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Long Term Performance of Cereals in Gujarat - An Empirical Analysis

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NS and BKB managed the analyses of the study. Author MSS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

High growth in agriculture sector was observed in Gujarat during recent years. This was mainly attributed to shift in cropping pattern of the state towards high value crops. Hence this particular study was conducted to know the status of cereal crops in the state by assessing the performance of cereals crops on long term basis using most recent and powerful statistical tools. Secondary time series data on area, production and yield of cereal crops was collected from Season and Crop Reports, Department of Economics and Statistics (DES), Government of Gujarat, online data bank of International Crop Research Institute for Semi-Arid Tropics and Economic and Political Weekly (EPW) data bank for the period from 1970-71 to 2011-12. Best fit non-linear model was fitted and parameters of the model were estimated using Marquardt algorithm. Instability was estimated by constructing Cuddy-Della Valle Index. Result shows that, production of cereal crops in the state has increased mainly because of improvement in the yield. The productivity of cereal crops was notably

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improved after the year 1991 in all the parts of state. Area under cereals has registered negative growth during entire study period at state as well as at district level also. The significant reduction in the magnitude of yield instability was recorded in the second sub-period of study, which helps to reduce the instability in production during the same period. More fluctuation in area under cereals crops was observed in second sub period of the study. It was observed that, yield variability was a most important source of instability in production of cereal crops. Hence, it is appropriate to adopt the yield stabilisation measure in cereal crops in the state.

Keywords: Cereals; Cuddy-Della Valle Index; Gujarat; growth; instability; marquardt algorithm; performance.

1. INTRODUCTION

Agriculture occupies a predominant place in economy of Gujarat state. The state showed diversification in the agriculture sector and a predominantly a non-food crop economy. Agriculture in the state is largely dependent on south-west monsoon, which is often erratic and unevenly distributed.

Gujarat's agriculture performance has been a topic of much discussion in both academics and popular media. In the state, during the 1980's and 1990's high growth was seen in manufacturing and service sector but during the same period agriculture growth was slowed down, showing little or no growth [1]. But in recent time, agriculture sector has recorded average annual growth rate of 9.6 per cent during the year 2000-01 to 2006-07. Literature showed that, [2,3] in recent time, high growth in agriculture sector was observed due to occurance of structural changes in this sector.Cropping pattern of the state was much changed towards high value crops viz; oilseeds, cotton, fruits and vegetables etc. Crop diversification was observed towards superior cereal crops and high value crops. This set the background of study to see critically long term performance of cereal crops in Gujarat state using most recent and power full statistical tools.

2. MATERIALS AND METHODS

2.1 The Study Area

Gujarat is one of the most important agriculture states of India. It has recorded fastest growth rate in agriculture (Double digit growth rate) among all Indian states [3]. Due to this, the state is in discussion in all the part of nation. Policy makers are thinking to replicate the agricultural success of Gujarat in other parts of the country. Hence, this particular study was undertaken in Gujarat to see critically the performance of cereal crops, which are main component of our food security system. Major eighteen agricultural districts of Gujarat state namely Ahmedabad, Amreli, Banaskantha, Bharuch, Baroda (Vadodara), Bhavnagar, Valsad, Dang, Jamnagar, Junagadh, Kheda, Kutch, Mehsana, Panchmahal, Rajkot, Sabarkantha, Surat and Surendranagar (As per 1971 census) were covered under the present study.

2.2 Data

Districts are the lowest administrative unit at which reliable agricultural data is available in Gujarat hence growth and instability in area, production and yield of cereals were analyzed at district level along with state. Secondary time series data of area, production and yield (APY) were collected from various sources viz; Season and Crop Reports, Department of Economics and Statistics (DES), Government of Gujarat, online data bank of International Crop Research Institute for Semi-Arid Tropics [4] and Economic and Political Weekly (EPW) data bank [5]. The data were collected for the years from 1970-71 to 2011-12. The CGR and instability were estimated for overall period i.e. 1970-71 to 2011-12 and two sub-periods. These sub-periods approximately represents phase of green revolution and post-green revolution. The period-I starts from the year 1970-71 to 1989-90, which represent a period of green revolution. Second period (Period-II) starts from the year 1990-91 to 2011-12. This period was known as post-green revolution period in which we have seen wider dissemination of technology [6].

