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Regional Trends of Sugarcane Cultivation in Himachal Pradesh

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Abstract: This study examines the district-wise trends and variations in sugarcane cultivation across Himachal Pradesh over three periods: 2000-01 to 2010-11, 2011-12 to 2021-22, and 2000-01 to 2021-22. Significant metrics analyzed include area, production, yield, and growth rates, alongside T-test evaluations to determine statistical significance. The findings reveal significant regional disparities, with Sirmaur and Kangra dominating sugarcane farming. Sirmaur, while leading in area and yield, experienced a decline in cultivation area and production. Kangra emerged as a strong performer, exhibiting consistent growth in area, output, and yield. Una maintained high yields despite a decline in area, while Hamirpur and other districts witnessed sharp reductions in area and limited contributions to production. Compound Annual Growth Rate (CAGR) analysis highlighted significant growth in Kangra's sugarcane sector, contrasting with declines in other regions. T-test results underscored robust cultivation trends in Kangra and notable improvements in Una's output, while Sirmaur faced declines in area but showed productivity gains. The study underscores the need for targeted interventions to address regional disparities, enhance productivity, and promote sustainable growth in sugarcane farming. Leveraging the strengths of high-performing districts like Kangra and Una, while addressing challenges in Sirmaur and underperforming regions, is essential for advancing the sector's contribution to the state's agriculture, economy, and rural development.

Keywords: Growth, Region, Share, Sugarcane, and Yield

INTRODUCTION

Himachal Pradesh, with its diverse agro-climatic zones ranging from subtropical to temperate, offers specific niches for sugarcane cultivation. Despite the challenges posed by its hilly terrain and variable climatic conditions, sugarcane is cultivated in certain regions, contributing to the local economy and the livelihood of small and marginal farmers. The state's sugarcane cultivation is mainly concentrated in the lower hill regions, including Kangra, Hamirpur, Una, Sirmaur, Solan, and Bilaspur districts, where the climatic conditions are more conducive to its growth. The sugarcane industry in Himachal Pradesh is characterized by smaller-scale farming operations, often integrated with other crops as part of mixed farming systems. Research and development efforts in the state have focused on improving sugarcane varieties, optimizing agronomic practices, and enhancing the sustainability of sugarcane farming. Studies have highlighted the potential of sugarcane as a cash crop that can be integrated into the state's agricultural landscape, especially with the adoption of climate-resilient varieties and improved water management techniques (Sharma *et al.*, 2011).

In recent years, there has been growing interest in promoting organic sugarcane farming in Himachal Pradesh, leveraging the state's relatively lower use of chemical inputs. This shift aims to capitalize on the increasing demand for organic produce, thus providing an additional income source for farmers and contributing to sustainable agricultural practices. The state's sugarcane sector, while not as dominant as in other major sugar-producing states, plays a critical role in supporting rural livelihoods and enhancing agricultural diversity (Negi *et al.*, 2014).

REVIEW OF LITERATURE

Sugarcane is a vital crop grown predominantly in tropical and subtropical regions. It is crucial for sugar production and various by-products like ethanol, molasses, and bagasse (Bakker, 1999).The historical significance of sugarcane traces back to ancient India, where it was first domesticated (Galloway, 1989). The global spread of sugarcane cultivation followed colonial trade routes, significantly influencing economic and social structures (Mintz, 1985). Agronomic studies emphasize the importance of varietal selection, soil health, and water management. Research shows that integrating crop rotation and green manuring improves soil fertility and sugarcane yields (Cheavegatti-Gianotto *et al.*, 2011). Irrigation techniques, such as drip and sprinkler systems, have proven to enhance water use efficiency and crop productivity (Singh *et al.*, 2007). Advances in genetic engineering and molecular breeding have led to the development of high-yielding, disease-resistant sugarcane varieties. Biotechnology has enabled the integration of traits like drought tolerance and pest resistance (Piperidis *et al.*, 2008). Marker-assisted selection (MAS) has accelerated the breeding process,

