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Review article

Crop diversification in India: a study of maize cultivation in Karnataka

K. Singha* and A. Chakravorty
Institute for Social and Economic Change, Bangalore 72, India.

*Corresponding author; Institute for Social and Economic Change, Bangalore 72, India.

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ABSTRACT

Growing need of agricultural production has been greatly felt with the growth of population, not only for the sake of food security but also for providing employment. Crop diversification within the sector has also been noticed to a great extent. Of which, the growth of production of maize has registered at the highest with CAGR at 8.5 per cent in the last three decades. Using one way Least Squares Dummy Variable (LSDV) for twenty-seven districts over twelve years, present study explored that the introduction of new hybrid seed (HYV) is one of the most important factors for significant growth of maize crop in the state. Further, though the crop is suitable in the drier region, the role of timely rainfall is also found to have significant on the yield level.

1. Introduction

Despite a paradigm shift in the economic activities from agricultural to non-agricultural sectors in recent years, the growing need for agriculture and its production has been greatly felt with the growth of population, not only for the sake of food security but also for providing employment in the developing countries like India. The sector still plays an important role in overall development of the country's southern state of Karnataka and supports nearly 65 per cent of the state's population (GoK, 2012). Agriculture in the state is now characterized by wide crop diversification and still remains highly dependent on the vagaries of southwest monsoon. Out of the net area sown, about 30 per cent is irrigated in the state (Economic Survey, 2010-11). Therefore, crop diversification from wet to dry land farming within the sector has also been noticed to a great extent. Maize crop is found to the

fastest growing crop in recent years (KCL, 2006). For instance, Compound Annual Growth Rate (CAGR) of maize production has registered at the highest with 8.5 per cent compared to 2.2 per cent of rice in the last three decades (GoK, 2012). In the national level as well, Joshi, et al., (2005) identified that the crop has high production potential, provided the available improved hybrids, necessary irrigation and composites research of the farming community is done. However, thorough understanding of growth and structure of crops has become a pre-requisite condition for further policy initiatives of the sector's development in the state.

2. Objectives of the study

Knowing the importance of agriculture, the Government of Karnataka has presented an exclusive agriculture budget 2011-12 for the first time and it is the only one of its kind in the country (GoK, 2012). Also, the government considers the high growth of agriculture and allied sectors as a means to accelerate the state's economic growth and enable farmers to earn higher income and ensure food security (GoK, 2011). Diversification of cultivation from rice and other conventional crops to maize crop has been extremely significant in the state (KCL, 2006). Keeping the knowledge of the sector's diversification in mind, the present paper tries to understand the structure and direction of agricultural crop diversification in Karnataka in the recent years. What makes the maize crop growing faster in the recent year? The specific objectives of the study are given below.

1. To identify the best performing crops and their diversification in the recent past;
2. To understand the growth trend of maize crop at the districts and state level;
3. To identify the major factors that enhanced maize production/yield in the state.

3. Brief literature of the study

Maize (*Zea mays L*.) is the most important crop in the world after wheat and rice (Verheys, Undated). Study finding by Wokabi (1998) revealed that traditional maize farming practices are no longer capable of meeting maize production requirements with the growth of population in African nations. Therefore, widespread application of scientific methods is essential. Also, in Africa, maize crop, among other crops, is identified as a strategic commodity for achieving food security and poverty reduction. The study result by FARA (2009) revealed that the total production between the two decades in Africa – 1986-1996 and 1996-2006, about 50 per cent (8.6 million tons) of the total maize production has increased due to growth of yield level.

In the national level, according to Joshi, et al., (2005), maize yield improvement in recent years is credited to adoption of modern maize varieties. The southern state of Karnataka is categorised as non-traditional maize growing areas, which are mostly commercial and more favorable production environments. They realised that hybrids (improved seed) outperformed local and composite cultivars both in terms of yield and profitability. Hybrids are popular mostly in Andhra Pradesh and Karnataka, where the seed sector is strong. Though the crop is suitable for dry-land farming, the role of irrigation was not ignored by the scholars. Timely rainfall or proper irrigation enhances maize output.