2.3 Analytical Tools

2.3.1 Growth

The compound growth rate was computed based on its fit using non-linear models, especially, the exponential model. The exponential model is more commonly used in economic analysis. Conventionally, the compound growth rates were estimated after converting the growth model to

semi-log form and estimated through Ordinary Least Square (OLS) technique assuming multiplicative error term.

$$Y_t = b_0 * b_1^t * e_t \quad (1)$$

$$ln\,(Y_t) = b_0 + t * ln\, b_1 + e_t \quad (2)$$

Where,

ln **(Y_t)** is the natural logarithm of time series data for area / production / yield for year t,
b_0 is the constant term,
t is the time trends for years of interest,
e_t is the error term and
b_1 is the slope coefficient

Then, Compound growth rate was calculated using following equation

$$\text{Compound Growth Rate} = [(\text{Antilog } b_1) - 1] * 100 \quad (3)$$

However, there are several problems associated with this methodology including the difficulty in estimating standard error of estimates of original parameters [7]. Hence, a non-linear estimation technique for solving exponential model assuming additive error terms was used to estimate the compound growth rate.

$$Y_t = \text{constant} * (1+CGR)^t + e_t \quad (4)$$

Where,

Y_t is the time series data for area / production / yield for year t,
t is the time trends for years of interest,
e_t is the error term and
CGR is compound growth rate for the period under consideration

The data were smoothened with the help of three year central moving average techniques to remove bias from the data if any induced by the outliers [8,9,10]. The Marquardt algorithm was used to estimate the parameters of equation [6]. The significance of regression coefficient 'b' (slope coefficient) was tested by applying standard 't' test procedure [11].

2.3.2 Instability

The measure that may use to estimate instability in a variable over time should satisfy two minimum conditions. First, it should not include deviations in the data series that arise due to secular trend or growth. Second, it should be comparable across the data sets having different means [12,13]. Simple coefficient of variation (CV) overestimates the level of instability in time series data, characterized by the long-term trends. To avoide the problem of overestimation, Cuddy-Della Valle, [14]; Mehra, [12]; Hazell, [13]; and Ray [15] have proposed alternative methods to estimate instability in time series data. However, method proposed by Mehra [12] and Hazell [13] have been criticized for measuring instability around arbitrarily assumed trend line, which greatly influences inference regarding changes in instability [15], hence these two methods were not selected in the present study. In recent time, international fraternity have mostly used Cuddy-Della Valle Index to measure the instability because of its superiority over other methods [16-18], hence we have used Cuddy-Della Valle Index as a measure of variability in the present study. This index is a modification of coefficient of variation [CV] to accommodate trend, which is commonly present in time series economic data. It is superior over other scale dependent measures such as Standard Deviation or Root Mean Square of the residuals (RMSE) obtained from the fitted trend lines of the raw data, and hence suitable for cross comparisons [14,19].

The Cuddy-Della Valle Index (I_x) was calculated as follows:

$$I_x = \frac{SEE}{\bar{y}} * 100$$

Where,

I_x = Instability index
SEE = Standard error of the trend line estimates
$\bar{y}$ = Average value of the time series data

The SAS macros for econometric analysis-I available on web address of Indian Agricultural Statistical Research Institute, New Delhi (http :// www. iasri. res. In / sscnars / ecoanlysis.aspx) was used to analyse the data with the help of Statistical Analyses System (SAS) software, Version 9.3. [20].

3. RESULTS AND DISCUSSION

3.1 Growth

The compound growth rate (CGR) of area, production and yield of cereals at district as well as at state level for Gujarat were estimated taking due care of econometric problems. Table 1 shows the compound growth rate of area,

production and productivity of cereals. The area of cereal crops at state level has decreased in both the sub-periods and also in overall period by -0.66, -0.90 and -0.98 per cent per annum, respectively. The positive trend in production of cereal crops was seen in all the three period. This was mainly because of positive trend seen in yield of cereal crops. Yield of cereal crops has improved by 1.74, 3.15 and 2.59 per cent per annum during period-I, period-II and overall period, respectively. All the growth rates were significant at least for 5 per cent level of significance except production of cereal crops during first period.

Districts level results also showed that, area of cereal crops has reduced as CGR has shown significant negative trend for many of the districts during overall periods. High level negative trend in area of cereals (more than 3 per cent) was register in Surendranagar and Jamnagar districts and medium level negative growth (between 1 to 3 per cent) was seen in Rajkot, Mehsana, Bharuch, Bhavnagar, Banaskantha, Kachchh and Amreli districts. Only three districts viz; Dang, Kheda and Panchmahal have registered significant positive but low level (between 0 to 1 per cent) growth in area of cereal crops during all three period of study.

