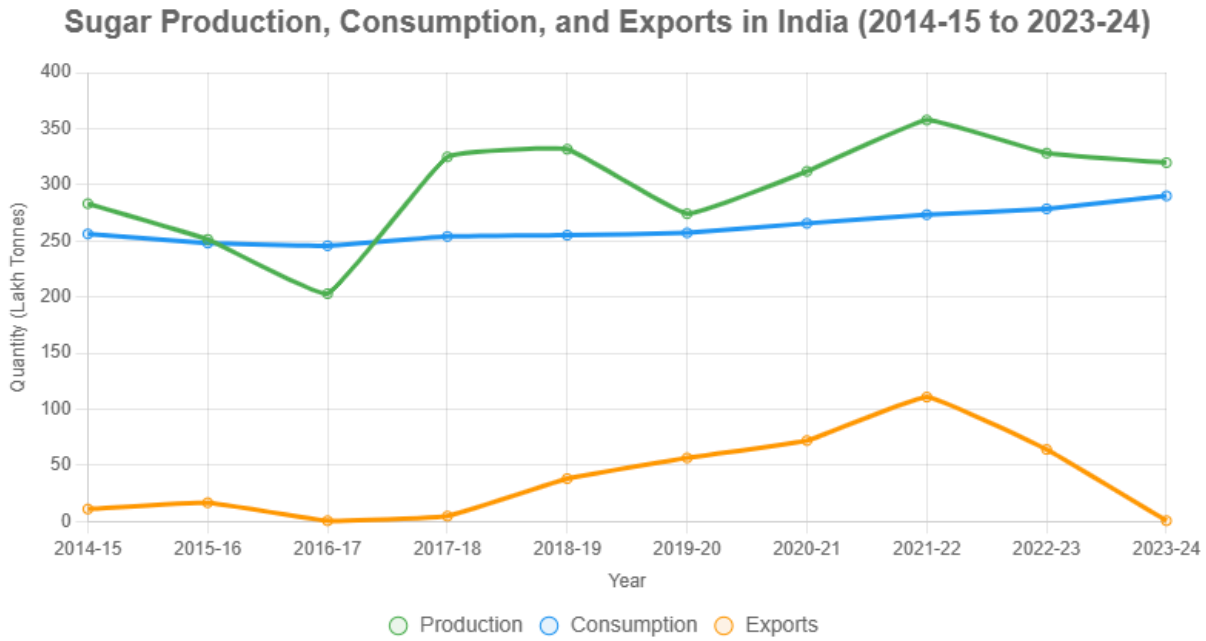
tonnes, with a CAGR of 4.17%. Uttar Pradesh's production rose from 64,479 to 98,168 thousand tonnes, achieving a CAGR of 4.79%. However, both states experienced declines in 2018-19 due to droughts.

Karnataka's crushing went up from 37,714 to 57,563 thousand tonnes, reflecting growth in the southern region. In contrast, Tamil Nadu and Puducherry, along with Andhra Pradesh, saw significant declines, dropping from 15,654 and 5,894 to 12,308 and 1,891 thousand tonnes, respectively. Smaller regions like Kerala and Goa stopped crushing after 2018-19, emphasizing the regional differences in production. National volatility, with a standard deviation of 53,981 thousand tonnes, indicates the sensitivity to climate and policy changes, highlighting the need for resilient practices.

Table 6 Exhibits the Sugar Stocks, Production, Consumption and Export of Sugar in India during Last 10 Years. (in Lakh Tonnes)

Year	Opening Stock	Production	Imports	Total Availability	Internal Consumption	Exports	Closing Stock
2023-24	55.65	319.64		375.29	290	0.5	84.79
2022-23	70.00*	328.15	-	398.15	278.5	64	55.65
2021-22	81.86	357.6	-	439.46	273.3	110.7	55.46
2020-21	107.4	311.92	-	419.32	265.55	71.91	81.86
2019-20	145.79	274.11	0	419.9	257.09	56.5	106.31
2018-19	107.2	331.62	-	438.82	255	38	145.82
2017-18	38.8	324.79	2.15	365.74	253.9	4.64	107.2
2016-17	77.52	202.85	4.46	284.83	245.61	0.46	38.76
2015-16	90.8	251.25	-	342.05	247.97	16.56	77.52
2014-15	74.74	283.1	-	357.84	256.1	10.94	90.8

Source: Annual Report, Directorate of Sugar, from 2014-15 to 2023-24



Production Trend: Production shows a slight upward trend, with a compound annual growth rate (CAGR) of 1.36%. It reached a high in 2021-22 of 357.6 lakh tonnes and a low in 2016-17 of 202.85 lakh tonnes, likely due to changes in the monsoon. Linear regression indicates a slope of 0.93 lakh tonnes per year, but high volatility, with a standard deviation of 45.95 lakh tonnes, suggests that factors like weather and policy changes, such as ethanol diversion after 2018, also play a role.

