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RESEARCH ARTICLE

Study on effect of area, yield and their interaction on change in production of major vegetable crops in India

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Abstract

The total vegetables production during last three decades increased by nearly 3.04-times, similarly area increased by 2.21 times and productivity increased by 1.38 times. Present investigation was undertaken to study the growth rate and relative contribution of area and productivity on production of vegetables. The study was based on secondary data for the period of 23 years (2002-03 to 2024-25). Eight important vegetable crops, *i.e.,* potato, onion, tomato, brinjal, cabbage, cauliflower, okra and pea considered for analysis on the basis of their importance. The overall compound annual growth rate in area, production and productivity of vegetables in the country during 23 years was 2.90, 4.09 and 1.17% per annum, respectively. The overall compound annual growth rate in area was highest for onion (5.83%) followed by pea (4.23%) and cauliflower (3.49%). Similarly, for production it was highest for onion (7.93%) followed by pea (6.76%) and tomato (5.23%) and for productivity it was highest for tomato (2.43%) followed by pea (2.26%) and onion (2.03%). The result reveals that an increase in vegetable production during study period was mainly due to area, with a contribution of 59.67 per cent. However, the contribution of productivity (20.83%) and the interaction effect of area and productivity (19.50%) to vegetable production growth were relatively lower. During overall period, all eight studied vegetable crops have area effect more than productivity effect and interaction effect. Study clearly indicates that area effect was more responsible factor for increasing vegetable production in the country than productivity and interaction effect between area and productivity.

Keywords: Area, production, productivity, decomposition analysis and vegetable growth

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Introduction

India is the second largest vegetables producing country in the world. The horticulture sector accounts for about 13.74% (2024-25) of gross cropped area (219.36 million hectares) in the country and contributes around 33% to agricultural GDP of India. Its share is about 37% of the total exports of agricultural commodities. The area under horticultural crops which was 12.77 million hectares during 1991-1992 increased to 30.14 million hectares during 2024-25, similarly horticultural crops production has increased from 96.56 million tonnes to 370.74 million tonnes during the same period. The total vegetables production during last three decades increased by nearly 3.04 times, similarly area increased by 2.21 times and productivity increased by 1.38 times (Anonymous, 2019; DoAFW, 2026).

The production of vegetables in India was 217.80 million tonnes from area of 11.79 million hectares during 2024-25 (DoAFW, 2026). In the world, India occupies first position in the production of okra; second in potatoes, tomatoes, eggplants, green peas, cauliflowers & broccoli, cabbages, green garlic and third in lettuce & chicory (FAO, 2026). Share

of vegetables export in India's total export is only 0.36%, share in export of agriculture and related products is 3.20% and share in export of horticultural products is 16.01 per cent respectively during 2025-26 though vegetable production is more important in terms of social, nutritional, livelihood security, income and employment generation for the majority of small of marginal farmers (APEDA, 2026; DoAFW, 2026 and DoC, 2026).

Agricultural diversification towards high-value crops has emerged as a critical strategy for enhancing farm profitability, generating rural employment and promoting sustainable agricultural development. Among high-value crops, vegetables occupy a prominent position due to their higher economic returns, labour-intensive nature and short production cycle. The cultivation of vegetables is particularly suitable for small and marginal farming systems, as it enables efficient utilization of limited land resources while providing regular income and employment opportunities throughout the year. Moreover, vegetable cultivation creates substantial on-farm employment, especially for women, who contribute significantly to various production and post-harvest operations (Joshi et al., 2006). Rapid urbanization, rising incomes, changing dietary preferences, and increasing awareness of nutritional security have accelerated the demand for vegetables and other high-value agricultural commodities. Consequently, diversification from traditional cereal-based production systems towards vegetables has gained considerable importance in many regions of India. Besides augmenting farm income, vegetable cultivation contributes to employment generation and resource-use efficiency owing to its labour-intensive character (Weinberger & Lumpkin, 2006). In regions dominated by cereal monocropping systems, particularly the rice–wheat production system, crop diversification through vegetables has been recognized as a viable alternative for addressing issues related to declining profitability, resource degradation and production sustainability. Furthermore, favourable market prices and increasing consumer demand have encouraged farmers to expand the area under vegetable cultivation (Sidhu et al., 2009).

