Growth dynamics and forecasting of finger millet (Ragi) production in Karnataka

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ABSTRACT

The study aims at examining the growth and instability of area, production and productivity and forecasting of area and production of Finger Millet crop in the state and India. The study is based on the time series data on area, production and productivity from 1984-85 to 2014-15. The study period was divided into two sub-periods coincides with the introduction Targeted Public Distribution System (TPDS) in 1997-98 *i.e.,* period I (1984-85 to 1997-98) and period II (1999-00 to 2014-15). Thus, the total study period consists of 31 years. The growth rates in the area, production and productivity were calculated using compound growth rates. The trend lines showed an increase in both production and productivity in major ragi growing districts of Karnataka in both the periods, even though the showed area under the crop is decreasing. The analysis indicates that there was negative of growth in area and positive growth in productivity in all the major ragi growing districts of Karnataka in period I (1984-85 to 1997-98) and period II (1999-00 to 2014-15). The variability in production is attributed to declining in area and increase in productivity. The instability in the area, production and productivity were found to be more accelerated in period-II (1999-00 to 2014-15), compared to period-I (1984-85 to 1998-99). For forecasting ragi production, different linear and nonlinear growth models were explored. The forecasting results showed that, even though there was a deceleration in area, the production of ragi was increasing due to increase in productivity in the future time.

Keywords: Growth, instability, forecasting, targeted public distribution system (TPDS), linear and non-linear, deceleration

In the subsistence-oriented, semi-arid production systems of Karnataka, India, the environment is marginal for crop growth and often there is no substitute for millet crops. Millets, the family of cereals grown globally with differential importance across continents and within regions of the world. In South India. Minor millets are examples of underutilized plant species, which are being locally important but commercially traded on a very limited scale outside the producing communities. Some of these species, called underutilized plant species, are characterized by the fact that a) they are locally abundant in developing countries but globally

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rare; b) scientific information and knowledge about them is scant; and c) their current use is limited relative to their economic potential (Gruère *et al*. 2006) Minor millets are often termed "coarse cereals". Furthermore, "minor" refers to the extent of research investment and commercial importance of the crop regarding the area, production, and consumption (Nagarajan and Smale, 2005).

Targeted Public Distribution System (TPDS) was implemented to serve the poorest of the poor in rural and urban areas. It is considered to be the most important food security network. The introduction of TPDS in 1997 did two things. First, the population was subdivided into above poverty line (APL) and below poverty line (BPL) groups. The main features of TPDS have been the introduction of targeting or specifically, the division of the entire population based on the poverty line defined by the Planning Commission. Food grains are now allotted at two sets of prices, a highly subsidized price for the poor and near open market price.

Finger millet [*Eleusine coracana* (*L.*) *Gaertn.*] commonly known as ragi is important minor millet widely grown in Africa and Asia. It is originally native to the Ethiopian highlands though it was introduced in India a long time ago. Its adaptability to the higher elevations makes it suitable to grow even at a height of more than 2,000 meters.

It is a staple food for the rural folk of South India. In India, Karnataka and Tamil Nadu are the principal ragi growing states, besides Uttarakhand, Maharashtra, Andhra Pradesh, Orissa, Gujarat, West Bengal and Bihar.

Karnataka has the largest area under finger millet and is the biggest producer of ragi in India. Ragi is the main staple food consumed by the majority of the population in South Karnataka. It is grown as rainfed as well as irrigated crop, mostly cultivated by marginal and small farmers and grown as a pure crop as well as intercrop. Ragi is mainly grown in Tumakuru, Ramanagara, Kolar, Mandya, Bengaluru Rural, Hassan, Chikkaballapura, Mysuru, Bengaluru Urban, Chitradurga, Chikkamagaluru, Chamarajanagar and Davanagere districts.

However, there was a deceleration in the area, the productivity of ragi showed increasing trend due to the use of high yielding varieties and technological interventions. The estimating trend to know the growth performance and calculating coefficient of variation of residuals from the trend apparently take note of both the trend and fluctuations. In this context, the present study has been taken up to analyze the growth and instability in the area, production, and productivity of ragi and forecasting of area and production.