Sabarkantha district has registered negative CGR in two sub-periods but positive CGR was observed during overall period. The estimate of growth in area of cereal crops was 0.59, 0.76, 0.34 and 0.18 per cent per annum during overall period for Dang, Kheda, Panchmahal and Sabarkantha districts, respectively.

Yield of cereal crops has shown positive trend during first and second sub-period as well as in overall period in all the districts of the state. The productivity of cereal crops was notably improved during second sub-period compared to first period in all the districts except in Surat and Valsad. Noteworthy higher growth in yield was observed during overall period in Ahmedabad (3.69 per cent), Amreli (3.31 per cent), Bhavnagar (3.61 per cent), Jamnagar (6.20 per cent), Rajkot (4.42 per cent) and Surendranagar (5.91 per cent) districts.

Production of cereal crops has shown positive trend which mean that, production of cereal crops was increased over the years at district level except in Kachchh district during overall period. Positive growth in yield was more than the negative growth in area reflected positive trend in production of cereal crops. As seen in yield, growth in production of cereal crops was more in second sub-period. High level of growth in production was seen in Ahmedabad and Junagadh districts and medium level of growth was observed in Dang, Kheda, Panchmahal, Rajkot, Sabarkantha, Surat, Vadodara and Valsad districts of Gujarat. Rest of the districts has shown low level of growth in production during overall period. Yield expansion was recognised as a major feature for increase in production of cereal crops as area of cereal crops has been reduced.

3.2 Instability

The results of instability analysis reported in Table 2 shows that, instability in area of cereals at state level was slightly increased to 10.21 from 7.34 per cent during second sub-period of study (1990-91-2011-12). In both the sub-periods of the study, magnitude of instability was around under 10 per cent which was considers as low level of instability. The significant reduction in the magnitude of yield instability of cereal crops in the second sub-period of study helps to reduce the instability in production of cereal crops, even though there was increase in the variability in the area of these crops during the same period.

Production is the interaction of area and yield series; hence the magnitude of instability in production was generally at higher side compared to area and yield. During the entire study period, average magnitude of instability in area, production and yield of cereal crops was 8.73, 25.24 and 18.32 per cent per annum, respectively. This gave us clear sign that, yield variability was a most important source of instability in production of cereal crops which was also reported by Mehra [12] and Hazell et al. [13].

Instability in area of cereal crops inside many of the districts of Gujarat state was also increased during second sub-period compared to first sub-period except in Ahmedabad, Bharuch, Jamnagar and Kachchh districts. Maximum reduction in instability was observed in Kachchh district, which is one of the major cereal crops growing district of the state. Instability in area of cereal crops was increased by more than 10 per cent in Junagadh, Rajkot, Bhavnagar, Surat and Valsad. The magnitude of instability in area of cereal crops has ranged from 2.26 per cent (Panchmahal) to 33.49 per cent (Kachchh) in first sub-period of study and it has ranged from 7.70 per cent (Bharuch) to 35.02 per cent (Rajkot) in second sub-period of the study.

Table 1. Growth rates of area, production and yield of cereals in various districts of Gujarat

(In Per cent)

