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Growth, instability and decomposition analysis of apple production in Himachal Pradesh

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Abstract
The study was conducted with the aim to know the growth performance of apple production in different districts of Himachal Pradesh. The objectives of the study are to study the growth trends and instability in the area, production and productivity of apple fruit in Himachal Pradesh and to examine the relative share of area and productivity of apple production in Himachal Pradesh. To fulfill the objectives of the study secondary data of 10 years was utilized for analysis using the statistical tools like Compound Annual Growth Rates (CAGR), Coefficient of Variation (CV), Cuddy Della Valle's Instability Index (CDVI) and Decomposition Analysis model. The study revealed that the growth rates of area, production and productivity of apple crops among the districts of Himachal Pradesh had a fluctuating trend during the study periods. The compound growth rate for area, production and productivity during the years 2012-13 to 2021-22 has been estimated at 0.85, (-) 0.64 and (-) 1.48 percent per annum, respectively. The coefficient of variation in the area, production and productivity far apple crop during the study period has been estimated at 2.60, 26.14 and 26.63 percent, respectively. The value of CDVI (0.61%) came in the range of 0-15 percent which confirm low level of instability in the area under apple crop in Himachal Pradesh. The value of CDVI (27.65 and 27.85%) came in the range of 15-30 percent which confirms medium level of instability in the production and productivity under apple crop in Himachal Pradesh. There was low level of instability in the growth rates of area among all the districts of Himachal Pradesh. Area effect played the key role in the differentiation of apple production in Himachal Pradesh.

Keywords: Apple, cuddy della valle index, growth, instability index, decomposition

Introduction

Horticulture sector in India has emerged as an important sector for diversification of agriculture. India is the second largest producer of fruits in the world. Country has made good progress in fruit production with a total production of 110207 thousand MT from an area of 7025 thousand ha in 2022-23. Horticulture sector has a significant impact on the growth of the country's economy and it is expected that in future also it can make significant contribution toward accelerating the agricultural growth and contribution in GDP.

The agro-climatic conditions in Himachal Pradesh are extremely suitable for growing different varieties of pome and stone fruit. The pome fruits (apple and pear, etc.) and stone fruits (apricot peach, plum and cherry etc.) are the most widely grown and eaten, owing to their adaptability. Apples grown in Himachal Pradesh are giving a run for their money to imported varieties, particularly those from the China, Italy and the US, in the Indian market although the crop has fallen prey to vagaries of the weather. The variation in productivity of different fruits in the recent years has become a serious concern of the fruit growers. Apple is the most important fruit crop of Himachal Pradesh, which constitutes about 48.78 percent of the total area under fruit crops and about 81.2 percent of the total fruit production during 2021-22 and area under apple fruits has seen a growth of 21.4 percent. The area under other temperate fruits, nuts & dry fruits, citrus and other sub-tropical fruits have seen a growth of 6.0, (-) 12.5, 22.1 and 21.5 percent and about 7.0, 0.5, 4.3 and 7.0 percent of the total fruit production during 2021-22, respectively.

The orchards in Himachal Pradesh are located generally on steep lands, the high and ultra high density plantations being followed in other countries involving very high capital investment may not be suitable here. As such very high density root stocks requiring fertile soil, flat lands, assured irrigation and provision of support in the form of stakes will not be suitable except in valley areas. In steep areas, the rootstock should be able to provide support to the main area. In case of apples, semi-intensive plantation densities involving plantation of 600 to 1,000 trees per hectare with free standing trees may be suitable. Besides using semi-high density rootstocks, the naturally high density mutants and suitable pruning practices shall be helpful in developing such plantations. In case of apple, 99 percent plants are presently being raised on seedling rootstocks. Hence, there is no uniformity in plants and they usually take about ten years to come into commercial bearing. Some of the promising clonally rootstocks like M9, M26, MM106, MM111 etc. are being cultivated in the State. So far, the best indigenous rootstock available in North-Western Himalayan region is the crab apple (Malus baccata).

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.

Need of the study

The study aims to analyse the area, production and Productivity of apple in different districts of Himachal Pradesh to understand the growth trends and instability and variations in apple crop production. By using time series data analysis, the study will identify long term trends in apple production. The study of growth trends and instability

in area, Production and productivity of apple is crucial for economic planning, resources allocation, risk management and policy formulation. Understanding these trends also encourages technological adoption, adapts to climate change, and promotes sustainability. The study will assess the performance of each district in terms of apple production. It will compare district wise production and evaluate the growth rates to identify districts that have experienced higher or lower rates of growth. This evaluation can provide information about successful practices or challenges faced by specific districts.