The sustained growth of the vegetable sector is reflected in changes in area, production, and productivity over time. An understanding of the dynamics of these growth components is essential for formulating policies aimed at enhancing vegetable production and ensuring nutritional and livelihood security. Decomposition of production growth into area and productivity effects provides valuable insights into the relative contributions of technological advancement and area expansion to overall production growth. Therefore, an assessment of long-term trends and growth patterns in the vegetable sector is of considerable policy relevance. Against this backdrop, the present study was undertaken to estimate the growth rates of area, production and productivity of vegetables in India and to examine the relative contributions of area expansion, productivity improvement and their interaction to vegetable production growth.

Methodology

This study used time series data of the area, production, and productivity of vegetables (major crops and aggregate) in India from 2002-03 to 2024-25 (23 years of data) obtained from Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India (http:// https://agricoop.nic.in/) and Vegetable Statistics (Vanitha et al., 2013). The study period has been divided into two sub-periods as Period I (2002-03 to 2011-12) and Period II (2012-13 to 2024-25).

Estimation of growth in area, production and productivity

Statistical tools like growth rate and percentages were used for analysis. The compound annual growth rate (CAGR) in area, production and productivity of vegetables as a whole and for important vegetables was worked out by fitting the exponential function given below:

$Y_t = ab^t$

Y = The dependent variable

a = Constant term

b = Regression coefficient

t = Time variable in years

The equation can be re-written in the logarithmic form (base 10) as follows

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

where, Y_t = area/ production/ productivity of vegetables in t^{th} year

We can, thus, calculate the compound annual growth rates (r) as under

CGR in per cent (r) = (Antilog of log b-1) x 100

Where, r = Compound annual growth rate per annum (per cent).

The 't' test was applied for test of significance of 'b'.

Decomposition analysis

The change in the production of a crop in physical terms depends on the changes in average area harvested under the crop and its productivity. A decomposition analysis model was used to measure the relative contribution of area and productivity and the interaction of the two in total vegetable production. A systematic scheme for decomposing the growth trend was first presented by Minhas & Vaidyanathan (1965) which equates changes in gross agricultural output to changes in four factors: area, yield, cropping pattern and interactions of later two. Many researchers have used the decomposition analysis to study the change in production of various crops (Jagannath, et al., 2013; Tamang, 2019; Ayele et al., 2021; Singh et al., 2021;

Parmar & Devi, 2021; Afrin & Umesh, 2021; Devi, et al., 2017; Sethi, et al., 2022).

The method states that if A_0, P_0 and Y_0 are area, production and productivity respectively in base year and A_n, P_n and Y_n are values of the respective variable in n^{th} year.

$P_0 = A_0 * Y_0$ and

$P_n = A_n * Y_n$ (1)

Where, A_0 and A_n represent the area and Y_0 and Y_n represents the yield in the base year and n^{th} year respectively.

$P_n - P_0 = \Delta P$,

$A_n - A_0 = \Delta A$ and

$Y_n - Y_0 = \Delta Y$ (2)

Where, Δ P is change in production, Δ Y is change in productivity and Δ A is change in the area.

From equation (1) and (2) we can write

$P_0 + \Delta P = (A_0 + \Delta A) * (Y_0 + \Delta Y)$

The contributions of productivity, area, and their interaction in production are estimated by applying following formula:

$$P = \frac{Ao^* \Delta Y^* 100}{\Delta P} + \frac{Yo^* \Delta A^* 100}{\Delta P} + \frac{\Delta Y^* \Delta A^* 100}{\Delta P}$$

roduction = Yield effect + Area effect + Interaction effect

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

Results and Discussion

The relative contributions of area, productivity and their interaction effects on the total vegetable production growth in the country are presented in Table 1. The result reveals that an increase in vegetable production during overall period (2002-03 to 2024-25) was mainly due to area, with a contribution of 59.67%. However, the contribution of productivity (20.83%) and the interaction effect of area and productivity (19.50 per cent) to vegetable production growth were relatively lower. Similarly, during the both sub-periods 2002-03 to 2011-12 and 2012-13 to 2024-25 area effect was more responsible factor for increasing vegetable production than productivity and interaction effect between area and productivity.

