



Research Article

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Growth Performance, Production Trends, and Instability in Sugarcane Cultivation in India

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Abstract: The present study examines the trends, growth, instability, and determinants of sugarcane cultivation in India during 2005–06 to 2024–25 using state-wise secondary data obtained from various government publications. The analysis is carried out for three periods: Period-I (2005–06 to 2014–15), Period-II (2015–16 to 2024–25), and the overall Period-III (2005–06 to 2024–25). The study employs Percentage Share analysis to assess the distribution of sugarcane area, production, and yield; the Coefficient of Variation to measure stability; the Compound Annual Growth Rate to estimate growth performance; and Minhas Decomposition Analysis to identify the relative contributions of area and yield to changes in sugarcane production. The findings reveal significant regional disparities in sugarcane cultivation across India. Uttar Pradesh remained the leading contributor to cultivated area and production, followed by Maharashtra and Karnataka, whereas Tamil Nadu and West Bengal recorded the highest productivity despite their relatively smaller cultivated areas. The stability analysis indicates increasing variability in sugarcane cultivation, particularly in Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Karnataka, Uttarakhand, and Assam, while Punjab, Haryana, Bihar, and West Bengal exhibited comparatively greater stability. The CAGR analysis shows stronger national growth during Period-II than Period-I, whereas the Minhas Decomposition Analysis indicates that sugarcane production growth shifted from area expansion to yield improvement, highlighting the growing importance of productivity enhancement. The study concludes that improving yield, ensuring production stability, and enhancing resource-use efficiency are essential for the sustainable development of India's sugarcane sector.

Keywords: Sugarcane; Growth; Instability; Area; Yield; Output; India.

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INTRODUCTION

Sugarcane is a crucial commercial crop in India, playing a significant role in the nation's agricultural economy. As the world's second-largest producer, following Brazil, India is a key player in the global sugar and ethanol markets. Cultivation is concentrated in two major regions: the sub-tropical zone, which includes states like Uttar Pradesh, Bihar, Punjab, and Haryana, and the tropical zone, covering Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh. While Uttar Pradesh dominates in overall production, tropical states achieve higher yields due to favourable climatic conditions and the adoption of advanced farming techniques. Economically, sugarcane is indispensable, providing employment to millions and supporting industries involved in the production of sugar, ethanol, jaggery, and molasses. Its by-products also contribute to electricity generation and serve as animal feed, while the export of sugarcane-based products boosts foreign exchange earnings.

Singh *et al.* (2016) studied the regional disparities in sugarcane production across India, focusing on Uttar Pradesh and Maharashtra. The research emphasized agro-climatic advantages, irrigation

availability, and government support in these states as drivers of production. Gupta *et al.* (2020) analysed sugarcane trends in India, showing shifts in cultivation patterns driven by water scarcity, land-use changes, and adoption of alternative crops like horticulture. Costa *et al.* (2018) highlighted Brazil's leading role in global sugarcane production, attributing success to mechanization, ethanol production, and favourable policies. Kumar and Sharma (2020) explored sugarcane cultivation in Himachal Pradesh, noting its concentration in low-altitude districts like Kangra and Una due to suitable climatic conditions. Aggarwal and Dutta (2012) highlighted significant regional disparities in sugarcane cultivation across India, attributing them to variations in soil fertility, climatic conditions, and irrigation availability. Singh *et al.* (2015) analysed production trends in Uttar Pradesh and Maharashtra, demonstrating the dominance of these states in sugarcane production due to favourable agro-climatic conditions. Chaudhary *et al.* (2018) explored the profitability of sugarcane farming, concluding that stable market demand and government subsidies make sugarcane a relatively lucrative crop in irrigated areas. Patil and Kulkarni (2017) analyzed the impact of sugar mills on rural economies, highlighting their role in creating employment and stabilizing farmers' incomes. Yadav *et*

al. (2021) demonstrated that rising input costs, including labor, fertilizers, and pesticides, have decreased profitability, leading to a decline in sugarcane cultivation in less favourable regions. Reddy and Patil (2019) evaluated sugarcane as a cash crop in Karnataka, reporting that while it provided high returns, rising input costs (labour, fertilizers) reduced profitability. Pandey *et al.* (2021) highlighted the economic vulnerability of smallholder farmers, emphasizing the need for cooperatives and subsidies to sustain sugarcane production in marginal regions. Singh and Singh (2016) investigated sugarcane's environmental footprint, highlighting issues like high water consumption, soil degradation, and chemical usage. Rao *et al.* (2019) studied the effects of climate change, showing that erratic rainfall and temperature shifts have led to yield fluctuations and reduced productivity. Kaur and Gill (2020) advocated for sustainable farming practices such as crop rotation and organic farming to minimize the adverse environmental effects of monocropping sugarcane. Reddy *et al.* (2017) documented the impact of High Yielding Varieties (HYV) on improving productivity in sugarcane farming across tropical regions. Sharma *et al.* (2023) analyzed mechanization's role in sugarcane cultivation, focusing on its potential to reduce labour dependency and operational costs. Costa *et al.* (2024) noted the environmental trade-offs in ethanol production from sugarcane, emphasizing the need for better carbon capture techniques. Goel (2015) highlighted the importance of sugar cooperatives in stabilizing farmer incomes and facilitating market access in Maharashtra and Uttar Pradesh. Patel and Yadav (2019) examined the role of government incentives in encouraging ethanol production, which bolstered sugarcane farming in India and Brazil. Deshpande *et al.* (2018) discussed the role of sugarcane farming in rural livelihoods, noting its contribution to employment generation and poverty alleviation in sugar belt regions. Bhatia *et al.* (2020) analyzed the gender dynamics in sugarcane farming, emphasizing women's increasing role in labor-intensive activities and decision-making processes. Arun and kumar (2022) analyzed sugarcane cultivation trends (2001-02 to 2017-18) and found positive growth in area, output, and productivity. They highlighted Uttar Pradesh and Maharashtra as major producers (65% of output) and noted higher yields in tropical regions. The study emphasized renewable energy potential and strategies to boost productivity. Kumar and Shobana (2024) examined historical trends in sugarcane farming and production in India, analyzing changes from the early 20th century to the present. The study highlighted regional disparities, technological advancements, and economic policies as key drivers of shifts in cultivation area and productivity. Kumar (2025) analysed sugarcane cultivation trends in Himachal Pradesh from 2000-01 to 2021-22 and found notable regional disparities in area, production, and yield. Sirmaur remained the leading district despite declining cultivated area, while Kangra showed strong and consistent growth in output and productivity. Una

