

A Comparative Analysis of Apple Production Across Districts in Himachal Pradesh: Exploring Time Series Trends and Growth Rates

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Abstract

Apples (Temperate fruit) contributed significantly 81.2% to the total horticultural output in Himachal Pradesh in the year 2021-22. With the growing interest among youth over apple crop cultivation, the variations in apple production across different districts have also highlighted the importance of comprehensive understanding of trends and patterns in apple crop production. Consequently, the present study aimed to analyze apple production across districts of Himachal Pradesh, taking into consideration time series analysis, district wise production, and growth rate evaluation. The study examines the trends, growth rates, and variation in apple crop production across different districts of Himachal Pradesh, India, over a decade (2012-2022). The analysis of district wise data reveals diverse growth patterns, with some districts experiencing substantial increases in both area and apple production, while other face challenges with fluctuations in production despite moderate growth in area. The study compares district wise production and evaluates growth rates to identify districts that have experienced higher or lower rates of growth over time. The one-way ANOVA analysis confirms that the production of apple crop varies significantly across different districts in Himachal Pradesh. The regression analysis demonstrates a strong positive relationship between the area of apple crop and apple production with approximately 72.6% of the variation in production explained by the area. The findings provide valuable insights for policymakers to formulate strategies that support sustainable agricultural development and address specific challenges faced by districts.

Keywords: Apple production, Time series analysis, District-wise production, Growth rates, Himachal Pradesh, Horticulture crop.

INTRODUCTION

Horticulture plays a pivotal role in driving the economy of Himachal Pradesh at such a pace which has led it to be known as 'Fruit Bowl of India' (APEDA). Diverse range of agro-climatic conditions, topographical differences, changing habits and work culture of people of Himachal Pradesh is well suited for diversified horticultural activities. Out of the 55673 square kilometers of total geographic area in the state, there are 9.44 lakh hectare of operational landholdings, which are operated by 9.97 lakh farmers. As per Agriculture Census 2015-16, small and marginal farmers own 88.85 percent of the total holdings and calls for the major attention to agricultural and horticultural practices incorporated by these farmers in improving their lifestyle. Horticultural adds to the aesthetic appeal of the state, attracting tourists and nature enthusiasts.

The beautiful orchards and gardens, especially during the blooming season, draw a considerable number of visitors. As per the Department of Horticulture, Government of Himachal Pradesh (2020-21), total fruit industry of the state estimates to 624485 MT which includes apple, mango, peach, apricot, persimmon, litchi, lemon, pomegranate etc. According to Economic survey of Himachal Pradesh 2022-23, the most significant fruit crop in the state is apple which, accounts for around 85 percent of the state's total fruit production and cover 48.8 percent of the state's total land under fruit crops. There are mango (51546 MT), Oranges/Kinnow (17030MT), pear (12181MT) and plum (11256MT), which are grown in abundance in the state.

Apple (*Malus Domestica*) is a temperate fruit which grows in the cool climatic conditions having specific characteristics, and requires certain number of chilling hours during their dormant period in winter, temperature, sunlight exposure, rainfall and irrigation, humidity, and altitude and medicinal treatment to prevent any damage to the crop. When all these conditions are met only after that an orchardist get a perfect piece of apple fruit having sweet taste, texture, color and size. If orchardist fails to address any of these requirements at any point of time, he must face the large number of fluctuations in the production of apple. And such fluctuations during last few years have attracted an attention of the govt. However, there is limited comprehensive analysis regarding the variations, trends, and performance of apple production across different districts of himachal Pradesh. Understanding the variations and inconsistencies in apple crop production is of paramount importance. And for this reason, the present study had analyzed trends and growth rates of apple crop in all districts of himachal Pradesh. It also focused on variations found in the total output of each district, their productivity and percentage changes over the years specified in the study. By identifying factors contributing to these variations such as abnormal growth during fruit development, corrective measures can be suggested to mitigate such issues. This knowledge will assist farmers, agriculture professionals, policymakers, researchers, trade and marketing agencies, financial institutions and local communities in improving apple production strategies, implementing sustainable agriculture practices and making informed decisions.

The study contributes towards the time series analysis of data pertaining to all districts of himachal Pradesh which produces apple. It adds value to identifying variations in the total output of apple crop across districts. This study helps in understanding growth rates of all districts. For the purpose of study, we have done comparative analysis of apple producing districts over a specified time period i.e., 2012-2022. We have utilized MS-excel and SPSS etc. to produce results in such a manner so that findings become easy to understand. The present study is divided into four sections which are as follows, 1) Introduction & review of the Literature 2) Need and Objectives of the study with Research Methodology 3) Analysis and Discussion, and 4) Conclusion.

