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CAN BUDGET GAINS TRANSLATE INTO CROP GAINS? IMPACT OF NATIONAL HORTICULTURE MISSION (NHM) ON CUMIN AND CORIANDER PRODUCTION IN GUJARAT

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ABSTRACT

India is a global leader in spice production, with Gujarat playing a crucial role in cultivating major seed spices like cumin and coriander. This study evaluates the impact of the National Horticulture Mission (NHM), launched in 2005-06, on the area, production, and yield of these spices in Gujarat. Using compound growth rate and decomposition analysis across three distinct periods (pre-NHM, post-NHM, and overall), the study finds that NHM significantly contributed to the growth of cumin and coriander production—primarily through area expansion and yield improvements. Cumin saw a 989% increase in area, 1,763% in production, and 83% in yield, while coriander experienced a tenfold rise in area and nearly twentyfold growth in production after NHM implementation. District-level analyses reveal that yield improvements played a greater role in cumin growth, while coriander growth was more influenced by area expansion, especially post-NHM. The study underscores NHM's role in boosting Gujarat's spice economy and highlights the need for continued investment in technology and extension services to sustain and enhance these gains.

KEYWORDS: *Growth Trends, Decomposition, Spatio-Temporal Analysis, Seed Spices.*

INTRODUCTION

"Variety is the spice of life" echoed Gurudev Rabindranath Tagore, our national poet par statesman when asked about what is important to life. Spices certainly add life and diversity to the Indian cultural fabric. In addition, spices never cease to add variety to the traditional Indian cuisine and dietary habits since time immemorial and the archaeological remnants of Indus Valley Civilization stand testimony. India is the 'spice bowl of the world' and it is widely known by its sobriquet 'land of spices.' Given the high stakes, if one could make a bold guess and if there could be any correlation analysis between the foreign invasions right from Mughals to the Europeans with India's spice production then the coefficient would certainly turn out to be highly and positively significant.

Out of the 109 commercial spices listed by the International Organization for Standardization (ISO), India produces as many as 75 owing to its varied agro-climatic regions (SBI, 2022). The spices produced in India are broadly categorized in to three major types: seed spices, tree spices and herb spices. Out of the 75 commercial spices grown in India, 20 are classified as seed spices with 46 per cent share in area and 23 per cent share in production of total spices in the country in 2017-18 (NHB, 2022). Seed spices are annual crops whose seeds are consumed as spice which make the food tasty and luxurious and also bear medicinal value and astringent properties. Among the seed spices that are grown, coriander, cumin, fennel, fenugreek and dill are classified as major seed spices, whereas ajwain, celery, anise, nigella and caraway are categorized as minor seed spices.

Gujarat has a special place when it comes to seed spice cultivation in the country. The major seed spices are extensively cultivated in the states of Gujarat, Rajasthan and to a smaller extent in Madhya Pradesh, Punjab, Haryana, and Maharashtra. Among which, the states of Rajasthan and Gujarat together contribute more than 82 per cent of the total seed spices production in the country thereby being touted as the "seed spices bowl" of India. Still, there is wide scope for the development of seed spice sector in these regions.

Impact of National Horticulture Mission on seed spices

With a share of 18.42 per cent in TE 2021-22 in the total acreage of horticultural crops, spices form a major component in Indian horticultural sector. Among the various policies/programmes launched for promoting horticulture, the National Horticulture Mission (NHM) has emerged as the path breaking intervention for aiding in agricultural diversification towards horticulture (Swain *et al*., 2011). The NHM scheme was officially launched on July 8, 2004 and it came to effect form the financial year 2005-06 onwards in

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all the States and Union Territories of India. The mission focuses on horticultural research, development, post-harvest management, processing and marketing in consonance with comparative advantage of each state/region along with the location-specific diverse agro-climatic features. Further, the mission aims at increasing the production and productivity of all horticultural crops through adoption of improved technologies in crop production. The impact of NHM can very well be understood from the increase in total area under horticulture before launch of NHM from 18.44 million ha (2004-05) to 28.04 million ha in 2021-22. Besides, the horticultural production has also increased from 166.93 million tonnes (2004-05) to 355.16 million tonnes (2021-22). Coming to the spice sector, the total spice area and production in India have increased form 24.03 lakh ha and 37.94 lakh tonnes, respectively in 2004-05 to 39.72 lakh ha and 84.23 lakh tonnes, respectively in 2021-22. Similarly, the area under seed spices and their production were 11.52 lakh ha and 7.56 lakh tonnes, respectively in 2004-05 which got improved to 20.62 lakh ha and 18.56 lakh tonnes in 2021-22 after the implementation of NHM in the state The scheme which was launched in 2005 with an initial budget of Rs. 600 crores as a centrally-sponsored scheme, happened to increase its budget to Rs. 2500 cores in 2021-22 (NHB, 2022). Some of the specific benefits that the seed spices received after the implementation of NHM scheme are as follows:

- Development and release of high yielding cultivars of seed spices and few unique short-duration varieties suitable for cultivation on conserved moisture.
- Mulching and low-pressure drip irrigation system in cumin.
- Use of mini-sprinklers in low rising crops like cumin.
- Intercropping of seed spices such as fennel, coriander and ajwain along with carrot, cabbage and cauliflower,
- Intercropping of seed spices in arid fruit orchards of ber and anola.
- Promoting bio-rationales for control of aphids in seed spices.
- Leveraging protected cultivation of seed spices to create more favourable environment for on-season and off-season crops.

