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Growth trend, instability and decomposition analysis of vegetable production in Himachal Pradesh

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Abstract
The goal of the current study was to analyze the productivity and growth of vegetable crops and to break down variations in production into their component parts. The study revealed that the area, production and production was increasing significantly during the study period and it was noticed that growth rate of production was higher than area. Pea contributed 31.99 percent of the total area followed by tomato (16.18%) while tomato contributed highest in case of total production (30.71%) and yield (15.52%). Cuddy Della Valle Index analysis revealed that the degree of variability of area, production and yield in the overall period was found to be 17.78 percentage, 8.87 percentage and 22.06 percentage, respectively. Decomposition analysis revealed that the vegetables production was increased mainly due to expansion of area during period I, period II and overall period in the state.

Keywords: Compound annual growth rate, Cuddy Della Valle index, instability, vegetables

Introduction
Himachal Pradesh has a wide range of agro-climatic conditions that enable the growth of numerous key vegetable crops, particularly in the state's mid and high hills, with an elevation range of 200-4000 metres with winter temperatures of 0-10 degree celsius and summer temperatures of 15–30 degree celsius. Farmers in the state have benefited greatly from the employment and revenue generated by the horticulture industry. According to Anonymous (2021a) [1], the state's agriculture and horticulture sector contributed 24.39 crore to the state's GDP overall. Owing to the state's comparative advantages in growing vegetables such tomato, capsicum, beans, cabbage, green peas, potatoes, cauliflower and cucumber, vegetable production is significant to the state's economy. In 2018–2019, 17.22 lakh tonnes of vegetables were produced; in 2019–2020, the number grew to 18.6 lakh tonnes, an 8.07 percent increase. With 86.7 thousand hectares in vegetable cultivation, the state produced 18.5 lakh tonnes in 2020–21. Tomatoes account for the greatest portion of all vegetables produced (5.8 thousand tonnes), with peas (3.2 thousand tonnes), cauliflower (1.4 thousand tonnes), cabbage (1.5 thousand tonnes), garlic (1.2 thousand tonnes), and other vegetables following in order of production (Anonymous, 2021b) [2]. The principal districts for the production of vegetables are Kullu, Kangra, Sirmour, Mandi, Solan and Shimla. Approximately 69 percentage of the workforce in the state is employed in agriculture. Furthermore, the state's various agro-ecological characteristics are better suited for growing a variety of vegetable crops than plains due to their longer growing season. Producing vegetables has become extremely profitable as a result, particularly in the state's mid- and high-hill regions. Since growth in crop area and production is more variable than that of other products, it is imperative to evaluate the trend pattern of area, production and yield of different vegetable crops in the state. The goals of this study were to assess the growth performance of the state's principal vegetable crops and to look into the causes of production variations during the research period. Decomposition analysis was also conducted. The study was based on secondary data. Secondary data for area and production of major vegetable crops for the period of 20 years (2001-2020) were collected from the Directorate of Agriculture, Shimla, Himachal Pradesh.

Materials and Methods

Compound Annual Growth Rate (CAGR)

The compound growth rates for different variables were computed by fitting the exponential function to the figures of area, production, productivity and price of major vegetable crops of the study area. The ordinary least square method was used to fit the power function of the following form $Y = ae^{bt}$. It was converted into log linear function with the help of log arithmetic transformation as under:

LnY= Ln a+t b.

Where,
Y = Dependent variable (area, production and productivity etc.)
t = Independent variable (time in a year).

Compound annual growth rate (CAGR) was calculated by using the formula:

CAGR =b*100

Variability Index

Variability can be calculated from the simple coefficient of variation also, but it often overestimates the level of instability in time series data due to the presence of long-term trend, so, Cuddy – Della- Valle index was constructed to correct the flaws present in coefficient of variation. Cuddy Della Valle Index was used to estimate variability in price &of selected vegetables. The variability coefficient has been computed using the following formula:

$C-D-V\ Index = CV * \sqrt{(1-R^2)}$
Where CV= (SD/Mean)*100
R^2 is the adjusted estimated coefficient of determination

Decomposition analysis

In order to have a broad spectrum of the relative contribution of area and yield output growth of vegetable production decomposition technique was employed as under.

$P = A * Y$
$(P + \Delta P) = (A + \Delta A) * (Y + \Delta Y)$
$\Delta P = \Delta A\ Y + \Delta Y\ A + \Delta A\ \Delta Y$

Change in production = Yield effect + Area effect + Interaction effect

Where,
Δ P = Change in production between 2001-02 and 2020-21
Δ A = Change in area between 2001-02 and 2020-21
Δ Y = Change in yield between 2001-02 and 2020-21
Δ A Y = Area effect
Δ Y A = Yield effect
$\Delta A\ \Delta Y$ = Interaction effect

Results and Discussion

Growth trends in vegetable cultivation in Himachal Pradesh.