Districts	Area			Production			Yield		
	Period-I	Period-II	Overall	Period-I	Period-II	Overall	Period-I	Period-II	Overall
Ahmedabad	-1.19**	0.69^{NS}	-0.55**	0.18^{NS}	5.98**	3.59**	1.50**	4.55**	3.69**
Amreli	-2.15**	-4.93**	-2.98**	-0.37^{NS}	-0.67^{NS}	-0.58^{NS}	1.42^{NS}	4.65**	3.31**
Banaskantha	-1.66**	-2.56**	-1.57**	-1.79**	2.28**	0.26^{NS}	-0.25^{NS}	4.46**	2.91**
Bharuch	0.14^{NS}	-1.17**	-1.17**	-0.37^{NS}	1.38**	0.45*	-0.65^{NS}	2.57**	1.96**
Bhavnagar	-0.29^{NS}	-7.28**	-2.41**	1.25^{NS}	-0.77^{NS}	-0.53^{NS}	1.34^{NS}	6.04**	3.61**
Dang	0.90**	0.44*	0.59**	0.88^{NS}	3.22**	2.29**	0.03^{NS}	2.70**	1.60**
Jamnagar	-2.44**	-2.63**	-3.74**	-0.25^{NS}	5.43**	0.50^{NS}	1.56^{NS}	8.50**	6.20**
Junagadh	-2.17**	5.88**	0.72^{NS}	1.05^{NS}	10.33**	5.70**	2.31*	3.10**	2.72**
Kheda	0.37*	1.06**	0.76**	1.96**	3.10**	2.66**	1.59*	1.75**	1.76**
Kachchh	-1.50^{NS}	-0.67*	-2.95**	-3.06*	2.31**	-1.13**	0.80^{NS}	3.41**	2.48**
Mehsana	-1.41**	-1.98**	-1.90**	0.60^{NS}	0.26^{NS}	-0.17^{NS}	1.94**	1.92**	1.80**
Panchmahal	0.35**	0.27^{NS}	0.34**	-0.93^{NS}	1.37*	1.15**	-1.29^{NS}	1.06*	0.76**
Rajkot	-2.65**	-1.14^{NS}	-2.77**	0.79^{NS}	6.08**	1.76**	2.27^{NS}	5.84**	4.42**
Sabarkantha	-0.29*	-0.67**	0.18*	-0.49^{NS}	1.13*	2.11**	-0.22^{NS}	1.71**	1.97**
Surat	-0.11^{NS}	-1.03**	-0.68**	1.90**	0.23^{NS}	1.28**	2.04**	1.16**	2.00**
Surendranagar	-2.64**	-2.96**	-3.20**	-1.36^{NS}	3.44**	2.52**	2.05^{NS}	5.58**	5.91**
Vadodara	0.37*	-0.54*	-0.36**	0.67^{NS}	2.39**	1.49**	0.29^{NS}	2.58**	1.90**
Valsad	0.14^{NS}	-0.03^{NS}	-0.29**	2.41**	0.49^{NS}	1.36**	2.33**	0.45**	1.62**
Gujarat	**-0.66****	**-0.90****	**-0.98****	**1.12^{NS}**	**2.48****	**1.54****	**1.74***	**3.15****	**2.59****

*Note: Period-I: 1970-71 to 1989-90; Period-II: 1990-91 to 2011-12 and Overall: 1970-71 to 2011-12 * significant at 5 % ** significant at 1%*

Table 2. Instability in area, production and yield of cereals in various districts of Gujarat

(In per cent)

Districts	Area			Production			Yield		
	Period-I	Period-II	Overall	Period-I	Period-II	Overall	Period-I	Period-II	Overall
Ahmedabad	17.30	16.80	18.30	29.10	29.90	38.90	20.70	15.30	22.70
Amreli	12.76	17.10	14.39	40.94	39.79	40.32	37.82	27.15	33.69
Banaskantha	07.58	16.96	12.01	33.58	28.60	33.65	30.93	19.18	29.88
Bharuch	12.73	07.70	12.71	25.81	20.33	23.47	19.61	17.09	20.68
Bhavnagar	08.99	23.89	20.67	39.69	39.73	40.67	39.85	26.24	36.97
Dang	02.95	11.94	09.18	20.79	23.44	25.21	20.60	16.33	20.15
Jamnagar	25.50	23.96	29.22	49.98	52.29	54.34	48.26	32.61	48.15
Junagadh	17.33	33.75	36.38	37.87	46.92	59.01	29.23	18.69	22.67
Kheda	04.97	10.73	09.27	22.09	19.49	21.83	19.56	11.34	14.33
Kachchh	33.49	21.22	34.99	52.56	39.72	48.47	43.37	25.12	32.32
Mehsana	06.47	16.28	11.16	22.77	20.96	22.02	18.69	15.28	16.65
Panchmahal	02.26	09.17	06.89	38.62	30.77	34.09	37.45	26.94	31.58
Rajkot	18.90	35.02	27.31	59.48	62.89	64.67	54.38	33.75	43.38
Sabarkantha	04.37	09.57	08.83	27.01	22.77	25.77	25.18	17.09	21.00
Surat	02.65	14.01	09.67	14.41	17.50	16.68	13.68	09.34	11.05
Surendranagar	12.89	13.05	15.09	49.30	30.28	38.68	48.48	23.97	36.75
Vadodara	05.37	14.13	11.05	23.76	30.79	29.84	21.05	17.61	20.26
Valsad	02.86	12.95	09.71	21.97	18.89	19.97	20.26	08.86	14.14
Gujarat	**07.34**	**10.21**	**08.73**	**26.73**	**23.07**	**25.24**	**22.88**	**13.77**	**18.32**

Note: Period-I: 1970-71 to 1989-90; Period-II: 1990-91 to 2011-12 and Overall: 1970-71 to 2011-12