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ensuring the cultivation of robust and high-yield varieties (Singh & Singh, 2015). The environmental footprint of sugarcane cultivation, especially in water-stressed regions, has been a concern. Studies suggest that adopting sustainable practices like reduced tillage, organic farming, and bio-fertilizers can mitigate adverse impacts (Renouf *et al.*, 2008). Life cycle assessments reveal that the energy balance and carbon footprint of sugarcane ethanol are favourable compared to fossil fuels, supporting its role in renewable energy strategies (Macedo *et al.*, 2008). Sugarcane is a critical economic crop for many developing countries, providing livelihoods and contributing significantly to GDP. The global sugar market dynamics, influenced by subsidies, tariffs, and trade policies, have been extensively analyzed (Jain & Agarwal, 2002). The role of cooperatives in sugarcane production and their impact on rural development and farmer incomes has been highlighted in several case studies (Tiffen, 2003). The sugarcane industry faces challenges such as climate change, pest infestations, and fluctuating market prices. Research suggests the need for adaptive strategies, including precision agriculture, climate-resilient crops, and integrated pest management (IPM) (Ramesh *et al.*, 2014). The potential for sugarcane in bioenergy and bio-products continues to grow, with studies exploring its use in bio-plastics, bio-electricity, and advanced biofuels (Buckeridge *et al.*, 2012).

Sugarcane is one of the most important commercial crops globally, primarily cultivated for sugar production. In India, it holds a vital place in the agricultural economy, especially in states like Uttar Pradesh, Maharashtra, and Tamil Nadu, which are major contributors to the country's sugarcane output. However, the cultivation of sugarcane is also significant in the northern state of Himachal Pradesh, albeit on a smaller scale due to its unique climatic and topographical conditions (Negi *et al.*, 2014). Uttar Pradesh has traditionally been the largest producer of sugarcane in India. The state has a well-developed sugar industry, with extensive research on improving productivity and sustainability (Kumar & Singh, 2010). Agronomic Practices: Studies in U.P. have focused on optimizing planting techniques, varietal improvements, and integrated pest management. Adoption of high-yielding varieties (HYVs) and efficient water management practices has shown significant yield improvements (Pandey *et al.*, 2012). The sugarcane industry in U.P. is a key driver of rural livelihoods. Research highlights the role of cooperatives and sugar mills in ensuring farmer profitability and stability (Shukla *et al.*, 2015). Sugarcane in Haryana is cultivated under semi-arid conditions, with studies emphasizing the importance of efficient water use and soil fertility management. Research by Yadav *et al.* (2014) highlights the impact of drip irrigation systems on improving water use efficiency and crop yields. Haryana's sugarcane sector has benefited from government initiatives aimed at improving productivity and supporting farmers through subsidies and technical assistance (Rana *et al.*, 2018). Punjab's sugarcane sector has seen a shift towards mechanization and technology-driven practices. Studies show that the adoption of mechanized planting and harvesting has reduced labour costs and increased efficiency (Gill & Singh, 2013). Research highlights concerns regarding the environmental impact of sugarcane cultivation, particularly in terms of water usage and soil degradation. Studies suggest the need for sustainable practices and crop diversification to mitigate these impacts (Dhaliwal *et al.*, 2016).

Himachal Pradesh, with its hilly terrain and diverse climatic conditions, presents unique challenges for sugarcane cultivation. Research has focused on developing climate-resilient varieties and optimizing agronomic practices suited to the region's conditions (Sharma *et al.*, 2011). Studies indicate that sugarcane cultivation in Himachal Pradesh is limited by economic factors such as lower yields and higher transportation costs. However, initiatives promoting organic farming and value-added products have shown potential for enhancing farmer incomes (Negi *et al.*, 2014). Comparative studies reveal significant disparities in yield and productivity across these states. U.P. consistently shows higher yields due to better irrigation infrastructure and research support, whereas Haryana and Punjab face challenges due to water scarcity and soil health issues (Kumar *et al.*, 2017). Differences in policy support and institutional frameworks also contribute to varying levels of success in sugarcane cultivation. U.P.'s strong cooperative network contrasts with the individualistic approach observed in Haryana and Punjab (Verma & Singh, 2019).