Area, production and productivity of vegetables in Himachal Pradesh from 2001-2002 to 2020-2021 have been presented in Table 1. The state during 2001 to 2020 has an average of 64205 hectares under vegetable cultivation with an average total production of 1276 thousand metric tonnes. The productivity of vegetable crops was 19.88 metric tonnes per hectares. It can be observed from the table that tomato (37.33 mt ha^{-1}) have the highest productivity followed by cucurbits (2.17 mt ha^{-1}) and brinjal (21.48 mt ha^{-1}). Pea contributed 31.99 percentage of the average total area of the state and the highest among the vegetables and followed by tomato (16.18%). Even though, pea has the highest contribution to area, tomato contributed highest in the production with 30.71 percentage which is followed by pea (18.38%). Kumar *et al*. (2017) [5] also noticed that green peas and tomatoes, among other crops, accounted for almost half of the total area and production of all vegetables in the state.

Table 1: Status of vegetable crops in Himachal Pradesh during 2001-2020

Crops	Area		Production		Yield	
	000'ha	%	000'MT	%	MT Ha^{-1}	%
Pea	20.537	31.99	234.570	18.38	11.24	4.67
Tomato	10.385	16.18	392.032	30.71	37.33	15.52
Bean	3.229	5.03	38.925	3.05	11.85	4.93
Onion	5.892	9.18	94.580	7.41	15.73	6.54
Cabbage	4.221	6.57	133.387	10.45	31.29	13.01
Cauliflower	3.731	5.81	81.965	6.42	21.43	8.91
Radish	2.307	3.59	46.283	3.63	20.48	8.51
Bhindi	2.435	3.79	30.432	2.38	12.02	5.00
Cucurbits	2.446	3.81	59.344	4.65	24.17	10.05
Capsicum	2.897	4.51	46.412	3.64	15.25	6.34
Brinjal	0.924	1.44	19.972	1.56	21.48	8.93
Other vegetables	5.196	8.09	98.535	7.72	18.31	7.61
Total	64.205		1276.442		19.88	

Trends in area of vegetable crops during 2001-2020 have been presented in Table 2. It can be seen from the table that area, production and productivity of vegetable crops showed a significant and positive growth in the state in period I, period II and overall period. Sharma (2007) [10] also reported that there was a significant growth of vegetables in Himachal Pradesh. Rashmi *et al*. (2020) [8] found that the area and production under vegetables in Kangra district of Himachal Pradesh has increased. It was also observed that in the overall period, the growth in production (5.71% p.a) was higher than the growth in area (3.70% p.a) and the growth rate of productivity was 1.95 percentage per annum. During the overall period, the maximum increase in area was found in cabbage (9.41% p.a) followed by cauliflower (8.55% p.a). Whereas, the highest increase in production was noticed in cauliflower with 9.56 percentage per annum which was

followed by bhindi (8.90% p.a). During period I, the area and production of all the selected vegetables increased significantly and the total growth of area and production was 7.16 percentage per annum and 8.70 percent per annum, respectively. While, the yield showed a positive growth rate for most of the vegetable crops except for cucurbits (0.72% p.a) and Brinjal (-0.85% p.a). The growth in area and production during period II was noticed to have positive growth rate for all the crops except for Brinjal (-1.23% p.a and -1.33% p.a, respectively). The yield during period II showed a negative growth rate for tomato (-0.19% p.a), cabbage (-0.77% p.a), radish (-0.7% p.a), Brinjal (-1.33% p.a) and other vegetables (-1.04% p.a). The growth rate of area, production and productivity of period II was lower than the growth rate of period I. Bidyasagar *et al*. (2017) [4] suggested that the increased growth rate could be due to the government's and state agriculture departments' initiatives in giving financial and technical assistance to the farmers.