REVIEW OF THE LITERATURE

Wani, F. A., & Songara, M. (2018) employed rigorous methodology, combining field surveys, statistical analysis, and data has been utilized from various government sources. They highlighted the need to address challenges such as pest management, market fluctuation, and infrastructure limitations. **Kumar, M., (2020)** compared apple production in Jammu and Kashmir and Himachal Pradesh, finding that Jammu and Kashmir experienced higher growth rates in production and area, while Himachal Pradesh had higher productivity. They emphasized the positive impact of both cultivation area and yield on apple production. **Kumar, S., & Parashar, D. (2012)** studied changing trends in agricultural factors in Himachal Pradesh, focusing on the dependence of agricultural production on timely rainfall and weather conditions due to

the lack of irrigation facilities. They highlighted the importance of increasing crop productivity and the adoption of high-yielding varieties. **Mohammed A.Y. Abdualrahman, (2015)** assessed the physical characteristics, proximity analysis, sensory evaluation, and suitability of local and imported apple fruits in Sudan for juice production. They found differences in physical characteristics and chemical composition between the two types of apples, influencing their suitability for juice production. **Rauf, A. (2017)** measured the managerial ability of orchardists in Himachal Pradesh and Jammu & Kashmir, finding variations in managerial ability among small orchardists in different states. They emphasized the significance of managerial skills for orchard productivity. **Sikander Kumar and Vishal Chauhan (2021)** examined productivity and resource efficiency among different blocks in Himachal Pradesh. They found variations in productivity among different blocks for different fruit crops, highlighting the importance of resource allocation and planning for optimization. **Randhir, O.T., & Krishnamoorthy, S. (1990)**. Studied the inter-farm variation in farm productivity in Chengalpattu district of Tamil Nādu, emphasizing the positive influence of farm area and supplemental irrigation on productivity. It could be concluded from the study that there should be credit facilities (short term and long term) for the installation of community wells to provide supplemental irrigation to help small and marginal farmers. **Ismail, Y., Mir, S. A., & Nazir, N. (2018)**. Analysed past trends in apple production in Jammu and Kashmir, finding that nonparametric and semi-parametric regression models provided better fits for trend analysis compared to parametric regression models. **Kumar, S., & Chauhan, V. (2021)** focused on almonds, apricots, cherries, and pears, analysing resource efficiencies and productivity in different blocks. They found variations in productivity among blocks for different fruit crops, emphasizing the need for proper resource management and planning.

NEED OF THE STUDY

The study aims to analyse apple production in different districts of Himachal Pradesh to understand the variations and inconsistencies in apple crop production. By conducting time series analysis, the study will identify long term trends in apple production. This information is crucial for predicting future production levels and making informed decisions related to resource allocation and policy formulation. The study will assess the performance of each district in terms of apple output. It will compare district wise production and evaluate growth rates to identify districts that have experienced higher or lower rates of growth. This evaluation can provide insights into successful practices or challenges faced by specific districts.

OBJECTIVES OF THE STUDY

The objectives of the study are following:

1. To assess the trends in apple production in different districts of Himachal Pradesh.
2. To evaluate the growth rates of apple production over a specified period in each district.
3. To study the variations in the production of apple crop across districts in Himachal Pradesh.

HYPOTHESIS OF THE STUDY

- H_0 : There is no significant impact of area on apple production across different districts in Himachal Pradesh
- H_1 : There is a significant impact of area on apple production across different districts in Himachal Pradesh.

- H_0 : There are no significant differences in production of apple crop across districts in Himachal Pradesh.
- H_1 : There are significant differences in production of apple crop across districts in Himachal Pradesh.

RESEARCH METHODOLOGY

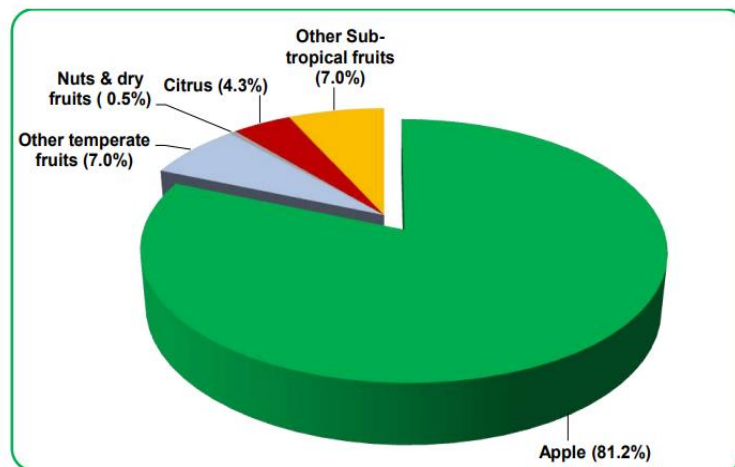
The present study is both descriptive and analytical in nature. It aims to analyse the trends, patterns, and growth rates of apple production across different districts in Himachal Pradesh. The study also highlights the variation of apple crop production across districts and the impact of area on production of apple in himachal Pradesh. It is based upon secondary data that has been obtained from the Department of Horticulture, Government of Himachal Pradesh, and some secondary sources such as official websites, reports, and news articles. The study covers a ten-year period from 2012 to 2022.

ANALYSIS AND DISCUSSION

Production of apple in the state:

According to the economic Survey of Himachal Pradesh for the year 2022-23, horticulture crops play a significant role in the state’s agriculture, with fruits being a major contributor. Among the various fruits categories, apples dominate the horticulture sector with an impressive contribution of 81.2% (2021-22). This highlights the crucial role of apple cultivation in the state’s economy and agricultural landscape.

Fruit Wise Contribution to Horticulture crops (2021-22)



Source: Economics & Statistics Department, Government of Himachal Pradesh

The cultivation of other temperate fruits (7.0%), Sub tropical fruits (7.0%), Citrus fruits (4.3%) and last but not the least, Nuts & dry fruits (0.5%), also makes a noteworthy contribution in the horticulture sector.