recorded improvements in yield and production, whereas Hamirpur and other districts contributed only marginally. At the state level, sugarcane area declined, but output and yield improved, indicating greater farming efficiency. Wani *et al.* (2025) examined the growth and instability of sugarcane cultivation in Maharashtra during 2002–03 to 2021–22 using CAGR, Coefficient of Variation, and the Cuddy–Della Valle Index. The study found positive growth in area and production, while yield remained relatively stable, indicating that production growth was mainly driven by area expansion. It also highlighted higher instability in districts with larger sugarcane acreage and recommended improved irrigation, modern technologies, and supportive policies to enhance productivity.

OBJECTIVES OF THE STUDY

- To analyse the growth in area, production, and yield of sugarcane in India.
- To examine the instability and regional disparities in sugarcane cultivation.
- To assess the contribution of area and yield to changes in sugarcane production.
- To examine the relevance of government policies for the sugarcane sector.

DATA AND METHODOLOGY

The present study is based entirely on secondary data collected from various published sources, including Agricultural Statistics at a Glance (Various Years), publications of the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, and other relevant government reports. The study examines the trends and performance of sugarcane cultivation in India for the period 2005–06 to 2024–25. To analyse the spatial and temporal changes in sugarcane cultivation, the following statistical techniques were employed:

Percentage Share: The percentage share of sugarcane area, production, and yield for each state was calculated using the following formula:

$$\text{Percentage share of sugarcane} = \frac{\text{State Area, output and Yield of sugarcane}}{\text{Sum of State Area, output and Yield of sugarcane}} \times 100$$

Coefficient of Variation: The Coefficient of Variation (CV) was used to measure the stability or variability in sugarcane area, production, and yield.

$$\text{C.V} = \frac{\sigma}{\bar{x}} \times 100$$

$$\text{Where } \sigma = \sqrt{\frac{\sum Xi^2}{N}}, \quad x_i = (x - \bar{x})$$

And Arithmetic Mean,

$$\bar{x} = \frac{\sum Xi}{N}$$

where:

X_i = Individual observation, $\bar{x}$ = Arithmetic mean, N = Number of observations

σ = Standard deviation

Compound Annual Growth Rate: The growth in sugarcane area, production, and yield was estimated using a semi-log trend model.

$$Y = ab^t$$

$$\ln Y_t = \ln a + t \log b$$

Taking logarithms:

$$\log Y_t = \log a + t \log b$$

The values of the parameters a and b is compound by using the formula

$$\text{i) } a = \bar{Y} - b\bar{t} \quad a = \bar{Y}; t = 0$$

$$\text{ii) } b = \frac{\sum(t-\bar{t})(y-\bar{y})}{\sum(t-\bar{t})^2}$$

where:

Y_t = Area, production, or yield in year t , a = Constant,

b = Growth coefficient, t = Time

The Compound Annual Growth Rate was calculated as:

$$\text{Compound Annual Growth Rate} = (\text{Antilog } (b)-1) \times 100$$

Minhas Decomposition Analysis: The Minhas Decomposition Analysis, developed by B. S. Minhas, was used to identify the sources of change in sugarcane production by decomposing total production change into **Area Effect (AE)**, **Yield Effect (YE)**, and **Interaction Effect (IE)**.

$$\begin{array}{lll} \text{Area Effect} & \text{Yield Effect} & \text{Interaction Effect} \\ AE=Y_0(A_1-A_0) & YE=A_0(Y_1-Y_0) & IE=(A_1-A_0)(Y_1-Y_0) \end{array}$$

$$\text{Total Change in Production} = \text{Area Effect} + \text{Yield Effect} + \text{Interaction Effect}$$

$$\Delta P = AE + YE + IE$$

Where:

A_0 & Y_0 = Area and yield in the base year, A_1 and Y_1 = Area and yield in the current year

ΔP = Total change in production

RESULTS AND DISCUSSION

Sugarcane is one of India's major commercial crops, contributing significantly to agricultural income, rural employment, and the sugar industry. This study examines the growth trends in sugarcane area, production, and productivity and analyses the extent of instability across major sugarcane-producing states. It further highlights the regional variations and key factors influencing changes in sugarcane cultivation in India.

Table 1.1 presents the state-wise percentage share of sugarcane area, production, and yield in India over three periods: Period-I (2005–06 to 2014–15), Period-II (2015–16 to 2024–25), and the overall Period-III (2005–06 to 2024–25). The results reveal substantial regional disparities in sugarcane cultivation, with a few states accounting for the majority of the country's cultivated area and production.

Uttar Pradesh consistently remained the leading sugarcane-producing state throughout the study period. During Period I, it accounted for 44.84 percent of the cultivated area, 37.93 percent of total production, and 6.19 percent of yield. These shares increased in Period II to 46.06 percent for area, 45.43 percent for production, and 7.51 percent for yield. Thus, from Period I to Period II, sugarcane area increased by 1.22 percent, production by 7.50 percent, and yield by 1.32 percent. Over the entire study period, Uttar Pradesh contributed 45.47 percent of India's sugarcane area and 42.05 percent of total production, while its average yield share remained comparatively moderate at 6.85 percent. From Period I to Period III, the state recorded an increase of 0.63 percent in area, 4.12 percent in production, and 0.66 percent in yield.