OBJECTIVES:

- To analyze the regional distribution of sugarcane cultivation in Himachal Pradesh in terms of area, production, and yield.
- To evaluate the Compound Annual Growth Rate (CAGR) of sugarcane cultivation in terms of area, output, and yield for individual districts.
- To identify the challenges and opportunities associated with sugarcane cultivation in Himachal Pradesh.
- To propose policy recommendations for promoting sustainable sugarcane cultivation in Himachal Pradesh.

DATA AND METHODOLOGY:

This study relies on secondary data, collected from reliable sources such as the Directorate of Land Records of Himachal Pradesh and the Himachal Pradesh Government's Annual Season and Crop Report for the period 2000-01 to 2021-22.

The Compound Annual Growth Rate (CAGR), used to assess the growth trends of sugarcane cultivation

***Corresponding Author:** Anay Kumar

in terms of area, production, and yield, is calculated using the following formula:

$$\text{CAGR} = [Log\left(\frac{Area/Output/Yield\ of\ Sugarcane\ (ending\ year)}{Area/Output/Yield\ of\ sugarcane\ (starting\ year)}\right)^{\frac{1}{N-1}}]\text{-}1\times100$$

Where:
Ending Year: The value of area, output, or yield in the last year of the period.
Starting Year: The value of area, output, or yield in the first year of the period.
N: The number of years in the period.
Divide this by N−1 (i.e., the number of intervals).
Take the exponential (antilog) to return to the original scale.
Subtract 1 and multiply by 100 to express the result as a percentage.

The formula for calculating the T-value in hypothesis testing is:

$$t = \frac{\overline{x}-\mu}{S.E}$$

Where:
$\overline{x}$: The sample mean, calculated from the sample data.
μ: The population mean under the null hypothesis(H_0).

Null Hypothesis (H_0): Assumes there is no significant difference between the sample mean and the population mean.

Alternative Hypothesis (H_1): Assumes that the sample mean differs significantly from the population mean.

S.E.: The standard error, which measures the variability of the sample mean.

$$S.E = \frac{\sigma}{\sqrt{N}}$$

Where:
σ: standard deviation.
N: number of observations in the sample.

RESULTS AND DISCUSSION

Sugarcane cultivation in Himachal Pradesh is limited due to the state's mountainous terrain and cooler climate, which are less favourable for this tropical crop. It is primarily grown in lower-altitude regions like Una, Kangra, Sirmaur and Hamirpur districts, where the climate and soil conditions are relatively suitable. Sugarcane serves as a significant cash crop for smallholder farmers in these areas, contributing to local economies.

Table 1 highlights the district-wise percentage distribution of area, production, and yield in sugarcane cultivation in Himachal Pradesh over three periods: 2000-01 to 2010-11, 2011-12 to 2021-22, and 2000-01 to 2021-22. Sirmaur consistently dominated sugarcane cultivation, accounting for the largest area share, although it declined from 56.26% in 2000-01 to 2010-11 to 45.43% in 2011-12 to 2021-22, with an overall share of 51.88%. Kangra experienced a significant rise in its area share, increasing from 23.37% to 42.24% over the same periods, with an overall share of 31%, indicating a growing focus on sugarcane farming. Una's share slightly decreased from 10.60% to 8.76%, contributing an overall 9.86%, while other districts saw a sharp decline from 8.20% to 1.82%, with an overall contribution of just 5.62%.