Objectives of the study

- To study the growth trends and instability in the area, production and productivity of apple fruit in Himachal Pradesh.
- To examine the relative share of area and productivity of apple production in Himachal Pradesh.

Data resources and methodology

The present paper is based on secondary data, which is collected for the year 2012-13 to 2021-22 from Directorate of Economics and Statistics and Directorate of Horticulture, Government of Himachal Pradesh on area, production and productivity of fruits crop. It aims to analyse the growth trends, instability and decomposition analyses of apple production across districts in Himachal Pradesh. Eight out of 12 major apple growing districts of Himachal Pradesh were selected for the study *viz*. Shimla, Kullu, Kinnaur, Mandi, Chamba, Sirmour, Kangra and Lahual & Spiti. In order to achieve the objectives of the study, following statistical measures such as compound growth rates, standard deviation, coefficient of variation, instability index and decomposition analysis is applied;

Compound growth rate

Exponential Growth Function has been used to compute the compound growth rate of area, production and productivity;

$Y = AB^t$

Where Y = dependent variable, t = time

By taking logarithms of both sides of the equations it takes the form: Log Y = Log A + t Log B.

If we put Log A = a and Log B = b, then equation becomes

Log Y = a + bt, which is linear function with independent variable t and dependent variable Log Y. The compound growth rate calculate as (antilog b – 1) × 100 and represent uniform rate of change from year to year.

Instability analysis

Instability in area, production, productivity of apple fruit has been estimated by using Coefficient of Variation and Cuddy-Della Valle Index. Although Coefficient of Variation (C.V) is the simplest measure of instability, it over-estimates the level of instability in time series data which are characterized by long-term trends. CV is calculated as follows:

$$CV = \frac{\textbf{Sandard Deviation}}{\textbf{Mean}} \textbf{X100}$$

Cuddy-Della Valle Index (%) with an objective to know that, up to what extent risk is occurred in the selected variables. The Cuddy Della Valle Index de-trends shows the exact direction of the instability. Therefore, it is a better measure to capture instability in horticulture production. The Cuddy-Della Valle Index is calculated as follows:

$$\textbf{Cuddy-Della Valle Index} = \frac{\textbf{Sandard Deviation}}{\textbf{Mean}} \text{ X } \textbf{100} \text{ X } \sqrt{\textbf{1} - \textbf{R}^{\textbf{2}}}$$

Where, C.V. was the Coefficient of Variation in per cent, and R^2 was the coefficient of determination from a time trend regression adjusted for its degrees of freedom.

A low value of this index indicates low instability in the selected variables. The ranges of CDVI are given as follows;

- Low instability = 0 to 15 (%)
- Medium instability = 15 to 30 (%)
- High instability = 30 and above (%)

Decomposition analysis

To measure the relative contribution of area and yield and the interaction of both (area and yield) in the production change, the following decomposition analysis model is used which is given below.

Production = Yield effect + area effect + interaction effect

$$\text{Area Effect} = \frac{\text{Ao}\,\Delta\text{Y}}{\Delta\text{P}} \text{x} 100$$

$$\text{Yield Effect} = \frac{\text{Yo}\,\Delta\text{A}}{\Delta\text{P}} \text{x} 100$$

$$\text{Interaction Effect} = \frac{\Delta\text{A}\Delta\text{Y}}{\Delta\text{P}} \text{x} 100$$

Where,

Ao = Area in base year

An = Area in current year

Yo = Yield in base Year

Yn = Yield in Current year

ΔA = Change in area (An-Ao)

ΔY = Change in yield (Yn-Yo)

ΔP = Change in Production

Pn = Production in current Year

Po = Production in base year

Thus, the total change in production can be decomposed into yield effect, area effect and the interaction effect due to change in yield and area.

Results and discussion

Growth trends and instability in the area of apple crop in Himachal Pradesh

The growth trends and instability in area of apple crop is presented in Table 1. The table shows that in Shimla district of Himachal Pradesh during the year 2012-13 the area under apple fruit was 37.25 thousand hectares which increased to 42.29 thousand hectares in 2021-22 by registering a compound growth rate of 1.47 percent per annum. The average area, coefficient of variance and CDVI has been worked out 40.11 thousand hectares, 4.48 percent and 0.94 percent respectively. The value of CDVI came in the range 0-15 percent which indicates that less instability and variability occurred in the area of apple.