The study by Wasim (2007) revealed that the influence of HYV seed on production, yield and area for major food crops in Punjab of Pakistan was found to be mixed. Its contribution on production, area and yield growth for wheat was remarkable. However, the adoption of HYVs has helped to accelerate the growth rate of production and yield of maize for few periods from 1965 to 1978 out of the long forty years period taken for the study in Punjab of Pakistan from 1951-52 to 1994-95.

In Haryana, Yadav, et al., (2011) found that with the reduction of groundwater, the farmers are shifting from unprofitable rice cultivation towards maize cultivation as it can be managed with 3–4 light irrigations. They also explored the role of HYV seed in maize crop cultivation, but the state faced the shortage of good hybrid seed. Similarly, Karnataka is found to be a dry land farming state and shortage of water or rainfall is also one of the important factors responsible for switching over many of the farmers from rice to maize cultivation in the state (Singha and Naphade, 2012).

Adoption of improved seed is concerned; Kaliba, et al., (2000) explored that the farmers' physical and capital endowment has no significant influence on the extent of adoption of new seed. Intensity of extension service was the major factor that positively influenced the adoption of improved maize seeds. The probability of adopting improved maize seeds for farmers in the lowlands which generally receive lower rainfall was higher by 25 per cent

than the intermediate altitude areas of Tanzania. This implies that the demand of improved seed in dry land is higher than the rain-fed region.

Further, using primary data of eastern and southern African nations, Smale and Jayne (2003) explored that maize successes in the future will continue to depend on strategic seed improvement. Since maize will remain a crucial part of the food security equation even while the agricultural economies of the region diversify, continued investments in both maize research and market institutions, some of which must be public, are essential in Africa.

Similarly, Thanh Ha, et al., (2004) found that the maize production has risen sharply since 1990 in Vietnam, when the government began to strongly support and promote maize hybrid technology. Vietnamese farmers have also widely adopted higher-yielding hybrid maize varieties. This was a timely response to Vietnam's growing livestock and poultry industry, which in turn generates an increasing demand for more maize to use as feed. This further verifies that the lion's share of the production is demanded by feed industry and the development of this sector is mainly enthused by improved seed.

In Karnataka, Vishwanatha (2005) focuses on the harvesting constraints of maize crop in Haveri and Davanagere districts of Karnataka. Using 2005-06 data of the two districts, threshing of maize due to the lack of labour was found to be one of the most important constraints of maize crop in Karnataka. The results of the study revealed that among traditional methods of threshing, bare hand separation and hand beating was adopted by 62.50 and 26.67 per cent of farmers, respectively. Whereas, in case of mechanical threshing methods, maize thresher and sheath removal maize thresher were found to be adopted by 34.17 and 27.50 per cent of farmers, respectively.

4. Methodology of the study

According to Mishra (2007), growth in the agriculture sector may well be judged by the increase in agricultural production over time. Three factors account for the increase in the total production of agricultural output: (a) increase in the total area under various crops, (b) increase in the yield rate of various crops and (c) substitution of more remunerative crops in place of less remunerative crops.

With the help of secondary data, collected from the Reserve Bank of India, Economic Survey of Karnataka, Economics and Statistics of Karnataka, Ministry of Agriculture and others, the present paper analysed growth trend and yield function of maize crop. Using semi-log growth model of Wasim (2007); Deosthali and Nikam (2004); Bhatia (1999), the growth trend of area and production of maize crop for twelve years (1998-99 to 2009-10) is estimated in twenty-seven districts of Karnataka. As productivity (yield) incorporates area and production, yield function is employed for the analysis of growth of the crop (Singha, 2012; Quddus, 2009). In the analysis, using One Way Least Squares Dummy Variable (LSDV) in the panel data of twelve years mentioned above, the paper tries to explore the factors that influence growth of maize crop in the state. Through the process, better performing districts can be identified as model districts and they can be set as target for the weaker districts of similar agro-climatic conditions for further development of the crop (Nath and Borah, 2011).

