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Performance of cotton in Gujarat: A long term critical analysis

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ABSTRACT : Cotton crop was considered as one of the main drivers of agriculture in Gujarat, hence its long term performance was studied for the year from 1970-1971 to 2011-2012. Performance of cotton was judged on 2 important parameters *i.e.* growth and instability. Compound growth rate was estimated by fitting non linear model to the area, production and productivity data. Model was estimated using Marquardt algorithm. Instability was assessed by constructing Cuddy Della Valle instability index. Results showed that, area under cotton was significantly reduced in the state during first sub period (1970-1971 to 1989-1990) so as the production. During second sub period (1991-1992 to 2011-2012) cotton crop performed far better, as it has achieved high growth in area, production and productivity and relatively low level of instability in its area. Instability in productivity was relatively increased in second sub period as compared to first sub period. The good performance of cotton during sub period was mainly due to wide spared adoption of *Bt* cotton under irrigated condition.

Key words : Cotton, Cuddy-Della Valle Index, growth, Gujarat, instability, marquardt algorithm, performance

Cotton is known as a "King of Fibre" crops due to its global importance in agriculture as well as industrial economy. It is grown in more than 100 countries and it is estimated that, the crop is planted on about 2.5 per cent of the world cultivable land (Shiv Sankar and Naidu, 2015). It is commonly known as “White Gold” in farming community. It is a multipurpose crop that supplies 5 basic products viz; lint, oil, seed meal, hulls and linters. Due to its multipurpose nature and use, it has huge demand from industry side, which makes this crop popular among the farming community.

India is the only country where all the 4 cultivated species of cotton are grown on commercial scale. The county is recognized as largest cotton growing country in the world with an area of around 12.7 million ha followed by China. Its average productivity was far low *i.e.* 537 kg/ha when compared to world average productivity of 760 kg/ha. Gujarat is second largest cotton growing state of India having 30.06 lakh ha area under cotton cultivation but ranked first place in terms of cotton production in the country. During the year 2013-2014, the total annual cotton production in the state was 121 lakh bales. The average productivity of cotton in state is 707 kg/ha which was far ahead than many of the Indian state and even than national average (Anonymous, 2015).

In most recent decade, Gujarat agriculture recorded the fastest growth (Above 9.6%) amongst all Indian states. This is 3 times agricultural growth at all India level (2.9% / annum during 2000-2001 to 2007-2008) and even higher to states like Uttar Pradesh (1.6%), Punjab (2.4%) and West Bengal (2.7%). This miracle growth in Gujarat agriculture was due to good performance of cotton, fruits, vegetable, livestock, milk and wheat crop in the state. (Gulati *et al.,* 2009).

Hence the study was undertaken to know the long term performance of cotton crop in the state by estimating the compound growth rate

and instability in area, production and productivity of cotton at state as well as district level.

MATERIALS AND METHODS

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 (Gulati *et al.,* 2009). Hence, this particular study was undertaken in Gujarat. Major 18 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.

Data : Districts are the lowest administrative unit at which reliable agricultural data is available in Gujarat hence performance of cotton was analysed at district level along with state. Secondary time seies 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 [VDSA, 2013] and Economic and Political Weekly (EPW) data bank. The data were collected for the years from 1970-1971 to 2011-2012. The CGR and instability were estimated for overall period *i.e.* 1971-1972 to 2011-2012 and 2 sub periods. These sub periods approximately represents phase of green revolution and post green revolution. The period I starts from the year 1971-1972 to 1989-1990, which represent a period of green revaluation. Second period (Period II) starts from the year 1991-1992 to 2011-2012. This period was known as post green revolution period in which we have seen wider dissemination of technology [Chand and Raju, 2008].

Analytical tools 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. However, there are several problems associated with this methodology including the difficulty in estimating standard error of estimates of original parameters [Prajneshu and Chandran, 2005]. Hence, a non linear estimation technique for solving exponential model assuming additive error terms were used to estimate the compound growth rates.

$Y_t = \text{constant} * (1+CGR)^t + e_t$ ————————[1]

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 3 year central moving average techniques to remove bias from the data if any induced by the outliers (Sawant and Achuthan, 2007). The Marquardt algorithm was used to estimate the parameters of equation [1]. The significance of regression coefficient 'b' (slope coefficient) was tested by applying standard 't' test procedure (Gujarati and Sangeetha, 2007).

Instability : In recent time, international fraternity have mostly used Cuddy-

Della Valle Index to measure the instability because of its supearity over other methods (Deb *et al.,* 2004), 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.