Table 1.1: State-wise Percentage Share of Sugarcane Area, Production, and Yield in India during 2005–06 to 2024–25

Periods	Period-I (2005-06 to 2014-15)			Period-II (2015-16 to 2024-25)			Period-III (2005-06 to 2024-25)		
States	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
Uttar Pradesh	44.84	37.93	6.19	46.06	45.43	7.51	45.47	42.05	6.85
Maharashtra	18.87	22.00	8.53	21.35	23.16	8.28	20.15	22.64	8.40
Karnataka	7.60	9.72	9.31	9.73	10.53	8.22	8.70	10.17	8.74
Tamil Nadu	6.81	10.36	11.14	3.27	4.14	9.78	4.99	6.94	10.43
Andhra Pradesh	4.12	4.71	8.29	1.38	3.11	7.58	2.71	2.87	7.91
Gujarat	4.06	4.20	7.60	3.63	3.33	6.96	3.84	3.72	7.26
Haryana	2.19	2.17	7.31	1.91	1.36	7.82	2.05	2.05	7.57
Uttarakhand	2.25	1.90	6.18	1.54	1.96	7.24	1.88	1.65	6.74
Punjab	1.77	1.67	6.87	1.78	1.82	7.84	1.77	1.75	7.38
Bihar	3.74	2.65	4.99	4.33	1.44	5.51	4.05	2.90	5.26
Madhya Pradesh	1.47	0.89	4.46	2.04	1.50	5.63	1.76	1.23	5.07
West Bengal	0.34	0.45	9.67	0.36	0.36	7.79	0.35	0.40	8.68
Assam	0.57	0.31	3.99	0.59	0.29	3.80	0.58	0.30	3.89
Other States	1.36	1.04	5.47	2.04	1.57	6.05	1.71	1.33	5.77
India	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Sources: 1. Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare, New Delhi.

2. Agricultural Statistics at a Glance for various Years.

3. Press Information Bureau (PIB), Ministry of Agriculture & Farmers Welfare, Government of India on 12 December 2025.

Maharashtra occupied the second position in both area and production throughout all three periods. Its share in cultivated area increased from 18.87 percent in Period I to 21.35 percent in Period II, reflecting a rise of 2.48 percent, while its production share increased from 22.00 percent to 23.16 percent, an increase of 1.16 percent. In the overall period, Maharashtra contributed 20.15 percent of the total area and 22.64 percent of production, with a relatively high yield share of 8.40 percent. From Period I to Period III, the state registered an increase of 1.28 percent in area and 0.64 percent in production, while yield declined by 0.35 percent.

Karnataka ranked third in both area and production throughout the study period. Its area share increased from 7.60 percent to 9.73 percent between Period I and Period II, showing a rise of 2.13 percent, while production increased from 9.72 percent to 10.53 percent, marking an increase of 0.81 percent. During the overall period, Karnataka accounted for 8.70 percent of the cultivated area and 10.17 percent of the total production. It also recorded one of the highest average yield shares at 8.74 percent. From Period I to Period III, the state showed an increase of 1.10 percent in area and 0.45 percent in production, although yield declined by 0.57 percent.

Tamil Nadu demonstrated exceptional productivity despite a sharp decline in the area under cultivation. Its area share fell from 6.81 percent in Period I to 3.27 percent in Period II, while its production share declined from 10.36 percent to 4.14 percent. From Period I to Period II, area decreased by 3.54 percent, production by 6.22 percent, and yield by 1.36 percent. Nevertheless, Tamil Nadu maintained the highest yield share throughout the study period, with an average of 10.43 percent, indicating superior productivity and efficient cultivation practices. From Period I to Period III, however, its yield declined by 0.71 percent.

Among the medium-contributing states, Andhra Pradesh, Gujarat, and Bihar experienced notable changes in area and production shares. From Period I to Period II, area declined from 4.12 percent, 4.06 percent, and 3.74 percent to 1.38 percent, 3.63 percent, and 4.33 percent, respectively, while production fell from 4.71 percent, 4.20 percent, and 2.65 percent to 3.11 percent, 3.33 percent, and 1.44 percent. Their yield shares declined from 8.29 percent, 7.60 percent, and 4.99 percent in Period I to 7.58 percent, 6.96 percent, and 5.51 percent in Period II. From Period I to Period III, sugarcane area decreased in Andhra Pradesh and Gujarat by 1.41 percent and 0.22 percent, respectively, while Bihar recorded an increase of 0.31 percent. Production decreased by 1.84 percent in Andhra Pradesh, 0.34 percent in Gujarat, and 0.84 percent in Bihar. Yield declined by 0.38 percent in Andhra Pradesh and 0.34 percent in Gujarat, whereas Bihar recorded an increase of 0.27 percent.

Haryana, Uttarakhand, and Punjab contributed modest shares to India's sugarcane sector throughout the study period. Between Period I and Period II, Haryana's share in cultivated area declined from 2.19 percent to 1.91 percent, while Uttarakhand's decreased from 2.25 percent to 1.54 percent. In contrast, Punjab's area share remained almost stable, changing marginally from 1.77 percent to 1.78 percent. Similarly, the production shares of Haryana and Uttarakhand declined from 2.17 percent and 1.90 percent to 1.36 percent and 1.96 percent, respectively, whereas Punjab's production share increased slightly from 1.67 percent to 1.82 percent. Despite these changes in area and production, all three states recorded improvements in yield, with Haryana increasing from 7.31 percent to 7.82 percent, Uttarakhand from 6.18 percent to 7.24 percent, and Punjab from 6.87 percent to 7.84 percent during the same period.