Consumption Trend: Consumption has grown steadily, with a CAGR of 1.24%, rising from 256.1 to 290 lakh tonnes. This reflects steady domestic demand. The linear slope is 3.83 lakh tonnes per year, and the R^2 value of 0.88 indicates a strong fit. Growth in this area is driven by population increases and the confectionery sector.

Export Trend: Exports are highly volatile, with a CAGR of 46.6%, although this figure is skewed by nearly zero exports in 2016-17. Exports peaked in 2021-22 at 110.7 lakh tonnes due to a surplus and strong global demand. However, there was a sharp drop to 0.5 lakh tonnes in 2023-24 because of export restrictions.

Stock Trends: Opening and closing stock levels fluctuated. Closing stocks peaked at 145.82 lakh tonnes in 2018-19 but have stabilized around 55-85 lakh tonnes recently. This indicates improved inventory management, but challenges with surplus remain.

Table 7 Exhibits Acreage, Molasses Production, Yield and Duration of Operation

Year	Acreage (000 hectares)	Molasses production (000 tonnes)	Yield per hectare (tonnes)	Duration days
2023-24	5944	15483*	71.2	129
2022-23	5907	16872*	75.7	137
2021-22	5583	18136*	82.7	154
2020-21	5288	14906*	76	136
2019-20	4841	11526*	71.1	126
2018-19	5502	13788	75.3	135
2017-18	5042	14063	81.5	140
2016-17	4945	9026	61.3	99
2015-16	5284	10873	63.7	117
2014-15	5307	12482	69.1	135

Source: Annual Report, Directorate of Sugar, from 2014-15 to 2023-24

*Including B-Heavy Molasses sent out for the ethanol production.

Table 7 provides a ten-year overview from 2014-15 to 2023-24 of key operational metrics for the Indian sugar industry. These metrics include acreage, molasses production, yield per hectare, and the duration of mill operations. Acreage under sugarcane cultivation varied between 4,841 thousand hectares in 2019-20 and 5,944 thousand hectares in 2023-24, with a compound annual growth rate of 1.14%. This reflects slight growth driven by policies like ethanol blending, but the dips, such as in 2019-20, indicate the effects of climate.

Molasses production, which includes B-heavy molasses for ethanol, peaked at 18,136 thousand tonnes in 2021-22. However, it declined to 15,483 thousand tonnes in 2023-24, showing a compound annual growth rate of 2.18%. This decline shows volatility, with a standard deviation of 2,911 thousand tonnes, linked to production changes and ethanol diversion. Yield per hectare ranged from 61.3 tonnes in 2016-17 to 82.7 tonnes in 2021-22, with an average of 72.76 tonnes and a compound annual growth rate of 0.31%. This indicates inconsistent productivity due to weather and changes in sugarcane varieties. The duration of mill operations varied from 99 days in 2016-17 to 154 days in 2021-22, with an average of 130.8 days and a compound annual growth rate of 0.49%. This reflects longer crushing seasons during years of high production. These trends highlight a growing but unpredictable industry. Ethanol policies are boosting molasses output and acreage, but the industry needs technology to stabilize yields and improve operational efficiency.

Challenges Facing by Indian Sugar Industry

Water Scarcity: Sugarcane needs a lot of water, which puts pressure on groundwater in Maharashtra and Uttar Pradesh. This situation makes drought conditions worse. Small farmers find it hard to adopt drip irrigation due to its high costs.

Climate Change: Unpredictable weather, such as droughts and heavy rains, disrupts sugarcane yields. The low output in 2024 is a clear example. Farmers are not using climate-resilient varieties much, mainly because research outreach is limited.

Environmental Pollution: Waste from sugar mills pollutes water and soil, damaging ecosystems and health. Not everyone follows regulations consistently, and many need expensive zero-liquid discharge systems.

Economic Instability: Prices fluctuate and cane payments are delayed, creating uncertainty for farmers and mills, even with the support of the Fair and Remunerative Price (FRP). While diversifying by-products could help, inconsistent policies remain a challenge.

Soil Degradation: Growing only one type of crop harms soil and increases pest problems, leading to more chemical use. While crop rotation and organic methods are necessary, they are not widely adopted by farmers.

Social Challenges: Low wages and seasonal work in mills lead to social inequality and health risks. Although fair trade and community programs could help, they do not have strong support across the industry.

