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Growth rate and instability analysis of area, production, and productivity of rapeseed-mustard crop in Gujarat state

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Abstract

Agriculture has been and will continue to be the lifeline of the Indian economy. As the largest private enterprise in India, agriculture contributes nearly about 14 percent of the national GDP. This sector employs about 50-60% of the Indian population. The crops that are cultivated for the production of oils are known as oilseed crops. Rapeseed-mustard is a group of oilseed crops belonging to the Brassicaceae family, primarily cultivated for their oil-rich seeds. Rapeseed-mustard cultivation in Gujarat shows varied trends, with regions like North Gujarat and Saurashtra exhibiting growth in production and productivity despite some district-level declines, while Central Gujarat highlights resilience through yield optimization amid mixed results. In North Gujarat Region Highest instability in area (CV 104.95%, CDVI 97.76%) and production (CV 118.58%, CDVI 107.54%) in Kutch region. Lower instability in area (CV 14.14%, CDVI 14.41%) and production (CV 25.16%, CDVI 24.98%) for overall India and productivity was more stable in Gujarat (CV 17.09%, CDVI 3.50%) compared to India (CV 15.38%, CDVI 13.13%).

Keywords: Growth rate, instability, rapeseed-mustard, Gujarat, India

Introduction

Agriculture has been and will continue to be the lifeline of the Indian economy. As the largest private enterprise in India, agriculture contributes nearly about 14 percent of the national GDP. This sector employs about 50-60% of the Indian population. Sustains livelihood of about two thirds of population and is the backbone of agro based industries. A large number of important industries like textiles, vanaspati oils, jute, tobacco and sugar are sustained on raw materials produced in farm sector. The crops that are cultivated for the production of oils are known as oilseed crops. Oilseeds are the raw materials for vegetable oils and they are energy rich crops. Oilseed crops are the most important commercial crops in India. Edible oils are next to food grains in Indian diet. Edible oils are the concentrated sources of energy. The energy content of oil is much higher (39.80 MJ/kg) than protein (23.88 MJ/kg) or carbohydrate (16.76 MJ/kg). Rapeseed-mustard is a group of oilseed crops belonging to the Brassicaceae family, primarily cultivated for their oil-rich seeds. Mustard oil is also rich in vit. E and has good stability at high temperature also.

Methodology

Description of study area and period

The study focused on mustard, which ranked third in terms of triennium average area and production among oilseeds in

Gujarat. The analysis covered the period from 2000-01 to 2021-22, examining district-wise and region -wise trends across the state. Data was thoroughly analysed to estimate mustard cultivation patterns and productivity levels within Gujarat, and these findings were subsequently compared with national trends across India.

Nature and sources of data

The study was entirely based on secondary data. Secondary time series data were utilized to address the specific objective of the study, namely the growth rate. Relevant secondary data for this objective were collected from the Directorate of Agriculture, Department of Agriculture, Farmers' Welfare & Cooperation, Government of Gujarat, the Indian Institute of Oilseeds Research (IIOR) (Anonymous^a), and Indiatat. (Anonymous^b).

Growth rates analysis

Growth rate can be defined as the rate of change per unit time. It is used to measure the past performance of the economic variables in question and describe the trends in those variables over time. The normal statistical procedure to obtain a growth dynamics of crops over a period is to postulate a hypothetical function which would adequately describe the series of economic variables over time and estimate their parameters. Growth rate is generally

expressed in two forms, viz., linear and compound. The linear form is obtained by fitting a straight line to the yearly data and estimating the parameters. The compound growth rate is obtained by fitting a straight line to the logarithms of the data and estimating the slope of the line (Acharya *et al.*, 2012).

Compound growth rate

The compound growth rates (CGR's) of vegetable products export in India was calculated by using the exponential function of the following specification:

$$Y_t = ab^t$$

Where,

Y = Dependent variable (Export quantity/ export value);

t = Time variable in years taking the value of 1, 2, 3,...,n;

a = Intercept;

b = Regression coefficient (1+ r);

r = Compound growth rate.