METHODOLOGY

The seed spices scenario in Gujarat has undergone a considerable change over the years. The production of all major seed spices has increased visibly owing to the growing importance of the crop in both the domestic and the international fronts. But it has to be seen whether the production has increased due to area expansion or due to improvement in yield. In this study, it can be seen that various seed spices have behaved differently with respect to their growth dimensions (*i.e.,* area, production and yield) in different districts. Accordingly, the present analysis was carried out to understand the trend in area, yield and production of cumin and coriander and to compute the relative shares of factors influencing the output growth of the crops under study for major producing districts as well as the state as a whole. The data on area, production and productivity of major seed spice crops in Gujarat state was obtained from the published reports of the Directorate of Horticulture, Government of Gujarat (DoH, 2022). The study was conducted separately for each of the three periods *viz.,* Period I (1994-95 to 2004-05); Period II (2005-06 to 2020-21); and Period III (1994-95 to 2020-21)., wherein the first and second period refer to the before and after periods of NHM implementation in the country.

TOOLS OF ANALYSIS

(i) Compound Growth Rate

Growth rate is used to measure the past performance of the economic variables in question and describe the trends in those variables over time. Among the different types of growth rate estimations, the compound growth rate (CGR) is commonly used for analysing the growth dimensions related to a particular crop. The CGR is obtained by fitting a straight line to the logarithms of the data and estimating the slope of the line. In the present study, the growth dynamics of seed spice crops was estimated by using compound growth rate of exponential form which is given as follows:

$\mathbf{Y_t = ab^t u_t}$

Where:

Y_t = Area/Production/Productivity/FHP of seed spices in the year 't';
t = Time element
U_t = Disturbance term with Ordinary Least Squares (OLS) assumptions; and
'a' and 'b' = Constant & parameter to be estimated by OLS regression technique.

Here, the parameter 'b' can be rewritten as b = (1+r), where 'r' is the compound growth rate. With the logarithmic transformation of the above equation leads to:

$\mathbf{Log Y_t = Log\ a + t\ Log\ b + Log U_t}$

The coefficient 'b' was obtained by running a log-linear OLS regression function by taking the log of only the dependent variables (*i.e.,* area, production, productivity of cumin and coriander) and the independent variable (*i.e.,* time period). Since the estimate of 'b' is in log-linear function, the following transformation was used to convert it into the original form of 'Y_t':

Log b = Log (1+r)

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Antilog (log b) = 1 + r
r = [Antilog (log 'b')] -1
CGR in percentage = [{Antilog (log 'b')} -1] X 100

The standard error (SE) of Log b was arrived using:

$$\text{Log (B)} = \sqrt{\frac{\sum(Y-\bar{Y})^2 - \text{Log b} * (\sum(Y*t) - \sum(Y)*\bar{t})}{(N-2)\sum(t-\bar{t})^2}}$$

Significance of the growth rates was adjudged by running Student's t-test as follows:

$\hat{g}$ = Compound growth rate in percentage per annum;
[i.e. ($\hat{b}$ – 1) X 100]
$\hat{b}$ = Antilog of log $\hat{b}$;
log $\hat{b}$ = Estimated value of log b;
Se ($\hat{g}$) = Standard error of compound growth rate given by:

$$\text{Se}(\hat{g}) = \frac{100\,\hat{b}}{\log_{10} e}\sqrt{\frac{[\Sigma(\log Y)^2 - (\Sigma \log Y)^2 / N] - [\Sigma t^2 - (\Sigma t)^2 / N](\log \hat{b})^2}{(N-2)[\Sigma t^2 - (\Sigma t)^2/N]}}$$

$\log_{10}^e$ = 0.4343
N = Number of observations; and
n-2 = Connotes the degree of freedom of 't'.

(ii) Decomposition Analysis

The relative contribution of area and yield to the total output change (growth) of an individual crop was first estimated by Minhas and Vaidyanathan (1964) using a component analysis model. Sharma (1977) redeveloped the model into the decomposition of output growth of an individual crop. In the present study, relative contributions of area, productivity and their interaction effect to the total output change in the study crops were worked out by two methods viz. (i) Simple decomposition model and (ii) Modified decomposition model. The Simple Decomposition Model is assumed as follows:

Let P = A*Y

Where: 'P' is the production of a major seed spice;
'A' is the area under a major seed spice; and
'Y' is the yield of a major seed spice.

Then, $\mathbf{P_o = A_o * Y_o}$ **and** $\mathbf{P_n = A_n * Y_n}$

Accordingly, the simple decomposition model was specified as:

$$\mathbf{P_n - P_O = (Y_n - Y_o)A_o + (A_n - A_o)Y_o + (Y_n - Y_o)(A_n - A_o)}$$
$$\mathbf{\Delta P = (\Delta Y)A_0 + (\Delta A)Y_0 + (\Delta Y)(\Delta A)}$$
(Yield Effect) (Area Effect) (Interaction Effect)

Where:
'n' refers to current year and 'o' refers to base year of the study period.