Over the entire study period (Period III), Haryana, Uttarakhand, and Punjab accounted for 2.05 percent, 1.88 percent, and 1.77 percent of the total cultivated area, respectively, while their corresponding production shares were 2.05 percent, 1.65 percent, and 1.75 percent. Their average yield shares stood at 7.57 percent, 6.74 percent, and 7.38 percent, respectively. Compared with Period I, Haryana and Uttarakhand experienced declines of 0.14 percent and 0.37 percent in area share, whereas Punjab's area remained virtually unchanged. Production shares declined by 0.12 percent in Haryana and 0.25 percent in Uttarakhand, while Punjab recorded a marginal increase of 0.08 percent. In contrast, yield shares improved across all three states, increasing by 0.26 percent in Haryana, 0.58 percent in Uttarakhand, and 0.51 percent in Punjab.

West Bengal, despite contributing less than 0.5 percent of the country's area and production, achieved one of the highest yield shares (8.68 percent) over the overall period, ranking third among all states. Madhya Pradesh and Assam remained minor contributors, with both low area and production shares as well as comparatively lower yield levels. The category of Other States together accounted for only 1.71 percent of the cultivated area and 1.33 percent of total production during the overall period, indicating that sugarcane cultivation in India is highly concentrated in a limited number of states.

Overall, the table highlights that Uttar Pradesh, Maharashtra, and Karnataka together dominated India's sugarcane sector, accounting for nearly three-fourths of the country's cultivated area and production during 2005–06 to 2024–25. While Tamil Nadu and West Bengal excelled in productivity, Uttar Pradesh maintained its leadership primarily through extensive cultivation area and large production volume. These findings underscore significant regional differences in sugarcane cultivation and productivity, reflecting

variations in agro-climatic conditions, irrigation facilities, and technological adoption.

Table 1.2 presents the state-wise coefficient of variation (CV) for sugarcane area, output, and yield, highlighting changes in the stability of sugarcane cultivation across the three study periods. A comparison between Period-I (2005–06 to 2014–15) and Period-II (2015–16 to 2024–25) reveals noticeable changes in the stability of sugarcane cultivation. In terms of cultivated area, stability improved in several states during Period-II. Punjab recorded a significant decline in the CV from 16.71 percent to 3.18 percent, indicating a substantial

improvement in the stability of cultivated area. Similar improvements were observed in Haryana (21.76% to 12.29%), Bihar (39.38% to 7.57%), Madhya Pradesh (21.96% to 11.55%), Karnataka (22.68% to 20.32%), and Other States (27.73% to 21.41%). In contrast, area instability increased considerably in Andhra Pradesh (20.61% to 51.07%), Tamil Nadu (10.97% to 24.33%), Uttarakhand (8.03% to 28.94%), Gujarat (10.86% to 12.57%), and Uttar Pradesh (3.64% to 10.58%). At the national level, the CV for cultivated area increased from 7.91 percent in Period-I to 9.48 percent in Period-II, indicating a marginal decline in the stability of sugarcane acreage.

Table 1.2: State-wise Instability in Sugarcane Area, Production, and Yield in India during 2005–06 to 2024–25

Periods	Period-I (2005-06 to 2014-15)			Period-II (2015-16 to 2024-25)			Period-III (2005-06 to 2024-25)		
States	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
Uttar Pradesh	3.64	6.67	4.78	10.58	15.73	8.24	9.13	23.41	16.22
Maharashtra	20.00	20.89	4.90	23.00	25.07	8.21	23.30	26.41	7.49
Karnataka	22.68	25.34	4.25	20.32	26.33	9.89	26.04	29.20	7.48
Tamil Nadu	10.97	11.65	3.63	24.33	21.33	7.40	36.62	38.19	5.89
Andhra Pradesh	20.61	23.79	4.39	51.07	50.59	5.73	56.17	57.83	4.98
Gujarat	10.86	9.19	6.04	12.57	16.52	4.32	11.69	13.01	5.11
Haryana	21.76	19.96	8.30	12.29	14.22	4.68	17.98	17.30	10.43
Uttarakhand	8.03	9.34	6.96	28.94	27.69	10.02	24.23	19.84	15.62
Punjab	16.71	20.61	10.94	3.18	5.23	3.79	11.81	19.44	13.68
Bihar	39.38	48.42	12.43	7.57	5.91	6.95	27.12	33.29	13.65
Madhya Pradesh	21.96	20.83	4.20	11.55	16.26	9.97	24.97	39.54	18.62
West Bengal	8.22	24.31	18.73	11.77	21.69	19.83	11.40	22.46	19.73
Assam	7.74	6.77	3.24	3.83	8.43	10.39	7.20	10.24	8.03
Other States	27.73	44.96	17.56	21.41	31.65	30.90	33.10	46.58	27.67
India	7.91	9.80	3.12	9.48	13.83	6.87	9.08	15.79	8.84

Sources: 1. Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare, New Delhi.

2. Agricultural Statistics at a Glance for various Years.

3. Press Information Bureau (PIB), Ministry of Agriculture & Farmers Welfare, Government of India on 12 December 2025.

With respect to output, production stability improved in Punjab, Bihar, West Bengal, Haryana, and Other States, as reflected by the decline in their CV values. Conversely, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Uttar Pradesh, Assam, and Madhya Pradesh experienced greater production instability during Period-II. At the all-India level, the CV increased from 9.80 percent to 13.83 percent, suggesting that sugarcane production became more volatile during the second period.