Table 1: Growth trends and instability in the area of apple crop in Himachal Pradesh Area (000 Hectare)

Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	Lahual & Spiti	Total
2012-13	37.25	25.37	10.12	16.02	12.77	2.95	0.42	1.47	106.36
2013-14	37.54	25.62	10.49	16.08	13.00	2.91	0.39	1.58	107.61
2014-15	38.78	25.81	10.95	16.31	12.82	2.75	0.40	1.65	109.48
2015-16	39.73	26.03	11.16	16.43	12.55	2.59	0.42	1.67	110.60
2016-17	40.16	26.63	11.22	16.57	12.51	2.57	0.43	1.68	111.77
2017-18	40.57	26.79	11.18	16.64	12.59	2.58	0.46	1.70	112.51
2018-19	40.96	27.05	10.97	16.75	12.54	2.50	0.49	1.75	113.01
2019-20	41.77	27.21	10.89	16.85	12.41	2.57	0.53	1.76	113.99
2020-21	42.09	27.26	10.91	16.93	12.41	2.58	0.53	1.78	114.47
2021-22	42.29	27.26	10.93	16.93	12.44	2.60	0.57	1.79	114.81
Mean	40.11	26.50	10.88	16.55	12.60	2.66	0.46	1.68	111.46
SD	1.80	0.73	0.34	0.33	0.20	0.16	0.06	0.10	2.90
CV	4.48	2.75	3.12	2.02	1.56	5.85	13.33	5.85	2.60
CDVI	0.94	0.71	2.85	0.40	0.86	3.90	4.65	2.29	0.61
CAGR	1.47	0.89	0.54	0.66	-0.44	-1.45	4.17	1.87	0.85

Sources: Directorate of Economics and Statistics and Directorate of Horticulture, Government of Himachal Pradesh

The area under apple crop in Kullu district during the year 2012-13 was 25.37 thousand hectares and it increased to 27.26 thousand Hectare in 2021-22 with a compound growth rate of 0.89 percent per annum. The coefficient of variance for these crops has been estimated at 2.75 percent. The value of CDVI came in the range 0-15 percent which indicate low level of instability and inconsistency in the area under the apple crops. The area under apple crop in Kinnaur and Mandi districts was 10.12 and 16.02 thousand hectares in 2012-13 which increased to 10.93 and 16.93 thousand hectares in 2021-22 by registering with compound growth rate of 0.54 and 0.66 percent per annum, respectively. The average area, coefficient of variance and CDVI has been worked out 10.88 thousand hectares, 3.12 percent and 2.85 percent respectively, for the Kinnaur district and for the Mandi district the average area, coefficient of variance and CDVI has been worked out 16.55 thousand hectares, 2.02 percent and 0.40 percent respectively. The value of CDVI came in the range 0-15 percent which indicates that less instability in the area of apple crop in both the districts. The area under apple crop in Chamba and Sirmour districts during the year 2012-13 was 12.77 and 2.95 thousand hectares and it decreased to 12.44 and 2.60 thousand Hectare in 2021-22, respectively. The compound annual growth rate has been estimated at (-) 0.44 and (-) 1.45 percent per annum in Chamba and Sirmour districts respectively. The value of CDVI came in the range 0-15 percent which indicate low level of instability in the area under the apple crops. During the year 2012-13, in case of Kangra district, the area was 0.42 thousand hectare and the same increase to 0.57 thousand hectares in 2021-22 with a compound growth rate of 4.17 percent per annum. The co-efficient of variation during the study period has been estimated at 13.33 percent. The value of CDVI (4.65%) confirms low level of instability in area under apple crop in Kangra district.

The area under apple crop in Lahual & Spiti district during the year 2012-13 was 1.47 thousand hectares and it increased to 1.79 thousand Hectare in 2021-22 with a positive compound growth rate of 1.87 percent per annum. The coefficient of variance for apple crops has been estimated at 5.85 percent. The value of CDVI (2.29%) came in the range 0-15 percent which indicate low level of instability and inconsistency in the area under the apple crops. Overall, total area under apple crop in Himachal Pradesh, during the year 2012-13 was 106.36 thousand hectares and it increased to 114.81 thousand Hectare in 2021-22. The compound annual growth rate during the years 2012-13 to 2021-22 has been estimated at 0.85 percent per annum. The coefficient of variation during the study period has been estimated at 2.60 percent. The value of CDVI (0.85%) came in the range of 0-15 percent which confirm low level of instability in the area under apple crop.