Table 3. Growth-Instability matrices of area, production and yield of cereals in Gujarat State

Growth/Instability	Area		Production		Yield	
	Low instability	**High instability**	**Low instability**	**High instability**	**Low instability**	**High instability**
Positive Growth	Dang, Kheda Panchmahal Sabarkantha	Junagadh	Banaskantha Bharuch Dang Kheda Panchmahal Sabarkantha Surat Vadodara Valsad	Ahmedabad Jamnagar Junagadh Rajkot Surendranagar	Ahmedabad Bharuch Dang Junagadh Kheda Sabarkantha Surat Vadodara Valsad Mehsana	Amreli Banaskantha Bhavnagar Jamnagar Kachchh Panchmahal Rajkot Surendranagar
Negative Growth	Amreli Banaskantha Bharuch Mehsana Surat Surendranagar Vadodara Valsad	Ahmedabad Bhavnagar Jamnagar Kachchh Rajkot	Mehsana	Amreli Bhavnagar Kachchh	-----	-----

Note: Low and high instability was categorised based on the average value of all districts

All the districts of Gujarat state have shown moderate to high level of instability in production of cereal crops in both the study periods. During first sub-period, instability was ranged from 14.41 per cent (Surat) to 59.48 per cent (Rajkot) and it was ranged from 17.50 per cent (Surat) to 62.89 per cent (Rajkot) during second sub-period.

Mixed types of results were noted in respect of change in the magnitude of instability in production of cereal crops at district level. Some districts namely Bhavnagar, Ahmedabad, Jamnagar, Dang, Surat, Rajkot, Vadodara, and Junagadh districts recorded increase (slight) in the level of instability while rest of the districts seen reduction in the magnitude of production instability in cereal crops in the state. This is mainly because magnitude and sign of instability in area and yield of cereal crops have differences.

Instability in yield of cereal crops has reduced in second sub-period of study in all the districts of the state, when compared to first sub period. Chand and Raju, 2008 [6] also stated that, instability in yield of cereal crops has declined over the time at national level as well as in Gujarat state. Maximum reduction in magnitude of instability in yield of cereal crops was noticed in Surendranagar district whereas minimum was seen in Bharuch district. In both the sub-periods of the study, magnitude of yield instability of cereal crops were categorized as medium to high in all the districts of the state except Valsad and Surat in second sub-period of the study.

During first sub-period of the study, lowest and highest level of instability in yield of cereals was noted in Surat (13.68 per cent) and Rajkot (54.38 per cent) districts, respectively whereas in second sub-period it was in Valsad (8.86 per cent) and Rajkot (33.75 per cent) districts, respectively.

The matrices of growth-instability in regards to area production and yield was reported in Table 3. The results reported in the table shows that, production of cereals crops in Ahmedabad, Jamnagar, Junagadh, Rajkot and Surendranagar has shown positive grown with high level of instability, which is not a desirable phenomenon. As instability in production leads to wider fluctuations in the market prices of these crops which distorts the perfect market conditions in the region. The worst situation in regards to production of cereals was seen in Mehsana, Amreli, Bhavnagar, Kachchh, where production of cereals crops has registered negative growth with high level of instability except in Mehsana where level of instability was low. In these districts production of cereals crops was gone down mainly due to reduction in area of cereal crops.

4. CONCLUSION AND POLICY RECOM-MENDATIONS

The production of cereals increased in Gujarat was mainly because of improvement in the yield of these crops as area under cereals has registered negative growth during entire study period at state as well as district level. Only few districts viz; Dang, Kheda and Panchmahal districts have registered low level significant positive growth in area of cereal crops during study period. The productivity of cereal crops has notably improved after the year 1991. Positive growth in yield was more than the negative growth in area reflected positive trend in production of cereal crops. At state level, instability in area was slightly increased during second sub-period of the study. The significant reduction in the magnitude of yield instability in the second sub-period of study helps to reduce the instability in production even though there was increase in the variability in the area. It was observed that, yield variability was a most important source of instability in production of cereal crops. Looking out these results, it is recommended that, Government has to intervene to maintain optimum level of foodgrains area in the form of various support mechanism for example providing “Cultivation Allowance” to the farmers in the form of kinds or cash or subsidy to foodgrain crops. Yield instability was identified as a major source of variation in the production of cereals which shows that, existing crop technologies are not enough capable to stabilize the yield of cereals in changing climatic conditions in the state. So, to mitigate the consequences of persisting instability, new technology should induced for relentless production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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