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RESEARCH PAPER

Trends in area, production and productivity of major coarse cereals in Hyderabad-Karnataka region: An economic analysis

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Abstract: India with its diversified agricultural assets in terms of soil, rainfall and climate. Hence, it has abundant crop diversity. Trends in area, production and productivity of major coarse cereals in Hyderabad-Karnataka region was estimated using the compound annual growth rate (CAGR). The necessary secondary data were collected for a period of 27 years from 1991-92 to 2017-18. Maize, bajra and sorghum were selected purposively because these three crops occupied highest area under coarse cereals group and rest of the coarse. In maize crop there was an increasing trend in area and production, but decreasing trend in productivity. In bajra crop there was an decreasing trend in area and production, but increasing trend in productivity. In sorghum crop there was an decreasing trend in area and production, but increasing trend in productivity. To improve the area and production of these two crops minimum support price (MSP) should be incentivised to meet out food and nutritional security.

Key words: Coarse cereals, Compound annual growth rate

Introduction

India with its diversified agricultural assets in terms of soil, rainfall and climate. Hence, it has abundant crop diversity.Owing to their several drought tolerant characteristics, cultivation of coarse cereals in drought prone areas for providing food for human consumption, feed and fodder for livestock and to provide fuel for industries and automobiles are common. During drought condition, the coarse cereals like maize, sorghum and bajra helps not only helps in providing sufficient food but also generate employment opportunity in low rainfall areas where other alternative crops are limited and these crops are used as a contingent crop.

Sorghum, pearl millet, maize, barley, finger millet and several minor millets such as kodo millet, little millet, foxtail millet, proso millet and barnyard millet together called coarse cereals. Sorghum, pearl millet, finger millet, maize and minor millets (barnyard millet, proso millet, kodo millet, little millet and foxtail millet) are also called nutri-cereals**.**

India holds 4th position in the world in coarse cereals production after USA, China and Brazil but the amount produced is only 3.60 per cent of the global coarse cereal production. In India, coarse cereals are grown over an average area of 24.28 million hectares (20.00 % of total food grain area) with a production of 46.99 million tonnes during 2017-18 and contributed about 17.00 per cent to national food basket. In 2017-18, Rajasthan, Karnataka and Maharashtra states are the top coarse cereal producer states in India. In Karnataka coarse cereals are cultivated on an average area of 3.43 million hectares, producing 6.59 million tonnes with a productivity of 1918 kg/ha (www.Indiastat.com).

Major coarse cereals like Maize, sorghum and bajra Karnataka rank first in the production of maize in the country followed by Madhya Pradesh Maharashtra, Bihar and Andhra Pradesh. Major maize growing districts in Karnataka are Koppal, Raichur, Davangere, Belagum, Haveri and Hassan. Sorghum is grown in 1088 thousand hectares with a production of 1140.33 million tonnes and productivity of 1048 kg/ha in Karnataka. Major sorghum growing districts of Karnataka are Kalaburagi, Raichur, Koppal, Belagavi and Vijayapur. With respect to bajra Karnataka which covers about 231 thousand hectares with a production of 286.69 thousand tonnes and productivity of 1241 kg/ha and major bajra growing districts of Karnataka are Koppal, Ballari, Chitradurga and Kalaburagi.

Material and methods

This study was based on a trend analysis of time series data on area, production and productivity of major coarse cereals in the sampled districts of Hyderabad-Karnataka region. Maize, bajra and sorghum were selected purposively because these three crops occupied highest area under coarse cereals group and rest of the coarse cereals which are grouped under minor millets were having less area under cultivation in Hyderabad Karnataka region. The time series data on the production, area and productivity of major coarse cereals (1991-92 to 2017-18) were collected from Directorate of Economics and Statistics (DES), Bengaluru, Karnataka. Compound annual growth rate (CAGR) was used to study the growth rate of area, production and productivity of major coarse cereals in Hyderabad Karnataka region.