Major Findings of the Study

1. The Indian sugar industry is mainly run by the private sector, which includes 62.4% or 333 mills, and the cooperative sector, which has 35.9% or 192 mills. Maharashtra has 210 mills, Uttar Pradesh has 118 mills, and Karnataka has 75 mills. Together, these states make up 75.47% of the 534 mills in 2024-25. This shows a significant concentration of the industry in these regions.
2. The Indian sugar industry's installed capacity will reach 765 lakh tonnes in 2024-25. The private sector holds 57.8%, which is 442 lakh tonnes, while the cooperative sector accounts for 37.4%, or 286 lakh tonnes. Maharashtra contributes 34.25% with 262 lakh tonnes, Uttar Pradesh contributes 20.78% with

159 lakh tonnes, and Karnataka adds 11.90% with 91 lakh tonnes. Together, these three states make up 66.93%, showing a significant concentration of production in specific regions.

3. India's sugar production from 2014-15 to 2023-24 varied widely, with a compound annual growth rate (CAGR) of -1.34%. Maharashtra, Uttar Pradesh, and Karnataka accounted for 60-70% of the total output. Production peaked at 35,760 thousand tonnes in 2021-22. In contrast, southern states such as Tamil Nadu and Andhra Pradesh & Telangana experienced sharp declines. Smaller areas like Kerala and Goa stopped production by 2019-20. These trends highlight environmental and regional differences.
4. India's sugar recovery rates from 2014-15 to 2023-24 show a slight decline, with a compound annual growth rate of -0.38% and an average of 10.4%. Uttar Pradesh leads with an average of 10.53% and a growth rate of 1.19%. Maharashtra follows closely with an average of 10.89%. In contrast, southern states struggle due to climate and variety challenges.
5. India's cane crushing rose from 236,492 to 317,958 thousand tonnes, with a compound annual growth rate of 3.35%, from 2014-15 to 2023-24. This growth was led by Maharashtra, which had a CAGR of 4.17% and produced 107,531 thousand tonnes, and Uttar Pradesh, with a CAGR of 4.79% and 98,168 thousand tonnes. In contrast, southern states like Tamil Nadu and Puducherry, as well as Andhra Pradesh, experienced sharp declines. The national volatility was high, measured at 53,981 thousand tonnes, highlighting challenges related to climate and policy.
6. India's sugar industry from 2014-15 to 2023-24 shows a fluctuating production trend with a CAGR of 1.36%. It peaked at 357.6 lakh tonnes in 2021-22, with a standard deviation of 45.95 lakh tonnes. Consumption, however, has grown steadily at a CAGR of 1.24%, moving from 256.1 to 290 lakh tonnes. Exports have been highly variable, recording a CAGR of 46.6%. They reached a high of 110.7 lakh tonnes in 2021-22 but fell to 0.5 lakh tonnes in 2023-24. Closing stocks are stabilizing, ranging between 55 and 85 lakh tonnes. These trends reflect difficulties from weather changes, policy shifts like ethanol diversion, and export limits.
7. India's sugarcane industry, from 2014-15 to 2023-24, shows fluctuating molasses production, with a compound annual growth rate of 2.18% and a peak of 18,136 thousand tonnes. Yields have been inconsistent, averaging 72.76 tonnes with a growth rate of 0.31%. Mill operation durations also vary, with an average of 130.8 days and a growth rate of 0.49%. These trends are influenced by ethanol policies and weather, highlighting the need for technological stability.

Conclusion

The Indian sugar industry from 2014-15 to 2023-24 shows strong growth but faces significant challenges. The private sector operates 333 mills, making up 62.4% of the industry, while the cooperative sector has 192 mills, accounting for 35.9%. Maharashtra, Uttar Pradesh, and Karnataka are key players, contributing 66.93% of the 765 lakh tonnes of installed capacity and 60-70% of production. Production has an annual growth rate (CAGR) of 1.36%, and cane crushing has a CAGR of 3.35%. However, there is volatility in these figures, with a standard deviation of 45.95 lakh tonnes for production and 53,981 thousand tonnes for crushing due to weather and policy changes, such as ethanol diversion. Consumption has grown steadily at a CAGR of 1.24%, while exports have varied greatly, with a CAGR of 46.6%. Recovery rates average 10.4%, with a CAGR of -0.38%. Yields average 72.76 tonnes, with a CAGR of 0.31%. These numbers reflect inefficiencies, especially in southern states. Molasses production, with a CAGR of 2.18%, benefits from ethanol policies but remains unstable. It is essential to address sustainability challenges such as water scarcity, climate change, and regional disparities. This can be done through technological solutions and balanced policy changes to ensure long-term resilience and fair growth.

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