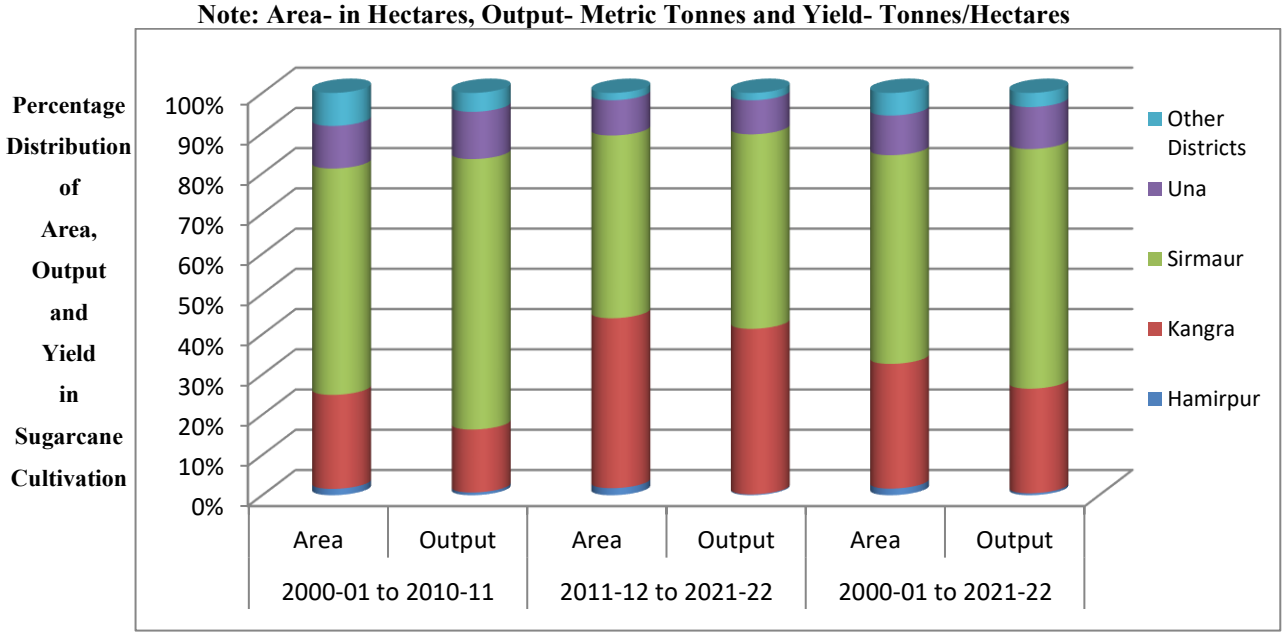
Table-1: District-Wise Percentage Distribution of Area, Output and Yield in Sugarcane Cultivation from 2000-01 to 2021-22

District/ Period	2000-01 to 2010-11			2011-12 to 2021-22			2000-01 to 2021-22		
	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
Hamirpur	1.57	0.67	11.32	1.75	0.21	3.12	1.64	0.48	7.43
Kangra	23.37	15.66	14.42	42.24	41.15	25.04	31.00	26.00	19.45
Sirmaur	56.26	67.23	29.07	45.43	48.35	27.03	51.88	59.57	28.10
Una	10.60	11.74	26.96	8.76	8.46	25.02	9.86	10.44	26.04
Other Districts	8.20	4.70	18.24	1.82	1.83	19.79	5.62	3.51	18.97
Himachal Pradesh	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Sources: 1) Directorate of Land Records of Himachal Pradesh for Various Years.
2) Himachal Pradesh Government, Annual Season and Crop Report for Various Years.

***Corresponding Author:** Anay Kumar

Note: Area- in Hectares, Output- Metric Tonnes and Yield- Tonnes/Hectares



In terms of production, Sirmaur maintained its leadership, although its share dropped from 67.23% to 48.35%, with an overall contribution of 59.57%. Kangra's production grew significantly from 15.66% to 41.15%, with an overall share of 26%, reflecting substantial improvements in both area and productivity. Una and Hamirpur saw declines, with overall production shares of 10.44% and 0.48%, respectively. Yield trends reveal that Sirmaur the highest productivity, averaging 28.10 tons/ha, while Kangra showed remarkable improvement, rising from 14.42 tons/ha to 25.04 tons/ha, with an overall yield of 19.45 tons/ha. Una maintained consistently high yields, averaging 26.04 tons/ha, while Hamirpur faced a significant decline, with an overall yield of 7.43 tons/ha. Other districts showed slight improvement, with an average yield of 18.97 tons/ha.

