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Growth Dynamics of Food Grains in Eastern Dry Zone of Karnataka - An Economic Analysis

M. Ashwini and H. Lokesha
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
e-Mail : ashwinimganesh1995@gmail.com

Abstract

The present study was initiated in Kolar and Chikkaballapur districts of Karnataka with the overall objective of assessing the growth in production and allocation of area under food crops in rainfed situation. The study was based on time series data collected from Directorate of Economics and Statistics, Bangalore. Compound annual growth rate and triennium averages were worked out to examine the trend in area, production and productivity of food crops. Markov chain analysis was used to examine the dynamic shift in area, production and productivity of food crops over two decades from 1997-98 to 2017-18. The triennium end average of area food crops in Kolar district for the period TE 2017-18 was 81142.00 ha reduced from 189171.00 ha in TE 2000-01. Productivity of food crops is reduced to 1334.7 kg/ha from 1710.3 kg/ha (TE 2000-01). The growth in area under food crops was -5.0 per cent (Period I), reduced to -0.2 per cent (Period II) with the overall growth rate of -5.2 per cent. Whereas, growth in productivity was -1.9 per cent (Period I), increased by -5.0 per cent (Period II) with the overall growth rate of -0.7. Implies growth in area, production and productivity showing decline turn to negative. Whereas, triennium end average of area for food crops for the period TE 2017-18 was 124765.7 ha with growth of 3.1 per cent and productivity average 2165.7 kg/ha with growth of -0.3 per cent. The retention capacity of maize was highest in both districts with 90 and 59 per cent, respectively. Horsegram, Cowpea and Field bean have zero retention capacity *i.e.,* horsegram lost its 100 per cent to. This will be projected by using Markov chain analysis.

Keywords : Compound annual growth rate (CAGR), Triennium average (TE), Transitional probability matrix, Markov chain analysis

Population in the developing countries increasing at alarming rate. To feed this population is challenging task to the world bodies. The Indian economy depends mainly on agriculture, about 42.39 per cent of the India's population directly or indirectly depends on agriculture and allied activities for their livelihoods (Anonymous, 2018). The agriculture sector plays a vital role in the economic development accounting for 17 per cent of Gross Domestic Product (GDP) in 2017-18 which is increased to 19.9 per cent in (2018-19) with the growth rate 2.9 per cent. Green revolution had bought tremendous change in the production of food crops. In spite of increase in area, production and productivity of food crops which led to increased in rural per capita incomes. A dynamic change has been witnessed in agricultural scene in the country, particularly during post-green revolution period. Over the years, area under cultivation of food crops has been diminishing as others like horticulture and commercial crops outpaced in the recent years. As population increasing drastically, there is huge demand for food crops in the country to sustain the livelihood. The country has made impressive progress in food front, which led to increase in production of food grains. The estimated production of food grains to be 308.65 million tonne during 2020-21 (Anonymous, 2020). Recently the Planning Commission reported that boosting farmer income by enhancing productivity of food crops to washout the poverty in rural area is imperative. Kolar and Chikkaballapur come under dry land where the production of most of the food crops is heavily dependent on rainfall. These situations affect the farmer to grow commercial crops to enhance the

income levels due to scarcity of water for the agriculture activities. Even though farmer in the study area practice agriculture by adopting advanced technologies to diversified cropping to ensure sustainability of production. Hence, this study is modest attempt to examine the dynamics of area, production level and productivity of food crops which is crucial to enhance livelihood of farmers.

Material and Methods

The study was undertaken to examine dynamic changes in area under food crops in Kolar and Chikkaballapur districts. Secondary data on production area of major food crops ranging from 1997-98 to 2017-18 was utilized analyze dynamic changes in area. The data was collected from Directorate of Economics and Statistics. The principal crops under present study were rice, ragi, maize, field bean, cowpea, horsegram, redgram, groundnut, sunflower and other crops. The data was segregated into decades to examine the dynamic changes in under production of food grains with other crops. Compound annual growth rate and triennium average were employed to examine the basic statistical properties of the data. Dynamics of production area of major principal food crops under study was analyzed using Markov chain analysis to examine the retention capacity of these food crops over the years. The detailed expression of the statistical methodology adopted for the study is given in the next section.