Thereby, the percentage contribution of each effect was estimated by:

$$\mathbf{P = \frac{A_o \Delta Y}{\Delta P} X100 + \frac{Y_o \Delta A}{\Delta P} X100 + \frac{\Delta Y \Delta A}{\Delta P} X100}$$

The triennium average of the start and end of the study period can be taken as the base year and the current year, respectively in the simple decomposition model. However, this method has a flaw as it considers only the data of the selected years and does not take all the years into consideration. Thereby, another method for decomposition analysis as suggested by Palanisami *et al*. (2002) and Laitonjam *et al*. (2018) was used in the present study. The method to be used to rectify the flaw in the model can be called as the Modified Decomposition Analysis as given below:

$$\mathbf{P_t - P_o = A_o(Y_t - Y_o) + Y_o(A_t - A_o) + (A_t - A_o)(Y_t - Y_o)}$$
$$\mathbf{\Delta P_t = A_o \Delta Y_t + Y_o \Delta A_t + \Delta A_t * \Delta Y_t}$$
(Yield Effect) (Area Effect) (Interaction Effect)

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Where: P, A and Y represents production, area and yield; '0' and 't' represents time periods such that 't' > '0' by an accounting period, which is usually a single year. The result obtained from this method is more reliable as the analysis is done for the continuous data without any omission as the case of simple decomposition model.

This way, the percentage contribution of the effects to the change in total production of an individual crop was arrived by:

$$\Delta P\ (\%) = \frac{Ao\,\Delta Yt}{\Delta Pt} X100 + \frac{Yo\,\Delta At}{\Delta Pt} X100 + \frac{\Delta At * \Delta Yt}{\Delta Pt} X100$$

Change in production (%) = Yield Effect + Area Effect + Interaction Effect

MAJOR FINDINGS AND DISCUSSIONS

Seed spice crops are extensively cultivated in the arid and semi-arid region of India during *rabi* season. As of TE 2021-22, the gross acreage under seed spices was 20.62 lakh ha with production of 18.56 lakh tones (SBI, 2022). The major producing states of seed spices are Rajasthan, Gujarat, Chhattisgarh, Haryana, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Uttar Pradesh. The prevailing worldwide demand for seed spices, India contributes 55.7 per cent of the total. As of TE 2021-22, the seed spices occupied 49 per cent area and contributed 21 per cent production of the total area and production of spices in country. The state-wise area, production and productivity statistics of major seed spices of India during the TE 2021-22 are furnished in Table 2. The table clearly shows the importance of seed spices in the Indian economy as some of the seed spices are grown in those areas where other crop cannot be taken and serve as nothing short of a lifeline for those farmers.

In India, the states of Gujarat and Rajasthan are the dominant producers of all the major seed spices. In case of coriander and fenugreek, both the states together contribute 47 per cent and 65 per cent of total production of India, respectively. In fact, Gujarat alone roughly contributed 40 per cent of cumin production in India during TE 2021-22. As presented in Table 2, though the state of Madhya Pradesh emerged as a major coriander producer both in terms of area and production during TE 2021-22, the productivity of coriander was higher in Gujarat. Even in terms of cumin, fennel and fenugreek, the productivity levels have been higher in Gujarat during the study period when compared to the other major seed spice producers. As far as India is concerned, among the major seed spices the acreage under cumin was the highest (8.21 lakh ha) followed by coriander (6.54 lakh ha), fenugreek (2.23 lakh ha) and fennel (0.85 lakh ha) during TE 2021-22 (SBI, 2022). However, in terms of seed spice production, the contribution of coriander was the highest (7.68 lakh tonnes in TE 2021-22) in India followed by cumin and fenugreek.

Table 2: Area, Production and Productivity of Seed Spices in India during TE 2021-22

Major States	Coriander			Cumin			Fennel			Fenugreek		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Madhya Pradesh	2.524	2.958	1.17	-	-	-	0.015	0.026	1.76	0.502	0.774	1.54
Rajasthan	1.921	2.137	1.11	5.038	2.049	0.41	0.393	0.477	1.21	1.388	1.687	1.22
Gujarat	0.943	1.483	1.57	3.189	3.256	1.02	0.424	0.908	2.14	0.097	0.188	1.95
Assam	0.292	0.300	1.03	-	-	-	-	-	-	-	-	-
Odisha	0.194	0.109	0.56	-	-	-	0.010	0.010	1.00	0.024	0.026	1.08
West Bengal	0.115	0.145	1.27	-	-	-	-	-	-	-	-	-
Uttar Pradesh	0.072	0.033	0.46	-	-	-	0.007	0.007	1.05	-	-	-
Andhra Pradesh	0.113	0.050	0.44	-	-	-	-	-	-	-	-	-
India	6.542	7.678	1.17	8.214	5.752	0.64	0.850	1.422	1.67	2.228	2.899	1.30

Note: A – Area in lakh ha; P – Production in lakh metric tonnes; and Y – Yield in metric tonnes / ha.
Source: SBI (2022)

Seed Spice Production in Gujarat

The horticultural sector has witnessed a turn-around in Gujarat since the intervention of National Horticulture Mission (NHM) with increase in total acreage from 9.71 lakh ha in TE 2004-05 to 16.10 lakh ha in TE 2021-22. Similarly, the total horticultural production has also increased in the state from 94.61 lakh tonnes in TE 2004-05 to 229.61 lakh tonnes in TE 2021-22. In terms of spices, Gujarat emerged as the third largest producer with 9.16 lakh tonnes next only to Andhra Pradesh (10.41 lakh tonnes) and Rajasthan (12.79 lakh tonnes) in TE 2021-22 (NHB, 2022). As it could be seen in Table 3, the contribution of Gujarat state in India alone comes out to be 26 per cent in area and 33 per cent in production of all the four spices taken under study. Besides, the major districts of Gujarat together contributing more than 75 per cent of the gross cropped area of major seed spices as furnished in in Table 4.