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

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

Where, I_x = Instability index

SEE = Standard error of the trend line estimates

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

I_x

RESULTS AND DISCUSSION

Growth : Compound growth rate in area, production and yield of cotton at state as well as districts level are presented in Table 1. At state level, trend in production of cotton was significantly negative during first sub period. This was mainly because, area of cotton during this period has shown significant negative trend of -3.66 per cent/annum which has nullified the significant positive growth in yield of cotton (1.10% /annum). During second sub period and overall period, production of cotton has registered significant positive CGR of 9.86 and 7.13 per cent /annum, respectively. High positive growth of cotton production in second sub period was a complementary effect in between area expansion (4.14% /annum) and improvement in productivity of cotton (5.41% /annum) in the state. During overall period, yield effect was more predominant over area expansion as CGR of yield was 3.83 per cent and it was only 0.71 per cent in case of cotton area. In line to our results, Mehta, 2012 reported that, by early 1990s, share of cotton crops in GCA was dropped and after the year 2000-2001, it was improved.

State level trend of area was also clearly seen at district level also, as all the districts of Gujarat state have shown significant negative trend in area during first sub period and positive trend in second sub period of the study except in Panchmahal district. During overall period, few districts *viz.,* Amreli (10.56%), Bhavnagar (4.90%), Jamnagar (13.23%), Rajkot (2.90%), Surendranagar (1.03%) and Junagadh (0.82%) were able to register positive growth in cotton area in the state.

The productivity of cotton was notably improved in second sub period of the study in all the districts of Gujarat state as estimates of compound growth rate of yield was comparably high during second sub-period compared to first sub-period except in Surat districts. During overall period, high growth (More than 3% / annum) in cotton yield was observed in Amreli, Banaskantha, Bharuch, Bhavnagar, Jamnagar, Junagadh, Kheda, Kachchh, Rajkot, Sabarkantha and Surendranagar districts, which signify that, cotton technology has shown its impact in the state. Other selected districts were also showed positive growth rate in yield of cotton during the overall study period.

The production of cotton during first sub period has recorded significant negative trend in all the districts of the state due to noteworthy reduction in area of cotton. In second sub period, compound growth rate in cotton production in all the districts of the state was remarkably high.

Table 1. Growth rates of area, production and yield of cotton in various districts of Gujarat (%)

Districts	Area			Production			Yield		
	Period I	Period II	Overall	Period I	Period II	Overall	Period I	Period II	Overall
Ahmedabad	-4.15**	2.78**	-0.09^{NS}	-3.66**	6.87**	3.85**	0.53 ^{NS}	2.96**	2.63**
Amreli	-2.59*	11.84**	10.56**	-1.96 ^{NS}	15.94**	15.63**	-0.02 ^{NS}	4.29**	3.00**
Banaskantha	-1.24 ^{NS}	1.41 ^{NS}	0.25 ^{NS}	-1.00 ^{NS}	17.77**	8.14**	-0.17 ^{NS}	8.28**	4.08**
Bharuch	-6.86**	4.36**	-1.19*	-7.38**	7.68**	4.29**	1.26 ^{NS}	3.94**	3.16**
Bhavnagar	-0.67 ^{NS}	5.81**	4.90**	1.03 ^{NS}	11.78**	11.18**	1.81*	5.02**	3.93**
Dang	-	-	-	-	-	-	-	-	-
Jamnagar	-0.86 ^{NS}	15.85**	13.23**	2.230 ^{NS}	18.65**	17.95**	2.58**	5.06**	3.70**
Junagadh	-4.28**	3.57**	0.82*	-1.47 ^{NS}	9.67**	7.00**	3.01**	5.59**	3.81**
Kheda	-4.70**	4.85**	-4.94**	-7.15**	11.38**	-2.06**	-2.60**	5.21**	4.00**
Kachchh	-2.13 ^{NS}	0.88 ^{NS}	-1.69**	-4.29**	13.22**	2.82**	-3.33**	9.32**	4.74**
Mehsana	-4.41**	2.41**	0.55 ^{NS}	-4.77**	7.77**	2.95**	0.62 ^{NS}	4.79**	1.36**
Panchmahal	-2.61**	-2.23**	-4.70**	-3.59**	4.28**	-4.42**	-1.54*	4.63**	2.19**
Rajkot	0.41 ^{NS}	6.83**	2.90**	1.72 ^{NS}	12.62**	10.99**	1.19 ^{NS}	5.77**	4.77**
Sabarkantha	-1.41**	12.64**	-2.67**	-2.09*	15.29**	2.18*	-1.00 ^{NS}	3.65**	3.16**
Surat	-7.02**	2.06**	-8.11**	-3.00**	0.41 ^{NS}	-4.82**	4.65**	-1.88*	2.24**
Surendranagar	-1.09**	1.96**	1.03**	-0.46 ^{NS}	9.00**	6.90**	0.09 ^{NS}	6.53**	4.61**
Vadodara	-2.80**	1.12**	-1.66**	-1.42 ^{NS}	6.63**	2.83**	1.73*	5.31**	3.99**
Valsad	-12.34**	-	-	-9.36**	-	-	3.63**	-	-
Gujarat	**-3.66****	**4.14****	**0.71***	**-2.65****	**9.86****	**7.13****	**1.10***	**5.41****	**3.83****

