

Original Research Article

Long Term Performance of Cereal Crops in Gujarat - A Critical Analysis

ABSTRACT

High growth in agriculture sector in Gujarat 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 paramerts of the model were estimated using Marquardt algorithm. Instability was estimated by contractuing Cuddy-Della Valle Index. Results shows that, production of cereal crops in the state was increased mainly because of improvement in the yield. The productivity of cereal crops was notably 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 district level. 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. 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.

KEY WORDS: Cereals, Cuddy-Della Valle Index, Gujarat, Growth, Instability, Marquardt algorithm, Performance.

1. INTRODUCTION

Agriculture occupies a predominat place in economy of Gujarat state. The state shows diversification in the agriculture sector and a pre-dominatly 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 perofrmance has been a topic of much discussuion in both academic and popular media. During the 1980's and 1990's high growth was seen in manufacturing and service sector but during the same period agricultre growth slowed down, showing little or no growth [1] (Hirway,2000). But in recent time, agriculture sector has recordded average annual growth rate of 9.6 per cent during the year 2000-01 to 2006-07. Literature showed that [2 and 3] high growth in agricultrre sector during recent time was observed due to stractural chages ocuured in this sector.Cropping pattern of the state was much chaged towards high value crops viz; oilseeds, cotton, fruits and vegetables etc. Crop divesification was observed towards superior cereal crops and high

value crops. This set the background 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 state [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 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 analysed 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. 1971-72 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 1971-72 to 1989-90, which represent a period of green revaluation. Second period (Period-II) starts from the year 1991-92 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.

$$Y_t = b_0 * b_1^t * e_t \text{ -----[1]}$$

$$\ln(Y_t) = b_0 + t * \ln b_1 + e_t \text{ -----[2]}$$

Where,

76 $\ln(Y_t)$ is the natural logarithm of time series data for area / production / yield for year t ,
 77 b_0 is the constant term,
 78 t is the time trends for years of interest,
 79 e_t is the error term and
 80 b_1 is growth rate for the period under consideration (i.e. slope coefficient).

81 Then, Compound growth rate was calculated using following equation

$$82 \quad \text{Compound Growth Rate} = [(Antilog b_1) - 1] * 100 \text{ -----}[3]$$

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

$$87 \quad Y_t = \text{constant} * (1 + \text{CGR})^t + e_t \text{ -----}[4]$$

88 Where,

89 Y_t is the time series data for area / production / yield for year t ,
 90 t is the time trends for years of interest,
 91 e_t is the error term and

92 CGR is compound growth rate for the period under consideration

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

97 2.3.2 Instability

98 The measure that may use to estimate instability in a variable over time should satisfy
 99 two minimum conditions. First, it should not include deviations in the data series that arise due to
 100 secular trend or growth. Second, it should be comparable across the data sets having different means
 101 [12 and 13]. Simple coefficient of variation (CV) overestimates the level of instability in time series
 102 data, characterised by the long-term trends. To avoid the problem of overestimation, Cuddy-Della
 103 Valle, 1978 [14]; Mehra, 1981 [12]; Hazell, 1982 [13]; and Ray, 1983 [15] have proposed alternative
 104 methods to estimate instability in time series data. However, Mehra, 1981 [12] and Hazell, 1982 [13]
 105 methods have been criticized for measuring instability around arbitrarily assumed trend line, which
 106 greatly influences inference regarding changes in instability [15], hence these two methods were not
 107 selected in present study. In recent time, international fraternity have mostly used Cuddy-Della Valle
 108 Index to measure the instability because of its superiority over other methods [16,17 and 18], hence we
 109 have used Cuddy-Della Valle Index as a measure of variability in the present study. This index is a
 110 modification of coefficient of variation [CV] to accommodate trend, which is commonly present in time
 111 series economic data. It is superior over other scale dependent measures such as Standard Deviation
 112 or Root Mean Square of the residuals (RMSE) obtained from the fitted trend lines of the raw data, and
 113 hence suitable for cross comparisons [14 and 19].

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

$$115 \quad I_x = \frac{SEE}{\bar{y}} * 100$$

116 **Where,**

117 I_x = Instability index

118 SEE = Standard error of the trend line estimates

119 $\bar{y}$ = Average value of the time series data

120 The SAS macros for econometric analysis-I available on web [adrees](#) of Indian
121 Agricultural Statistical Research Institute, New Delhi (<http://www.iasri.res.in/sscnars/econanalysis.aspx>) was used to analyse the data with the help of Statistical Analysis System (SAS)
122 software, Version 9.3.[20].
123

124 3. RESULTS AND DISCUSSION

125 3.1 Growth

126 The compound growth rate (CGR) of area, production and yield of Cereals at district
127 as well as state level for Gujarat were estimated taking due care of econometric problems. Table 1
128 shows the compound growth rate of area, production and productivity of cereals. The area of cereal
129 crops at state level was decreased in both the sub-periods and also in overall period by -0.66, -0.90
130 and -0.98 per cent per annum, respectively. The positive trend in production of cereal crops was seen
131 in all the three period. This was mainly because of positive trend in yield of cereal crops. Yield of
132 cereal crops was improved by 1.74, 3.15 and 2.59 per cent per annum during period-I, period-II and
133 overall period, respectively. All the growth rates were significant at least for 5 per cent level of
134 probability except production of cereal crops during first period.

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

142 Sabarkantha district has registered negative CGR in two sub-periods but positive
143 CGR was observed during overall period. The estimate of growth in area of cereal crops was 0.59,
144 0.76, 0.34 and 0.18 per cent per annum during overall period for Dang, Kheda, Panchmahal and
145 Sabarkantha districts, respectively.

146 Yield of cereal crops has shown positive trend during first and second sub-period as
147 well as in overall period in all the districts of the state. The productivity of cereal crops notably
148 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 was observed 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 like 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 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, area of cereals at state level was slightly increased to 10.21 from 7.34 per cent during second sub-period of study (1991-2012). In both the sub-periods of study, the 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, 1981 [12] and Hazell *et al.*, 1984 [13].

Instability in area of cereal crops in 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 was ranged from 2.26 per cent (Panchmahal) to 33.49 per cent (Kachchh) in first sub-period of study and it was ranged from 7.70 per cent (Bharuch) to 35.02 per cent (Rajkot) in second sub-period of study.

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) and 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 levels. Some districts namely Bhavnagar, Ahmedabad, Jamnagar, Dang, Surat, Rajkot, Vadodara, and Junagadh districts recorded slight increase 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 was reduced in second sub-period of study in all the districts of the state, when compared to first period. Chand and Raju, 2008 [6] also stated that, instability in yield of cereal crops was 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 categorised as medium to high in all the districts of the state except Valsad and Surat in second period of study.

During first sub-period of 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.

4. CONCLUSION

The production of cereals increased mainly because of improvement in the yield 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 was 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.

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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%

267 **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

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