Growth trends and instability in the production of apple crop in Himachal Pradesh

Growth trends and instability in production of apple crop in Himachal Pradesh are presented in Table 2. The table shows that the production of apple fruit in Shimla district during the year 2012-13 was 259.78 thousand ton and in 2021-22 it increased to 369.72 thousand tonnes with a negative compound growth rate of (-) 2.74 percent per annum. The average production of this fruit during the study period was 339.11 thousand tonnes. The co-efficient of variation in the production of this crop is 33.73 percent. The value of CDVI (34.77%) came above the range of 30 percent which indicates high level of instability and fluctuation in the production of apple crop during the study years *viz*.; 2012-13 to 2021-22.

The production of apple crop in district Kullu during the year 2012-13 was 87.91 thousand tonnes which increased to 115.05 thousand tonnes in 2021-22 with a negative compound growth rate of (-) 1.21 percent per annum. The coefficient of variation in the production of apple is estimated at 25.47 percent. The value of CDVI (26.71%) is in the range of 15-30 percent which confirms medium level of instability in the production of apple crop in district Kullu. In Kinnaur district the production of apple crop during the year 2012-13 was 52.02 thousand tonnes which decreased to 48.68 thousand tonnes in 2021-22 with a positive compound growth rate of 0.36 percent per annum. The coefficient of variation is estimated at 14.93 percent. The value of CDVI (15.79%) indicates medium level of instability in production of apple crop as the value of this index is in the range of 15-30 percent. The production of apple crop in Mandi district during the year 2012-13 was 9.02 thousand tonnes which increased to 49.79 thousand tonnes in 2021-22 with a highest compound growth rate of 15.88 percent per annum. The mean, standard deviation and coefficient of variation has been worked out to be 38.70 thousand tonnes, 14.89 percent and 38.48 percent, respectively. The values of CDVI (24.32%) fall into the range of 15-30 percent which confirms medium level of instability and inconsistency in the production of apple crop in Mandi district.

Table 2: Growth trends and instability in the production of apple crop in Himachal Pradesh Production (000 MT)

Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	Lahual & Spiti	Total
2012-13	259.78	87.91	52.02	9.02	2.74	0.48	0.26	0.17	412.37
2013-14	499.42	152.65	54.04	24.23	7.19	0.64	0.32	0.20	738.70
2014-15	407.75	104.59	59.20	24.71	26.05	2.29	0.31	0.28	625.18
2015-16	482.39	143.48	75.20	48.61	24.02	2.82	0.32	0.27	777.11
2016-17	265.99	89.57	60.21	38.34	11.73	1.69	0.28	0.31	468.12
2017-18	251.90	78.95	52.19	42.08	18.96	1.90	0.29	0.30	446.55
2018-19	169.96	76.02	61.67	43.97	12.69	3.67	0.30	0.30	368.58
2019-20	437.02	131.19	56.86	57.16	28.08	4.29	0.30	0.30	715.22
2020-21	247.18	92.26	73.33	49.14	14.45	4.02	0.34	0.31	481.03
2021-22	369.72	115.05	48.68	49.79	18.24	9.38	0.25	0.75	611.86
Mean	339.11	107.17	59.34	38.70	16.42	3.12	0.30	0.32	564.47
SD	114.39	27.29	8.86	14.89	8.22	2.56	0.03	0.16	147.53
CV	33.73	25.47	14.93	38.48	50.09	82.16	9.46	49.98	26.14
CDVI	34.77	26.71	15.79	24.32	44.58	38.30	10.02	30.65	27.65
CAGR	-2.74	-1.21	0.36	15.88	13.50	30.24	-0.15	11.00	-0.64

Sources: Directorate of Economics and Statistics and Directorate of Horticulture, Government of Himachal Pradesh