Sirmaur and Kangra districts remained the dominant regions for sugarcane cultivation in Himachal Pradesh, with Sirmaur maintaining its leadership despite some decline and Kangra emerging as a significant player due to substantial improvements in area and yield. While Una and Hamirpur contributed minimally, Una consistently achieved high yields, second only to Sirmaur. In contrast, Hamirpur faced a significant decline in both area and yield. Other districts experienced a sharp drop in area and production, indicating a concentration of sugarcane cultivation in select regions, particularly Sirmaur and Kangra, which continue to drive the state's sugarcane farming sector.

Table-2: District-Wise Compound Annual Growth Rate of Sugarcane Area, Output, and Yield in Himachal Pradesh from 2000-01 to 2021-22

District/ Period	2000-01 to 2010-11			2011-12 to 2021-22			2000-01 to 2021-22		
	Area	Output	Yield	Area	Output	Yield	Area	Output	Yield
Hamirpur	-8.19	21.27	32.09	-4.20	-1.50	2.82	-2.46	0.11	2.62
Kangra	0.82	29.99	28.94	5.55	5.55	-0.07	3.50	15.83	12.05
Sirmaur	-4.32	27.18	32.92	-6.99	-12.65	-6.08	-5.88	3.66	10.18
Una	-6.21	-0.60	5.97	-2.08	-2.08	-0.01	-5.68	-4.40	1.34
Other Districts	-19.73	-0.75	23.64	-5.71	-4.62	-1.78	-25.59	-4.33	10.26
Himachal Pradesh	-4.49	17.66	23.94	-1.13	-4.98	-3.08	-3.00	3.99	7.22

Sources: 1) Directorate of Land Records of Himachal Pradesh for Various Years.
2) Himachal Pradesh Government, Annual Season and Crop Report for Various Years.

***Corresponding Author:** Anay Kumar

Note: Area- in Hectares, Output- Metric Tonnes and Yield- Tonnes/Hectare

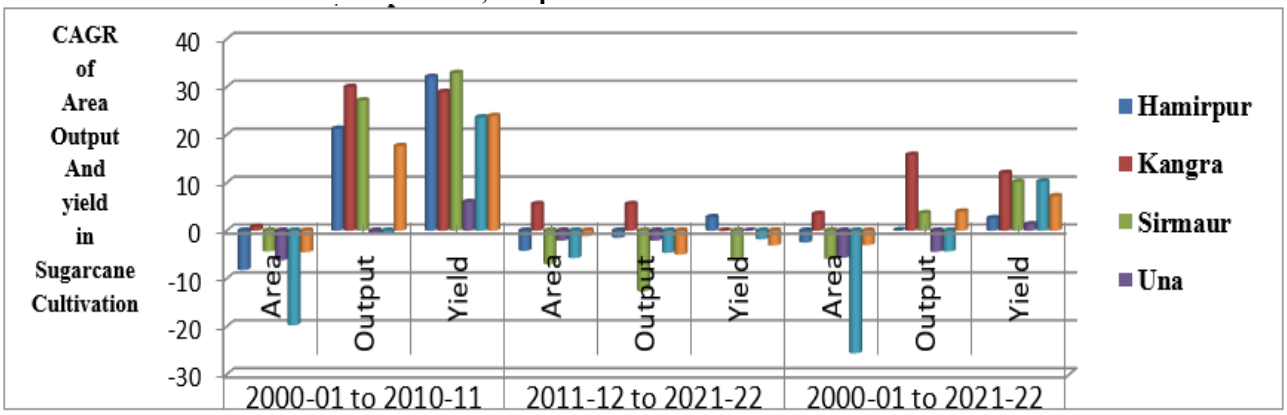


Table 2 outlines the Compound Annual Growth Rates (CAGR) of sugarcane area, output, and yield in Himachal Pradesh from 2000-01 to 2021-22. The area under sugarcane cultivation in Hamirpur experienced significant declines, with a CAGR of -8.19% in 2000-01 to 2010-11 and -4.20% in 2011-12 to 2021-22, resulting in an overall decrease of -2.46%. In contrast, Kangra showed consistent growth, with a modest 0.82% CAGR in 2000-01 to 2010-11 and a more robust 5.55% in 2011-12 to 2021-22, culminating in an overall increase of 3.50%. Sirmaur and Una also witnessed declines in area, with Sirmaur dropping at -5.88% overall and Una at -5.68%. The other districts experienced the most dramatic decline, with a -25.59% decrease in area.