For the purpose of estimation, the equation is expressed in logarithmic form.

$$\text{Log } Y_t = \text{Log } a + t \text{ log } b$$

The value of log b in equation (2) was computed using the formula,

$$\text{Log } b = \frac{(\sum t \text{ Log } Y - (\sum t \sum \text{Log } Y / N))}{\sum t^2 - (\frac{\sum t^2}{N})}$$

Where,

N = Number of years.

Subsequently, the compound growth rate (%) was computed using the formula,

$$\text{Compound growth rate (r)} = [(\text{Antilog of log } b) - 1] \times 100$$

Student 't' test was used to determine the significance of the growth rates obtained for which, the following formulation was employed,

$$t = \text{Log } b / \text{SE}(\text{Log } b)$$

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

The calculated 't' values, from equation (6), was compared with the table 't' values and the significance was tested for 1 and 5 percent, probability levels.

Instability analysis

Instability is the one of the important decision parameters in development dynamics, more so in the context of agriculture production. Wide fluctuations in crop output not only affect prices and bring about sharp fluctuations in them but also result in wide variation in the disposable income of the farmer. The magnitude of fluctuation depends on the nature of product technology, its sensitivity to weather, economic, environment, availability of material input and many other factors. Here, instability or variability measures how spread out or closely clustered a set of data is. The instability was

measured with the following two methods,

a) Coefficient of variation (CV %)

b) Cuddy Della Valle Index (CDVI %)

Coefficient of variation (CV %)

The coefficient of variation was computed to find out the extent of variability in area, production and productivity during the study period.

$$\text{CV \%} = \frac{\text{Standard deviation } (\sigma)}{\text{Mean } (\bar{X})} \times 100$$

Cuddy Della Valle Index (CDVI %)

Cuddy- Della index is most commonly used measures of instability of time series data. The indices were originally developed by John Cuddy and Della Valle for measuring the instability in time series data. Cuddy Della-Valle index first de-trends the given series and gives a clear direction about the instability. The simple coefficient of variation over-estimates the level of instability in time-series data characterized by long-term trends whereas the Cuddy-Della Valle index corrects the coefficient of variation. As against that, Cuddy-Della Valle index attempts to de-trend the CV by using adjusted coefficient of determination ($\bar{R}^2$). Thus, it is a better measure to capture instability in agricultural production. A low value of this index indicates the low instability in time series data and vice-versa.

$$\text{CDVI \%} = \text{CV} \times \sqrt{(1 - \bar{R}^2)}$$

Where,

CDVI = Cuddy-Della Valle index, i.e., Corrected Coefficient of Variation

CV = Coefficient of Variation

= Adjusted R², i.e., Coefficient of determination (R²) from time trend regression adjusted by the number of degrees of freedom

Results and Discussion

Growth Rate

District and region wise growth rates of area, production and productivity of rapeseed-mustard crop in Gujarat state.

North Gujarat region

The annual growth rates of rapeseed-mustard crop in North region of Gujarat state have been estimated.

Table 1: Compound growth rate of rapeseed-mustard in North Gujarat region. (2000-01 to 2021-22)

Districts	Area	Production	Productivity
Kutch	6.22	8.83	2.45***
Banaskantha	-0.30***	2.26***	2.57***
Patan	17.88	20.28	27.45
Mehsana	-6.16***	-4.30***	1.99***
Sabarkantha	-6.24	-3.24	0.78
Gandhinagar	-7.34	-5.55	-1.46
North Gujarat	-0.75***	1.61***	2.37***

Note: *, ** and *** represents level of significance at 10, 5 and 1 percent respectively.

According to Table 1, the results revealed that Kutch district

exhibited substantial positive growth in area (6.22%) and production (8.83%), with a significant productivity increase (2.45%), indicating overall improvement in rapeseed-mustard cultivation. Banaskantha district showed a marginal decline in area (-0.30%), but both production (2.26%) and productivity (2.57%) experienced significant positive growth. Patan district recorded the highest growth rates in area (17.88%), production (20.28%), and productivity (27.45%), reflecting a strong expansion and enhancement in the cultivation of the crop. Mehsana district faced significant declines in area (-6.16%) and production (-4.30%), although productivity showed a significant positive growth (1.99%). Sabarkantha district experienced declines in both area (-6.24%) and production (-3.24%), with a slight increase in productivity (0.78%), showing a reduction in cultivated area but a minor improvement in yield. Gandhinagar district saw negative growth across all parameters, with area (-7.34%), production (-5.55%), and productivity (-1.46%) all decreasing, indicating an overall decline in rapeseed-mustard cultivation in the district. Overall, the North Gujarat region exhibited a slight decline in area (-0.75%), but positive growth in production (1.61%) and productivity (2.37%), suggesting that while the total area under cultivation reduced slightly, overall production and efficiency improved.