Year wise Area, Production, and percentage yield of apple crop in Himachal Pradesh:

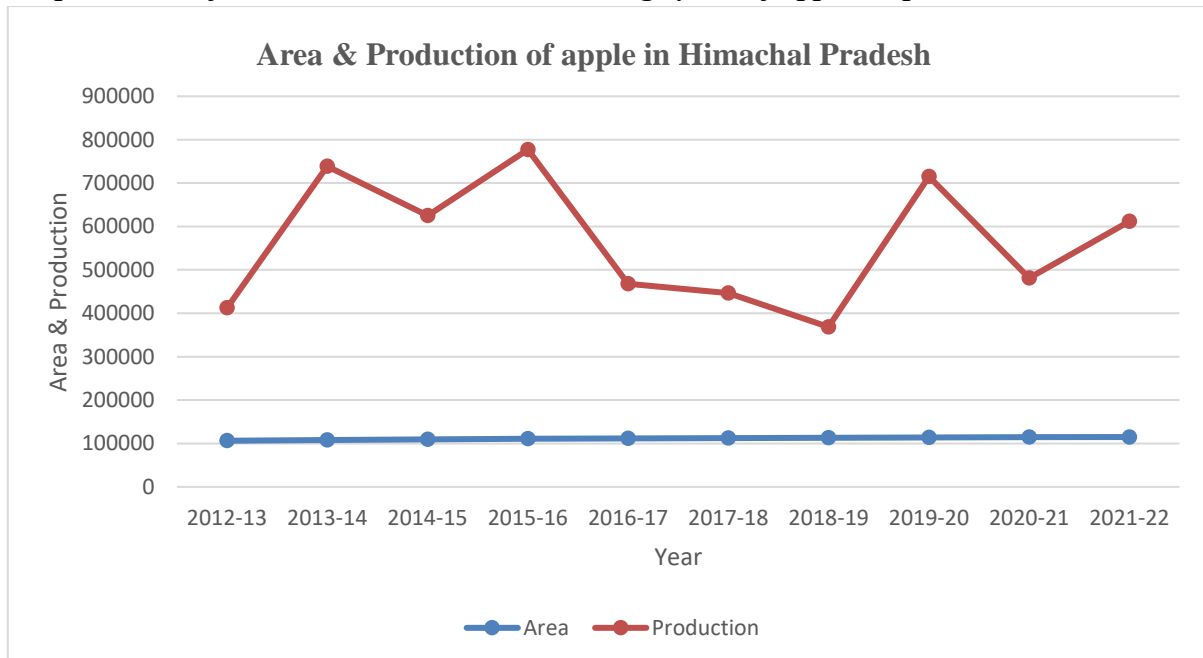
Table: Year wise Area, Production and Percentage yield of apple crop in Himachal Pradesh

Percentage yield of apple crop in HP			
Year	Area	Production	Percentage Yield
2012-13	106362	412368	388.04%
2013-14	107611	738704	686.32%
2014-15	109478	625175	571%
2015-16	110597	777108	702.77%
2016-17	111772	468115	418.83%
2017-18	112507	446552	397.03%
2018-19	113013	368580	326.13%
2019-20	113987	715220	627.66%
2020-21	114470	481026	420.59%
2021-22	114807	611859	533.01%

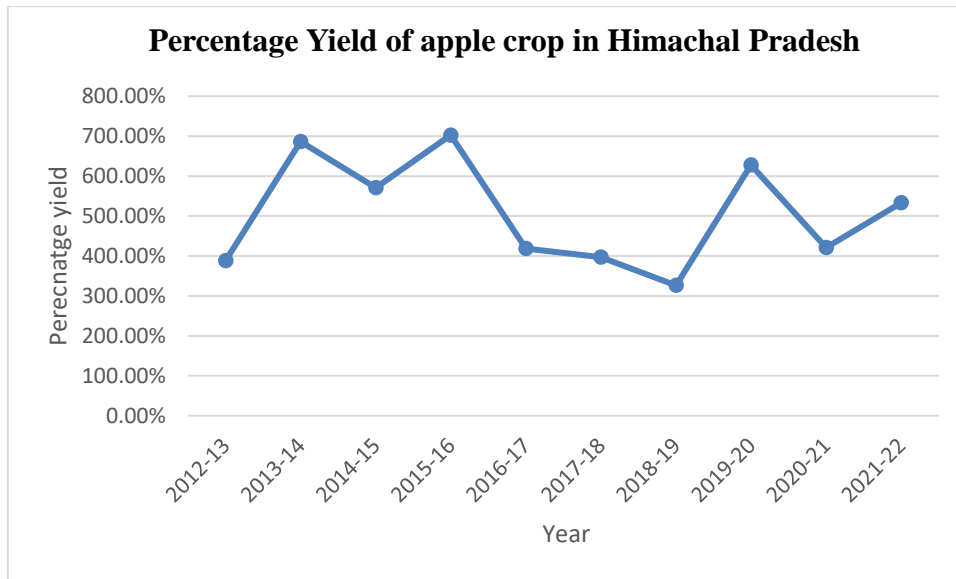
Source: Department of Horticulture, Government of Himachal Pradesh

The data exhibits the fluctuations and trends in apple production over the past decade (2012-13 to 2021-22). There is a clear upward trend in both the area under apple cultivation and the total production. This suggests that apple farming has been expanding in Himachal Pradesh, likely due to factors such as increasing demand, favourable climatic conditions, and government support for horticulture. The percentage yield, which represents the ratio of production to the area under cultivation, demonstrates significant variability over the years. The year 2013-14 stands out with an extraordinarily high percentage yield of 686.32%, which could be an anomaly or potentially attributed to favourable weather conditions or improved agricultural practices during that period. On the other hand, there are years with lower percentage yields, such as 2016-17 and 2017-18, indicating that the apple crop might have faced challenges or experienced suboptimal growth during those years.