Analytical Tools

(a) Compound Annual Growth Rate

Compound growth rates of production area were estimated to study the growth in food grain groups under study. Growth rates of production area were obtained from exponential function as follows:

$Y = ab^t$

$log\ y = log\ a + t\ log\ b$

CGR (%) = (Antilog b – 1) *100

where, CGR = Compound growth rate; t = Time period in year; y =Area / production / productivity; a & b = Regression parameters.

(b) Triennium Average : is a specified period of three years average. Calculated for the food crops using simple tabular calculations.

Markov Chain Technique

Markov chain analysis was used to examine the dynamic shift in production area under food crops in Kolar and Chikkaballapur districts of Karnataka. Markov chain approach is based on less stringent assumptions and provides more information than the regression approach (Matis, 1985). If the probability distribution of assigning agriculture land to one of food grain crop in any period depends on distribution in the previous period and the dependencies are more or less same for all period, the process of structural change could be represented by a stationary first order Markov chain. It should be noted that this techniques assumes the Markov property to forecast the area distribution. Since the predictions are not constrained by any *a prior* specification of distribution, this procedure is non-parametric (Matis, 1985).

In addition, the transition probabilities have been estimated with assumption of constancy, *i.e.*, all the forces which influenced agricultural structural change in the past will continue to do so in the future (Gaffney, 1992).

A stochastic matrix with the probability, *Aij* of movement of area under a given food grain *i* in period *t* to another food gain group *j* in period $t + 1$ is called transition probability matrix (TPM). The TPM is expressed as

$$P = \begin{bmatrix} A_{ij} & \cdots & A_{is} \\ \vdots & \ddots & \vdots \\ A_{ij} & \cdots & A_{ss} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $A_{ij} \geq 0$ and $\sum_j A_{ij} = 1$

Here P is a square matrix ($n \times n$), with n being the total number of grains which are total number of individual crops. Each element (Aij) represents the probability of moving from one crop i to other j.

Let F denotes the final probability matrix for each state through finite Markov chain theory

$$F = \begin{bmatrix} \prod_{i=1}^{s-1} A_{i,i+1} \\ \prod_{i=2}^{s-1} A_{i,i+1} \\ \prod_{i=3}^{s-1} A_{i,i+1} \\ \vdots \\ A_{ss} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Finally, this matrix may be reduced as below: The F matrix can be used to project the area under selected food grain crop. Since, the single value projections are less realistic and do not reveal the uncertainty of projections, complete distribution of projected value is more appropriate. Hence, a markov chain simulation of the transition probability on the assumption that 100 per cent probability shift in the transitional matrix. Thereby, Projection for area of selected food crops in next five years has been made by forecasting the transitional probabilities.

RESULTS AND DISCUSSION

Triennium end average of area, production and productivity of food crops in Kolar district (Table 1) was calculated for two decades from (1997-98 to 2017-18). The average area under food crops during 2017-18 was 81142.0 ha reduced from 189171.0 ha (2007-08). The triennium end average of Production level was 106818.7 tonne (2017-18), reduced from 312393.3 tonne in 2007-08. Whereas, average yield levels of food crops in the study area was 1344.7 kgs/ ha in (TE 2017-18) declined from 1,710.3 kgs / ha (2000-01). This is mainly due to the bifurcation of Chikkaballapur from the Kolar district withdrawn area under food crops. This might be due to food crops lost their area for other crops like horticulture and commercial crops as farmers moving out from consumption oriented to towards market oriented mainly to undertake income generating operations. Which led to increase in their per capita income by shifting traditional form of self sufficiency in the production of food grains to production of modern market oriented commodities. One more reason for the decline in area under food grain is before 2007 Chikkaballapur taluk was under the Kolar district which was bifurcated as separate district on 7th August 2007, therefore, area under food crops was declined drastically.