5. Growth trend of major crops

According to Dev (2012), there are three goals of agricultural development in the country. They are: (a) achieve 4 per cent growth and raise incomes by increasing productivity (land, labor), diversification to high value agriculture and rural non-farm by maintaining food security; (b) sharing growth (equity) by focusing on small and marginal farmers, lagging regions, women, etc.; (c) to maintain sustainability of agriculture by focusing on environmental concerns. In Karnataka, though the state has achieved an impressive growth rate in the overall infrastructural development compared to some other weaker states in the country, the agricultural infrastructure development has not evenly distributed within the state. This resulted in regional imbalances in the state (Venkatachalam, 2003). Therefore, development should be inclusive and balanced between the regions. Using composite development index of thirty-nine components, Narain, *et al*. (1997) have studied district level development in Karnataka and found wide disparities in the state. Further, they explored a positive correlation between agricultural growth and socio-economic development in the state. In the context of maize cultivation, two things are required to keep in mind that: 1) yields during the winter season were higher than yields during the rainy season; hybrid yields are substantially higher than yields of composites and local/traditional cultivars (Joshi,

et al., 2005). So, as the state of Karnataka is dry region, maize cultivation is preferred by the farmers and found to be beneficial.

Based on decadal growth rate estimated from the Ministry of Agriculture, three cereal crops – Maize, Tur (Arhar) and Rice have been found positive and significant growth, in terms of area expansion and production in the recent decades (GoK, 2012). On the basis of area and production expansion, *maize* is identified as the best performing crop in the state from 1980-81 to 2010-11, followed by *tur* during the same period. The rice crop, which was the leading crop in the 1980s and 1990s have fallen at the bottom after 2000s (refer to Table 1).

Table 1
CAGR of area and production of major crops in karnataka

Crop	Area/Production*	1980-81	1990-91	2000-01	2010-11	CAGR
Rice	Area	11.1	11.7	14.8	15.4	1.1
	Production	22.6	24.3	38.5	43.0	2.2
Maize	Area	1.6	2.5	6.7	12.9	7.2
	Production	3.8	6.3	21.4	44.4	8.5
Tur	Area	3.4	4.6	5.8	8.9	3.3
	Production	1.3	1.8	2.6	5.3	4.9

* Area in Lakh Ha; Production in Lac ton
Source: GoK (2012)

From the Table 1, we can deduce that the growth rate of maize crop registered at the highest compared to other traditional crops in the state. For instance, growth rate (CAGR) of maize is observed to be 8.5 per cent and 7.2 per cent for production and area expansion respectively in the last thirty years. It is much higher than the growth of rice which registered at 2.2 per cent and 1.1 per cent of production and area expansion respectively during the same period. The same holds true for the Tur crop as well; that the growth rate of area and production of Tur is much lower than maize crop during the same period. As the growth rate of maize production is higher than the growth rate of its area expansion during the last three decades, it infers that the yield level of the crop performed well during the period.

Further, to identify growth performance of the four best crops (as selected in this study) in the last decade (1998-99 and 2009-10) in the state, an analysis is made for area and production in Tables – 2 and 3 respectively. The contribution of the districts to the state total in terms of area and production is assessed. Which districts occupy larger share of area and production is also analysed. From the Table 2 we can find that the growth rate of area expansion of maize crop from 1998-99 to 2009-10 outperformed other competing crops – rice and tur. Excepting three districts – Bangalore (u), Kolar and Udupi, the remaining twenty-four districts have shown positive and significant growth rate. Though the area share of maize crop to state total is very low, the growth rate in the last decade of the districts of Chikmaglur, Hassan, Mandya and Uttarakanada was extremely high in the state.

From Table 3 we can further clarify that the growth rate of production of maize crop outperformed other two competing crops – rice and tur. Similar to Table 2 or area expansion in the last decade (1998-99 to 2009-10), the growth rate of production of the three districts – Bangalore (u), Kolar and Udupi have shown negative growth rate. This is probably because the district of Udupi was bifurcated recently from Dakshinakannada and both are highly developed districts in terms of secondary and tertiary sector. The agricultural contribution to the state by these two districts is extremely low. Similarly, the districts of Bangalore (U) and Kolar are also found to be extremely poor in terms of agriculture due to urbanisation. Besides, the Kolar district is an extremely dry area and the irrigation facility is neglected in the district. But further research is needed for the purpose.