Graph: Trend of Area, Production and Percentage yield of apple crop in Himachal Pradesh



Source: Department of Horticulture, Government of Himachal Pradesh



Source: Department of Horticulture, Government of Himachal Pradesh

Table: Percentage change of Area & Production over a decade considering 2012-13 as base year to see overall changes in each district

Percentage change of Area & Production over a decade		
Name of Districts	Year	
	2012-22	
	Area	Production
Shimla	8.43%	35.33%
Kullu	5.27%	19.4
Kinnaur	8.65	17.51%
Mandi	3.63	358.93%
Chamba	-1.56	545.86%
Sirmour	-10.26%	625.47%
Kangra	12.95%	15.19%
Lahaul Spiti	15.42%	116.12%

Source: Department of Horticulture, Government of Himachal Pradesh

The above table shows the percentage change in the area and production of various districts in Himachal Pradesh over a decade, from 2012-13 to 2021-22. Among the districts, Shimla witnessed an 8.43% increase in area and a significant 35.33% increase in production. Kullu also experienced growth, with a 5.27% increase in area and a 19.4% rise in production. Kinnaur exhibited a notable 8.65% increase in area and a 17.51% growth in production. Mandi, on the other hand, showed moderate growth in area at 3.63%, but an impressive 358.93% surge in production, indicating a substantial boost in agricultural output. Chamba, however, saw a slight decline in area by -1.56%, but its production experienced a substantial 545.86% increase, suggesting possible improvements in agricultural practices or technological advancements. In contrast, Sirmour faced challenges with a decline of -10.26% in area, while its production increased by 625.47%. This contrasting trend warrants further investigation to understand the factors affecting agricultural productivity in the district. Kangra district demonstrated positive growth in both area and production, with 12.95% and 15.19% increases, respectively, suggesting favorable conditions for agriculture in the region. Lahaul and Spiti district showed remarkable progress with a 15.42% rise in area

and a substantial 116.12% increase in production, indicating significant development and potential in the agricultural sector.

In summary, the table illustrates the diverse growth patterns in the area and production of different districts in Himachal Pradesh over the past decade. While some districts experienced consistent growth in both aspects, others faced challenges with varying degrees of change. Understanding the underlying reasons behind these fluctuations can guide policymakers and stakeholders in formulating strategies to support sustainable agricultural development in the region.

District wise Area & Apple Production in different districts in Himachal Pradesh

To conduct a growth rate analysis on a yearly basis for the apple crop production in different districts of Himachal Pradesh, you can calculate the percentage growth rate for each year compared to the previous year. The formula to calculate the percentage growth rate is as follows: $\text{Growth Rate} = ((\text{New Value} - \text{Old Value}) / \text{Old Value}) * 100$, Where: New Value is the crop production in the current year. Old Value is the crop production in the previous year.

Step 1: Table representing District wise apple production in different districts of Himachal Pradesh since 2012 onwards (in MT)

District wise production of apple crop in Himachal Pradesh since 2012 onwards (in MT)									
Year	Shimla	Kullu	Kinnaur	Mandi	Chambala	Sirmour	Kangra	L/Spiti	Total
2012-13	259779	87906	52020	9015	2739	481	259	169	412368
2013-14	499422	152654	54044	24229	7189	644	322	200	738704
2014-15	407751	104589	59196	24709	26054	2290	309	277	625175
2015-16	482388	143475	75202	48608	24018	2821	324	272	777108
2016-17	265987	89570	60210	38344	11734	1688	277	305	468115
2017-18	251897	78948	52189	42078	18959	1896	285	300	446552
2018-19	169962	76019	61673	43968	12688	3670	298	302	368580
2019-20	437024	131194	56864	57158	28083	4291	304	302	715220
2020-21	247179	92260	73330	49143	14451	4017	336	310	481026
2021-22	369720	115049	48678	49792	18240	9377	252	751	611859
Grand Total									5644707

Source: Department of Horticulture, Government of Himachal Pradesh

Step 2: Calculation of the growth rate for each year compared to the previous year for each district.

Growth rate for district wise apple production (in MT)									
Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	L/Spiti	Total
2012-13	-	-	-	-	-	-	-	-	-
2013-14	92.00%	73.40%	3.89%	168.35%	162.61%	33.68%	24.71%	18.34%	79.01%
2014-15	-18.25%	31.45%	9.41%	1.87%	263.18%	255.59%	-	51.49%	15.29%
2015-16	18.44%	37.20%	27.18%	96.82%	-7.74%	23.32%	5.18%	-0.36%	24.24%
2016-17	-44.94%	37.53%	-19.88%	-20.89%	-51.10%	-40.29%	14.41%	12.87%	39.74%
2017-18	-5.27%	11.57%	-13.27%	9.79%	61.92%	12.31%	2.88%	-1.64%	-4.67%
2018-19	-32.55%	-3.68%	18.15%	4.46%	-33.11%	93.50%	4.56%	0.67%	17.44%
2019-20	157.06%	72.34%	-7.93%	29.82%	121.22%	16.83%	2.02%	0.00%	94.16%
2020-21	-43.38%	29.63%	29.06%	-14.01%	-48.61%	-6.47%	10.53%	2.63%	32.70%
2021-22	49.70%	24.76%	-33.74%	1.38%	26.20%	132.65%	-	143.05%	27.01%