Relative contributions of various components to aggregate growth of important vegetable production in the country are presented in Table 2 and the same has demonstrated the per cent contribution of area, productivity and their interaction for increasing important vegetable production in the country for two period (2002-03 to 2011-12 and 2012-13 to 2024-25) and overall period (2002-03 to 2024-25). Eight important vegetable crops, *i.e.,* potato, onion, tomato, brinjal, cabbage, cauliflower, okra and pea considered for decomposition analysis on the basis of their

Table 1: Decomposition Analysis for vegetables production in India (per cent)

Sl. No.	*Period*	*Area effect*	*Productivity effect*	*Interaction effect*
1	2002-03 to 2011-12	95.68	3.82	0.50
2	2012-13 to 2024-25	81.95	14.08	3.97
3	2002-03 to 2024-25	59.67	20.83	19.50

Table 2: Decomposition analysis for important vegetable production in India (per cent)

Sl. No.	*Period*	*Area effect*	*Productivity effect*	*Interaction effect*
Potato				
1	2002-03 to 2011-12	53.89	32.33	13.78
2	2012-13 to 2024-25	64.88	29.47	5.65
3	2002-03 to 2024-25	50.50	27.94	21.56
Onion				
1	2002-03 to 2011-12	49.30	19.82	30.88
2	2012-13 to 2024-25	104.90	-2.60	-2.30
3	2002-03 to 2024-25	57.58	9.16	33.26
Tomato				
1	2002-03 to 2011-12	61.67	20.24	18.09
2	2012-13 to 2024-25	-61.20	175.00	-13.80
3	2002-03 to 2024-25	40.50	35.20	24.30
Brinjal				
1	2002-03 to 2011-12	63.01	27.10	9.89
2	2012-13 to 2024-25	197.00	-101.00	4.60
3	2002-03 to 2024-25	55.90	32.40	11.60
Cabbage				
1	2002-03 to 2011-12	119.03	-11.42	-7.61
2	2012-13 to 2024-22	81.70	15.20	3.10
3	2002-03 to 2024-22	93.50	3.40	3.10
Cauliflower				
1	2002-03 to 2011-12	81.59	12.01	6.40
2	2012-13 to 2024-25	83.30	13.20	3.40
3	2002-03 to 2024-25	74.30	13.00	12.70
Okra				
1	2002-03 to 2011-12	61.85	24.23	13.92
2	2012-13 to 2024-25	28.40	67.30	4.30
3	2002-03 to 2024-25	51.80	28.10	20.10
Pea				
1	2002-03 to 2011-12	41.38	43.82	14.80
2	2012-13 to 2024-25	62.90	25.20	11.90
3	2002-03 to 2024-25	43.00	28.10	28.90

importance. During overall period (2002-03 to 2024-25) all eight studied vegetable crops have area effect more than productivity effect and interaction effect. Area effect was more than 50% in production growth of potato, onion, brinjal, cabbage, cauliflower and okra. Production growth of potato was mainly contributed by area effect (50.50%) followed by productivity effect (27.94%) and interaction effect (21.56%). Similarly, Production growth of onion was mainly contributed by area effect (57.58%) followed by interaction effect (33.26%) and productivity effect (9.16%). Production growth of tomato was mainly contributed by area effect (40.50%) followed by productivity effect (35.20%) and interaction effect (24.30%). Production growth of brinjal was mainly contributed by area effect (55.90%) followed by productivity effect (32.40%) and interaction effect (11.60%). Production growth of cabbage was mostly contributed by area effect (93.50%) followed by productivity effect (3.40%) and interaction effect (3.10%). Production growth of cauliflower was mostly contributed by area effect (74.30%) followed by productivity effect (13.00%) and interaction effect (12.80%). Production growth of okra was mostly contributed by area effect (51.80%) followed by productivity effect (28.10%) and interaction effect (20.10%). Production growth of pea was mainly contributed by area effect (43.00%) followed by productivity effect (28.10%) and interaction effect (29.00%).

Compound annual growth rate in area, production and productivity of vegetables in India during the period of 23 years (2002-03 to 2024-25) have been presented in Table 3. During two groups of periods, growth rate in vegetable area showed that it was highest during 2002-03 to 2011-12 (4.35% per annum). Similarly, growth rate in vegetable production was highest during 2002-03 to 2011-12 (6.89% per annum) and vegetable productivity was also highest during same period (2.43% per annum). The overall compound annual growth rate in area, production and productivity of vegetables in the country during twenty-three years (2002-03 to 2024-25) was 2.90, 4.09 and 1.17% per annum, respectively. The increase and growth in vegetable production is mainly due to area expansion under vegetable crops, development of improved high yielding varieties and hybrids, development of production, protection and post-harvest technologies, various infrastructure and developmental projects, efforts of farmers and policy support in the field of vegetable sector.