TABLE 1

Triennium end average of area, production and productivity of food crops in Kolar and Chikkaballapur districts

Year	Area (ha)	Production (tonne)	Yield (kg/ha)
Kolar district			
TE 2000-01	189171.0	312393.3	1710.3
TE 2007-08	127125.7	193640.0	1508.7
TE 2017-18	81142.0	106818.7	1344.7
Chikkaballapur district			
TE 2009-10	98782.0	183468.0	1944.7
TE 2017-18	124765.7	261041.7	2165.7

Source: Author's Calculation using DES data

Triennium end average of area, production and productivity of food crops in Chikkaballapur district (Table 1) was calculated for a decade from (2007-08 to 2017-18). The average area, production and productivity of food crops during TE 2009-10 was 98,782.0 ha, 1,83, 468.0 tonne and 1,944.7 kgs / ha which is increased by 1,24,765.7 ha, 2,61,041.7 tonne and 2,165.7 kgs / ha in (TE 2017-18). This revealed that positive trend in the production of food crops was found in the study area.

Growth rates of area, production and productivity of food crops in Kolar district is depicted in Table 2. The compound annual growth rate of area was -5.0 per cent (1997-98 to 2007-08), reduced to -0.2 per cent (2008-07 to 2017-18) and the overall growth rate in area under food crops for two decades was -5.2 per

cent. This is mainly due to the bifurcation of Chikkaballapur from the Kolar district there by withdrawn area under food crops. Negative growth rate was found in production of food crops with -6.8 per cent (1997-98 to 2007-08), reduced to -5.2 per cent in (2007-08 to 2017-18) with the overall growth rate of -5.9 per cent. Whereas, growth rate in case of yield levels was increased by -0.7 per cent (2017-18) from -1.9 per cent in 2017-18. Growth rates of area, production and productivity of food crops in Chikkaballapur district were found with 3.1, 2.8 and -0.3 per cent, respectively. This table revealed that positive trend in the production of food crops was found in the study area. This is clearly given the picture that productivity of food crops took negative growth *i.e.,* yield per unit area is declining nowadays. This shown that farmers put their step out of production of food crops, step in the cultivation of commercial crops and other crops. This led to generate per capita income of a farmer but it adversely affects the food grain production. This will takes negative sing in growth rate of food crops in near future.

TABLE 2

Trends in area, production and productivity of food crops in Kolar and Chikkaballapur districts

Year	Area (ha)	Production (tonne)	Yield (kg/ha)
Kolar district			
1997-98 to 2007-08	-5.0	-6.8	-1.9
2008-09 to 2017-18	-0.2	-5.2	-5.0
1997-98 to 2017-18	-5.2	-5.9	-0.7
Chikkaballapur district			
2007-08 to 2017-18	3.1	2.8	-0.3

Source: Author's Calculation using DES data

However, it is evident to know the individual retention capacity of food crops in Kolar district is depicted in (Table 3 & Fig.1). Transitional probability matrix revealed that change or shift in area under one crop to another crop in two decades. The off diagonal element Aij (i≠j), indicates the probability of the ith crop moving to the jth crop. While, the diagonal element Aij (i=j), indicates the probability of retaining capacity of individual crops over the years.

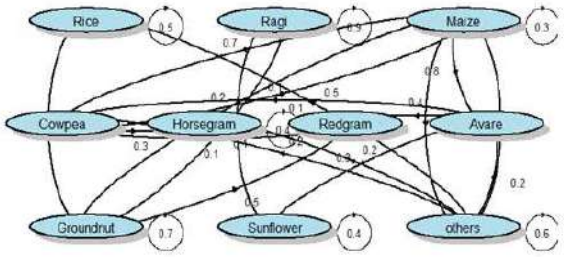

Fig 1: Probability of area losing and gaining of food crops in Kolar district (1997-98 to 2017-18)

Source: Author's Calculation using DES data

TABLE 3

Transitional probability matrix of food crops Kolar district (1997-98 to 2017-18)