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Table 3: Area and production of seed spices in India and Gujarat during TE 2021-22

Particular	India		Gujarat		Share of Gujarat in the country	
	A	P	A	P	A (%)	P (%)
Cumin	8.21	5.75	3.18	3.25	38.73	56.52
Fenugreek	2.22	2.90	0.09	0.18	4.05	6.21
Fennel	0.85	1.42	0.42	0.91	49.41	64.08
Coriander	6.54	7.68	0.94	1.48	14.37	19.27
Total of four seed spices	17.82	17.75	4.63	5.82	25.98	32.79
Total spices	38.19	79.75	5.33	9.16	13.96	11.49
Total Horticulture	250.58	3044.09	16.10	229.61	6.43	7.54

Note: A – Area in lakh ha; P – Production in lakh metric tonnes; and Y – Yield in metric tonnes / ha
Source: NHB (2022)

District-Wise Trend in Growth Dimensions of cumin in Gujarat

In 2021-22, Gujarat produced 3.84 lakh metric tonnes of cumin from an area of 3.82 lakh hectare with a productivity of 1,005 kg/ha. The area under cumin has shown increasing trend from 1.25 lakh ha of acreage in 1994-95 to 4.55 lakh ha acreage in 2013-14. However, during 2014-15 the cumin acreage declined to 2.67 lakh ha and in the next three years an increasing trend became visible with the cumin acreage reaching 3.83 lakh ha during 2017-18. Similarly, the production and yield of cumin has shown decreasing trend from 1994-95 to 1999-2000 but afterwards an increasing trend was visible over the years. Putting it in a nutshell, the cumin production in Gujarat which was 65,000 tonnes with a yield of 520 kg/ha in 1994-95 got increased to 3.85 lakh tonnes and 1,005 kg/ha, respectively, in 2021-22.

The mean and standard deviation (S.D.) of area, production and yield of cumin in total Gujarat along with top major four growing districts was given in Table 4. It can be observed that in period I (1994-95 to 2004-05), mean of total Gujarat in terms of area, production and yield was 1,40,004 ha, 62,104 tonnes and 0.45 ton/ha respectively. Similarly, in Period II (2005-06 to 2021-22), mean of total Gujarat in area, production and yield was 3,25,645 ha, 2,70,477.86 tonnes and 0.83 ton/ha respectively. And in case of Period III (1994-95 to 2021-22), Gujarat as a whole was recorded an average acreage of 2,38,154 ha along with average production of 1,69,854 tonnes and productivity of 0.64 ton / ha. Thereby, it can be seen that the Period II (*i.e.*, after National Horticultural Mission) witnessed increased averages in terms of all the growth dimensions across the state of Gujarat.

Table 4: District-wise mean and standard deviation of cumin in Gujarat

District	Study period					
	Period I (1994-95 to 2021-22)		Period II (2005-06 to 2021-22)		Period III (1994-95 to2021-22)	
	Mean	S. D.	Mean	S. D.	Mean	S. D.
Ahmedabad						
Area	18968.18	7931.82	22696.17	6748.57	20983.33	7260.94
Production	8056.00	3709.40	11923.92	4161.65	10125.04	4249.85
Yield	0.43	0.07	0.55	0.23	0.50	0.18
Surendranagar						
Area	21388.45	6799.59	84486.25	22943.51	53750.63	35676.27
Production	10215.91	4379.48	78937.50	31579.89	44969.17	41144.31
Yield	0.48	0.11	0.91	0.19	0.69	0.27
Banaskantha						
Area	29015.91	9963.54	53416.8	18122.20	41194.75	18870.81
Production	11400.45	4078.88	51565.3	20333.55	31661.00	24881.89
Yield	0.41	0.12	0.95	0.08	0.68	0.29
Kachchh						
Area	4471.45	2472.42	17450.08	10856.34	10961.96	10146.51
Production	2081.64	1085.93	13290.42	11504.17	7693.04	9823.57
Yield	0.49	0.10	0.69	0.23	0.59	0.20

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Gujarat						
Area	140004.55	43123.84	325644.50	61577.60	238154.33	106120.10
Production	62104.36	19212.61	270477.86	69643.60	169854.01	115485.80
Yield	0.45	0.07	0.83	0.15	0.64	0.22

Note: Area in ha, production in tonnes and yield in ton / ha.

The mean and standard deviation (S.D.) of area, production and yield of coriander crop when Gujarat state as whole is considered is given in Table 5. Coming to period-wise classification, the mean of total Gujarat in area, production and yield in period I (1994-95 to 2004-05) was noted to be 3,990.91 ha, 3,726.27 tonnes and 0.94 ton/ha, respectively. At the same time, in Period II (i.e. 2005-06 to 2017-18), the mean of total Gujarat in area, production and yield was estimated as 43,468.08 ha, 69,430.91 tonnes and 1.72 ton/ha, respectively. And in case of Period III (1994-95 to 2017-18), Gujarat state as a whole was recorded average coriander acreage of 25,374.8 ha along with a mean production of 39,316.28 tonnes and productivity of 1.36 ton/ ha.

District-Wise Trend in Growth Dimensions of coriander in Gujarat

During the year 2021-22, Gujarat produced 1.17 lakh tonnes of coriander from an area of 0.75 lakh hectare and with a productivity of 1,558 kg/ha. Further, it is also found that the area under coriander has shown stable trend from 1994-95 (2000 ha) to 2002-03 (2194 ha). At the same time, during the time period 2003-04 to 2009-10, acreage under the crop has increased from 6,823 ha to 28,675 ha, respectively but in next three years it showed decreasing trend and cumin acreage became 15,396 ha in 2012-13. In terms of production and yield, coriander has shown secular trend from 1994-95 to 2000-01 but soon followed by increasing trend over the years. Overall, the coriander production in Gujarat during 1994-95 was 2,000 tonnes with productivity of 1,000 kg/ha which increased to 1,16,812 tonnes with a yield of 1,558 kg / ha in 2021-22. The district growth dimensions data of coriander reveal that Junagadh continues to lead the state in coriander production and both the production and yield parameters of the districts have increase after NHM implementation. In fact, in Kachchh district the yield component has doubled with the implementation of NHM. In terms of relative change (%) the increase in the growth dimensions of cumin for the entire state was found to the tune of 989%, 1763% and 83% for cumin acreage, production and yield, respectively. Such higher gains affirm the role of NHM along with the state government machinery despite the fact the production growth still continues to be led by area expansion.