The above discussion and evidences provided by the Table 1 to 3 certified that the growth rate of maize crop outperformed other two competing crops – rice and tur. This envisaged us to analyse the growth trend of area and production of maize crop by district. It will show us the performance of the districts within the state over the period of time. The detail growth trend of area and production maize crop by district is given in Table 4. The growth rate is calculated by using the following equation, $\text{Log}Y_t = a + bt + \xi_t$ Where Y= production/area of Maize; a=constant; b=coefficient; t=time variable in year (1, 2, ……., 12).

Table 2

Area of three major crops in different districts, their share to state total and growth rate between 1998-99 and 2009-10

Districts	Rice			Tur			Maize		
	1998-99	2009-10	Change*	1998-99	2009-10	Change*	1998-99	2009-10	Change*
Bagalkot	197 (0.01)	133 (0.01)	-32.5	6154 (1.3)	4811 (0.8)	-21.8	43402 (8.5)	82030 (6.8)	89.0
Bangalore (r)	20967 (1.5)	1667 (0.1)	-92.0	5522 (1.2)	1306 (0.2)	-76.3	5368 (1.0)	10935 (0.9)	103.7
Bangalore (u)	7245 (0.5)	2041 (0.1)	-71.8	936 (0.2)	617 (0.1)	-34.1	1415 (0.3)	655 (0.1)	-53.7
Belgaum	62731 (4.4)	71888 (4.9)	14.6	8602 (1.8)	4671 (0.8)	-45.7	109370 (21.3)	162344 (13.5)	48.4
Bellary	68854 (4.8)	120414 (8.2)	74.9	7563 (1.6)	8938 (1.5)	18.2	32090 (6.3)	100517 (8.4)	213.2
Bidar	9587 (0.7)	5039 (0.3)	-47.4	54354 (11.4)	67000 (11.2)	23.3	306 (0.1)	1685 (0.1)	450.7
Bijapur	394 (0.01)	27 (0.01)	-93.1	14304 (3.0)	104091 (17.4)	627.7	12170 (2.4)	64558 (5.4)	430.5
Chamnnagar	18465 (1.3)	17114 (1.2)	-7.3	2487 (0.5)	1949 (0.3)	-21.6	9129 (1.8)	37899 (3.2)	315.1
Chikmagalur	49841 (3.5)	43642 (3.0)	-12.4	1035 (0.2)	717 (0.1)	-30.7	460 (0.1)	10697 (0.9)	2225.4
Chitradurga	9422 (0.7)	11075 (0.8)	17.5	7582 (1.6)	8012 (1.3)	5.7	33386 (6.5)	84438 (7.0)	152.9
Dakshinnada	67754 (4.7)	54899 (3.7)	-19.0	-	-	-	-	10 (0.001)	-
Davangere	118178 (8.3)	137449 (9.3)	16.3	6657 (1.4)	4385 (0.7)	-34.1	103680 (20.2)	174172 (4.5)	68.0
Dharwad	37633 (2.6)	26958 (1.8)	-28.4	2473 (0.5)	2573 (0.4)	4.0	18569 (3.6)	51862 (4.3)	179.3
Gadag	1044 (0.1)	2012 (0.1)	92.7	2449 (0.5)	2939 (0.5)	20.0	18063 (3.5)	48292 (4.0)	167.4
Gulbarga	22202 (1.6)	79472 (5.4)	257.9	273391 (57.5)	336853 (56.4)	23.2	2021 (0.4)	6352 (0.5)	214.3
Hassan	66684 (4.7)	47659 (3.2)	-28.5	3730 (0.8)	2235 (0.4)	-40.1	5242 (1.0)	62825 (5.2)	1098.5
Haveri	54375 (3.8)	49995 (3.4)	-8.1	7477 (1.8)	2546 (0.4)	-65.9	54083 (10.6)	125965 (10.5)	132.9
Kodagu(coorg)	40666 (2.9)	34844 (2.4)	-14.3	-	-	-	1495 (0.3)	3576 (0.3)	139.2
Kolar	29267 (2.1)	7096 (0.5)	-75.8	12694 (2.7)	1852 (0.3)	-85.4	14021 (2.7)	845 (0.1)	-94.0
Koppal	68847 (4.8)	73955 (5.0)	7.4	13481 (2.8)	11005 (1.8)	-18.4	15664 (3.1)	41056 (3.4)	162.1
Mandya	79892 (5.6)	79961 (5.4)	0.1	2060 (0.4)	1316 (0.2)	-36.1	22 (0.01)	4073 (0.3)	18413.6
Mysore	109666 (7.7)	123650 (8.4)	12.8	6687 (1.4)	3368 (0.6)	-49.6	17602 (3.4)	29391 (2.5)	67.0
Raichur	117347 (8.2)	176440 (12.0)	50.4	19100 (4.0)	12984 (2.2)	-32.0	249 (0.01)	915 (0.1)	267.5
Shimoga	158633 (11.1)	133259 (9.0)	-16.0	508 (0.1)	362 (0.1)	-28.7	8295 (1.6)	69481 (5.8)	737.6
Tumkur	47448 (3.3)	36335 (2.5)	-23.4	15946 (3.4)	12229 (2.0)	-23.3	6219 (1.2)	20306 (1.7)	226.5
Udupi	69598 (4.9)	57509 (3.9)	-17.4	-	-	-	33** (0.01)	15 (0.001)	-54.5
Uttaranada	89868 (6.3)	80272 (5.4)	-10.7	204 (0.01)	45 (0.01)	-77.9	47 (0.01)	4451 (0.4)	9370.2
State Total	1426800 (100)	1474805 (100)		475400 (100)	596804 (100)		512401 (100)	1199345 (100)	