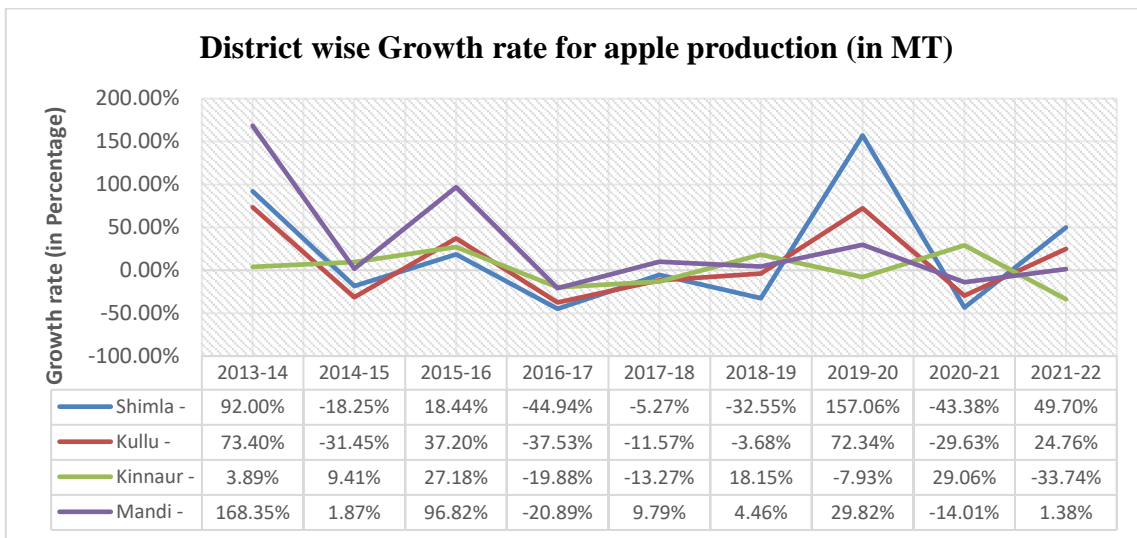
Source: Department of Horticulture, Government of Himachal Pradesh

The analysis of the growth table for apple crop production in different districts of Himachal Pradesh since 2012 provides valuable insights into the trends and fluctuations over the years. Several districts experienced substantial fluctuations in apple production, with growth rates varying from positive to negative.

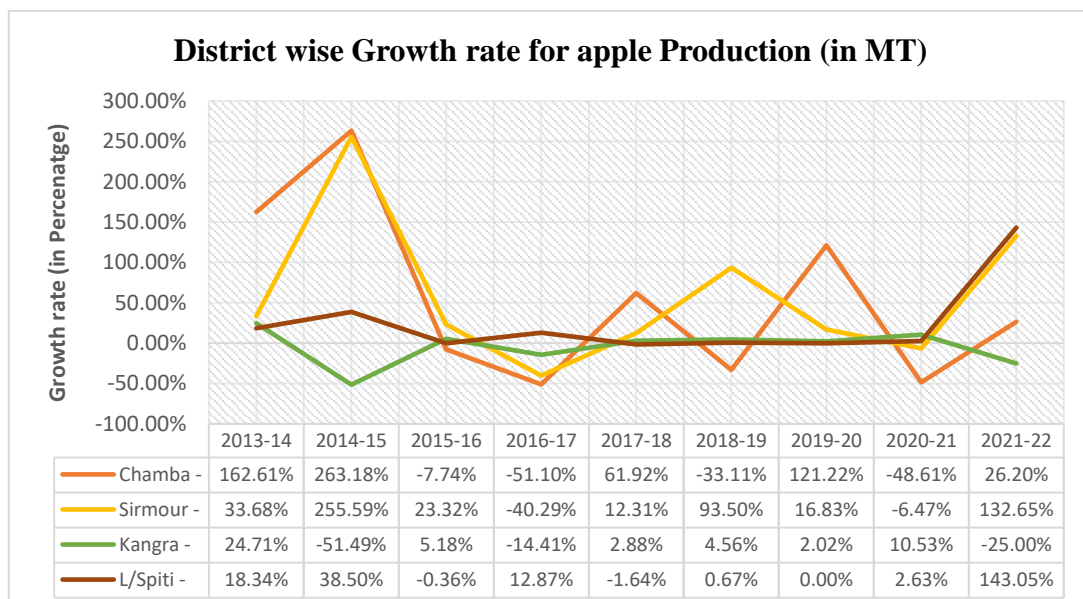
Shimla district started with a powerful leap, witnessing a staggering 92% surge in apple production in 2013-14. But then, like a seasoned mountaineer, it faced its challenges, experiencing a notable decline of 44.94% in 2016-17. Kullu district demonstrated a similar pattern with massive 73.40% growth in 2013-14 followed by decline of 37.53% in 2016-17. Kinnour district displayed fluctuations but remained relatively stable, with a maximum growth rate of 29.06% in 2020-21 and a minimum of -33.74% in 2021-