Table 5: District-wise mean and standard deviation of coriander in Gujarat

District	**Study period**					
	Period I (1994-95 to 2004-05)		**Period II (2005-06 to 2021-22)**		**Period III (1994-95 to 2021-22)**	
	Mean	**S. D.**	**Mean**	**S. D.**	**Mean**	**S. D.**
Junagadh						
Area	537.91	551.79	20091.08	18464.56	11129.21	16645.08
Production	471.64	551.74	28733.81	26225.70	15780.31	23788.66
Yield	0.84	0.24	1.56	0.47	1.23	0.53
Kachchh						
Area	596.77	750.93	4788.46	1926.91	2867.27	2595.01
Production	705.07	994.38	10513.5	4266.14	6017.99	5903.26
Yield	1.06	0.11	2.19	0.09	1.68	0.58
Surendranagar						
Area	120.38	100.57	2100.62	3269.68	1193.01	2568.67
Production	85.38	49.85	3342.77	5222.97	1849.80	4120.99
Yield	0.82	0.19	1.53	0.08	1.20	0.38
Rajkot						
Area	623.18	551.24	1709.46	1460.75	1211.58	1245.43
Production	597.91	479.84	2950.17	2723.66	1872.05	2324.64
Yield	0.99	0.12	1.59	0.30	1.32	0.39
Gujarat						
Area	3990.91	2539.84	43468.08	37656.63	25374.38	33858.09
Production	3726.27	2613.38	69430.91	57294.20	39316.28	53235.54
Yield	0.94	0.15	1.72	0.39	1.36	0.49

Note: Area in ha, production in tonnes and yield in ton / ha.

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Trend in Growth Dimensions of Major Seed Spices in Gujarat

The seed spices scenario in Gujarat has undergone a considerable change over the years. The production of all major seed spices has increased visibly owing to the growing importance of the crop in both the domestic and the international fronts. But it has to be seen whether the production has increased due to area expansion or due to improvement in yield. In this study, it can be seen that various seed spices have behaved differently with respect to their growth dimensions (*i.e.*, area, production and yield) in different districts. The present analysis was carried out to understand the trends in the growth dimensions of the major seed spices of cumin and coriander in major production districts in Gujarat as well as Gujarat state as a whole. In addition, decomposition analysis was also carried out to delineate the relative shares of the factors contributing to output growth and to interpret their interaction effects. This way, the study could be of use to grasp the growth dynamics of cumin and coriander cultivation and to understand the effect of targeted NHM interventions promoting yield levels, area expansion and sustainable output.

Spatio-Temporal Growth Pattern of major seed spices

It is pertinent that the common growth dimension of any agricultural crop (*viz.*, area, production and productivity change over the time period. But the extent and intensity in the change depend on the rate of technological interventions as well as policy implications. Thereby, it is important to ascertain trends in growth particulars of crops against its concerned study period. The data on area, production and productivity of major seed spice crops in Gujarat state was employed separately for each of the three periods *viz.*, Period I (1994-95 to 2004-05); Period II (2005-06 to 2021-22); and Period III (1994-95 to 2021-22), coinciding with the before and after implementation of NHM periods. The growth trends for cumin and coriander are presented in the following discussions covering all the major producing districts for each crop as well as the state as a whole.

District-Wise Growth Pattern in cumin

The district-wise trend in the growth dimensions of area, production and productivity of cumin crop in Gujarat state during the study period is presented in Table 6. From the analysis of compound growth rate, it could be found that the all the major cumin growing districts of Gujarat state *i.e*., Ahmedabad, Surendranagar, Banaskantha and Kachchh showed significantly positive growth rate in terms of area in Period I. Among these districts, the Kachchh district recorded the highest growth of 16.80 per cent per annum followed by the Surendranagar district (7.32% per annum), Ahmedabad district (3.00 % per annum) and Banaskantha district (0.14 % per annum). As far as the compound growth rate of production is concerned the Kachchh district stood first with growth rate of 14.05 per cent per annum followed by Surendranagar district (3.67% per annum) at 5 percent level of significance. At the same time, Banaskantha district (-0.89% per annum) showed significantly negative growth at 5 per cent level of significance in Period I. The compound growth rate of productivity in Period I was found to be negatively significant at Ahmedabad (-2.18% / annum), Surendranagar (-3.40% / annum), Kachchh (-2.37% / annum) and Banaskantha district (-1.05% / annum) at various levels of significance.

The compound growth of area of cumin in Period II was found to be significantly highest in Kachchh district with a growth rate of 14.77 per cent per annum at 10 per cent level of significance followed by Banaskantha district (9.33 % / annum), Surendranagar district (5.84 % / annum) and Ahmedabad district (-1.30% / annum) at 5 per cent level of significance. The growth rate of production was found to be highest and significant in Kachchh district with compound growth rate of 21.86 per cent per annum followed by Banaskantha (13.28% / annum), Surendranagar (12.82% per annum) and Ahmedabad (5.06 % / annum). Coming to the growth dimension of productivity, Surendranagar depicted significantly highest growth with 6.56 per cent per annum followed by Ahmedabad (6.44% / annum), Kachchh (6.18% / annum) and Banaskantha (3.60% / annum) at varying levels of significance.