Source: MoA (2012)

* Percentage change from 1998-99 to 2009-10; ** data of 2005-06

Notes: Figures in parentheses are percents of the state total; Area in ha

Table 3

Production of three major crops in different districts, their share to state total and growth rate between 1998-99 and 2009-10

Districts	Rice			Tur			Maize		
	1998-99	2009-10	Change*	1998-99	2009-10	Change*	1998-99	2009-10	Change*
Bagalkot	316 (0.01)	381 (0.01)	20.6	2602 (1.2)	2610 (0.9)	0.3	121873 (7.3)	197519 (7.1)	62.1
Bangalore (r)	61073 (1.7)	7189 (0.2)	-88.2	2151 (1.0)	1069 (0.4)	-50.3	16189 (1.0)	50412 (1.8)	211.4
Bangalore (u)	21102 (0.6)	6016 (0.2)	-71.5	436 (0.2)	285 (0.1)	-34.6	4175 (0.2)	1627 (0.1)	-61.0
Belgaum	114147 (3.1)	84042 (2.2)	-26.4	3645 (1.6)	1424 (0.5)	-60.9	306391 (18.3)	343578 (12.3)	12.1
Bellary	224687 (6.1)	380920 (9.9)	69.5	2234 (1.0)	3303 (1.2)	47.9	99860 (6.0)	198142 (7.1)	98.4
Bidar	5825 (0.2)	3857 (0.1)	-33.8	41464 (18.7)	49647 (18.0)	19.7	715 (0.01)	1406 (0.1)	96.6
Bijapur	541 (0.01)	77 (0.01)	-85.8	5191 (2.3)	31050 (11.3)	498.2	35920 (2.1)	96242 (3.4)	167.9
Chamnnagar	59350 (1.6)	45717 (1.2)	-23.0	572 (0.3)	1494 (0.5)	161.2	34231 (2.0)	82932 (3.0)	142.3
Chikmagalur	118813 (3.2)	108173 (2.8)	-9.0	482 (0.2)	332 (0.1)	-31.1	1567 (0.1)	29449 (1.1)	1779.3
Chitradurga	27541 (0.8)	22137 (0.6)	-19.6	3393 (1.5)	4635 (1.7)	36.6	105152 (6.3)	141928 (5.1)	35.0
Dakshinnada	141211 (3.9)	124141 (3.2)	-12.1	-	-	-	-	12 (0.008)	-
Davangere	390808 (10.7)	469296 (12.2)	20.1	3482 (1.6)	4066 (1.5)	16.8	383332 (22.9)	518239 (18.5)	35.2
Dharwad	35730 (1.0)	31584 (0.8)	-11.6	611 (0.3)	1995 (0.7)	226.5	65302 (3.9)	118104 (4.2)	80.9
Gadag	2565 (0.1)	3722 (0.1)	45.1	503 (0.3)	782 (0.3)	55.5	65112 (3.9)	91242 (3.3)	40.1
Gulbarga	41335 (1.1)	180692 (4.7)	337.1	124147 (56.0)	153285 (55.6)	23.5	5859 (0.4)	7141 (0.3)	21.9
Hassan	156248 (4.3)	127886 (3.3)	-18.2	858 (0.4)	871 (0.3)	1.5	17271 (1.0)	222250 (7.9)	1186.8
Haveri	83333 (2.3)	60166 (1.6)	-27.8	2216 (1.0)	1461 (0.5)	-34.1	175258 (10.5)	262420 (9.4)	49.7
Kodagu(coorg)	85142 (2.3)	85137 (2.2)	0.0	-	-	-	5800 (0.3)	16736 (0.6)	188.6