Methodology

The district-wise time series data for the period from 1984-85 to 2014-15 about area, production and productivity of ragi in Karnataka were collected from Directorate of Economics and Statistics (DES), Government of Karnataka, Bengaluru. The time series data for Karnataka and India for the period from 1984-85 to 2014-15 for the area, production, and productivity of ragi were collected from India stat.

Trend analysis

The exponential growth function was used to estimate the growth rates of the selected economic variables, and the model is

$$Y = a\, b^t e$$

Where,

Y = Dependent variable for which the rate of increase is estimated (area, production, and productivity of ragi).

a = Intercept

b = Regression coefficient

t = Time variable (1984-85 to 2014-15)

e = Error term

The compound growth rate was obtained from the logarithmic form of the equation $Y = a\, b^t e$ as below

$$\ln Y = \ln a + t \ln b$$

The % compound growth rate (y) was derived using the relationship

$$y = (\text{Anti ln of } b - 1) \times 100$$

Instability analysis

The coefficient of variation was used as a measure to study the variability in the area, production and productivity of ragi. The coefficient of variation (CV) was computed using the following formula.

$$CV = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Linear trend was fitted to the original time series data on area, production and productivity for 31 years from 1984-85 to 2014-15 and separately for two sub-periods. The formula suggested by Cuddy and Della (1978) was used to compute the degree of variation around the trend, means coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of determination (R^2). A high degree of instability index signifies great changes.

$$\text{Instability Index} = \frac{\text{Standard Deviation}}{\text{Mean}} \quad 100 \quad \sqrt{1 - R^2}$$

R^2 = Coefficient of determination

Results and Discussion

Growth in area, production and productivity of ragi

Compound growth rates for the area, production, and productivity of ragi was analyzed using the exponential function.

Growth rates for the area, production and productivity were estimated for all the major ragi growing districts of Karnataka. The study further attempted to determine the growth rates for Karnataka and India as a whole. The study period was divided into two sub-periods, coinciding with Targeted Public Distribution System (TPDS) that was introduced during 1997-98, *i.e.*, period-I (1984-85 to 1997-98) and period-II (1999-00 to 2014-15), thus the total study period consist of 31 years from 1984-85 to 2014-15.

Before Targeted Public Distribution System

The estimates showed a decrease in growth rates in area across all ragi growing districts of Karnataka, except Tumakuru and Chikkamagaluru districts (Table 1). The positive and significant growth in production were observed in Tumakuru (4.31 %), Hassan (3.53 %), Kolar (3.74 %), Bengaluru rural (2.78 %) and Chikkamagaluru (4.28 %) districts. However, decline in production was observed in Chitradurga (5.34 %), Belagavi (7.75 %), Shivamogga (7.99 %), Uttara Kannada (10.11 %), Dharwad (16.5 %) and Kodagu (14.43%) districts. Productivity was found to be significant and positive across all districts, except Dharwad, Chitradurga and Shivamogga. The increase in productivity can be attributed to the use of high yielding varieties released during the periods.

Table 1: Growth rates in area, production and productivity of ragi for the period - I (1984- 85 to 1997-98)

(In Per cent)

Sl. No.	Districts	Area (ha)	Production (tonnes)	Productivity (kg/ha)
1	Tumakuru	1.06***	4.31***	3.15***
2	Hassan	-0.06	3.53**	3.16**
3	Kolar	-1.45***	3.74***	5.34***
4	Mandya	-0.39	1.87	2.26
5	Mysuru	-1.93***	2.16	4.11**
6	Bengaluru	-0.47	2.78**	3.36**
7	Chitradurga	-4.83***	-5.34***	-0.51
8	Chikkamagaluru	2.11	4.28***	2.06
9	Bengaluru urban	-7.56***	-3.32	4.04**
10	Bellary	-9.98***	-4.7	6.05**
11	Shivamogga	-7.72***	-7.99***	-0.81
12	Belagavi	-11.48***	-7.75***	3.82
13	Kodagu	-16.57**	-14.43***	2.98**
14	Dharwad	-16.24***	-16.5***	-0.37
15	Uttar Kannada	-12.21***	-10.11***	2.29
16	Karnataka	-1.43***	2.23**	3.19***
17	India	-3.14***	-0.52	2.41***