The results of Period III revealed that the compound growth rate of area of Kachchh district was found to be the highest with growth rate 12.15 per cent per annum followed by Surendranagar (10.39% per annum), Banaskantha (5.13 % per annum) and Ahmedabad (1.57 % per annum) at 5 per cent level of significance. Likewise, the production growth rate was found highest in Surendranagar with compound growth rate of 15.33 per cent per annum followed by Kachchh (15.10 % / annum), Banaskantha (11.25% / annum) and Ahmedabad districts (3.54 % / annum) at 5 per cent level of significance. The compound growth rate of productivity of cumin in Period III was found to be highest in Banaskantha with a growth rate 5.84 per cent per annum followed by Surendranagar (4.47 % / annum), Kachchh (2.63 % / annum), and Ahmedabad districts (1.94% / annum).

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Table 6: District-wise growth rate analysis of cumin in Gujarat

Sl. No.	District	Study period					
		Period I (1994-95 to2004-05)		Period II (2005-06 to 2017-18)		Period III (1994-95 to 2017-18)	
		CGR (%)	SE (b)	CGR (%)	SE (b)	CGR (%)	SE (b)
1	**Ahmedabad**						
	Area	3.00*	0.51	-1.30**	0.29	1.57**	0.40
	Production	0.76*	0.49	5.06**	0.33	3.54**	0.40
	Yield	-2.18***	0.16	6.44**	0.32	1.94**	0.29
2	**Surendranagar**						
	Area	7.32**	0.29	5.84**	0.27	10.39**	0.31
	Production	3.67**	0.43	12.82**	0.38	15.33**	0.47
	Yield	-3.40***	0.22	6.56***	0.15	4.47***	0.26
3	**Banaskantha**						
	Area	0.14**	0.45	9.33***	0.18	5.13**	0.35
	Production	-0.89**	0.44	13.28***	0.21	11.25**	0.42
	Yield	-1.05**	0.33	3.60***	0.11	5.84**	0.29
4	**Kachchh**						
	Area	16.80**	0.50	14.77*	0.52	12.15**	0.51
	Production	14.05**	0.46	21.86**	0.51	15.10**	0.50
	Yield	-2.37***	0.19	6.18***	0.19	2.63***	0.23
5	**Gujarat**						
	Area	7.62***	0.17	1.72***	0.18	6.49***	0.22
	Production	5.53**	0.25	6.94***	0.16	11.07***	0.27
	Yield	-1.98***	0.17	5.12***	0.07	4.32***	0.19

*Note: 1. *, ** and *** indicate significance at 10 %, 5 % and 1% levels, respectively;*
2. CGR – Compound Growth Rate and SE- Standard Error of the coeff. estimates;
3. Period I, Period II and Period III are Pre-NHM, Post-NHM and Overall periods of Study, respectively.

On the other hand, Gujarat state as a whole recorded significant growth rates of area, production and productivity for cumin in all three study periods. To be specific, during Period I the compound growth rates per annum of area (7.62 %) and production (5.53 %) were found to be both positive and significant. On the contrary, the productivity showed negative growth rate (-1.98 % / annum) at 1 per cent level of significance. Similarly, in Period II the growth rates of area (1.72 % / annum), production (6.94 % / annum) and productivity (5.12% / annum) were found to be positive at 1 per cent level of significance. In similar vein, the growth rates in Period III were found to be positively significant in terms of area (6.49 % / annum), production (11.07 % / annum) and productivity (4.32% / annum). Similar to the present findings, Soumya *et al.* (2014) and Jhajhria (2015) also reported positive and significant growth rates in their study for the cumin crop at all-India levels. From the results it can observed that the growth rates in terms of area in Gujarat state as a whole were found to be more in pre-NHM period compared to post-NHM period. At the same time, growth rates of production and productivity were found to be more in post-NHM period which may be due to the introduction of high yielding varieties of cumin in the period. At the same time, the increased growth rates can also be due to the advancement of technologies as well as technical practices over the time period.

District-Wise Growth Pattern in Coriander

The district-wise trend in the growth dimension of area, production and productivity of coriander crop in Gujarat state during the study period is presented in Table 7. The results from the analysis revealed that the districts of Junagadh (39.53 % / annum), Kachchh (16.58 % / annum), Surendranagar (-4.04 % / annum) and Rajkot (1.26 % / annum) showed positive but non-significant growth in area of coriander crop during Period I. Similarly, the compound growth rate of production was found to be positive yet non-significant in Junagadh (34.28 % / annum), Kachchh (18.87 % / annum) and Rajkot (0.81 % / annum) whereas, Surendranagar (-2.71 % / annum) showed significantly negative growth in coriander during the same Period I at 10 per cent level of significance. The productivity growth rate of Kachchh district was found highest with a growth rate of 1.60 per cent per annum followed by Surendranagar (1.38 % / annum) whereas, Junagadh district (-3.77 % / annum) and Rajkot (-0.46 % / annum) reported significant but negative growth rates in period I.