22. Mandi district experienced an exceptional 168.35% surge in apple production in 2013-14, but thereafter, it witnessed a moderate positive growth rate. Chamba district encountered significant variations in apple production, with an astonishing 263.18% growth in 2014-15 but a decline of 51.10% in 2016-17. Sirmour district also demonstrated fluctuations, with a peak growth rate of 132.65% in 2021-22 and a low of -40.29% in 2016-17. Kangra district, known for its apple cultivation, displayed a high growth rate of 93.50% in 2018-19 but had relatively moderate growth in other years. Lahaul and Spiti (L/Spiti) district showed consistent growth in apple production, ranging from 0.67% to 143.05%, with a notable surge in 2021-22. Overall, the total apple crop production in Himachal Pradesh experienced substantial fluctuations, with a significant 79.01% growth in 2013-14, followed by a decline of 39.74% in 2016-17. The highest growth rate recorded was 94.16% in 2019-20, and the lowest was -32.70% in 2020-21.

Graph: District wise Growth rate for apple production for each year compared to the previous year for each district.



Source: Department of Horticulture, Government of Himachal Pradesh



Source: Department of Horticulture, Government of Himachal Pradesh

To conduct a growth rate analysis on the yearly basis for the district wise area of apple production in Himachal Pradesh, we have calculated the percentage growth rate for each year compared to the previous year. The formula to calculate the percentage growth rate is as follows: $\text{Growth rate} = ((\text{New Value} - \text{Old Value}) / \text{Old Value}) * 100$. Where, New Value is the crop area in the current year. Old Value is the crop area in the previous year.

Step 1: Table representing District wise area of apple crop in Himachal Pradesh since 2012 onwards (in Ha)

District wise area of apple crop (in Ha)									
Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	L/Spiti	Total
2012-13	37249	25372	10116	16018	12766	2948	420	1473	106362
2013-14	37542	25624	10487	16077	12997	2912	393	1579	107611
2014-15	38781	25813	10953	16311	12818	2753	396	1653	109478
2015-16	39728	26029	11164	16434	12554	2592	423	1673	110597
2016-17	40160	26633	11219	16568	12510	2566	434	1682	111772
2017-18	40566	26794	11179	16638	12594	2579	455	1702	112507
2018-19	40961	27053	10973	16748	12539	2500	493	1746	113013
2019-20	41765	27209	10891	16849	12407	2574	530	1762	113987
2020-21	42085	27258	10911	16930	12405	2580	525	1776	114470
2021-22	42292	27256	10926	16933	12436	2601	570	1793	114807
Grand total									1114604

Source: Department of Horticulture, Government of Himachal Pradesh

Step 2: Calculation of the growth rate for each year compared to the previous year for each district.

Growth rate for district wise area of apple crop (in Ha)									
Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	L/Spiti	Total
2012-13	-	-	-	-	-	-	-	-	-

2013-14	0.79%	0.97%	3.74%	0.38%	1.83%	-1.34%	-6.43%	7.14%	1.18%
2014-15	3.29%	0.74%	4.40%	1.95%	-1.43%	-5.55%	0.76%	4.52%	1.74%
2015-16	2.42%	0.81%	1.91%	0.76%	-2.03%	-5.95%	6.82%	1.21%	1.02%
2016-17	1.08%	2.33%	0.49%	0.79%	-0.35%	-1.01%	2.60%	0.54%	1.05%
2017-18	1.01%	0.60%	-0.36%	0.44%	0.71%	0.51%	5.06%	1.18%	0.66%
2018-19	0.96%	0.95%	-1.85%	0.66%	-0.43%	-3.20%	8.35%	2.70%	0.45%
2019-20	1.98%	0.58%	-0.62%	0.65%	-0.97%	2.96%	7.56%	0.92%	0.86%
2020-21	0.76%	0.18%	0.22%	0.48%	-0.02%	0.16%	-0.94%	0.79%	0.33%
2021-22	0.49%	0.01%	0.14%	0.02%	0.24%	0.08%	8.57%	0.95%	0.29%