Before calculating the growth rate, the exponential function of area, production and yield has to be estimated *i.e.*

$$Y_t = ab^t u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

Y_t: Dependent variable for which growth rate was estimated (area/production/yield)

a: Intercept (constant)

b: Regression coefficient

t: Years which take values, 1, 2, …,n

u_t: Disturbance term for the year t

Logarithmic transformation was applied to the above exponential function and hence, the estimating equation was

$$\log Y_t = \log a + t \log b + \log u_t \text{……..(2)}$$

The equation (2) was estimated by ordinary least square technique (OLS). Compound growth rate (g) was then estimated by

$$g\hat{} = (b\hat{}-1)\ 100$$

Where,

g^ = Estimated compound growth rate in per cent per year

b^ = Anti log of b

The standard error of the growth rate was estimated and tested for its significance by using t-test.

Results and discussion

Maize

The results of compound growth rates of area, production and productivity of maize in Hyderabad Karnataka region are presented in Table 1. The growth analysis of maize area, production and productivity in Ballari district revealed that, the production had registered positive annual growth of 6.68 per cent in Period-I. The productivity had registered positive growth rate of 17.79 per cent and productivity had recorded positive growth of 0.46 per cent during the study period.

In Ballari district for the Period-II, the area under maize registered significant positive growth rate of 8.79 per cent per annum, production was found to be significantly positive growth rate of 6.97 per cent per annum and productivity was found to be negative growth rate of 1.61 per annum. Whereas in Period-III, the growth performance of the production recorded positive growth rate of 7.83 per cent per annum and productivity of maize recorded significant positive growth rate of 9.39 per cent.

For overall study period, the area under maize in Ballari district had registered significant positive growth rate of 4.98 per cent per annum. This may be due to rapid expansion in area under this crop and it was mainly due to its important features like short duration, adaption to a wide range of soils and climatic conditions and high yield per hectare as compared to other cereal crops and also poultry industry is dependent on this crop, which is on increasing trend. The district had positive growth rate of 5.75 per cent per annum in production. The productivity of maize registered negative growth of 0.23 per cent per annum. Similar trend was reported by Pavitra *et al.* (2018) and Savitha and Kunal (2015).

The results of the compound annual growth rates for Bidar district revealed that, the production had registered positive annual growth of 6.59 per cent in Period-I. The productivity had registered positive growth rate of 3.21 per cent and productivity had recorded negative growth of 3.17 per cent during the study period.

A positive and significant growth rate of maize area and production was observed in the Period-II, the area under maize registered significantly positive growth rate of 18.63 per cent per annum and production was found to be significantly positive growth rate of 17.66 per cent per annum. Whereas in Period-III, the area under maize, maize production and productivity of maize in the district has registered negative growth of 11.93, 14.77 and 3.22 per cent per annum, respectively,

For overall study period, the average area under maize in Bidar district had registered significantly positive growth rate of 8.67 per cent per annum. The district had significant positive growth rate of 8.04 per cent per annum in maize production. The productivity of maize registered negative growth of 0.58 per cent per annum. Similar trend was reported by Pavitra *et al.* (2018).

The area, production and productivity under maize in Kalaburagi for Period-I had non-significant negative growth rates. The results obtained were because of the fact that, the farmers were shifted towards growing competing crops like redgram and cotton in the study area. In Period-II, the area under maize registered significant positive growth rate of 15.43 per cent per annum, this may be due to price volatility prevailing in the markets. In Period-III, the area under maize marked huge significantly negative annual growth rates of 15.33 per cent.

For the overall study period, the area under maize in Kalaburagi district registered positive growth rate of 2.87 per cent per annum. The district had positive growth rate of 1.64 per cent per annum in production and negative growth of 1.19 per cent per annum in productivity of maize. Similar trend was reported by Pavitra *et al.* (2018).

For Period-I there was no data available for the Koppal district, because Koppal was formed in the year 1998 and data was available from the year 2000 onwards and the available data was analysed for period II and period III.

The results of the compound annual growth rates for Koppal district revealed that, for Period-II the growth in area under maize had recorded significantly positive growth rate of 17.67 per cent per annum and 15.40 cent per annum for maize production. In Period-III, Koppal district registered non-significant growth rates in area, production and productivity.