In terms of output, Hamirpur saw a sharp increase of 21.27% in 2000-01 to 2010-11, followed by a decline of -1.50% in 2011-12 to 2021-22, leading to marginal overall growth of 0.11%. Kangra showed remarkable growth in output, with a CAGR of 29.99% in 2000-01 to 2010-11, moderating to 5.55% in 2011-12 to 2021-22, and achieving an overall 15.83% growth. Sirmaur also demonstrated strong growth initially (27.18%), though it faced a decline of -12.65% in the second period, resulting in a moderate overall growth of 3.66%. Una and other districts showed minimal or negative growth in output.

Regarding yield, Hamirpur had a significant increase of 32.09% in 2000-01 to 2010-11 but saw moderation to 2.82% in 2011-12 to 2021-22, achieving an overall growth of 2.62%. Kangra exhibited a similarly strong yield growth of 28.94% in2000-01 to 2011-12, with a slight decline of -0.07% in 2011-12 to 2021-22, achieving a 12.05% growth overall. Sirmaur achieved the highest yield growth in the first period (32.92%), but its yield dropped by -6.08% in the second, yielding an overall growth of 10.18%.

The data highlights the regional differences in sugarcane cultivation across Himachal Pradesh. Kangra district showed steady growth in all aspects- area, output, and yield- while Sirmaur continued to lead in yield despite experiencing declines in both area and output. Hamirpur and Una districts faced significant declines in cultivation area, with minimal improvements in output. On the other hand, other districts showed sharp declines in both area and output during the second period but experienced significant gains in yield during the first period. At the state level, there was an overall decrease in sugarcane area, but moderate growth was observed in both output and yield.

The table 3 presents a district-wise T-test analysis of sugarcane area and output in Himachal Pradesh over three periods: 2000-01 to 2010-11, 2011-12 to 2021-22, and the combined period of 2000-01 to 2021-22. The T-test values provide insights into the statistical significance of variations in sugarcane cultivation area and output during these timeframes. In Hamirpur district, the T-values for the area under sugarcane cultivation show a steady increase, rising from 12.829 to 16.692, which indicate significant growth in sugarcane cultivation over the study period. In Kangra district, the area T-values exhibit moderate growth, increasing from 10.512 to 13.997, reflecting stable and consistent trends in cultivation. Sirmaur district, on the other hand, displays a declining trend, with T-values for the area dropping from 20.849 to 13.352, suggesting a reduction in the sugarcane cultivation area. Una district demonstrates remarkable growth in sugarcane area, with T-values increasing significantly from 9.183 to 19.114, highlighting substantial expansion in cultivation. In contrast, the "Other Districts" category shows a decline in T-values, from 5.668 to 4.400, pointing to a reduction in sugarcane cultivation in these regions. At the state level, Himachal Pradesh's area T-values remain consistently high, ranging from 19.422 to 23.467, indicating robust sugarcane cultivation across the state.

***Corresponding Author:** Anay Kumar

Table-3: District-Wise T-Test Analysis of Sugarcane Area and Output in Himachal Pradesh from 2000-01 to 2021-22

District/ Period	2000-01 to 2010-11		2011-12 to 2021-22		2000-01 to 2021-22	
	Area	Output	Area	Output	Area	Output
Hamirpur	12.829	4.028	15.011	17.719	16.692	4.084
Kangra	10.512	3.179	10.258	10.258	13.997	7.134
Sirmaur	20.849	4.303	13.668	8.387	13.352	5.757
Una	9.183	11.709	19.114	19.042	10.698	10.656
Other Districts	5.668	2.773	3.670	3.660	4.400	3.110
Himachal Pradesh	23.467	5.075	23.061	18.202	19.422	8.101

Sources: 1) Directorate of Land Records of Himachal Pradesh for Various Years.
2) Himachal Pradesh Government, Annual Season and Crop Report for Various Years.