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In period II, the growth of area was found to be positive in Junagadh (24.81 %) followed by Kachchh (4.06 %). The growth of production was also found to be highest in Junagadh with 20.99 per cent followed by Kachchh 3.99 per cent. In case of productivity, Rajkot showed highest positive growth rate with 4.48 per cent followed by Surendranagar 1.21 per cent. In connection to the results of Period III, the compound growth rate of area of Junagadh (36.01 % / annum), Kachchh (19.31 % / annum), Surendranagar (17.97 % / annum) and Rajkot (8.96 % / annum) showed positive but non-significant growth rates. In a similar pattern, the growth rates of production across the study districts were also found to be non-significant. The compound growth rate of productivity of coriander for the overall period (i.e. Period III) was found to be highest per annum in Kachchh (4.78 % / annum) followed by Surendranagar (4.45 % / annum), Junagadh (3.14% / annum) and Rajkot (3.06 % / annum) at varying levels of significance based on the given hypotheses.

Table 7: District-Wise Growth Rate Analysis of Coriander in Gujarat

Sr. No.	District	Study period					
		Period I (1994-95 to 2004-05)		Period II (2005-06 to 2017-18)		Period III (1994-95 to 2017-18)	
		CGR (%)	SE(b)	CGR (%)	SE(b)	CGR (%)	SE(b)
1	**Junagadh**						
	Area	39.53	1.06	24.81*	0.68	36.01	0.88
	Production	34.28	1.27	20.99*	0.66	40.29	1.06
	Yield	-3.77**	0.33	-3.05***	0.21	3.14**	0.38
2	**Kachchh**						
	Area	16.98	0.86	4.06**	0.46	19.31	0.78
	Production	18.87	0.94	3.99**	0.46	25.03	0.91
	Yield	1.60***	0.09	-0.08***	0.04	4.78**	0.31
3	**Surendranagar**						
	Area	-4.04	0.81	43.42	1.08	17.97	1.17
	Production	-2.71*	0.63	45.16	1.08	23.22	1.11
	Yield	1.38**	0.27	1.21***	0.03	4.45**	0.31
4	**Rajkot**						
	Area	1.26	0.74	19.59	0.60	8.96	0.71
	Production	0.81	0.73	24.94	0.62	12.88	0.75
	Yield	-0.46***	0.13	4.48***	0.14	3.60***	0.16
5	**Gujarat**						
	Area	11.88**	0.46	22.69**	0.42	19.63**	0.45
	Production	9.95**	0.49	21.14**	0.31	23.68**	0.48
	Yield	-1.73***	0.18	-1.25***	0.19	3.39***	0.27

*Note: 1. *, ** and *** indicate significance at 10 %, 5 % and 1% levels, respectively;*
2. CGR – Compound Growth Rate and SE- Standard Error of the coeff. estimates;
3. Period I, Period II and Period III are Pre-NHM, Post-NHM and Overall periods of the study, respectively.

Overall, the state of Gujarat recorded significant growth rates in terms of area, production and productivity of coriander in all three study periods. To be precise, the growth rates of area (11.88 % / annum) and production (9.95 % / annum) in Period I were found to be positively significant at 95 per cent probability level. But in terms of productivity the growth rate was found to be significantly negative (-1.73 %/annum) at 99 per cent probability level. Similarly, in case of Period II, the area (22.69 % / annum), production (21.14 % / annum) showed significant and positive growth rates at 5 per cent level of significance while productivity (-1.25 % / annum) showed negative growth rate at 1 per cent level of significance. Coming to period III, the growth rates of area (19.63 % / annum), production (23.68 % / annum) and productivity (3.39 % / annum) were significant as well as positive at different levels of significance. Kumar *et al*. (2017) also reported similar findings in their study on coriander Thus, it can be observed from the results that though area and production parameters of coriander crop have generally increased during post-NHM period, the growth rate in productivity has significantly decrease not only in terms of Gujarat state as a whole but across the districts as well.

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Decomposition Analysis of Major Seed Spices in Gujarat

A quantitative assessment of contribution of the various factors to growth of major seed spice crops in major growing districts of Gujarat state is helpful in reorienting institutional interventions and setting priorities of agricultural development so as to achieve higher growth rates of agricultural production. There are many factors which affect the growth of a crop output. The factors that are assumed to affect the production of crop as given in the available literature are area effect; yield effect and their interaction effect. Accordingly, all these factors have been considered in the present study. The decomposition analysis was performed for all the three periods under study *viz.* 1994-95 to 2004-05 (Period I); 2005-06 to 2021-22 (Period II); and 1994-95 to 2021-22 (Period III or Overall Period).

Decomposition Analysis in Cumin Crop

The decomposition of cumin production in terms of area, yield and interaction effects are presented in Table 8. The results demonstrate that the per cent contribution of all the effects for increasing production of cumin in all the major districts of Gujarat.

As it could be observed from the table, during period I, the area effect of -14.93 per cent was responsible for decreasing the production of cumin in Ahmedabad district whereas, both yield effect (83.33 %) and interaction effect (31.59 %) contributed positively. At the same time, the area effect was found to be positive for the districts of Surendranagar, Banaskantha and Kachchh during Period I. In similar vein, the yield effect was also found to be positive in all the districts. On the contrary, interaction effect was negative in Banaskantha and Kachchh districts.

During period II the area effect in Ahmedabad district was found to contribute more (164.88 %) to production when compared to that of yield effect (-34.28 %) and interaction effect (-29.95 %). Lowest area effect was observed in Kachchh district i.e. 24.73 per cent and highest yield effect was also found in this district with 70.73 per cent during the same period. In the districts of Surendranagar, Banaskantha and Kachchh the yield effect was found to be at.44.23, 67.47 and 70.73 per cent, respectively and their contribution to the cumin production during post-NHM phase was also found to be positive. In case of interaction effect, Surendranagar showed highest contribution to production with 22.85 per cent.