In terms of yield, variability declined in several major sugarcane-producing states. Punjab recorded a substantial reduction in CV from 10.94 percent to 3.79 percent, while Bihar (12.43% to 6.95%), Haryana (8.30% to 4.68%), and Gujarat (6.04% to 4.32%) also showed improved yield stability. Although the CV of Tamil Nadu increased from 3.63 percent to 7.40 percent, its yield remained relatively stable compared with many other states. Andhra Pradesh also maintained a comparatively stable yield despite a slight increase in CV (4.39% to 5.73%). In contrast, Karnataka, Madhya Pradesh, Assam, Uttarakhand, and Other States recorded higher yield variability. At the national level, the CV of yield increased from 3.12 percent in Period-I to 6.87

percent in Period-II, indicating a moderate increase in productivity fluctuations.

A comparison between Period-I and the overall study period (Period-III: 2005–06 to 2024–25) indicates that long-term variability generally increased across the major sugarcane-producing states. In terms of cultivated area, most states recorded higher CV values during the overall period, suggesting that fluctuations in area became more pronounced over time. Marked increases were observed in Andhra Pradesh (20.61% to 56.17%), Tamil Nadu (10.97% to 36.62%), Uttar Pradesh (3.64% to 9.13%), Madhya Pradesh (21.96% to 24.97%), and Other States (27.73% to 33.10%). However, Punjab, Bihar, Haryana, and Assam exhibited improved long-term stability. At the national level, the CV for cultivated area increased marginally from 7.91 percent to 9.08 percent, indicating that sugarcane acreage remained relatively stable despite considerable regional variations.

Regarding output, long-term instability increased in several states. Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Karnataka, Uttar Pradesh, and Other States exhibited substantially higher CV values during the overall study period, reflecting greater

fluctuations in production. In contrast, Punjab, Bihar, and West Bengal maintained relatively stable production throughout the study period. At the national level, the CV increased from 9.80 percent in Period-I to 15.79 percent in Period-III, indicating a significant rise in production instability over the long term.

Similarly, yield variability increased during the overall period. Madhya Pradesh (4.20% to 18.62%), Uttar Pradesh (4.78% to 16.22%), Punjab (10.94% to 13.68%), Uttarakhand (6.96% to 15.62%), and Other States (17.56% to 27.67%) experienced substantial increases in instability. Nevertheless, Andhra Pradesh (4.98%), Gujarat (5.11%), Tamil Nadu (5.89%), Maharashtra (7.49%), and Karnataka (7.48%) maintained comparatively stable yield performance over the long run. At the national level, the CV for yield increased from 3.12 percent in Period-I to 8.84 percent in Period-III, indicating a noticeable increase in productivity fluctuations over time.

Overall, the analysis suggests that Period-II was characterised by greater instability than Period-I, particularly with respect to sugarcane area and output, while yield remained comparatively more stable despite a moderate increase in variability. The comparison between Period-I and Period-III further demonstrates that long-term fluctuations in sugarcane cultivation intensified across many states. Although the all-India CV values indicate a moderate level of stability relative to several individual states, the upward trend in national CV values over time suggests that sugarcane cultivation in India has become progressively more variable, especially in terms of production and productivity. These findings underscore the need for region-specific interventions

aimed at enhancing production stability and mitigating the adverse effects of climatic variability, market fluctuations, and changing cropping patterns.

Table 1.3 presents the state-wise Compound Annual Growth Rate of sugarcane area, output, and yield during Period-I (2005–06 to 2014–15), Period-II (2015–16 to 2024–25), and the overall period (2005–06 to 2024–25). Uttar Pradesh recorded an increase in area growth from 0.1 percent to 2.7 percent, while Gujarat improved from –1.2 percent to 2.5 percent, Madhya Pradesh from 3.5 percent to 0.4 percent (remaining positive), Punjab from –0.6 percent to –0.3 percent, Haryana from –3.6 percent to –1.9 percent, and Other States from 5.5 percent to 0.3 percent, although the latter experienced a slower positive growth. In contrast, Andhra Pradesh witnessed a sharp decline from –5.6 percent to –19.3 percent, followed by Tamil Nadu (–2.1% to –5.7%), Uttarakhand (–0.9% to –4.1%), Bihar (12.1% to –2.5%), West Bengal (0.6% to –2.5%), and Assam (1.9% to –0.8%). At the national level, area growth improved from 1.2 percent in Period-I to 2.4 percent in Period-II, indicating an expansion in sugarcane acreage.

In terms of output, production growth accelerated in Uttar Pradesh (0.8% to 4.8%), Maharashtra (4.2% to 7.3%), Gujarat (–1.9% to 3.2%), Madhya Pradesh (3.3% to 2.7%), Punjab (2.5% to 0.4%), Assam (1.3% to 1.9%), and India (1.8% to 4.1%). However, output growth deteriorated significantly in Andhra Pradesh (–6.2% to –18.6%), Tamil Nadu (–2.2% to –4.1%), West Bengal (5.5% to –6.2%), Bihar (15.4% to –0.8%), Other States.

Table 1.3: Compound Annual Growth Rate of Sugarcane Cultivation in India during 2005–06 to 2024–25

Periods/ States	Period-I (2005-06 to 2014-15)			Period-II (2015-16 to 2024-25)			Period-III (2005-06 to 2024-25)		
	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
Uttar Pradesh	0.1	0.8	0.8	2.7	4.8	2.1	1.00	3.5	2.5
Maharashtra	3.6	4.2	0.6	0.6	7.3	1.3	2.50	3.3	0.7
Karnataka	7.3	8.0	0.7	4.7	6.1	1.4	3.8	3.8	0.01
Tamil Nadu	-2.1	-2.2	-0.1	-5.7	-4.1	1.6	-6.2	-6.3	-0.1
Andhra Pradesh	-5.6	-6.2	-0.6	-19.3	-18.6	0.7	-11.8	-11.8	0.1
Gujarat	-1.2	-1.9	-0.7	2.5	3.2	0.7	-0.2	-0.1	0.1
Haryana	-3.6	-1.7	2.0	-1.9	-1.1	0.8	-1.2	0.4	1.6
Uttarakhand	-0.9	-0.2	0.7	-4.1	-0.8	3.2	-3.4	-1.0	2.4
Punjab	-0.6	2.5	3.2	-0.3	0.4	0.7	-0.4	2.7	2.2
Bihar	12.1	15.4	3.2	-2.5	-0.8	1.7	3.3	5.4	2.1
Madhya Pradesh	3.5	3.3	-0.3	0.4	2.7	2.3	3.5	6.2	2.7
West Bengal	0.6	5.5	4.7	-2.5	-6.2	-3.7	0.5	-0.2	-0.8
Assam	1.9	1.3	-0.5	-0.8	1.9	2.6	0.8	1.4	0.6
Other States	5.5	8.2	2.7	0.3	0.1	-0.4	4.3	5.9	1.6
India	1.2	1.8	0.6	2.4	4.1	1.8	0.9	2.2	1.3