Saurashtra region

The annual growth rates of rapeseed-mustard crop in Saurashtra region of Gujarat state have been estimated.

Table 2: Compound growth rate of rapeseed-mustard in Saurashtra region. (2000-01 to 2021-22)

Districts	Area	Production	Productivity
Surendranagar	13.08	15.53	2.13***
Rajkot	10.33	11.77	2.82***
Jamnagar	-8.48	-5.92	3.81***
Junagadh	-18.16	-16.29	3.57***
Bhavnagar	-14.77*	-11.92	5.12***
Saurashtra region	3.71	5.61	1.84***

*Note: *, ** and *** represents level of significance at 10, 5 and 1 percent respectively

**Note: In Saurashtra region, data was not available for Porbandar and Amreli districts

As per the results in Table 2, it was indicated that Surendranagar and Rajkot had exhibited positive growth in area, production, and productivity. Surendranagar had shown the highest growth in production (15.53%) and a significant increase in productivity (2.13%). Rajkot had also seen notable growth in production (11.77%) and productivity (2.82%). On the other hand, Jamnagar, Junagadh, and Bhavnagar had experienced a decline in both area and production. However, productivity had increased significantly in all three, with Bhavnagar having the highest increase in productivity (5.12%), despite a significant decline in area (-14.77%) and production (-11.92%). Overall, the Saurashtra region had shown positive growth rates in both area (3.71%) and production (5.61%), and it had also exhibited significant positive growth in productivity. The positive growth in productivity across the region suggests that a continued focus on improving efficiency and yield could help offset the declines in area and production in certain districts.

Central Gujarat

The annual growth rates of rapeseed-mustard crop in Central Gujarat region have been estimated.

Table 3: Compound growth rate of rapeseed-mustard in Central Gujarat. (2000-01 to 2021-22)

Districts	Area	Production	Productivity
Ahmedabad	-8.17	-5.20	3.31***
Anand	4.98	7.81	28.24
Kheda	-8.94*	-7.18	1.94***
Panchmahal	1.06**	3.59**	5.73***
Vadodara	-9.21	-7.23	3.49
Central Gujarat	-5.45***	-3.23***	2.35***

*Note: *, ** and *** represents level of significance at 10, 5 and 1 percent respectively

**Note: In Central Gujarat region, data was not available for Dahod district

According to Table 3, results revealed that Ahmedabad district experienced negative growth rates in both area (-8.17%) and production (-5.20%), but showed a significant increase in productivity (3.31%). Anand district witnessed positive growth in both area (4.98%) and production (7.81%), with an exceptionally high productivity growth of 28.24 percent. Kheda district demonstrated a decrease in area (-8.94%) and production (-7.18%), but productivity showed a significant increase (1.94%). Panchmahal district showed positive growth in both area (1.06%) and production (3.59%), with a significant productivity increase (5.73%). Vadodara district experienced negative growth rates in both area (-9.21%) and production (-7.23%), but with a significant increase in productivity (3.49%).

Overall, Central Gujarat exhibited a negative growth rate in both area (-5.45%) and production (-3.23%), but with a positive growth in productivity (2.35%). This suggests that while there were challenges in expanding cultivation and production, there were notable improvements in efficiency and yield per unit area.

South Gujarat

*Note: In the entire South Gujarat region, data of area, production, and productivity for rapeseed-mustard crops was unavailable.

Gujarat state Vs India

The annual growth rates of rapeseed-mustard crop in Gujarat state Vs. India have been estimated.