(Per cent)

Crops	Rice	Maize	Ragi	Horse gram	*Field bean*	Cowpea	Redgram	Groundnut	Sunflower	Others
Rice	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Maize	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Ragi	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.6
Horse gram	0.0	0.0	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.2
Field bean	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.2
Cowpea	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.5	0.0	0.0
Redgram	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Groundnut	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Sunflower	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0
Others	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6

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The group of ten crops which are Rice, Ragi, Maize, Horsegram, *Field bean*, Cowpea, Redgram, Groundnut, Sunflower and others. Among which maize had highest retention capacity with (90%) followed by groundnut (70%), others (60%), rice (50%), *field bean* & sunflower (40%) and ragi (30%), respectively. This is mainly due to fodder requirement of livestock is supplemented by the crops like maize, groundnut, rice and ragi straw which is main source of income of the farmers in dry land area. Therefore, farmers are undertaking allied activities with agriculture operations mainly to enhance their income. The crops with zero retention capacity are horsegram, cowpea and redgram since these crops lost their area for other crops over time *i.e.,* horsegram lost to ragi, redgram & others constituted 70, 20 and 10 per cent, respectively. whereas, red gram lost area to ragi (80%) and others (20%).

Since ragi is traditionally growing crop in dry land situation, thereby these crops lost area to ragi and cowpea lost 50 per cent area for groundnut, regram (40%) and horsegram (10%). whereas other crops like rice (50%) and maize lost (10%) area for groundnut and ragi lost its area for others and horse gram with 60 and 10 per cent, respectively. Other crops had 60 per cent of retention capacity which lost 40 per cent area to ragi. Since others might be vegetables, commercial crops and horticulture crops which are highly suitable under dry land conditions. Thereby it lost least area for horse gram about 10 per cent. Reason might be horsegram is the next best suitable crop to dry land conditions. So, the framers will go for this crop in the absence of ragi some times.

Projected area of food crops to Kolar district for the period from 2022-23 to 2025-26 is depicted in Table 4. The projected area for other crops will be highest with 86255.2 ha followed by ragi (55130.6 ha), groundnut (11479.2 ha), horsegram (6568.5 ha), *field bean* (5998.6 ha), redgram (3097.7 ha), rice (2393.2 ha), maize (1233.3 ha), cowpea (1173.0 ha) and sunflower (66.5 ha), respectively in 2026. These projections gave clear picture that food crops less scope to gain area for cultivation. The projected percentage share of area under food crops with others in Kolar district in 2026 drawn in Fig 4. Area under Other crops will be 50 per cent followed by ragi (32%), groundnut (6%), horsegram (4%), *field bean* (3%), redgram (2%), rice (1%), maize (1%), cowpea (1%) and sunflower (0%), respectively. This revealed that other crops will gain area from the food crops, indicated that food crops will have less scope in the production of food crops in future. There by, it should be noted that production of food crops is

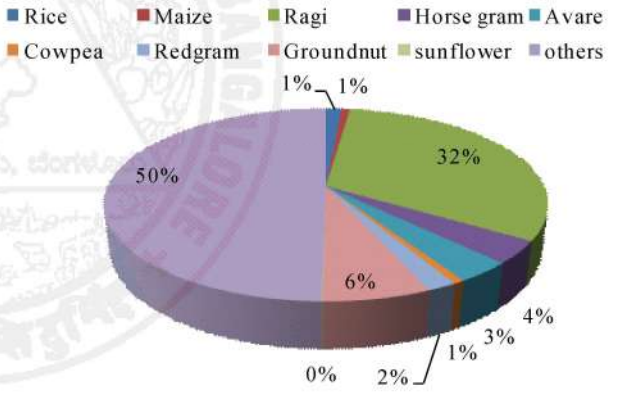

Fig. 2: Projected percentage area of food crops in Kolar district in the year 2026

TABLE 4

Projected area of food crops to Kolar district from 2022-23 to 2025-26

(ha)