Note: Period I: 1970-1971 to 1989-1990 Period II: 1990-1991 to 2011-2012 Overall: 1970-1971 to 2011-2012
*significant at 5 per cent **significant at 1 per cent

During this period, area of cotton in many of the districts was recovered from initial fall and productivity of cotton has significantly improved. In overall period, all the districts have shown positive trend in production of cotton except Panchmahal, Kheda and Surat districts. Few districts viz; Amreli, Bhavnagar, Jamnagar and Rajkot districts have recorded more than 10% CGR in production of cotton. Some districts *viz.,* Banaskantha, Junagadh, and Surendranagar districts have recorded compound growth rate of 5 to 10 per cent /annum. In rest of the districts CGR was in between 2 to 5 per cent /annum *i.e.* Bharuch, Ahmedabad, Kachchh, Mehsana, Sabarkantha and Vadodara.

Instability : The estimates of instability in area, production and yield of cotton crop were reported in Table 2. On perusal of data in Table, we can say that, yield of cotton crop was more unstable compared to its area in both the sub-periods as well as during the entire study period. Area variability was slightly reduced whereas yield variability was increased during the second sub-period when compared to first sub period. Suresh *et al.,* 2013 reported that, due to high spread of *Bt* cotton, instability in cotton area was reduced, which supports our finding. It was seen that, yield variability is a prime source of instability in production of cotton crop and area variability seen as secondary source of instability. At state level, the magnitude of instability in area, production and yield in cotton during entire study period was 25.78, 54.12 and 32.34 per cent, in that order. Production variability in cotton was increased during second sub period from 24.59 to 30.86 per cent. This was mainly attributed to increase in yield

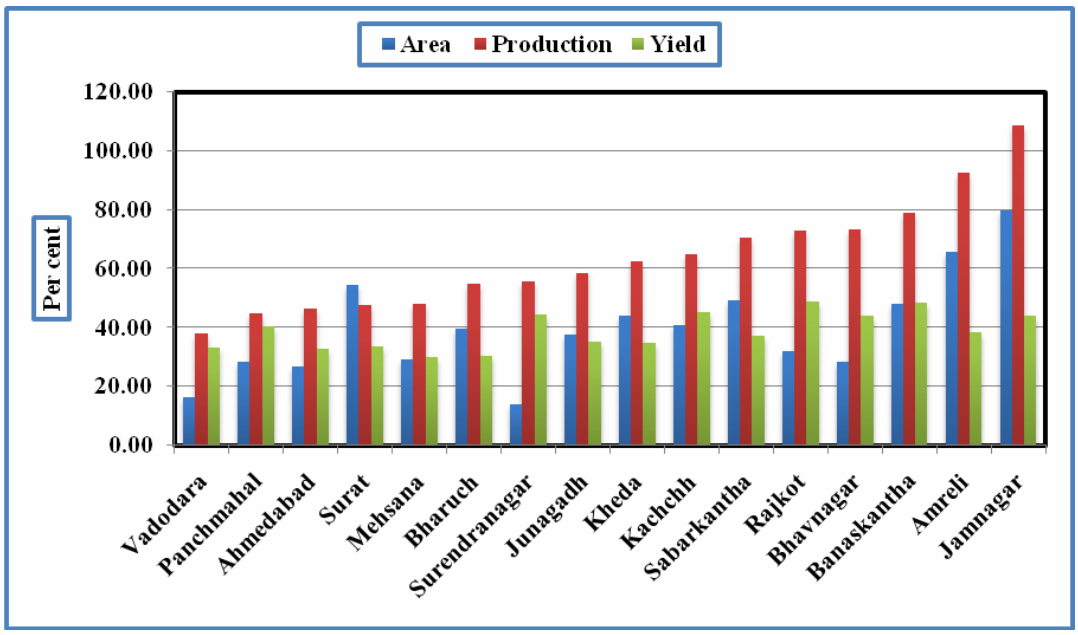

Fig. 1. District wise instability in area, production and yield of cotton in Gujarat (1970-71 to 2011-12).

variability in cotton during same period. Results reported by Suresh *et al.,* 2013 mentioned that, *Bt* cotton boosted the cotton production but increased instability in its productivity level. This gives confirmation to our results.