Sources: 1. Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare, New Delhi.
2. Agricultural Statistics at a Glance for various Years.
3. Press Information Bureau (PIB), Ministry of Agriculture & Farmers Welfare, Government of India on 12 December 2025.

(8.2% to 0.1%), and Haryana (−1.7% to −1.1%). Overall, sugarcane production at the national level registered a higher growth rate during Period-II.

With respect to yield, most states experienced an improvement in productivity growth during Period-II. Uttar Pradesh recorded an increase from 0.8 percent to 2.1 percent, Tamil Nadu from −0.1% to 1.6%, Andhra Pradesh from −0.6% to 0.7%, Gujarat from −0.7% to 0.7%, Madhya Pradesh from −0.3% to 2.3%, Uttarakhand from 0.7% to 3.2%, and Assam from −0.5% to 2.6%. Conversely, productivity growth slowed in Punjab (3.2% to 0.7%), Bihar (3.2% to 1.7%), West Bengal (4.7% to −3.7%), and Other States (2.7% to −0.4%). At the all-India level, yield growth increased from 0.6 percent to 1.8 percent, indicating improved productivity during the second period.

From Period-I to Period-III, the growth pattern in sugarcane cultivated area exhibited notable changes across the major producing states. Uttar Pradesh recorded an improvement in area growth from 0.1 percent to 1.0 percent. In contrast, Maharashtra, Karnataka, and Other States experienced a moderation in growth, declining from 3.6 percent to 2.5 percent, 7.3 percent to 3.8 percent, and 5.5 percent to 4.3 percent, respectively, although all continued to maintain positive growth rates. Bihar also remained in positive territory despite a substantial decline from 12.1 percent to 3.3 percent. Conversely, Andhra Pradesh, Tamil Nadu, and Uttarakhand exhibited a further deterioration in cultivated area, with growth rates declining from −5.6 percent to −11.8 percent, −2.1 percent to −6.2 percent, and −0.9 percent to −3.4 percent, respectively. At the national level, the growth rate of sugarcane area moderated slightly from 1.2 percent in Period-I to 0.9 percent in Period-III, indicating a slowdown in the long-term expansion of sugarcane acreage.

From Period-I to Period-III, the growth pattern of sugarcane output showed mixed trends across the major producing states. Long-term output growth improved in Uttar Pradesh, increasing from 0.8 percent to 3.5 percent, followed by Madhya Pradesh (3.3 percent to 6.2 percent), Punjab (2.5 percent to 2.7 percent), and Assam (1.3 percent to 1.4 percent). In contrast, output growth moderated in Maharashtra (4.2 percent to 3.3 percent) and Karnataka (8.0 percent to 3.8 percent), while West Bengal shifted from positive to marginally negative growth (5.5 percent to −0.2 percent). A further deterioration was observed in Tamil Nadu (−2.2 percent to −6.3 percent) and Andhra Pradesh (−6.2 percent to −11.8 percent). Similarly, the growth rate in Other States declined from 8.2 percent to 5.9 percent, although it remained positive. At the national level, sugarcane output growth increased from 1.8 percent in Period-I to 2.2 percent in Period-III, indicating a modest improvement in long-term production performance despite considerable inter-state variations.

Regarding yield, the overall trend indicates improved productivity in several states. Uttar Pradesh (0.8% to 2.5%), Madhya Pradesh (−0.3% to 2.7%), Haryana (2.0% to 1.6%), Uttarakhand (0.7% to 2.4%), and Andhra Pradesh (−0.6% to 0.1%) recorded better long-term productivity than in the initial period. In contrast, Punjab (3.2% to 2.2%), Bihar (3.2% to 2.1%), West Bengal (4.7% to −0.8%), Other States (2.7% to 1.6%), and Karnataka (0.7% to 0.01%) experienced slower yield growth. Nationally, yield growth increased from 0.6% in Period-I to 1.3% in Period-III, indicating sustained improvements in sugarcane productivity over the long run.

The comparative analysis shows that Period-II performed better than Period-I at the national level, with higher growth rates in area (1.2% to 2.4%), output (1.8% to 4.1%), and yield (0.6% to 1.8%), reflecting improvements in sugarcane cultivation during the second decade. However, these gains were uneven across states, with Uttar Pradesh, Gujarat, and Madhya Pradesh showing notable improvements, while Andhra Pradesh and Tamil Nadu continued to experience persistent declines.

The comparison between Period-I and Period-III indicates that, over the entire study period, output (2.2%) and yield (1.3%) maintained positive long-term growth despite a slight moderation in area growth (0.9%). This suggests that the long-term increase in sugarcane production in India was driven more by improvements in productivity than by expansion of cultivated area, highlighting the growing role of technological advancement, improved crop management practices, and better input use in enhancing sugarcane production.