Year / Crops	Rice	Maize	Ragi	Horse gram	*Field bean*	Cowpea	Redgram	Groundnut	Sunflower	Others
2022	2207.3	811.8	55516	6655.7	6095.4	1183	3121.5	10795.4	36.4	86973.5
2023	2277.6	932.8	55389.6	6621.2	6057.4	1179.8	3112.2	11042.1	44.8	86738.5
2024	2328.5	1043.3	55284.9	6598.6	6031.7	1177.1	3105.6	11228	52.6	86545.8
2025	2365.7	1143.3	55200.3	6581.7	6013	1174.8	3101	11369.7	59.9	86386.6
2026	2393.2	1233.3	55130.6	6568.5	5998.6	1173	3097.7	11479.2	66.5	86255.2

Source: Author's Calculation using DES data

equally important with the production of other crops. Therefore, these projection may help the farmers in taking the about production of food crops which are going to be extinct based on historical evidences.

Before 2007 Chikkaballpur taluk was under the Kolar district which was bifurcated as separate district on 7th August 2007 therefore area under food crops was declined drastically. Transitional probability matrix for food crops is given (Table 5 & Fig 3) revealed that retention capacity of area for food crops over two decades is given to the crops like Rice, Ragi, Maize, Horsegram, Field bean, Cowpea, Redgram, Groundnut, Sunflower and others. Among these other crops had highest retention capacity with 71% followed by maize (59%), groundnut (52%), sunflower (49%), ragi (17%), cowpea (16%), rice (10%) and redgram (8%),

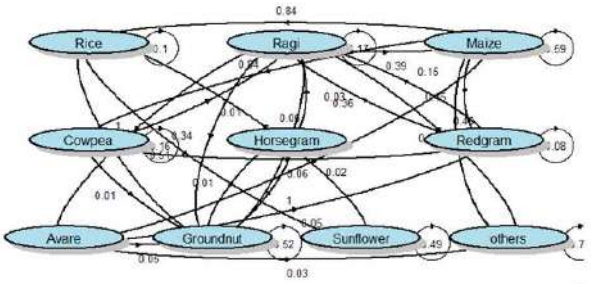

Fig 3: Probability of loosing and gaining area of food crops in Chikkaballapur district from 2007-08 to 2017-18

Source: Author's Calculation using DES data

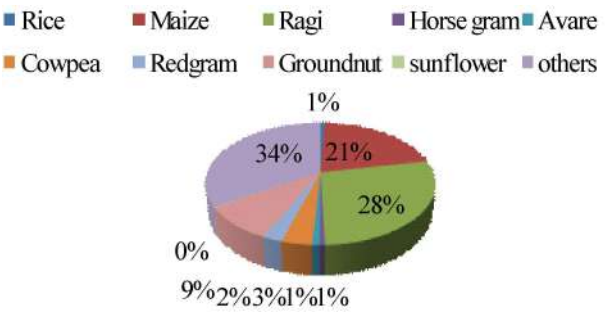

Fig 4: Projected percentage area for food crops in chikkaballapur district from 2022-23 to 2025-26

respectively. This is mainly due to fodder requirement of livestock is supplemented by the crops like maize, groundnut and ragi straw, as livestock rearing is one of the main source of income of the farmers in dry land area. Therefore, farmers are undertaking allied activities with agriculture mainly to enhance their income.

Horse gram and field bean had zero retention capacity over a decade, means horse gram lost 100 per cent area to groundnut and Field bean lost its 100 per cent area to the ragi. Other crops had 71 % retention capacity and gained area from ragi of 46 %. This implies that retention capacity of other crops like commercial and oilseed crops is more which are market oriented nowadays. But ragi is traditionally growing crop is loosing its area over the years to other

TABLE 5

Transitional probability matrix for food crops to Chikkaballapur district (2007-08 to 2017-18)

(Per cent)