For output, Hamirpur district's T-values remain relatively stable, hovering around 4.0 during the periods 2000-01 to 2010-11 and 2000-01 to 2021-22. However, a sudden and exceptional spike (17.719) is observed during 2011-12 to 2021-22, suggesting an unusual or extraordinary occurrence in production. In Kangra district, the T-values for output show a significant rise, increasing from 3.179 (2000-01 to 2010-11) to 7.134 (2000-01 to 2021-22), indicating considerable growth in sugarcane production. Sirmaur districts output T-values increase from 4.303 to 5.757, reflecting improvements in productivity or efficiency despite a reduction in cultivation area. Una district also demonstrates consistent growth in sugarcane output, with T-values peaking at 19.042 during 2011-12 to 2021-22, signalling strong production trends. For the "Other Districts," output T-values remain low, with a slight rise from 2.773 to 3.110, indicating limited contributions to the state's overall sugarcane production. At the state level, Himachal Pradesh exhibits a marked improvement in sugarcane output, with T-values increasing from 5.075 to 8.101 over the combined period, showcasing significant growth in production across the state.

Hamirpur and Una exhibit notable growth in both sugarcane area and output, with Una showing the most significant improvements. Sirmaur faces a decline in cultivation area but compensates with improved output, suggesting enhanced productivity. Kangra demonstrates consistent growth in both area and output, reflecting stable trends. Other Districts contribute minimally, with declining area and modest output improvements.

At the state level, the overall trends indicate consistent sugarcane cultivation and significant growth in production, driven largely by select districts like Una and Kangra.

Challenges and Opportunities in Sugarcane Cultivation in Himachal Pradesh

Sugarcane cultivation in Himachal Pradesh faces unique challenges due to the state's mountainous terrain, cooler climate, and limited arable land. Being a tropical crop, sugarcane thrives best in warmer lowland regions, making it suitable primarily in districts such as Sirmaur, Kangra, Una, and Hamirpur. The rugged topography, small landholdings, and fragmented plots restrict large-scale mechanization and intensification, leading to uneven productivity across districts. Climatic constraints, including lower temperatures at higher altitudes and irregular rainfall patterns, further limit potential cultivation areas and may impact crop yields. Additionally, smallholder farmers often face limited access to modern inputs, irrigation facilities, credit, and markets, which hinders optimal production and income generation.

Analysis of district-level data reveals a pronounced concentration of sugarcane cultivation in a few regions. Sirmaur and Kangra emerge as dominant districts, with Sirmaur maintaining leadership in area, output, and yield, though its overall share has declined over the years. Kangra, on the other hand, has shown significant improvements in cultivation area, output, and yield, highlighting its growing significance in the state's sugarcane sector. Una, despite a reduction in area, consistently achieves high yields, second only to Sirmaur, while Hamirpur and other districts face sharp declines in both cultivation area and productivity. These disparities indicate regional inequalities and underscore the need for targeted interventions to ensure balanced sectoral growth.

Despite these challenges, several opportunities exist to strengthen sugarcane cultivation in Himachal Pradesh. High-performing districts like Sirmaur and Kangra can be further supported through enhanced irrigation infrastructure, adoption of high-yielding and disease-resistant varieties, and the introduction of modern cultivation techniques. Expansion of water-efficient and climate-resilient technologies can help mitigate environmental constraints and stabilize yields. For districts facing stagnation, such as Hamirpur and the "Other Districts," focused initiatives like farmer training programs, extension services, and provision of credit and subsidies can improve productivity and participation in the sugarcane economy.