Table 1.4 presents the Minhas Decomposition Analysis, which decomposes the change in sugarcane production (ΔP) into three components: Area Effect (AE), Yield Effect (YE), and Interaction Effect (IE). A comparison between Period-I (2005–06 to 2014–15) and Period-II (2015–16 to 2024–25) reveals that total sugarcane production increased from 88,530.2 thousand tonnes to 112,441.5 thousand tonnes, registering a rise of 23,911.3 thousand tonnes (27.0%). This growth was largely driven by a substantial improvement in the Yield Effect, which increased from 16,084.6 thousand tonnes to 62,933.7 thousand tonnes, an increase of 46,849.1 thousand tonnes (291.3%). The findings indicate that productivity improvement became the primary driver of sugarcane production growth during the second period. In contrast, the Area Effect declined from 66,941.5 thousand tonnes to 40,299.7 thousand tonnes, a decrease of 26,641.8 thousand tonnes (39.8%), suggesting that the contribution of expansion in cultivated area diminished over time. Meanwhile, the Interaction Effect increased from 6,368.4 thousand tonnes to 9,208.1 thousand tonnes, recording a moderate rise of 2,839.7 thousand

tonnes (44.6%), indicating a stronger combined influence of changes in area and yield.

At the state level, Uttar Pradesh recorded the most remarkable improvement, with production gains

increasing from 7,476.9 thousand tonnes in Period-I to 75,541.0 thousand tonnes in Period-II, representing an increase of 68,064.1 thousand tonnes. This growth was primarily attributed to significant improvements in both cultivated area and productivity.

Table 1.4: Minhas Decomposition Analysis of Changes in Sugarcane Production in India during 2005–06 to 2024–25

Periods	Period-I (2005-06 to 2014-15)				Period-II (2015-16 to 2024-25)				Period-III (2005-06 to 2024-25)			
States	A E	Y E	I E	ΔP	A E	Y E	I E	ΔP	A E	Y E	I E	ΔP
Uttar Pradesh	-873	8408.4	-58.5	7476.9	36917.0	30799.8	7824.2	75541.0	32824.8	49588.0	12972.0	95384.8
Maharashtra	41050.4	2304.6	2443.4	45798.4	13446.0	19246.5	3510.0	36202.5	51681.6	8316.6	11055.6	71053.8
Karnataka	21767.4	1708.2	2035.8	25511.4	7569.0	2205.0	441.0	10215.0	26771.4	1226.4	1797.6	29795.4
Tamil Nadu	-7643.1	705.6	-153.3	-7090.8	-12245.2	176.4	-84.7	-12153.5	-21463.5	-940.8	574.0	-21830.3
Andhra Pradesh	814.0	-1150.0	385.0	49.0	-7670.0	1647.0	-1350.0	-7373.0	-15974.4	3082.0	-2787.2	-15679.6
Gujarat	-1932.0	-1004.7	-56.1	-2992.8	2265.6	282.6	57.6	2605.8	-592.0	-275.8	11.2	-856.6
Haryana	60.7	1871.5	-285.0	1647.2	-1512.0	837.0	-189.0	-864.0	-3542.0	2108.2	-913.0	-2346.8
Uttarakhand	57.9	-30.3	-0.3	27.3	424.9	2318.3	-167.3	2575.9	-667.7	2413.9	-262.9	1483.3
Punjab	6579.0	1428.0	170.0	8177.0	73.4	756.0	-8.4	821.0	289.5	2007.6	119.5	2416.6
Bihar	736.1	1242.3	1881.9	3860.3	2641.8	2732.8	-571.2	4803.4	3956.0	2020.0	1840.0	7816.0
Madhya Pradesh	2381.5	-123.2	-121.0	2137.3	205.8	597.4	23.2	826.4	2208.3	772.8	703.8	3684.9
West Bengal	249.6	507.0	101.4	858.0	-488.4	-926.5	218.0	-1196.9	-166.4	-234.0	31.2	-369.2
Assam	223.2	-13.8	-4.2	205.2	-34.6	243.0	-8.1	200.3	223.2	126.5	33.0	382.7
Other States	2605.5	231.0	29.4	2865.9	-1293.6	2018.4	-487.2	237.6	1910.7	313.5	188.1	2412.3
India	66077.2	16084.6	6368.4	88530.3	40299.7	62933.7	9208.1	112441.5	77459.5	70524.9	25362.9	173347.3

Sources: 1. Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare, New Delhi.

2. Agricultural Statistics at a Glance for various Years.

3. Press Information Bureau (PIB), Ministry of Agriculture & Farmers Welfare, Government of India on 12 December 2025.

In contrast, Maharashtra experienced a decline in production gains from 45,798.4 thousand tonnes to 36,202.5 thousand tonnes, a reduction of 9,595.9 thousand tonnes, while Karnataka's production gains decreased from 25,511.4 thousand tonnes to 10,215.0 thousand tonnes, a decline of 15,296.4 thousand tonnes.

Despite these reductions, both states continued to make positive contributions to national sugarcane production. Tamil Nadu showed a further deterioration, with production declining from -7,090.8 thousand tonnes to -12,153.5 thousand tonnes, while Andhra Pradesh shifted from a marginal increase of 49.0 thousand tonnes in Period-I to a decline of -7,373.0 thousand tonnes in Period-II. These adverse trends primarily reflected continuous reductions in cultivated area despite some improvements in productivity.

A comparison between Period-I and the overall Period-III (2005–06 to 2024–25) indicates that cumulative sugarcane production increased from 88,530.3 thousand tonnes to 173,347.3 thousand tonnes, representing an overall increase of 84,817.0 thousand tonnes (95.8%), nearly doubling the production gain recorded during Period-I. The Area Effect increased modestly from 66,941.5 thousand tonnes to 77,459.5 thousand tonnes, registering a growth of 10,518.0 thousand tonnes (15.7%). In contrast, the Yield Effect increased sharply from 16,084.6 thousand tonnes to

70,524.9 thousand tonnes, recording an increase of 54,440.3 thousand tonnes (338.5%). Likewise, the Interaction Effect rose substantially from 6,368.4 thousand tonnes to 25,362.9 thousand tonnes, an increase of 18,994.5 thousand tonnes (298.3%). These results suggest that over the entire study period, sustained improvements in productivity, supported by technological progress and the complementary influence of area expansion, played a decisive role in enhancing sugarcane production.