Further, in Chamba district the production of apple crop during the year 2012-13 was 2.74 thousand tonnes which increased to 18.24 thousand tonnes in 2021-22 with a compound growth rate of 13.50 percent per annum. The coefficient of variation in the production of these crops is estimated at 50.09 percent. The value of CDVI (44.58%) falls above the range of 30 percent which confirms high level of instability in the production of apple crop in Chamba district. The production of apple crop in district Sirmour during the year 2012-13 was 0.48 thousand tonnes which increased to 9.38 thousand tonnes in 2020-21 with positive compound growth rate of 30.24 percent per annum. The coefficient of variation in the production of apple is estimated at 82.16 percent. The value of CDVI (38.30%) falls above the range of 30 percent which confirms high level of instability in the production of apple crop in district Sirmour. In Kangra and Lahual & Spiti district the production of apple crop during the year 2012-13 was 0.26 and 0.17 thousand tonnes which increased to 0.25 and 0.75 thousand tonnes in 2021-22, respectively. The compound growth rate registered to be (-) 0.15 and 11 percent per annum for Kangra and Lahual & Spiti districts, respectively. The coefficient of variation is estimated at 9.46 and 49.98 percent. The value of CDVI (10.02%) indicates low level of instability in production of apple crop as the value of this index is in the range of 15-30 percent in Kangra district and for the district of Lahual & Spiti the value of CDVI (30.65%) indicates high level of instability in production of apple crop.

At overall level the average production in Himachal Pradesh came out to be 564.47 thousand tonnes. The production of apple crops at overall level was 412.37 thousand tonnes during the year 2012-13 which increased to 611.86 thousand tonnes in 2021-22 by registering with a Negative compound growth rate of (-) 0.64 percent, per annum. The standard deviation and coefficient of variation far apple crops during the study period has been estimated at 147.53 and 26.14 percent, respectively. The value of CDVI (27.65%) falls in the range of 15-30 percent which indicates medium level of instability and fluctuation in the production of apple crop during the study period.

Growth trends and instability in the productivity of apple crop in Himachal Pradesh

The per hectare productivity of apple in shimla district during the year 2012-13 was 6.97 thousand tones which increased to 8.74 thousand tonnes per hectare in 2021-22 with a negative compound growth rate of (-) 4.15 percent per annum. The average productivity, standard deviation and coefficient of variation have been estimated 8.50 thousand tonnes per hectare, 3.00 percent and 35.35 percent, respectively. The value of CDVI (35.16%) indicates high level of instability in the productivity of apple crop in Shimla district. In Kullu district per hectare productivity of apple crop during the year 2012-13 was 3.46 thousand tonnes which increased to 4.22 thousand tonnes in 2021-22 with a negative compound growth rate of (-) 2.08 percent per annum. The average productivity and standard deviation have been estimated 4.05 thousand tonnes per hectare and 1.08 percent, respectively. The coefficient of variation in the productivity of these crops is estimated at 26.54 percent. The value of CDVI (27.27%) came in the range of 15-30 percent which confirms medium level of instability in the production of apple crop in Kullu district. The per hectare productivity of apple crop in Kinnaur district during the year 2012-13 to 2021-22 decreased from 5.14 thousand tonnes per hectare to 4.46 thousand tonnes per hectare with registering negative compound growth rate of (-) 0.17 percent per annum. The average productivity, standard deviation and coefficient of variation have been estimated 5.45 thousand tonnes per hectare, 0.76 percent and 13.87 percent, respectively. The value of CDVI (14.70%) ranges between 15-30 percent which confirms medium level of instability in the productivity of apple crop in Kinnaur district.

Table 3: Growth trends and instability in the productivity of apple crop in Himachal Pradesh Productivity (000 MT/ Hectare)

Year	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	Lahual & Spiti	Total
2012-13	6.97	3.46	5.14	0.56	0.21	0.16	0.62	0.11	3.88
2013-14	13.30	5.96	5.15	1.51	0.55	0.22	0.82	0.13	6.86
2014-15	10.51	4.05	5.40	1.51	2.03	0.83	0.78	0.17	5.71
2015-16	12.14	5.51	6.74	2.96	1.91	1.09	0.77	0.16	7.03