During the overall period, largest area effect was recorded in Ahmedabad district *i.e.* 1013.51 per cent and both yield and interaction effects were observed to be negative *i.e.* -513.94 and -399.57 per cent, respectively. Except for Ahmedabad district, all other districts showed positive effect in terms of yield. The largest interaction effect over production was found in Surendranagar district (24.85 %) and largest yield effect was found in Banaskantha district *i.e.* 80.43 per cent.

Table 8: Decomposition of Growth in Cumin Production (1995-2018)

Sl. No.	District / Period	Per Cent Contribution (%)		
		Area	Yield	Interaction
1.	**Ahmedabad**			
	1994-95 to 2004-05 (Period I)	-14.93	83.33	31.59
	2005-06 to 2017-18 (Period II)	164.88	-34.93	-29.95
	1994-95 to 2017-18 (Overall)	1013.51	-513.94	-399.57
2.	**Surendranagar**			
	1994-95 to 2004-05 (Period I)	17.74	34.84	45.97
	2005-06 to 2017-18 (Period II)	32.90	44.23	22.85
	1994-95 to 2017-18 (Overall)	27.04	48.15	24.80
3.	**Banaskantha**			
	1994-95 to 2004-05 (Period I)	138.74	255.56	-294.30
	2005-06 to 2017-18 (Period II)	30.82	67.47	1.70
	1994-95 to 2017-18 (Overall)	40.62	80.43	-21.05
4.	**Kachchh**			
	1994-95 to 2004-05 (Period I)	37.85	128.40	-66.26
	2005-06 to 2017-18 (Period II)	24.73	70.73	4.53
	1994-95 to 2017-18 (Overall)	26.44	72.73	0.82
5.	**Gujarat**			
	1994-95 to 2004-05 (Period I)	26.33	85.11	-12.91
	2005-06 to 2017-18 (Period II)	66.49	53.68	-20.17
	1994-95 to 2017-18 (Overall)	55.42	60.52	-15.89

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Coming to the additive decompositional analysis of cumin for the state of Gujarat as a whole, the largest contribution of yield effect *i.e.* 85.11 per cent was observed during period I. The impact of NHM as captured in Period II showed that the contribution of area (66.49 %) over production was more than that of yield (53.68 %). During the overall period, the area and yield effects displayed positive contribution over production while interaction effect was observed to be negative.

Decomposition Analysis in Coriander Crop

The decomposition of coriander production in terms of area, yield and interaction effect is presented in Table 9. As the findings reveal that during period I the area effect was highly negative (-295.65 %) followed by negative yield effect (-191.08 %) in Surendranagar district leading to decline in production levels.

Table 9: Decomposition of growth in coriander production (1995-2018)

Sr. No.	District/period	Percent contribution		
		Area	Yield	Interaction
1.	**Junagadh**			
	1994-95 to 2004-05 (Period I)	0.42	61.47	38.10
	2005-06 to 2017-18 (Period II)	1.85	118.61	-20.46
	1994-95 to 2017-18 (Period III)	12.63	92.15	-4.78
3.	**Kachchh**			
	1994-95 to 2004-05 (Period I)	2.40	85.99	11.59
	2005-06 to 2017-18 (Period II)	-6.81	106.99	-0.17
	1994-95 to 2017-18 (Period III)	12.55	82.21	5.23
5.	**Surendranagar**			
	1994-95 to 2004-05 (Period I)	-295.05	-191.08	487.13
	2005-06 to 2017-18 (Period II)	5.30	73.11	21.57
	1994-95 to 2017-18 (Period III)	10.86	74.86	14.26
6.	**Rajkot**			
	1994-95 to 2004-05 (Period I)	333.24	-115.83	-117.41
	2005-06 to 2017-18 (Period II)	-11.36	108.05	3.30
	1994-95 to 2017-18 (Period III)	-7.47	118.64	-11.17
7.	**Gujarat**			
	1994-95 to 2004-05 (Period I)	28.86	93.56	-22.22
	2005-06 to 2017-18 (Period II)	6.39	142.90	-49.25
	1994-95 to 2017-18 (Period III)	16.58	128.38	-44.96

Except for Surendranagar district, the area effect was found to be positively contributing to coriander production in all the remaining districts during Period II. During the same period, the yield effect was found to be larger in overall Gujarat (93.56 %) followed by Kachchh (85.99 %) and Junagadh (61.47 %). Coming to Period III, the contribution of area effect to coriander production was found to be negative in Rajkot district (-7.47 %) alone. On the contrary the contribution of yield effect over production was observed to be positive across the districts and Gujarat state as well with the highest effect of yield being noticed in Gujarat (128.38 %) followed by Rajkot (118.64 %) and Junagadh (92.15 %).

CONCLUSION

The study conclusively demonstrates that the National Horticulture Mission (NHM) has had a significant positive impact on the production of cumin and coriander in Gujarat, primarily by expanding cultivation area and, to a considerable extent, improving yields. The decomposition analysis further revealed that while cumin benefited from both area expansion and technological interventions leading to yield gains, coriander's growth was largely area-driven, though yield improvements followed in recent years. To sustain and amplify these gains, policy focus should shift toward intensifying yield-enhancing measures—such as promoting high-yielding and disease-resistant varieties, scaling up micro-irrigation and protected cultivation techniques, and strengthening the crop advisory services. Further, region-specific interventions that target low-productivity districts can enhance the efficiency and equity of spice crop development in the times to come.

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