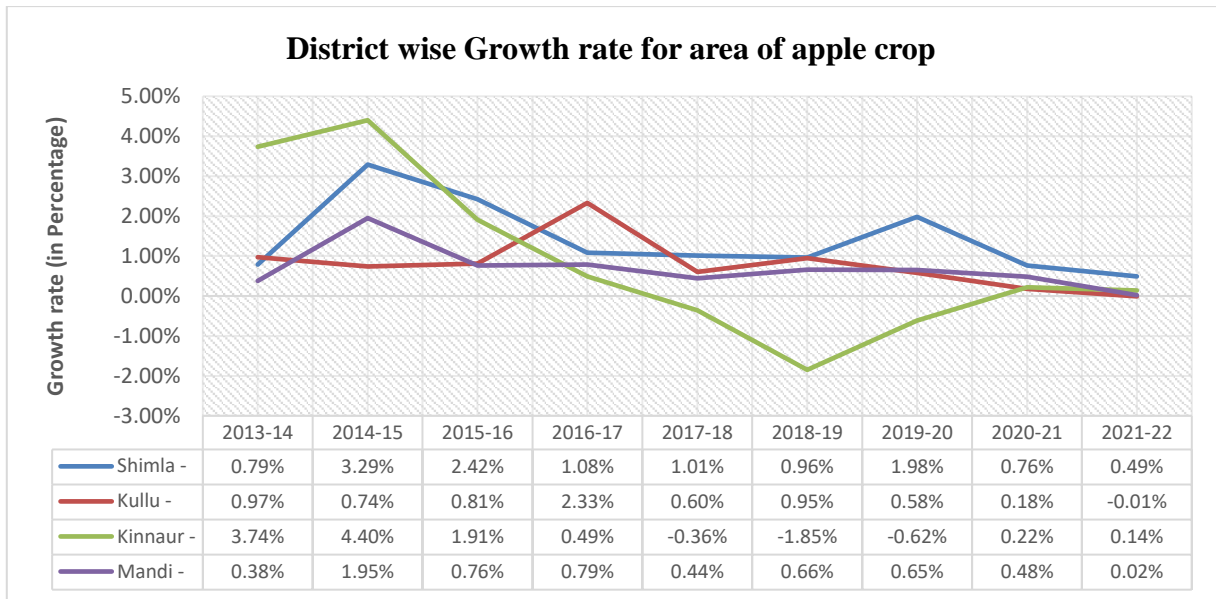
Source: Department of Horticulture, Government of Himachal Pradesh

The table presents the yearly apple crop area in different districts of Himachal Pradesh from 2012-13 to 2021-22, along with the calculated growth rates for each year compared to the previous year. Over this period, the apple crop area in most districts experienced a consistent positive growth rate, indicating overall expansion in apple cultivation across the state.

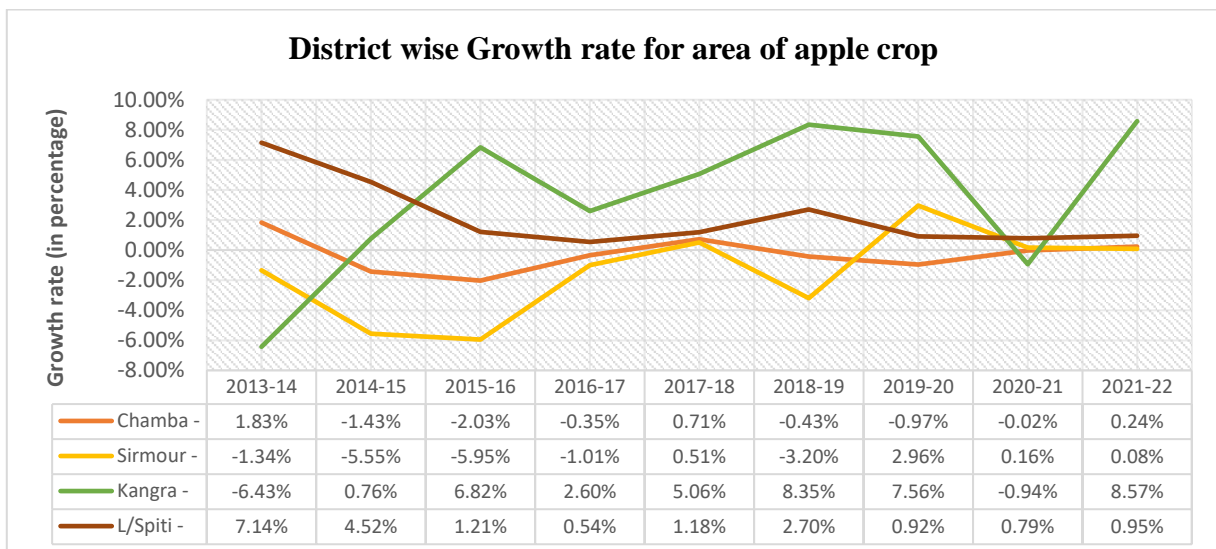
Shimla district, known for its apple orchards, showed a steady increase in crop area, with growth rates ranging from 0.76% to 3.29% annually. Kullu district also demonstrated a positive trend, with growth rates ranging from 0.18% to 2.33%. Kinnaur, Mandi, and Chamba districts experienced moderate but steady growth in apple crop area, with fluctuations in growth rates between -1.85% to 4.40%. Sirmour district shown relatively stable growth, ranging from -6.43% to 2.96%, while Kangra district, one of the major apple-producing regions, showcased a consistent upward trend, with growth rates fluctuating between -1.01% to 8.57%. Similarly, Lahaul and Spiti district consistently showed positive growth, ranging from 0.54% to 8.35%. The total apple crop area in Himachal Pradesh witnessed an overall positive growth rate, ranging from 0.29% to 1.74%, reflecting the general trend of increasing apple cultivation in the state. The highest growth rate was observed in 2018-19, while the lowest was seen in 2020-21.

The analysis emphasizes the resilience and expansion of apple cultivation in Himachal Pradesh, driven by favorable climatic conditions and the state's reputation as a prominent apple-producing region. However, it also highlights the need to closely monitor and address fluctuations in specific districts to ensure sustainable growth in the apple farming sector. This analysis serves as a valuable reference to understand historical trends and informs future agriculture strategies in Himachal Pradesh.

Graph: District wise Growth rate for area of apple crop for each year compared to the previous year for each district.