Table 4: Compound growth rate of rapeseed-mustard in Gujarat state vs. India. (2000-01 to 2021-22)

Gujarat		India	
Area	-0.69***	Area	1.17***
Production	1.65***	Production	3.28***
Productivity	2.36***	Productivity	2.09***

*Note: *, ** and *** represents level of significance at 10, 5 and 1 percent respectively

In Table 4, the results revealed that Gujarat experienced a significant decline in the area under rapeseed-mustard cultivation, with an annual rate of -0.69 percent. In contrast, the area in India increased significantly at an annual rate of 1.17 percent. Both regions saw significant increases in production. Gujarat's production grew at 1.65 percent per

annum, while India's production grew at a higher rate of 3.28 percent per annum. Productivity improvements were significant in both regions. Gujarat's productivity increased at an annual rate of 2.36 percent, which was higher than the national rate of 2.09 percent.

Overall, the results concluded that despite a decrease in the area under cultivation, Gujarat achieved notable gains in both production and productivity of rapeseed-mustard. At the national level, the positive growth rates in area, production, and productivity for rapeseed-mustard in India highlighted overall agricultural expansion and efficiency

improvements. Similar results were found for India by Kalia *et al.* (2021)^[6].

Instability

District and region wise instability analysis of area, production and productivity of rapeseed-mustard crop in Gujarat state.

North Gujarat region

The instability of rapeseed-mustard crop in North region of Gujarat state have been estimated.

Table 5: Instability analysis of rapeseed-mustard in North Gujarat region. (2000-01 to 2021-22)

Districts	Area		Production		Productivity	
	CV (%)	CDVI (%)	CV (%)	CDVI (%)	CV (%)	CDVI (%)
Kutch	104.95	97.76	118.58	107.54	16.87	7.84
Banaskantha	20.52	20.80	26.95	24.36	18.84	10.13
Patan	51.51	52.33	49.06	48.57	42.30	31.25
Mehsana	46.84	26.36	37.99	26.37	16.31	10.23
Sabarkantha	68.96	61.80	69.04	67.48	53.03	44.53
Gandhinagar	82.45	73.99	81.20	75.19	26.78	26.30
North Gujarat	22.79	21.88	26.66	23.22	17.22	3.93

Table 5, shows the district wise instability analysis of rapeseed and mustard in North Gujarat region from the year 2000-01 to 2021-22. In North Gujarat, the Kutch district accounted for the highest instability indices in area and production, *i.e.* values of CV and CDVI are 104.95 percent and 97.76 percent in case of area and in case of production values of CV and CDVI are 118.58 percent and 107.54 percent respectively. While the Banaskantha district had the lowest instability indices in area, production and productivity, *i.e.* values of CDVI are 20.80 percent, 24.36 percent and 10.13 percent respectively. The productivity of

rapeseed and mustard also showed notable variability. Sabarkantha district observed highest instability indices, *i.e.* values of CV and CDVI are 53.03 percent and 44.53 percent respectively. It can be inferred from the results that Banaskantha district recorded lower instability index in comparison with North Gujarat district in case of rapeseed and mustard.

Saurashtra region

The instability analysis of rapeseed-mustard crop in Saurashtra region of Gujarat state have been estimated.

Table 6: Instability analysis of rapeseed-mustard in Saurashtra region. (2000-01 to 2021-22)

Districts	Area		Production		Productivity	
	CV (%)	CDVI (%)	CV (%)	CDVI (%)	CV (%)	CDVI (%)
Surendranagar	190.38	171.46	212.05	190.96	16.13	9.15
Rajkot	215.07	197.42	223.13	204.67	43.98	40.08
Jamnagar	218.34	217.09	253.47	248.68	40.43	31.97
Junagadh	108.94	70.94	104.55	67.72	40.98	33.55
Bhavnagar	112.12	68.80	103.83	73.71	48.60	33.30
Saurashtra region	188.92	167.65	214.86	184.01	14.90	15.07

Note: In Saurashtra region, data was not available for Porbandar and Amreli districts

Table 6, shows the district wise instability analysis of rapeseed and mustard in Saurashtra region from the year 2000-01 to 2021-22. In Saurashtra, the Jamnagar district accounted for the highest instability indices in area and production, *i.e.* values of CV and CDVI are 218.34 percent and 217.09 percent in case of area and in case of production values of CV and CDVI are 253.47 percent and 248.68 percent respectively. While the Bhavnagar district had the lowest instability indices in area, *i.e.* values of CDVI is 68.80 percent. While in case of production, Junagadh district had the lowest instability indices in production, *i.e.* values of CDVI is 67.72 percent. The productivity of rapeseed and mustard, Surendranagar district observed lowest instability indices, *i.e.* values of CV and CDVI are 16.13 percent and 9.15 percent respectively. On the other hand, Rajkot district had the highest instability indices in

productivity, *i.e.* values of CDVI is 40.08 percent.