Crops	Rice	Maize	Ragi	Horse gram	*Field bean*	Cowpea	Redgram	Groundnut	Sunflower	Others
Rice	0.10	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Ragi	0.00	0.17	0.00	0.01	0.03	0.15	0.00	0.16	0.00	0.46
Maize	0.00	0.39	0.59	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Cowpea	0.00	0.00	0.84	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Horsegram	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Redgram	0.00	0.36	0.45	0.06	0.00	0.08	0.05	0.00	0.00	0.00
Field bean	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundnut	0.06	0.34	0.00	0.01	0.01	0.00	0.05	0.52	0.00	0.00
Sunflower	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Others	0.00	0.00	0.25	0.00	0.00	0.00	0.03	0.00	0.00	0.71

Source: Author's Calculation using DES data

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TABLE 6

Projected area for food crops in Chikkaballapur district 2022-23 to 2025-26

(ha)

Year / Crops	Rice	Maize	Ragi	Horse gram	*Field bean*	Cowpea	Redgram	Groundnut	Sunflower	Others
2022	1554	46947.6	61228.6	1396.9	1931.7	7862.8	5251	20180.3	205.2	75327.9
2023	1555.5	46942.5	61266	1395.2	1930.3	7860.3	5249.3	20142	210.4	75334.5
2024	1555.8	46940.7	61288.4	1394.4	1929.5	7859.3	5248.2	20119.7	213	75336.9
2025	1555.8	46940.2	61301.3	1394	1929.1	7858.9	5247.6	20107	214.3	75337.7
2026	1555.6	46940.2	61308.6	1393.8	1928.9	7858.8	5247.2	20099.9	214.9	75338.1

crops, this led less quantity of ragi is available for consumption. Thereby, it led to nutritional insecurity.

However, to correct these imbalances in the production of food crops by analyzing the current situation, projected the area under food crops with other crops for the period from 2022-23 to 2025-26 (Table 6). This table revealed that area under food crops will decrease in preceding years expect in case of ragi. Area under other crops will be 75338.1 ha followed by ragi (61308.6 ha), maize (46940.2 ha), groundnut (20099.9 ha), cowpea (7858.8 ha), redgram (5247.2 ha), *field bean* (1928.9 ha), rice (1555.6 ha), horsegram (1393.8 ha) and sunflower (214.9 ha), respectively in 2026. The projected percentage share of area under food crops with others in 2026 given in fig. 4. Other crops will have 34 per cent of area followed by ragi (28%), maize (21%), groundnut (9%), cowpea (3%), redgram (2%), *field bean* (1%), rice (1%), horsegram (1%) and sunflower (0%) retention capacity. This implies other crops will gain area from the food crops, indicated that these crops will have future scope in the production activities. Therefore, need to take the decisions about production of food gain at least to meet the self sufficiency which dampens the dependence on other district in coming years Therefore these projections help the policy maker to analysis and to take balanced decision in creating awareness about the cultivation activities.

Akin to food crops, area under production of other crops is increasing over years. Nevertheless, there exists inequality in growth rates within the agriculture. Hence the objective of this study is to understand the pattern of area allocation for food crops and to ensure the sustainability in the production of food crops with other crops. Time series data of area of two districts namely, Kolar and Chikkaballa pur is used to analyze the dynamic shift in area under production of food crops with other crops under dry land conditions is most appropriate to meet the self sufficiency. Hence, to create the awareness among the farmers about the production of food crops to sustain their livelihood in the study area.

Growth in area and production of major food crops in both the districts accelerated sharply whereas productivity growth decelerated. Though, diversification in non-food sector includes livestock and horticulture in which income elasticities of demand and employment potentialities are high. Imbalance shift in area under food crops cultivation could be detrimental to food security which dampens the livelihood security by likelihood dependence on other district for the purchase of food grains by incurring huge transportation cost.

To avoid imbalance in the production of food crops with other crops in the study area, in view of diversification of major food crops towards other crop group, enough attention has to be given to food crops from the point of sustaining food security in both the districts. The Government should take initiative to create awareness about new technologies available to increase the productivity as well as growth even under dry land situation. Also Government should bring the programs which will concentrate more on reducing the risk associated with production of food crops under rainfed conditions.

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