For the overall study period, the area under maize in Koppal district had recorded positively significant growth rate of 11.64 per cent per annum. The production also increased significantly at 9.73 per annum. The district registered negative annual growth rate of 1.72 per cent in the productivity of maize.

The area and production of maize in Raichur district for Period-I had significant negative growth rates. The results obtained were because of the fact that, the farmers were shifting

towards growing competing crops like redgram and cotton in the study area. In Period-II, the area under maize registered significant positive growth rate of 26.30 per cent per annum, this may be due to price volatility of competing crops prevailing in the markets.

Production under maize registered significant positive growth rate of 26.45 per annum due to increase in the area under the crop. In Period-III, Raichur district registered non-significant positive growth rates in area, production and productivity.

Table 1. Growth rates of area, production and productivity of maize in Hyderabad - Karnataka region.

District	Particulars	Maize		
		Area	Production	Productivity
Ballari	Period I	6.68	17.79	0.46
	Period II	8.79**	6.97**	-1.61
	Period III	-1.42	7.83*	9.39*
	Over all	4.98**	5.75**	-0.90
Bidar	Period I	6.59	3.21	-3.17
	Period II	18.63**	17.66**	-0.82
	Period III	-11.93	-14.77	-3.22
	Over all	8.67**	8.04**	-0.58
Kalaburagi	Period I	-11.37	-12.03	-0.74
	Period II	15.43**	9.69	-4.98
	Period III	-15.33*	-15.35	-0.02
	Overall	2.87	1.64	-1.19
Koppal	Period I	-	-	-
	Period II	17.67**	15.40**	-1.93
	Period III	1.29	-5.25	-6.46
	Over all	11.64**	9.73**	-1.72
Raichur	Period I	-35.31*	-34.65*	0.77
	Period II	26.30**	26.45**	0.12
	Period III	17.09	18.88	1.52
	Over all	-7.37*	-7.30*	-0.02
Yadgir	Period I	-	-	-
	Period II	-	-	-
	Period III	-16.20	-13.36	3.39
	Over all	-16.20	-13.36	3.39

Period -I = 1991-92 to 2000-01, Period-II = 2001-02 to 2010-11, Period III= 2011-12 to 2017-18 and Over all = 1991-2017-18.
Area: ha, Production: Tonnes and Productivity: kg/ha
** Significant at 1 % level and *Significant at 5 % level

For overall study period, the average area and production under maize in Raichur district had registered significantly negative growth rate of 7.37 and 7.30 per cent per annum. The productivity of maize registered negative growth of 0.02 per cent per annum and found statistically non-significant.

Yadgir is newly formed district in Karnataka state and the growth trends were analysed from 2010-2017 as Period-III. The area under maize in Period-III had registered a negative growth rate of 16.20 per cent per annum. The production under district had recorded negative growth rate of 13.36 per cent per annum. The reasons for the decline in area and the fluctuations in production and productivity are to be given urgent attention and various studies have examined the reasons for the same and concluded that variations in weather and price fluctuations were observed as the main factors affecting growth and instability in maize crop. These findings are contradictory to the study conducted by Pavitra *et al.* (2018), which might be due to adaption to a wide range of soils and climatic conditions and high yield per ha as compared to other cereal crops and also this crop is dependent on poultry industry which is on increasing trend.

Bajra

The result of compound growth rates of area, production and productivity of bajra in Hyderabad-Karnataka region are presented in Table 2. It is seen that, bajra has shown positive significant growth in both area and production in Period-I. The area under bajra in Period-I had significant and positive growth rate of 8.77 per cent per annum and production of bajra recorded significant positive growth rate of 12.83 per cent.

In Period-III, the area under bajra in the district had registered growth of 1.88 per cent per annum. Production was recorded significantly positive growth rate of 20.76 per cent per annum and productivity also recorded significantly positive compound annual growth rate of 18.54 per cent.

For overall study period, the area under bajra in Bellary district had registered non-significant growth rate of 0.49 per cent per annum. The district had significant positive growth rate of 2.57 per cent in production and 2.07 per cent per annum in the productivity of bajra. This might be due to inducement by better relative prices for the crop, relatively low water requirement, availability of good quality seeds and availability of package of practices.