Table 2: Trends in area, production and productivity of vegetable crops in Himachal Pradesh during 2001 to 2020

Crops	Period I (2001-2010)			Period II (2011-2020)			OVERALL		
	A	P	Y	A	P	Y	A	P	Y
Pea	8.99* (0.11)	10.46* (0.14)	1.35* (0.05)	1.29* (0.03)	2.41* (0.03)	1.09* (0.03)	4.18* (0.13)	5.31 (0.15)	1.09* (0.04)
Tomato	1.09* (0.03)	6.33* (0.05)	5.18* (0.07)	3.77* (0.06)	3.57* (0.04)	-0.19** (0.07)	2.13* (0.06)	4.65* (0.05)	2.48* (0.09)
Bean	5.73* (0.08)	6.42* (0.07)	0.66** (0.05)	1.52* (0.04)	3.89* (0.07)	2.33* (0.04)	3.31* (0.08)	5.09* (0.07)	1.73* (0.04)
Onion	5.85* (0.16)	8.86* (0.09)	2.84* (0.10)	6.50* (0.12)	7.95* (0.06)	1.36* (0.11)	5.78* (0.13)	8.06* (0.08)	2.16* (0.10)
Cabbage	9.41* (0.09)	10.93* (0.11)	1.39** (0.06)	1.74** (0.07)	0.95** (0.06)	-0.77** (0.05)	9.41* (0.1)	4.32* (0.15)	0.60* (0.06)
Cauliflower	9.79* (0.06)	9.89* (0.14)	0.09** (0.09)	3.67* (0.06)	4.12* (0.04)	0.44** (0.04)	8.55* (0.12)	9.56* (0.15)	0.93* (0.07)
Radish	9.96* (0.11)	12.48* (0.11)	2.29* (0.07)	5.38** (0.24)	4.64* (0.07)	-0.7** (0.21)	7.03* (0.18)	7.02* (0.13)	-0.02** (0.15)
Bhindi	12.32* (0.14)	14.94* (0.13)	2.33* (0.05)	5.78* (0.07)	8.25* (0.04)	2.34* (0.06)	7.20* (0.14)	8.90* (0.14)	1.58* (0.06)
Cucurbits	2.29* (0.06)	1.55* (0.12)	-0.72** (0.08)	0.96** (0.07)	2.47* (0.08)	1.49* (0.04)	1.76* (0.06)	2.44* (0.09)	0.66* (0.07)
Capsicum	10.21* (0.04)	13.71* (0.14)	3.18* (0.11)	2.68* (0.03)	3.69* (0.14)	0.99** (0.12)	5.38* (0.11)	8.50* (0.18)	2.97* (0.11)
Brinjal	12.76* (0.14)	11.80* (0.24)	-0.85** (0.21)	-1.23* (0.05)	-2.55* (0.08)	-1.33* (0.05)	4.49* (0.21)	4.72* (0.26)	0.22** (0.15)
Other vegetables	12.03* (0.19)	13.91* (0.22)	1.68* (0.05)	3.31* (0.08)	2.24** (0.11)	-1.04** (0.05)	6.85* (0.17)	8.32* (0.22)	1.38* (0.07)
Total	7.16* (0.05)	8.70* (0.05)	1.44* (0.03)	2.82** (0.25)	3.45* (0.02)	0.61* (0.25)	3.70* (0.18)	5.72* (0.08)	1.95* (0.17)

Figures in the parentheses are the standard errors of the compound growth rates.
* Significant at 1 percent level of significance, ** Significant at 5 percent level of significance

Instability in vegetable production

The instability index was computed to study the variability in area, production and yield of various vegetable crops in Himachal Pradesh. The relative variability in vegetable production is very important for sustainable production and was measured in terms of Cuddy-Della Valle instability index. The high instability index indicates the high risk of cultivation of that crop in the state. Instability indices for selected vegetable crops in Himachal Pradesh have been shown in Table 3. The degree of variability of area, production and yield in the overall period was found to be 17.78 percentage, 8.87 percentage and 22.06 percentage, respectively. Radish has the highest variation under area with 20.44 percentage and cucurbits have the lowest variation (6.07%). For production, Brinjal (23.13%) has the highest variation and found lowest for tomato (5.41%). The yield showed a low fluctuation compared to area and production where the highest fluctuation was found in Brinjal (16.45%) and lowest for pea (4.01%). During period I (5.63%), the variation under area was lower than period II (18.98%) and was also noticed the same for production and yield which means that during period I the vegetable production was more stable than period II. The high instability is due to factors such as its specific growth requirements, susceptibility to diseases and variation in market (Priyanka and Kerur, 2023) [7].