Among the major sugarcane-producing states, Uttar Pradesh remained the largest contributor, recording cumulative production gains of 95,384.8 thousand tonnes, followed by Maharashtra (71,053.8 thousand tonnes) and Karnataka (29,795.4 thousand tonnes). Conversely, Tamil Nadu and Andhra Pradesh continued to exhibit overall production declines due to persistent reductions in cultivated area and adverse interaction effects.

Overall, the Minhas Decomposition Analysis demonstrates that both expansion in cultivated area and improvements in yield have been the principal determinants of sugarcane production growth in India, although their relative contributions changed over time. During Period-I, production growth was driven predominantly by expansion in cultivated area, whereas during Period-II, productivity improvement emerged as

the dominant source of growth, reflecting technological advancement, adoption of improved sugarcane varieties, enhanced irrigation facilities, and better crop management practices. Over the entire study period, the combined contribution of area expansion, yield improvement, and their interaction highlights the importance of both extensive and intensive agricultural development in sustaining sugarcane production growth. Furthermore, the analysis reveals significant regional disparities, with Uttar Pradesh, Maharashtra, and Karnataka emerging as the major contributors to national production growth, while Tamil Nadu and Andhra Pradesh experienced persistent production declines. These findings underscore the need for state policy interventions aimed at improving irrigation efficiency, promoting technological adoption, optimizing land use, and enhancing productivity to achieve sustainable growth in sugarcane production.

Government Policies and Their Relevance to the Study

The findings of the study have important implications for government policies concerning sugarcane cultivation in India. The increase in sugarcane production during the study period was influenced by both expansion in cultivated area and improvement in yield. The Minhas decomposition results indicate that the contribution of yield improvement became more important during the later period. Therefore, future policies should give greater emphasis to productivity enhancement rather than relying mainly on area expansion.

The Fair and Remunerative Price (FRP) policy provides price support to sugarcane farmers and encourages continued cultivation. However, price incentives should be accompanied by measures to improve farm productivity and reduce production costs.

The increasing instability in sugarcane production and yield highlights the need for efficient irrigation, water conservation, climate-resilient varieties, improved farm technology, and better extension services. These measures can help reduce production risks and improve yield stability.

The Ethanol Blending Programme has also increased the importance of sugarcane as a source of ethanol feedstock. This provides an additional demand for sugarcane and can support the economic sustainability of the sugar sector.

The substantial regional differences observed in the study indicate the need for state-specific policies based on local conditions such as water availability, productivity, climate, and infrastructure. Overall, government policy should focus on productivity growth, stability, efficient resource use, farmer income, and sustainable sugarcane cultivation rather than merely increasing the area under sugarcane.

CONCLUSION AND SUGGESTIONS

The overall analysis of sugarcane cultivation in India during 2005–06 to 2024–25 (Period-III) reveals significant regional disparities in area, production, yield, stability, and growth performance. Uttar Pradesh emerged as the dominant state in terms of cultivated area and production throughout the study period, followed by Maharashtra and Karnataka. In contrast, Tamil Nadu and West Bengal recorded the highest productivity despite their relatively smaller cultivated areas, highlighting the role of efficient cultivation practices, technological adoption, and better resource-use efficiency.

The coefficient of variation analysis indicates that sugarcane cultivation became increasingly unstable over time, particularly in Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Karnataka, Uttarakhand, and Assam, where greater fluctuations were observed in area, production, and yield. Conversely, Punjab, Haryana, Bihar, and West Bengal exhibited relatively higher stability throughout the study period.

The Compound Annual Growth Rate analysis shows that Period-II (2015–16 to 2024–25) performed better than Period-I (2005–06 to 2014–15) at the national level, with higher growth in area, production, and yield. Notable improvements were observed in Uttar Pradesh, Gujarat, and Madhya Pradesh, whereas Andhra Pradesh and Tamil Nadu continued to experience persistent declines in cultivated area and production. Over the overall study period (Period-III), Uttar Pradesh, Maharashtra, Karnataka, and Madhya Pradesh maintained positive long-term growth in production, whereas Andhra Pradesh and Tamil Nadu experienced persistent declines in cultivated area and production, indicating structural shifts in sugarcane cultivation.

The Minhas Decomposition Analysis further reveals that the principal source of sugarcane production growth shifted from area expansion during Period-I to yield improvement during Period-II and Period-III. Uttar Pradesh made the largest contribution to production growth, followed by Maharashtra and Karnataka, while Tamil Nadu and Andhra Pradesh continued to record negative production changes due to declining cultivated area and adverse interaction effects.

The findings of the study indicate that Period-III was characterised by sustained growth in sugarcane production, with productivity improvement emerging as a more important driver than expansion in cultivated area. This suggests that future growth of the sugarcane sector cannot rely primarily on increasing the area under cultivation. Greater emphasis should be placed on improving yield, reducing production instability, and increasing the efficiency of land and water resources.

The observed regional variations in area, production, yield, and stability highlight the need for region-specific policy interventions. These should include improved irrigation management, efficient water-use technologies, climate-resilient varieties, better crop management practices, modern farm technology, and strengthened extension services. Particular attention should be given to regions experiencing persistent declines in cultivated area and production.

In addition, policies aimed at reducing production costs, improving resource-use efficiency, and strengthening farmer incomes can contribute to the long-term sustainability of sugarcane cultivation. Thus, a balanced approach combining productivity enhancement, technological improvement, climate resilience, efficient resource use, and regional policy support is essential for sustainable growth of India's sugarcane sector.

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