During first sub period, variability in area of cotton was ranged from 6.11 per cent (Vadodara) to 43.90 per cent (Kachchh). This range of variability was slightly extended during second sub period *i.e.* from 5.52 per cent (Vadodara) to 54.31 per cent (Surat). All the major cotton growing districts *viz.,* Surendranagar, Bhavnagar, Rajkot, Vadodara, Ahmedabad, Bharuch, Mehsana districts have shown reduction in area variability during second sub-period of the study. Moderate to high level of area instability was observed in these major cotton growing districts *i.e.* Surendranagar (14.01%), Vadodara (16.28%), Ahmedabad (27.01%), Bhavnagar (28.32%) and Mehsana (29.22%) districts have shown moderate level of instability whereas Rajkot (31.88%), Bharuch (39.79%) and Amreli (65.57%) districts have shown high level of area instability during entire study period.

The production and yield of cotton crop was highly unstable in major cotton growing districts. The magnitude of instability for production and yield for Surendranagar was 55.62 and 44.66 per cent, Vadodara 38.04 and 33.11 per cent, Ahmedabad 46.29 and 32.74 per cent, Bhavnagar 73.43 and 43.93%, Mehsana 47.94 and 30.03 per cent, Rajkot 72.95 and 48.93 per cent, Bharuch 59.83 and 30.61 per cent and Amreli 92.74 and 38.65 per cent, respectively.

In many of the districts, instability in production of cotton was because of yield variability (Surendranagar, Vadodara, Ahmedabad, Bhavnagar, and Rajkot) however area variability was prime factor for instability in production of cotton crop in Bharuch and Amreli districts. In Mehsana district area and yield variability was equally responsible for bringing instability in production of cotton crops.

Table 2. Instability in area, production and yield of cotton in various districts of Gujarat (%)

Districts	Area			Production			Yield		
	Period I	Period II	Overall	Period I	Period II	Overall	Period I	Period II	Overall
Ahmedabad	20.60	09.04	27.01	27.63	33.18	46.29	24.93	32.35	32.74
Amreli	24.01	29.93	65.57	34.00	45.93	92.74	25.53	38.08	38.65
Banaskantha	42.30	51.56	48.08	44.12	60.85	78.96	32.92	36.19	48.58
Bharuch	15.34	12.80	39.79	42.47	29.79	54.83	40.01	23.49	30.61
Bhavnagar	15.17	11.66	28.32	47.24	45.75	73.43	45.48	39.65	43.93
Dang	-	-	-	-	-	-	-	-	-
Jamnagar	32.03	50.55	79.62	59.25	59.75	108.47	38.26	41.78	44.09
Junagadh	26.49	27.25	37.64	37.25	39.20	58.34	20.48	33.49	35.06
Kheda	17.23	21.57	43.95	28.86	34.26	62.57	33.38	23.83	34.71
Kachchh	43.90	26.34	40.97	50.93	39.38	64.92	39.19	22.72	45.43
Mehsana	21.48	08.87	29.22	18.58	28.71	47.94	23.62	25.99	30.03
Panchmahal	12.88	24.72	28.30	27.45	45.94	44.69	31.74	38.40	40.66
Rajkot	16.98	16.22	31.88	41.90	43.18	72.95	36.94	43.75	48.93
Sabarkantha	12.19	34.39	49.20	36.47	45.29	70.62	32.56	32.31	37.20
Surat	13.23	54.31	54.49	23.61	80.10	47.52	25.57	28.76	33.56
Surendranagar	13.91	06.26	14.01	38.93	37.34	55.62	35.96	34.42	44.46
Vadodara	06.11	05.52	16.28	31.02	26.26	38.04	33.25	27.10	33.11
Valsad	39.79	-	-	37.82	-	-	19.93	-	-
Gujarat	**08.96**	**07.66**	**25.78**	**24.59**	**30.86**	**54.12**	**22.99**	**27.21**	**32.34**

Note: Period I : 1970-1971 to 1989-1990 Period II: 1990-1991 to 2011-2012 Overall: 1970-1971 to 2011-2012

CONCLUSION

Cotton crop was considered as one of the main drivers of agricultural growth in Gujarat state. The performance of cotton was seen far better in second sub period of study *i.e.* 1991-1992 to 2011-2012 in regards to area, production and productivity. During the first sub-period (1970-71 to 1989-1990) area under cotton was significantly reduced due to devastating attacks by bollworm which makes cultivation of this crop was uneconomical. The good performance of cotton during second sub period light of high growth in area, production and yield with comparatively low instability in its area was mainly due to wide spread adoption of *Bt* cotton by the farmers of the state. In addition to this, Government of Gujarat in support with central government has taken serious efforts to extend irrigation facilities in form of water harvesting through check dams, Narmada Project and by constructing other medium and minor irrigation projects in the state.

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