For Bidar district area under bajra in Period-I, there was a decline in area of cultivation had negative growth rate of 1.94 per cent per annum. But this decline in area has not affected the production and productivity of the crop, as the productivity marked a positive growth rate. The productivity of bajra registered significant and positive growth of 8.70 per cent per annum. In period II, the area under bajra registered significant negative growth rate of 2.76 per cent per annum. Whereas, the area under bajra in the district has registered negative growth of 17.29, per cent per annum in period III.

For overall study period, there was a decline in area of cultivation with a significant negative growth rate of 6.61 per cent per annum. Bidar district had also registered significant negative growth rate of 3.28 per cent per annum in production. The productivity of bajra had recorded significant positive growth of 0.58 per cent per annum for the three study periods.

The production of bajra in Kalaburagi district showed a systematic growth pattern during the study period of 1990-91 to 2017-18. The production of bajra in Period-I had positive growth rate of 5.66 per cent and values were significant at 1 per cent level of significance. The bajra production in Period-II had registered negative growth rate of 10.28 per cent per annum.

Overall, the area and production under bajra in Kalaburgi district registered a significantly negative compound annual growth rate of 8.12 and 5.58 per cent, respectively. Productivity

had recorded significantly positive growth rate of 2.85 per cent per annum. Among the area, production and productivity, the productivity exhibited positive growth rates with an increasing trend in spite of declined growth rates of area and production.

The Koppal district was formed in the year 1998 and data was available from the year 2000-01 onwards and the available data was analysed for Period-II and Period-III. The growth analysis of bajra production in Koppal revealed that, the production had registered positive annual growth of 25.06 per cent at 1 per cent level of significance in Period-II. The productivity had significantly positive growth rate of 18.11 per cent during the study period.

In period III, the area, production and productivity of bajra in the district had registered a negative growth.

The significant and positive growth in production and productivity of bajra for the overall study period was observed in Koppal district and the growth rates were 8.39 and 7.70 per cent per annum, respectively. Thus the growth in the production of bajra in the district had come mainly from the growth in the bajra productivity than from the growth in area. This could be attributed to the high price prevailed for bajra as well the suitability of the crop to the dry tracts which acted as an incentive for the farmers to extend bajra cultivation. The above results are contradictory to results of Acharya *et al*. (2012).

Table 2. Growth rates of area, production and productivity of bajra in Hyderabad -Karnataka region.

District	Particulars	Bajra		
		Area	Production	Productivity
Ballari	Period I	8.77**	12.83*	3.73
	Period II	-3.46	-2.03	1.49
	Period III	1.88	20.76**	18.54*
	Over all	0.49	2.57*	2.07**
Bidar	Period I	-1.94	6.59	8.70**
	Period II	-2.76*	-2.07	0.70
	Period III	-17.29**	-17.80	-0.61
	Over all	-6.61**	-3.28**	3.57**
Kalaburagi	Period I	2.20	5.66*	3.38
	Period II	-5.91	-10.28*	-0.92
	Period III	-15.46	-4.67	12.75
	Overall	-8.12**	-5.58**	2.85**
Koppal	Period I	-		-
	Period II	5.88	25.06*	18.11*
	Period III	-0.80	-5.31	-4.55
	Over all	0.64	8.39**	7.70**
Raichur	Period I	-3.77	-4.20	-0.43
	Period II	-0.40	8.97	9.40
	Period III	-2.67	3.92	6.77
	Over all	-2.80**	0.45	3.34**
Yadgir	Period I	-	-	-
	Period II	-	-	-
	Period III	-6.00**	1.04	7.48
	Over all	-6.00**	1.04	7.48

Period -I = 1991-92 to 2000-01, Period-II = 2001-02 to 2010-11, Period III= 2011-12 to 2017-18 and Over all = 1991- 2017-18.
Area: ha, Production: Tonnes and Productivity: kg/ha
** Significant at 1% level and *Significant at 5% level

The area, production and productivity of bajra crop in Raichur for Period-I had non-significant negative growth rates. In Period-II, the area under bajra registered non-significant negative growth rate of 0.40 per cent per annum, but production and productivity of bajra had recorded positive growth rates. In Period-III, the area under bajra had registered negative growth rate per annum. But production and productivity had recorded positive growth rate per annum.