Promoting regional diversification and intercropping systems is another viable strategy, allowing smallholders to optimize land use, reduce risks from monocropping, and increase income security. Soil fertility management, crop rotation, and organic inputs

***Corresponding Author:** Anay Kumar

can further enhance sustainability and long-term productivity. Strengthening market linkages, establishing small-scale processing units, and integrating crop insurance and financial support mechanisms will encourage farmers to invest in sugarcane cultivation and stabilize production. While sugarcane cultivation in Himachal Pradesh faces structural, climatic, and resource-based challenges, targeted interventions and technological improvements offer significant opportunities for growth. By focusing on high-performing districts, enhancing infrastructure, supporting lagging regions and promoting sustainable farming practices, the state can increase productivity, reduce regional disparities, and ensure sugarcane remains a profitable and sustainable crop. These measures can collectively contribute to strengthening the sector's role in the state's agricultural economy while improving livelihoods for smallholder farmers across Himachal Pradesh.

CONCLUSION AND SUGGESTIONS

The analysis of sugarcane area, output, and yield in Himachal Pradesh reveals a pronounced concentration of cultivation in a few districts, with Sirmaur and Kangra emerging as the dominant regions. Sirmaur maintained its leadership across area, production, and yield, although its overall share declined over the study period. In contrast, Kangra achieved substantial gains in both cultivation area and output, highlighting its growing importance in the state's sugarcane sector. Una, despite a slight reduction in area, consistently recorded high yields, second only to Sirmaur, while Hamirpur experienced a sharp decline due to significant reductions in both area and productivity. The "Other Districts" category saw a steep contraction, contributing only marginally to total production. Overall, the data indicate a clear regional concentration of sugarcane farming in Sirmaur and Kangra, which continue to drive Himachal Pradesh's sugarcane economy, while other districts face stagnation or decline (See table 1).

The regional compound annual growth rates (CAGR) for sugarcane cultivation from 2000-01 to 2021-22 highlight distinct district-level trends. Kangra emerged as the strongest performer, showing consistent growth in area, output, and yield, emphasizing its increasing significance in the state's sugarcane sector. Sirmaur maintained the highest yield, though declines in both area and output moderated its overall growth. Hamirpur and Una experienced reductions in cultivation area, with only minimal gains in output and yield, indicating stagnation or declining productivity. The "Other Districts" category recorded the steepest contraction in area and output, despite some early yield gains. At the state level, while total sugarcane area declined, moderate growth in output and yield reflects improvements in productivity and cultivation efficiency. Collectively, these trends underscore a regional concentration of growth and productivity in select districts, particularly Kangra and Sirmaur, highlighting uneven development across the state (See table 2).

District-level analysis further reveals that Hamirpur and Una show notable improvements, with Una demonstrating the most significant gains in cultivation area and output, reflecting its expanding role in the sector. Sirmaur, despite a decline in area, maintained improved output, indicating enhanced productivity and efficiency. Kangra demonstrated steady and consistent growth in both area and output, reflecting stable and sustained development. The "Other Districts" category contributed minimally, with declining area and only modest improvements in output. At the state level, these trends indicate robust sugarcane cultivation and significant growth in production, driven primarily by select districts such as Una and Kangra, reinforcing a regional concentration of productivity and highlighting uneven development across Himachal Pradesh (See table 3).

To stabilize and increase sugarcane production across the state, a combination of technological, infrastructural, and policy interventions is essential. High-performing districts like Kangra and Sirmaur should be further supported with enhanced irrigation systems, high-yielding and disease-resistant varieties, and modern cultivation practices to sustain and boost productivity. Districts facing stagnation or decline, including Hamirpur and the "Other Districts," require targeted measures such as farmer training, extension services, and adoption of climate-resilient and water-efficient technologies. Promoting regional diversification, intercropping, and soil fertility management can optimize land use and reduce production risks. Establishing market linkages, small-scale processing units, and financial support mechanisms such as subsidies and crop insurance will incentivize farmers and ensure consistent production. Together, these measures can enhance productivity, stabilize cultivation, and strengthen the sector's contribution to Himachal Pradesh's agricultural economy.

While sugarcane cultivation in Himachal Pradesh faces significant geographic, climatic, and resource-related challenges, strategic interventions and modern farming practices can enhance productivity and sustainability. Focusing on high-performing districts and supporting lagging regions will help reduce regional disparities, stabilize production, and strengthen the crop's contribution to the state's agricultural economy and farmers' livelihoods.

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