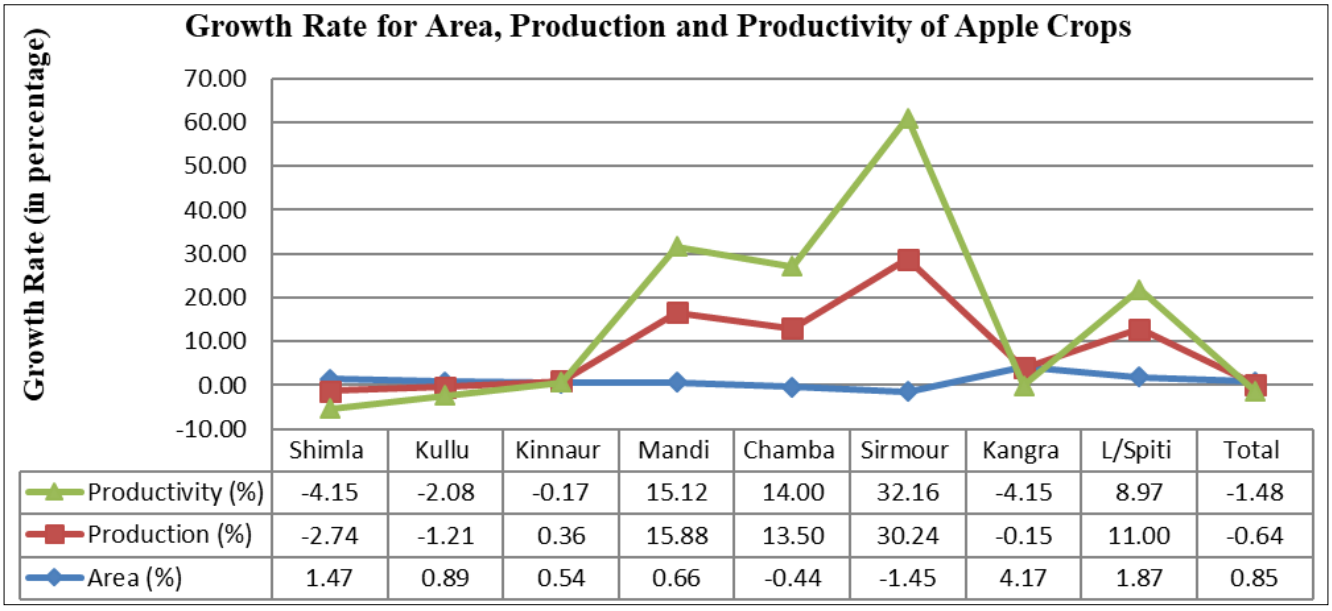
2016-17	6.62	3.36	5.37	2.31	0.94	0.66	0.64	0.18	4.19
2017-18	6.21	2.95	4.67	2.53	1.51	0.74	0.63	0.18	3.97
2018-19	4.15	2.81	5.62	2.63	1.01	1.47	0.60	0.17	3.26
2019-20	10.46	4.82	5.22	3.39	2.26	1.67	0.57	0.17	6.27
2020-21	5.87	3.38	6.72	2.90	1.16	1.56	0.64	0.17	4.20
2021-22	8.74	4.22	4.46	2.94	1.47	3.61	0.44	0.42	5.33
Mean	8.50	4.05	5.45	2.32	1.31	1.20	0.65	0.19	5.07
SD	3.00	1.08	0.76	0.87	0.66	0.99	0.11	0.08	1.35
CV	35.35	26.54	13.87	37.43	50.25	82.87	17.15	45.29	26.63
CDVI	35.16	27.27	14.70	24.26	44.27	38.03	12.64	31.22	27.85
CAGR	-4.15	-2.08	-0.17	15.12	14.00	32.16	-4.15	8.97	-1.48

Sources: Directorate of Economics and Statistics and Directorate of Horticulture, Government of Himachal Pradesh

The per hectare productivity of apple crop in Mandi and Chamba Districts during the year 2012-13 was 0.56 and 0.21 thousand tonnes which increased to 2.94 and 1.47 thousand tonnes in 2021-22 with a compound growth rate of 15.12 and 14.00 percent per annum, respectively. The average productivity, standard deviation and coefficient of variation have been worked out to be 2.32 thousand tonnes per hectare, 0.87 percent and 37.43 percent, respectively for Mandi district and in case of Chamba district it have been estimated 1.31 thousand tonnes per hectare, 0.66 percent and 50.25 percent, respectively. The values of CDVI (24.26%) fall into the range of 15-30 percent which confirms medium level of instability in the productivity of apple crop in Mandi district and in case of Chamba district the value of CDVI (44.27%) indicates high level of instability and variability in the productivity of apple crop.