Kolar	79828 (2.2)	12830 (0.3)	-83.9	11239 (5.1)	1510 (0.5)	-86.6	47194 (2.8)	2122 (0.1)	-95.5
Koppal	233409 (6.4)	245406 (6.4)	5.1	2818 (1.3)	2415 (0.9)	-14.3	55687 (3.3)	61771 (2.2)	10.9
Mandya	245663 (6.7)	263413 (6.9)	7.2	959 (0.4)	609 (0.2)	-36.5	77 (0.01)	5261 (0.2)	6732.5
Mysore	333026 (9.1)	381919 (9.9)	14.7	1957 (0.9)	1766 (0.6)	-9.8	75139 (4.5)	92500 (3.3)	23.1
Raichur	395453 (10.8)	492337 (12.8)	24.5	3429 (1.5)	3626 (1.3)	5.7	816 (0.05)	1855 (0.1)	127.3
Shimoga	383617 (10.5)	319806 (8.3)	-16.6	236 (0.1)	167 (0.1)	-29.2	32134 (1.9)	199932 (7.1)	522.2
Tumkur	136903 (3.7)	92959 (2.4)	-32.1	6787 (3.1)	7098 (2.6)	4.6	16144 (1.0)	39348 (1.4)	143.7
Udupi	122106 (3.3)	138204 (3.6)	13.2	-	-	-	117** (0.01)	40 (0.001)	-65.8
Uttaranada	157039 (4.3)	155245 (4.0)	-1.1	95 (0.01)	21 (0.01)	-77.9	94 (0.01)	16361 (0.6)	17305.3
State Total	3656900 (100)	3843252 (100)		221500 (100)	275521 (100)		1671300 (100)	2798569 (100)	

Source: MoA (2012)

* Percentage change from 1998-99 to 2009-10; ** data of 2005-06

Notes: Figures in parentheses are percents of the state total; Production in ton

Table 4
Log-linear regression growth trend of area and production of maize (1998-99 to 2009-10).

District	Area (in %)	Production (in %)
Bagalkot	5.760** (2.6)	7.090** (2.9)
Bangalore (rural)	6.609* (6.9)	11.572* (6.1)
Bangalore (urban)	-7.781** (-2.4)	-6.947) (-2.1)
Belgaum	3.977** (2.5)	5.443 (1.9)
Bellary	9.527* (9.3)	6.609* (4.7)
Bidar	8.405** (2.2)	4.362 (1.2)
Bijapur	16.767* (5.1)	13.928* (3.5)
Chamarajannagar	12.817 (9.4)	11.561* (5.2)
Chikmagalur	37.438* (10.6)	38.542* (6.9)
Chitradurga	6.716* (3.3)	1.816 (0.5)
Dakshinakannada	NA	NA
Davangere	4.603* (5.1)	5.232 (1.6)
Dharwad	12.075* (3.2)	10.960 (1.6)
Gadag	9.450 ** (2.5)	9.013 (1.5)
Gulbarga	9.09* (3.7)	5.106 (1.7)
Hassan	20.804* (11.5)	19.339* (6.8)
Haveri	8.004* (5.3)	4.949*** (1.8)
Kodagu	8.394* (8.1)	12.345* (6.1)
Kolar	-22.740** (-2.75)	-21.667** (-2.9)
Koppal	10.296* (5.01)	4.959 (1.7)
Mandya	NA	NA
Mysore	6.078* (4.5)	6.056** (2.6)
Raichur	21.531* (4.9)	19.877* (3.5)
Shimoga	20.081* (7.1)	18.341* (5.9)
Tumkur	10.175* (8.1)	9.429* (4.1)
Udupi	NA	NA
Uttarakannada	56.988* (9.2)	63.395* (8.2)