Table 3: Compound annual growth rate of area, production and productivity of vegetables in India during 2002-03 to 2024-25 (%)

Period	*Area*	*Production*	*Productivity*
2002-03 to 2011-12	4.35**	6.89**	2.43**
2012-13 to 2024-25	2.35**	2.65**	0.68*
2002-03 to 2024-25	2.90**	4.09**	1.17**

**, * indicates significance at 1 and 5% level

With the increase in vegetable production, country has not only achieved almost self-sufficiency in vegetables but also produces surplus for export.

Compound annual growth rate of area, production and productivity of important vegetables in India during 2002-03 to 2024-25 has been presented in Table 4. The overall compound annual growth rate in area in the country during twenty-three years (2002-03 to 2024-25) was highest for onion (5.83 per cent) followed by pea (4.23 per cent), cauliflower (3.49 per cent), tomato (2.91 per cent), cabbage (2.87 per cent), okra (2.57 per cent), potato (2.20 per cent) and

Table 4: Compound annual growth rate of area, production and productivity of important vegetables in India during 2002-03 to 2024-25 (%)

S. No.	*Period*	*Area*	*Production*	*Productivity*
Potato				
1	2002-03 to 2011-12	3.82**	6.27**	2.36*
2	2012-13 to 2024-25	1.36**	14.67^{NS}	9.58^{NS}
3	2002-03 to 2024-25	2.20**	3.35^{NS}	1.16^{NS}
Onion				
1	2002-03 to 2011-12	9.26**	14.57**	4.86**
2	2012-13 to 2024-25	4.65**	5.94**	0.79^{NS}
3	2002-03 to 2024-25	5.83**	7.93**	2.03**
Tomato				
1	2002-03 to 2011-12	6.84**	9.70**	2.68**
2	2012-13 to 2024-25	0.08^{NS}	1.78*	1.98**
3	2002-03 to 2024-25	2.91**	5.23**	2.43**
Brinjal				
1	2002-03 to 2011-12	3.39**	4.74**	1.31**
2	2012-13 to 2024-25	-0.17^{NS}	0.23^{NS}	0.11^{NS}
3	2002-03 to 2024-25	1.86**	2.31**	0.42**
Cabbage				
1	2002-03 to 2011-12	5.31**	4.96**	-0.34^{NS}
2	2012-13 to 2024-25	0.81**	1.16**	0.29^{NS}
3	2002-03 to 2024-25	2.87**	3.12**	0.21**
Cauliflower				
1	2002-03 to 2011-12	5.23**	5.68**	0.42^{NS}
2	2012-13 to 2024-25	1.86**	1.91**	0.18^{NS}
3	2002-03 to 2024-25	3.49**	3.99**	0.42**
Okra				
1	2002-03 to 2011-12	4.97**	7.00**	1.93**
2	2012-13 to 2024-25	0.69^{NS}	1.13^{NS}	0.93^{NS}
3	2002-03 to 2024-25	2.57**	3.88**	1.37**
Pea				
1	2002-03 to 2011-12	4.01**	8.01**	3.84**
2	2012-13 to 2024-25	3.65**	5.12**	1.32**
3	2002-03 to 2024-25	4.23**	6.76**	2.26**

**,* indicates significance at 1 and 5 per cent level

brinjal (1.86 per cent). Similarly, overall compound annual growth rate in production in the country during twenty-three years was highest for onion (7.93 per cent) followed by pea (6.76 per cent), tomato (5.23 per cent), cauliflower (3.99 per cent), okra (3.88 per cent), potato (3.35 per cent), cabbage (3.12 per cent) and brinjal (2.31 per cent). Overall compound annual growth rate in productivity in the country during same period was highest for tomato (2.43 per cent) followed by pea (2.26 per cent), onion (2.03 per cent), okra (1.37 per cent), potato (1.16 per cent), brinjal (0.42 per cent), cauliflower (0.42 per cent) and cabbage (0.21 per cent). Compound annual growth rate in area during two groups of periods (2002-03 to 2011-12 and 2012-13 to 2024-25) showed that it was higher during 2002-03 to 2011-12 in all studied crops *i.e.* potato, onion, tomato, brinjal, cabbage, cauliflower, okra and pea. Similarly, compound annual growth rate in production was also higher during 2002-03 to 2011-12 in all studied crops except potato. Compound annual growth rate in productivity was also higher during 2002-03 to 2011-12 in all studied crops except potato and cabbage.