The per hectare productivity of apple crop estimated for district Sirmour during the year 2012-13 was 0.16 thousand tonnes which increased to 3.61 thousand tonnes in 2021-22 with positive compound growth rate of 32.16 percent per annum. The coefficient of variation in the productivity of apple is estimated at 82.87 percent. The value of CDVI (38.03%) falls above the range of 30 percent which confirms high level of instability in the productivity of apple crop in district Sirmour. The per hectare productivity of apple in Kangra district during the year 2012-13 was 0.62 thousand tonnes which decreased to 0.44 thousand tonnes per hectare in 2021-22 with a negative compound growth rate of (-) 4.15 percent per annum. The average productivity, standard deviation and coefficient of variation have been estimated 0.65 thousand tonnes per hectare, 0.11 percent and 17.15 percent, respectively. The value of CDVI (12.64) indicates low level of instability in the productivity of apple crop in Kangra district. In Lahual & Spiti district per hectare productivity of apple crop during the year 2012-13 was 0.11 thousand tonnes which increased to 0.42 thousand tonnes in 2021-22 with a positive compound growth rate of 8.97 percent per annum. The average productivity, standard deviation and coefficient of variation have been estimated 0.19 thousand tonnes per hectare, 0.08 percent and 45.29 percent, respectively. The value of CDVI (31.22%) indicated high level of instability in the production of apple crop in Lahual & Spiti district.

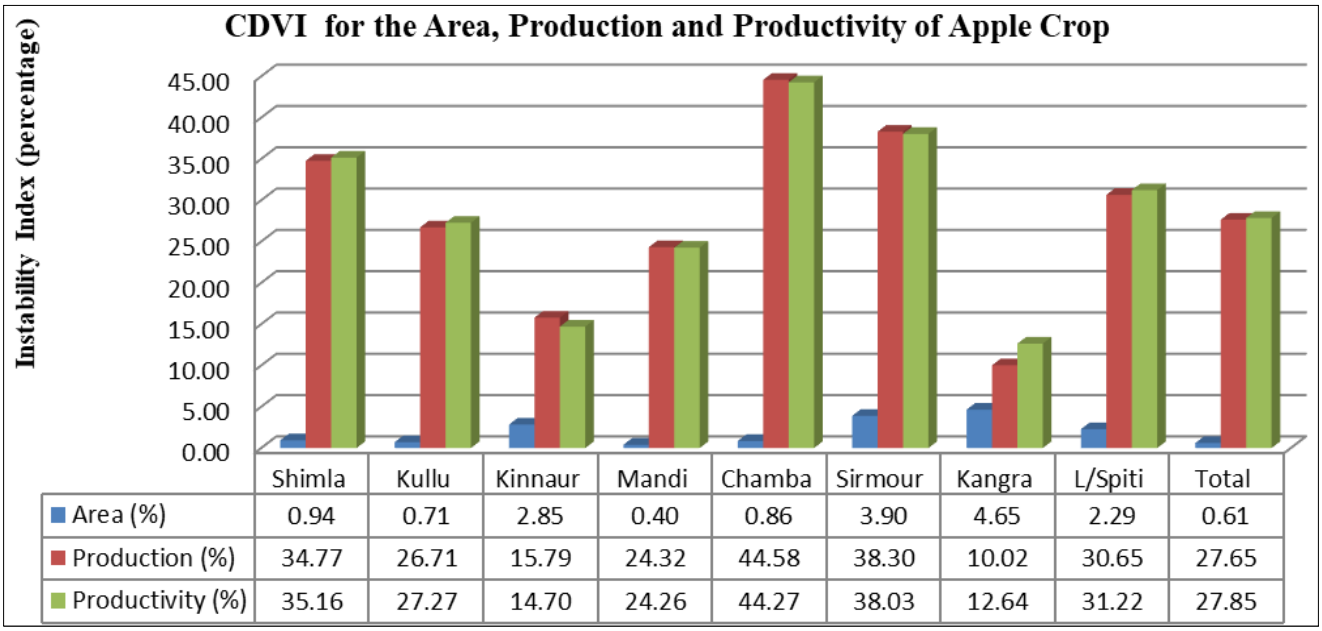
Per hectare productivity registered a negative compound growth rate of (-) 1.48 per cent per annum at overall level the apple crop in Himachal Pradesh. The average productivity and standard deviation is estimated at 5.07 thousand tonnes per hectare and 1.35 percent. The coefficient variation came out to be 26.63 percent. The value of instability index indicates medium level of instability and inconsistency in the productivity of apple crops in Himachal Pradesh during the year 2012-13 to 2021-22.