Notes: Values in the parentheses are the t-value
* 1% level of significance; ** 5% level of significance; *** 10% level of significance
Source: Authors estimation from MoA (2012)

From Table 4 we can find that the districts of Uttarakanada and Chikmagalur have witnessed a significantly high growth rate in terms of their area and production, followed closely by Bijapur, Hassan, Raichur and Shimoga. The remaining districts have had a moderate growth rate, ranging from 3 per cent to 10 per cent in area and 4 per cent to 12 per cent in production. However, there has been a substantial fall in the growth rate of area and production, in the districts of Bangalore (Urban) and Kolar due to the same factors mentioned above. However, the growth rate of the districts of Udupi, Mandya and Dakshinakannada was not estimated in this present study due to data constraints.

6. Growth performance and yield function of maize

In the country, the state of Karnataka is considered as the largest maize producing state, contributing 10 per cent to the country's total maize production in 1995 (Singh and Morris, 1997) and it rose to 15.3 per cent in 1999 (Joshi, et al., 2005). In terms of yield, Karnataka maintains first position in India with 3.10 tonnes per ha in 1999 (Joshi, et al., 2005), but according to Sridhar (2008), it was 2.79 tonnes per hectare in 2006-07. Whichever the estimate, it is much higher than 1.7 ton/ha produced by major maize producing countries of Africa during the same time (FARA, 2009). On the demand side, the major factors for speedy development of maize crop in the state of Karnataka in recent years are credited to high demand from the feed industries; assured market price and introduction of hybrid seed (Joshi, et al., 2005; Thanh Ha, et al., 2004) and the same holds true in the African case (Verheye, Undated). Though the share of human consumption of maize crop is relatively much lower than the

demand of feed industries, the growing need of semi-finished product in the form of baby corn, sweet corn, and pop corn in the recent years taken together, total production of maize crop in the state would have been higher than the estimates given by the government agencies, especially in Karnataka (Singha and Naphade, 2012). Of course, it needs further research for the same and is not directly related to the present study.

To determine the growth rate of yield of maize, three independent variables have been incorporated. They are – High Yielding Varieties Seed (HYV seed), Average annual rainfall and type of soil, for twelve years in the twenty-seven districts of the state. Technically, the data set used in the analysis is considered as an unbalanced panel, as twenty-five districts out of twenty-seven have twelve years time series data of the three independent variables – HYV, annual rainfall and type of soil. However, two districts – Dakshinkannada and Udupi, have three and five years time series data respectively for the said three independent variables.

In the process of analysis, the basic assumptions of classical regression model are tested. The multicolinearity test was done by using the VIF method (VIF < 10). The Breusch-Pagan and White's test was also done to check heteroscedasticity problem and confirmed the presence of non-constant variance across the districts. In order to specify the appropriate model to fit the panel data, the F-statistic obtained from Fixed Effects estimation and the LM Statistic from the Random Effect estimation were also used. Further, Hausman test rejected the null hypothesis of the presence of Random Effects; thereby accepting the presence of Fixed Effects in the model. Since the time effects were jointly significant, time dummies were included in the Fixed Effects model. Hence, the One Way Least Squares Dummy Variable (LSDV) was found to be the best fit to estimate the panel data. The yield function of maize is given as:

$$Y_{it} = \alpha + \beta_1 \ln HYVarea_{it} + \beta_2 \ln rain_{it} + \beta_3 s_i + \delta_i t_{it} + \xi_{it} \quad \text{..... (1)}$$

Where, Y_{it} is the dependent variable of maize production in the districts, β_1 is the coefficient of the total area covered by HYV seed, β_2 is the coefficient of average annual rainfall, β_3 coefficient of soil type in the districts, δ_i is the coefficient of time dummies.