Central Gujarat: The instability analysis of rapeseed-mustard crop in Central Gujarat region have been estimated.

Table 7: Instability analysis of rapeseed-mustard in Central Gujarat. (2000-01 to 2021-22)

Districts	Area		Production		Productivity	
	CV (%)	CDVI (%)	CV (%)	CDVI (%)	CV (%)	CDVI (%)
Ahmedabad	69.24	63.72	80.07	81.54	23.14	11.25
Anand	58.98	60.02	55.99	57.37	43.90	29.45
Kheda	60.27	38.97	54.44	43.04	18.27	13.34
Panchmahal	41.89	42.37	48.09	43.89	47.60	28.96
Vadodara	85.57	78.71	86.02	82.10	38.81	32.19
Central Gujarat	45.86	2.71	45.00	1.21	17.89	14.92

Note: In Central Gujarat region, data was not available for Dahod district

Table 7 shows the district wise instability analysis of rapeseed and mustard in Central Gujarat region from the year 2000-01 to 2021-22. In Central Gujarat, the Vadodara district accounted for the highest instability indices in area and production, *i.e.* values of CV and CDVI are 85.57 percent and 78.71 percent in case of area and in case of production values of CV and CDVI are 86.02 percent and 82.10 percent respectively. While the Kheda district had the lowest instability indices in area and production, *i.e.* values of CDVI is 38.97 percent and 43.04 percent respectively. The productivity of rapeseed and mustard, Ahmedabad district observed lowest instability indices, *i.e.* values of CDVI is 11.25 percent. On the other hand, Vadodara district had the highest instability indices in productivity, *i.e.* values of CDVI is 32.19 percent.

South Gujarat

Note: In the entire South Gujarat region, data of area, production, and productivity for rapeseed-mustard crops was unavailable.

Gujarat state Vs India

The instability analysis of rapeseed-mustard crop in Gujarat state Vs. India have been estimated.

The table 8 presents an instability analysis of rapeseed and mustard production in Gujarat state compared to the entire country of India from the period 2000-01 to 2021-22. Gujarat showed higher instability indices in the area under cultivation for rapeseed and mustard (CV of 24.09% and CDVI of 23.61%) compared to India as a whole (CV of 14.14% and CDVI of 14.41%). The production of rapeseed and mustard was more unstable in Gujarat (CV of 28.84% and CDVI of 25.83%) than in India overall (CV of 25.16% and CDVI of 24.98%). Productivity in Gujarat was more stable (CV of 17.09% and CDVI of 3.50%) compared to the national level (CV of 15.38% and CDVI of 13.13%). Similar results were found for India by Kalia *et. al.* (2021) [6].

Table 8: Instability analysis of rapeseed-mustard in Gujarat state vs. India. (2000-01 to 2021-22)

Gujarat			India		
Area	CV (%)	24.09	Area	CV (%)	14.14
	CDVI (%)	23.61		CDVI (%)	14.41
Production	CV (%)	28.84	Production	CV (%)	25.16
	CDVI (%)	25.83		CDVI (%)	24.98
Productivity	CV (%)	17.09	Productivity	CV (%)	15.38
	CDVI (%)	3.50		CDVI (%)	13.13

Conclusion

Rapeseed-mustard varied growth trends were observed across North Gujarat, Saurashtra, and Central Gujarat, with some districts showing expansion in production and productivity while others faced challenges. Gujarat experienced a decline in cultivation area but showed positive growth rates in production and productivity, underscoring the need for targeted policies to address regional disparities and across Gujarat highlights significant instability in agricultural production. Cultivation witnessed pronounced instability in Kutch and Jamnagar for area and production, emphasizing regional disparities in stability. Over all Gujarat had higher instability in area and

production compared to India.

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