	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	L/Spiti	Total
Productivity (%)	-4.15	-2.08	-0.17	15.12	14.00	32.16	-4.15	8.97	-1.48
Production (%)	-2.74	-1.21	0.36	15.88	13.50	30.24	-0.15	11.00	-0.64
Area (%)	1.47	0.89	0.54	0.66	-0.44	-1.45	4.17	1.87	0.85

Source: Data representation from Table-1, 2 and 3

Fig 1: Growth rate for area, production and productivity of apple crop in Himachal Pradesh



	Shimla	Kullu	Kinnaur	Mandi	Chamba	Sirmour	Kangra	L/Spiti	Total
Area (%)	0.94	0.71	2.85	0.40	0.86	3.90	4.65	2.29	0.61
Production (%)	34.77	26.71	15.79	24.32	44.58	38.30	10.02	30.65	27.65
Productivity (%)	35.16	27.27	14.70	24.26	44.27	38.03	12.64	31.22	27.85

Source: Data representation from Table-1, 2 and 3

Fig 2: Cuddy Della Valle Instability Index for the Area, Production and Productivity of Apple Crop in Himachal Pradesh

Decomposition analysis

To determine how contribution of area, yield and their interaction are responsible for the overall growth of apple crops production in Himachal Pradesh during the study period, decomposition analysis was carried out. In this analysis attempt has been made to identify the contribution of area and productivity for change in production of fruits crop. The decomposition analysis of fruits crops production in area, yield and interaction effect were presented in Table 4. The Table 4 indicates that, the area effect is plays major role in growth of apple production in all districts of Himachal Pradesh. The highest area effect was observed during the study period in Kangra district i.e. (1047.37%) with negative yield effect i.e. (-) 1321.43 percent and interaction effect i.e. 374.6 percent.

Table 4: District wise decomposition analysis of apple production in Himachal Pradesh

Particular	Area Effect	Yield Effect	Interaction Effect
Shimla	59.90	31.99	8.11
Kullu	70.70	24.05	5.25
Kinnaur	207.98	-124.64	16.65
Mandi	93.40	1.26	5.34
Chamba	103.12	-0.46	-2.67
Sirmour	114.06	-0.64	-13.43
Kangra	1047.37	-1321.43	374.06
Lahual & Spiti	76.97	6.31	16.72
Total	77.44	16.41	6.15

Source: Calculated by author

The lowest area effect was observed during the study period in Kullu district i.e. 70.70 percent with yield effect i.e. 24.05 percent and interaction effect i.e. 5.25 percent due to adverse climatic condition and others factors during the study period. The highest yield effect was observed in Shimla district during the study period i.e., 31.99 per cent with area effect i.e. 59.90 per cent and interaction effect i.e. 8.11 per cent. The yield effect have been found negative in production of apple are (-) 1321.43, (-) 124.64, (-) 0.64 and (-) 0.46 percent in Kangra, Kinnaur, Sirmour and Chamba districts respectively, due to adverse climatic condition and others factors during the study period. While for the Shimla, Kullu, Mandi and Lahual & Spiti the yield effect was observed 31.99, 24.05, 1.26 and 6.31 percent, respectively. The interaction effect means the effect of change in area and yield together towards increase in production of apple. It is evident from the Table 4 that, the maximum interaction effect found was (374.06%) in Kangra district followed by Lahual & Spiti (16.72%), Kinnaur (16.65%), Shimla (8.11%), Mandi (5.34%) and Kullu (5.25%). The interaction effect was influencing apple production in Sirmour (-13.43%) and Chamba district (-2.67%).

Conclusion and policy implications

The study confirms that the variation in productivity of different fruits in the recent years has become a serious concern of the fruit growers. Apple is the most important fruit crop of Himachal Pradesh, which constitutes about 48.78 per cent of the total area under fruit crops and about 81.2 per cent of the total fruit production during 2021-22 and area under apple fruits has seen a growth of 21.4 per cent. The analysis of district wise apple production over a decade reveals significant variations in area production and productivity levels. The growth rates of area, production and productivity of apple crops among the districts of Himachal had a fluctuating trend during the study periods. Also, the area, production and productivity of apple crop in Himachal Pradesh had instability and variability during the study periods. The area effect was a driving force for the change in production of apple crop in Himachal Pradesh during the study periods. However, notable annual fluctuations indicate instability due to climatic variations, pests, market volatility, and policy changes. Regional disparities highlight the need for targeted interventions in underperforming areas. Policy recommendations emphasize enhancing stability and sustaining growth through research, pest management, and better infrastructure. Addressing these instabilities is crucial for long term sustainability and resilience, providing valuable insights for policymakers and stockholders to foster a more stable and productive apple industry. In a

nutshell it can be suggested that to combat these negative yield effects and improve productivity, it requires integrated pest management, sustainable soil management practices, efficient water use, adoption of climate-resilient plant varieties, and improved horticultural techniques. These measures can help maintain or increased yield despite the challenges posed by environmental and biotic stressors.

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