For overall study period, the area under bajra in Raichur district registered significant negative growth rate of 2.80 per cent per annum. Productivity of bajra in Raichur district had significant positive growth rate of 3.34 per cent per annum. This might due to use of improved variety of seeds made available by the university and agriculture department in the area.

Yadgir is newly formed district in Karnataka state and the growth trends were analysed from 2010-11 to 2017-18 as period III. The district had registered an annual decrement in area under bajra in Period-III (5.75 % per annum). The district had non-significant production and productivity growth rate of 1.04 and 7.48 per cent per annum during Period-III. The wide spread use of High Yielding Varieties coupled with irrigation and fertilizer application at crucial stages of crop growth had led to increase in productivity.

Sorghum

Compound annual growth rate of area, production and productivity of sorghum in Hyderabad Karnataka region is presented in the Table 3. Post-rainy sorghum is primarily used as a food owing to its good grain quality and also serves as a main source of fodder, especially during dry seasons. The area under irrigated and post-rainy sorghum had declined over the years and is grown predominantly in all the six districts of Hyderabad Karnataka region. The findings of the study also revealed that most of the districts of the region experienced positive growth rates of productivity of sorghum during the reference period and statistically significant.

In Bellary district the area under sorghum had decreased significantly in Period-I and Period-II with compound annual growth rate of 6.27 and 4.29 per cent. The area under sorghum had witnessed a marginal annual decrement during the study periods. The production under sorghum in Period-I and Period-II had recorded negative growth rate of 2.09 and 3.61 per cent per annum, but in period III it had positive growth rate of 3.55 per cent per annum and the values were non-significant. Productivity under sorghum in Period-I had recorded positive growth rate of 4.46 per cent per annum and the values were significant at 5 per cent level of significance. Period-II and Period-III registered growth rates of 1.30 and 5.67 per cent per annum, respectively.

For overall study period, area and production under sorghum decreased significantly with annual growth rate of 5.87 and 4.07 but the productivity of sorghum had increased significantly with annual growth rate of 1.90 per cent and the values were significant at 5 per cent level of significance. This increase in productivity might also be due to the efforts of the research

projects at the national and state level in improving productivity of sorghum over years; availability of good quality seeds that minimize the incidence of soil borne diseases and availability of improved package of practices.

The growth performance of sorghum in Bidar district revealed that, area under sorghum decreased in Period-II and Period-III with annual growth rate of 2.87 and 7.92 per cent, respectively. Production was found to be decreased annually in Period-II and Period-III with 3.74 and 13.59 per cent and values were non-significant. Productivity under sorghum in Period-II and Period-III registered similar trend in the district.

The overall study period revealed that, the area and production under sorghum was decreased significantly with negative growth rate of 3.71 and 3.67 per cent per annum. The productivity of jowar in the district recorded a slight positive growth during the entire study period.

The details of growth in area, production and productivity of sorghum in Kalaburgi are presented in Table 3. The area under sorghum in Period-II decreased significantly with annual growth rate of 2.97 per cent per annum. Production was found to be positive in period I, period II and period III with annual growth rates of 0.98, 0.57 and 3.69 per cent. Productivity was found to be significant with annual growth rate 3.64 per cent in Period-II.

Table 3. Growth rates of area, production and productivity of sorghum in Hyderabad- Karnataka region.