Conclusion

Vegetable production offers substantial economic advantages owing to its high value, labour intensive character, and short crop cycle. These attributes make it an ideal enterprise for small and marginal farmers. By providing regular employment and income throughout the year, the vegetable sector enhances livelihood security while contributing significantly to agricultural growth, employment generation, and national production. The analysis showed that the overall compound annual growth rate in area, production and productivity of vegetables in the country during twenty-three years (2002-03 to 2024-25) was 2.90, 4.09 and 1.17% per annum respectively. During two groups of periods, growth rates in vegetable area, production and productivity were higher during 2002-03 to 2011-12 in comparison to 2012-13 to 2024-25. The overall compound annual growth rate in area in the country during twenty-three years was highest for onion (5.83%) followed by pea (4.23%) and cauliflower (3.49%). Similarly, in production it was highest for onion (7.93%) followed by pea (6.76%) and tomato (5.23%) and in productivity it was highest for tomato (2.43%) followed by pea (2.26%) and onion (2.03%). Decomposition analysis concluded that the area contributed significantly in the production of vegetables followed by productivity effect and interaction (area and productivity) effect during the study period. Similarly, during two groups of periods, area effect was more responsible factor for increasing vegetable production than productivity and interaction effect between area and productivity. During overall period (2002-03 to 2024-25) all eight studied vegetable crops have area effect more than productivity effect and interaction effect. Since the supply of resources especially land is limited in nature, productivity of vegetables should be boosted up by adoption of improved high yielding varieties and hybrids, adoption of improved production, protection and post-harvest technologies to meet the future increased demand.

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सारांश

वर्तमान अध्ययन सब्जी उत्पादन में वृद्धि दर एवं कुल सब्जी उत्पादन में सब्जी के अन्तर्गत क्षेत्रफल और उत्पादकता के योगदान को जानने के लिये किया गया। यह अध्ययन 23 वर्षों (2002-03 से 2024-25) की अवधि के द्वितीयक आंकड़ों पर आधारित था। आठ महत्वपूर्ण सब्जियों यथा– आलू, प्याज, टमाटर, बैंगन, पत्तागोभी, फूलगोभी, भिण्डी एवं मटर को विश्लेषण के लिये सम्मिलित किया गया। पिछले 23 वर्षों के दौरान देश में सब्जियों के क्षेत्र, उत्पादन और उत्पादकता में चक्रवृद्धि वार्षिक वृद्धि दर क्रमशः 2.90, 4.09 और 1.17 प्रतिशत प्रति वर्ष रही। क्षेत्रफल में चक्रवृद्धि वार्षिक वृद्धि दर प्याज में सबसे अधिक रही (5.83 प्रतिशत), उसके बाद मटर (4.23 प्रतिशत) एवं फूलगोभी (3.49 प्रतिशत) में थी। इसी प्रकार उत्पादन में वृद्धि दर प्याज में सबसे अधिक (7.93 प्रतिशत), उसके बाद मटर (6.76 प्रतिशत) एवं टमाटर (5.23 प्रतिशत) में थी। उत्पादकता में वृद्धि दर टमाटर में सबसे अधिक (2.43 प्रतिशत) थी, उसके बाद मटर (2.26 प्रतिशत) और प्याज (2.03 प्रतिशत) का स्थान था। अध्ययन अवधि के दौरान सब्जी उत्पादन में वृद्धि मुख्यतः क्षेत्रफल वृद्धि के कारण हुई जिसका योगदान 59.67 प्रतिशत था। सब्जी उत्पादन वृद्धि में उत्पादकता का योगदान 20.83 प्रतिशत था। अध्ययन की गयी सभी आठ सब्जी फसलों में भी उत्पादन वृद्धि में क्षेत्रफल का प्रभाव उत्पादकता एवं अंतःक्रिया प्रभाव से अधिक था। अध्ययन से स्पष्ट है कि देश में सब्जी उत्पादन बढ़ाने में सब्जी के अन्तर्गत क्षेत्रफल, उत्पादकता एवं अंतःक्रिया से ज्यादा महत्वपूर्ण कारक था।