Table 5
LSDV Estimates

Yield	Coef.	Robust std err	T	P>|t|	95% conf interval	
ln_hyv	0.047161	0.0190598	2.47	0.014*	0.009647	0.084675
ln_rain	0.026461	0.0126578	2.27	0.024**	0.005159	0.049406
s1	-0.15046	0.301399	-0.5	0.618	-0.74368	0.442768
s2	-0.30658	0.25875	-1.18	0.237	-0.81586	0.202703
t2	-0.43197	0.1392916	-3.1	0.002*	-0.70613	-0.15781
t3	0.021751	0.1228444	0.18	0.86	-0.22004	0.263538
t4	-0.42391	0.180062	-2.35	0.019**	-0.77831	-0.0695
t5	-0.80062	0.1690933	-4.73	0*	-1.13344	-0.46781
t6	-0.73627	0.2099845	-3.51	0.001*	-1.14957	-0.32297
t8	-0.08301	0.1729611	-0.48	0.632	-0.42343	0.257422
t9	-0.31688	0.1975338	-1.6	0.11	-0.70567	0.071914
t10	-0.11752	0.1426048	-0.82	0.411	-0.3982	0.163162
t11	-0.27205	0.1694805	-1.61	0.11	-0.60563	0.061527
t12	-0.74077	0.1997242	-3.71	0*	-1.13388	-0.34767
_cons	1.139347	0.9830767	1.16	0.247	-0.79558	3.074273

* Significant at 1 per cent; ** Significant at 5 per cent

lnhyv = Log of High Yielding Verities Seed

lnrain = Log of average annual rainfall

s_i (i = 1 to 3) implies Soil Dummies (s1= Red and black; s2 = Red, Black and Laterite, s3 = Red, Alluvial and Laterite)

t_i (i = 1 to 12) implies Time Dummies

From the Table 5, it is clear that the impact of HYV seed to maize yield is significant. With a change of 1 unit in HYV area of maize in the state, we observe a change of 4.7 per cent in maize yield. Similarly, the impact of average annual rainfall on the yield growth is also found to be 2.4 per cent. However, the impact of soil on the yield growth

is not found to be significant. As for the time dummies, we find that the period between 2001 and 2003 is witnessed as a significant growth in yield of maize relative to the year 1998.

7. Conclusion

From the above analysis we can summarize that the role of agriculture in the state economy is still significant in Karnataka. Crop diversification within the sector is widely noticed. Though the contribution of agriculture to the state economy has been declining consistently, majority of the rural masses are directly or indirectly depending on it and the state's contribution of the sector to the national level is still very big. In the recent past, the growth rate of maize crop in terms of area and production has increased significantly and overtaken the traditional crop, and occupies largest share of area and production in the state. In this manner, the state of Karnataka, traditionally known for rice cultivation has slowly switched over to the cultivation of maize crop in the recent years.

Among the districts, Utttarkannada, Shimogha, Raichur, Hassan and Chigmaglur have been identified as better performing districts in terms of growth of area and production of maize crop in the state. The districts of Chamranagar, Dharwad and Bijapur, etc., have also increased their area and production of maize moderately in the state. In totality, the growth of maize is enthused by the performance of yield level which is much higher not only than the national average, but also the other competing crops in the state. The recent growth of maize production is credited to the HYV seed and timely rainfall. Therefore, the better performing districts mentioned above can be set as the targets for the weaker districts in the state.

As the modern seed (HYV seed) has been identified as an engine of growth of maize crop in the state, government should make the required seed available to the farmers at affordable prices. For better and faster marketing, the necessary processing units can be made available at the farmers' door step and support price should be strengthened. Of course, necessary irrigation facility and finance should be made available at a low interest rate.

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