District	Particulars	Sorghum		
		Area	Production	Productivity
Ballari	Period I	-6.27**	-2.09	4.46**
	Period II	-4.29*	-3.61	1.30
	Period III	-2.00	3.55	5.67
	Over all	-5.87**	-4.07**	1.90**
Bidar	Period I	-0.80	0.33	2.72
	Period II	-2.87**	-3.74	-0.89
	Period III	-7.92*	-13.59	-6.16
	Over all	-3.71**	-3.67**	-0.15
Kalaburagi	Period I	-4.46	0.98	0.55
	Period II	-2.97*	0.57	3.64*
	Period III	0.07	3.69	3.62
	Overall	-2.32**	-0.12	2.62**
Koppal	Period I	-	-	-
	Period II	0.55	8.40	7.80
	Period III	-1.49	-6.18	-4.78
	Over all	-3.86**	-3.33	0.55
Raichur	Period I	-5.77**	-4.64	1.19
	Period II	-6.17**	4.70*	11.57**
	Period III	-5.75	-1.48	4.53
	Over all	-5.61**	-3.23**	2.52**
Yadgir	Period I	-	-	-
	Period II	-	-	-
	Period III	-5.75*	-0.14	5.95
	Over all	-5.75*	-0.14	5.95

Note: Period -I = 1991-92 to 2000-01, Period-II = 2001-02 to 2010-11, Period III= 2011-12 to 2017-18 and Over all = 1991 -2017-18.
Area: ha, Production: Tonnes and Productivity: kg/ha
** Significant at 1% level and *Significant at 5% level

During the entire study period (1991-92 to 2017-18), there was a significant decrease in area under sorghum in the district which might be due to low output price in the market for this crop. The district had recorded significantly negative growth rate 2.32 per cent per annum. In contradiction to area, productivity in the sorghum had recorded significant positive growth of 2.62 per cent per annum.

The details of growth in area, production and productivity of Koppal district revealed that, during Period-II and Period-III the area under sorghum recorded positive and negative growth rates. Similar trend was observed in productivity of sorghum for Period-II and Period-III. The overall study period indicated that, the area under sorghum decreased significantly with annual growth rate of 3.86 per cent. From study it is concluded that, the Koppal district dry land agriculture has observed definite change in the cropping pattern. The area variation had more influence on production fluctuation in the sorghum crop. The magnitude of variability in area was observed to be small in the district and variability was quite large in productivity. The growth rates of area, production and productivity of sorghum crop in Raichur district revealed that, the area under sorghum in Period-I and Period-II had recorded significant negative growth rate of 5.77 and 6.17 per cent. In Period-II, production under sorghum recorded significant positive growth of 4.70 per cent. Productivity had recorded significant positive growth of 11.57 per cent per annum in Period-II. For entire study period, the area and production under sorghum had recorded significant negative growth rate of 5.61 and 3.23 per cent. Productivity under sorghum had recorded positive growth rate pf 2.52 per cent per annum. Similar trend was reported by Savitha and Kunal (2015).

The growth rates of area, production and productivity of sorghum in Yadgir district revealed that, the area under sorghum had recorded significant negative growth rate of 5.75 per cent per annum in Period-III. The reason for the decrease in the area under the sorghum might be due to better relative prices of the competing crops in the growing seasons.

From the above results it can be concluded that, in Hyderabad Karnataka region, there is increasing trend in area, production, but decreasing trend in productivity of maize crop. Rapid expansion in area under this crop was mainly due to its important features like short duration, adaption to a wide range of soils and climatic conditions and high yield per hectares as compared to other cereal crops. Trends in area and production of bajra and sorghum were decreasing due to lesser benefit cost ratio and post-harvest management is quite difficult as well as price fluctuations were common as compared to maize crop, hence the farmers were in trend of moving slowly towards cultivation of other crops.

Conclusion

The results of compound growth rate in area, production and productivity of major coarse cereals in H-K region revealed that there is increasing trend in area and production, but decreasing trend in productivity of maize crop. This may be attributed to

lack of technological breakthrough in maize production and fluctuations in prices. Hence, there is a need for gearing up the research and extension activities so as to improve the productivity of maize and provide remunerative price to farmers.

Trends in area and production of bajra and sorghum were decreasing due to lesser benefit cost ratio and post-harvest management is quite difficult as well as price fluctuations were common as compared to maize crop, hence the farmers were in trend of moving slowly towards cultivation of other crops. Hence, to improve the area and production of these two crops Minimum Support Price (MSP) should be incentivised to meet out food and nutritional security.

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