Table 3: Instability indices for vegetable crops in Himachal Pradesh during 2001 to 2020. (%)

Crops	Period I			Period II			OVERALL		
	A	P	Y	A	P	Y	A	P	Y
Pea	11.39	14.49	5.07	3.24	3.45	3.21	12.51	13.83	4.01
Tomato	7.20	5.26	6.37	6.46	4.14	6.13	7.03	5.412	8.56
Bean	8.10	6.92	5.39	4.96	7.65	3.88	7.90	6.99	4.77
Onion	18.56	10.04	12.32	12.92	6.68	9.69	13.95	8.15	9.71
Cabbage	9.86	11.05	6.51	7.79	7.15	4.22	8.67	14.81	6.27
Cauliflower	6.65	14.29	9.48	7.17	5.04	4.15	11.13	13.55	7.05
Radish	10.73	10.91	7.75	31.28	7.18	16.52	20.44	12.55	13.06
Bhindi	14.25	13.92	8.11	6.88	4.58	6.41	13.06	13.47	7.13
Cucurbits	6.73	13.88	8.26	7.23	7.49	3.62	6.07	9.23	6.56
Capsicum	4.94	14.15	12.79	3.47	15.11	12.80	10.01	16.15	11.90
Brinjal	13.65	24.14	24.03	4.62	7.82	5.13	18.47	23.13	16.45
Other Vegetables	15.55	19.67	10.45	9.23	11.77	4.47	15.09	18.89	9.32
Total	5.63	5.52	3.01	18.98	6.40	31.76	17.78	8.87	22.06

Effect of area and yield on vegetable production

The decomposition analysis was carried out to examine the factors responsible for change in production of vegetables in

the state. Yield and area are considered important contributors in the production of vegetables. In order to visualize the contribution of each of them in the production, Narula and Vidyasagar (1973) [6] model was used. Relative contribution of components in vegetable growth in Himachal Pradesh during 2001-2020 was decomposed in yield effect, area effect and interaction effect and results have been presented in Table 4. Overall increase in production of vegetable crops was due to acreage expansion. Crop-wise analysis revealed that in case of pea, the production was increased due to area effect (66.01%) followed by interaction effect (21.14%). Similarly, tomato production was effected mostly by expansion of area with the percentage of 70.38 followed by yield effect (15.10%). For bean, the production was increased by area effect (47.48%), yield effect (27.67%) and interaction effect (24.85%). The onion production was solely due to area effect (99.95%), similarly, for cucurbits (91.66%) and brinjal (80.83%). Overall increase in production of vegetable crops was due to acreage expansion (78.99%) followed by interaction effect (12.73%) and yield effect (8.28%). This suggests that increase in productivity, area expansion and interaction between area and yield all contributed to Himachal Pradesh's increasing vegetable production. Balai *et al.* (2021) [3] and Sethi *et al.* (2022) [9] also reported that the area effect was stronger than yield effect and interaction effect in case of vegetables crops.

Table 4: Decomposition analysis of vegetables production during 2001 to 2020 (%)

Crops	Area effect	Yield effect	Interaction effect
Pea	66.01	12.85	21.14
Tomato	70.38	15.10	14.51
Bean	47.48	27.67	24.85
Onion	99.95	0.01	0.04
Cabbage	72.49	12.98	14.53
Cauliflower	70.67	7.13	22.20
Radish	71.57	9.82	18.62
Bhindi	47.46	9.80	42.74
Cucurbits	91.66	7.40	0.93
Capsicum	46.71	22.02	31.27
Brinjal	80.83	7.20	11.97
Other vegetables	50.71	18.29	30.99
Total Vegetables	78.99	8.28	12.73

Conclusion

The compound annual growth rate was used to estimate the growth in the area, production, productivity and prices of major vegetable crops. The coefficient of variation was used to measure the instability in the area, production, productivity and prices. Decomposition was carried out to study the relative contribution of the area, yield, interaction effect of area and yield in production. Vegetable crop production in the state has a lot of potential. The study revealed that pea (31.99%) contributed highest to the total area whereas, tomato (30.71%) contributed highest to the total production. The area, production and yield of vegetables crops showed a significant growth. The growth in production (5.71% p.a) was higher than the growth in area (3.70% p.a) which implies that the state has varied agro-climatic condition for growing vegetable crops. The degree of variability of area, production and yield was found to be 17.78 percentage, 8.87 percentage and 22.06 percentage, respectively. The instability of production was lower than area and yield which means that production of vegetables increased more steadily. The study also revealed that increase in production of vegetable crops was due to expansion in area. Since, land is fixed resource, hence in order to enhance production, productivity enhancement approach should be adopted. Productivity can be enhanced through adoption of improved agronomic practices including improved varieties. Hence, extension agencies involved in the vegetable cultivation should demonstrate the advances in agronomic practices to the growers through trainings as well as in farm demonstrations.

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