Source: Department of Horticulture, Government of Himachal Pradesh



Source: Department of Horticulture, Government of Himachal Pradesh

To investigate the variations of production of apple across different districts in Himachal Pradesh and impact of area of apple crop on apple production, two statistical methods such as One way ANOVA and linear regression analysis were used in the study. Before the analysis of the data two problems were stated and hypothesis were tested accordingly.

Problem 1: To investigate if the production of apple crop differs across districts in Himachal Pradesh.

H₀: There are no significant differences in production of apple crop across districts in Himachal Pradesh.

H₁: There are significant differences in production of apple crop across districts in Himachal Pradesh.

The hypothesis tests if the production of apple crop differs across different districts in Himachal Pradesh. Districts considered under study were Shimla, Kullu, Kinnaur, Mandi, Chamba, Sirmour, Kangra, Lahaul Spiti. The ANOVA results suggest that the Production of apple crop across different districts differs

significantly ($F = 73.978, p < .001$). this means that we have enough evidence to reject the null hypothesis and accept alternate hypothesis. In simpler terms, the apple crop production varies significantly across the districts under consideration.

Table: One way ANOVA results.

Test of Homogeneity of Variance					ANOVA	
Districts	Mean	Std. Deviations	Levene's Statistics	Sig.	F - value	Sig.
Shimla	339110.90	114393.607	40.811	<.001	73.978	<.001
Kullu	107166.40	27290.161				
Kinnaur	59340.60	8857.635				
Mandi	38704.40	14894.448				
Chamba	16415.50	8222.411				
Sirmour	3117.50	2561.474				
Kangra	296.60	28.048				
Lahaul Spiti	318.80	159.330				

To further explore which specific districts have significantly different apple crop production levels, post hoc (Multiple comparisons) comparisons were conducted using the Dunnett T3 test. Since the Levene's statistic is significant, the equal variance was not assumed. The test indicated that the mean production between each pair of districts varies significantly. Shimla has significantly higher apple crop production compared to Kullu, Kinnaur, Mandi, Chamba, Sirmour, Kangra, and Lahaul Spiti. Each district has significant difference in apple crop production in comparison to other district considered under study except Sirmour, Kangra and Lahaul Spiti. These three districts do not have significant difference in apple crop production among them over a decade. But the overall mean difference was significant at the 0.05 level.

This analysis substantiate that the production of apple crop varies significantly across different districts in Himachal Pradesh, and there is distinct difference in apple production levels between specific districts.

Problem 2: To investigate if Area of Apple crop has a significant impact on production of apple crop.

H_0 : There is no significant impact of the area of apple crop on apple production in Himachal Pradesh

H_1 : There is a significant impact of the area of apple crop on apple production in Himachal Pradesh.

The hypothesis tests if area of apple crop carries as significant impact on apple production. The dependent variable apple production was regressed on predicting variable Area, to test the hypothesis H_0 .

Table: Analysis of Regression results.

Hypothesis	Regression Weights	Beta Coefficient	R ²	F	p-value	Hypothesis Supported
H1	Area → Apple production	.852	.726	206.83	<.001 ^b	Yes

The results of the regression analysis are as follows:

Beta Coefficient (Regression Weight): The beta coefficient for the predictor variable "Area" is 0.852. This coefficient represents the strength and direction of the relationship between the area of apple crop and apple production. **R-squared (R²):** The R-squared value is 0.726. R-squared indicates the proportion of variance in the dependent variable (apple production) that is explained by the predictor variable (area of apple crop). In this case, approximately 72.6% of the variation in apple production can be explained by the variation in the area of apple crop. **F-value:** The F-value is 206.83. This is the result of an F-test, which assesses whether the overall regression model is statistically significant. **p-value:** The p-value associated with the F-test is less than 0.001 (denoted as <.001b), which means the result is highly statistically significant. **Hypothesis Supported:** The p-value is less than the chosen significance level (usually 0.05), indicating strong evidence **to reject the null hypothesis (H₀)**. Therefore, we can conclude that there is a significant impact of the area of apple crop on apple production in Himachal Pradesh.

CONCLUSION

The study confirms the critical role of apple cultivation in the state's economy and horticulture sector. Apples dominate the horticulture crops, contributing a significant 81.2% to the total crop output. This highlights the importance of apple production in sustaining agricultural activities and livelihoods in Himachal Pradesh. The analysis of district wise apple production over a decade reveals significant variations in both area and production levels. Districts like Shimla Kullu and Kinnaur experienced substantial growth in both area and production while others like Mandi and Chamba shown impressive increase in production despite moderate growth in area. Some districts such as Lahul Spiti showcased consistent positive growth in both area and production indicating the stability of apple cultivation in those regions. In contrast Sirmaur faces challenges with a decline in area but its production increased significantly. The regression analysis confirms a strong positive relationship between area of apple crop and apple production. Approximately 72.6% of the variation in apple production can be explained by the variation in the area of apple crops.

The findings of the study provide valuable insights for policy makers and stakeholders to formulate strategies to support sustainable agricultural development. Understanding the factors influencing apple production and fostering growth in specific districts (Sirmaur, Kangra, Lahul Spiti) can lead to more effective interventions and policies. Apple production in Himachal Pradesh demonstrates both opportunities and challenges while the state agricultural landscape heavily relies on apple cultivation there are distinct variation in apple production levels across different districts expanding apple cultivation areas and addressing specific level issues will be crucial in enhancing overall apple production and supporting the state's agricultural economy.

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