Note: ***&** indicate significant levels at 1 and 5%, respectively

After Targeted Public Distribution System

It is evident from the analysis that, there was a decrease in area and production across all ragi growing districts of Karnataka (Table 2). The results revealed that, there

was highly significant decrease in area and production in Kodagu (13.65 % and 20.18 %), Gadag (13.12 % and 15.88 %) Haveri (19.15 % and 21.14 %), Shivamogga (17.55 % and 14.58 %), Dharwad (15.85 % and 11.11 %), Uttara Kannada (15.38% and 10.05 %) and Bengaluru Rural district (11.49 % and 9.28%).

Table 2: Growth rates in area, production and productivity for the period –II (1999-00 to 2014-15)

(In per cent)

S. No.	Districts	Area (ha)	Production (tonnes)	Productivity (kg/ha)
1	Tumakuru	-1.06	0.49	2.25
2	Hassan	-4.32***	-2.3	2.42
3	Ramanagara	-0.35**	-1.44	2.39**
4	Kolar	-5.17***	-2.66	2.84
5	Mandya	-1.48	-0.88	1.11
6	Mysuru	-4.66***	-2.49	3.19**
7	Chikkaballapura	0.87**	4.25	5.16**
8	Bengaluru rural	-11.49***	-9.28***	2.61
9	Chitradurga	-2.46**	-2.55	-0.04
10	Chikkamagaluru	-2.99***	-5.12***	-1.71
11	Bengaluru urban	-5.4***	-3.28	2.52
12	Chamarajanagar	-2.99***	-2.87	0.61
13	Davanagere	-9.3***	-8.01***	1.38
14	Bellary	-6.23***	-6.71***	-1.02
15	Shivamogga	-17.55***	-14.58***	2.35***
16	Haveri	-19.15***	-21.14***	-1.34
17	Belagavi	-6.1	-8.54***	-1.37
18	Kodagu	-13.65**	-20.18***	-7.29**
19	Dharwad	-15.85***	-11.11***	5.01**
20	Gadag	-13.12***	-15.88***	2.66
21	Uttar Kannada	-15.38***	-10.05****	4.79***
22	Karnataka	-2.4***	-0.77	2.02
23	India	-2.49***	-1.3	1.7**

Note: ***&** indicate significant levels at 1 and 5%, respectively

The districts with positive and meaningful growth in productivity were observed in Ramanagara (2.39%), Mysuru (3.19%), Chikkaballapura (5.16 %), Shivamogga (2.35%,) Uttara Kannda (4.79%) and Dharwad (5.01 %). Whereas, negative and significant growth was found in Kodagu (7.29 %) district. During the same period both Karnataka (2.40 %) and India (2.49 %) showed significant decline in area and production. The productivity was found to be significant and positive in India (1.70 %). The findings are in conformity with the results of Niti Mehta (2013). After the implementation of Targeted Public Distribution System, there was more demand for ragi in Karnataka; this was significantly contributed to an increase in productivity of ragi crop.

Instability in area, production and productivity

Variations in the area, production and productivity are a cause for concern. Hence, it is important to know the extent of variability in the area, production and productivity. The variability in the area, production and productivity are analyzed by computing the instability index.

Ragi production exhibited a higher degree of uncertainty when compared to area and productivity during the period - I (1984-85 to 1997-98). The variation in ragi production compared to the area was found to be higher across all the ragi growing districts of Karnataka, except for Mysore and Bengaluru rural districts (22.51 % and 19.86 %) (Table 3). However in case of productivity, the variation in production of ragi was found to be high in almost all the districts except for Mysuru (18.37 %) and Chikkaballpura (22.36 %).

In period-I (1984-85 to 1997-98), the instability on area, production and productivity were found to be less in Tumakuru district (6.13 %, 16.53 % and 15.08 %, respectively). Concerning area next stable districts are Ramanagara (6.31 %), Mandya (7.37 %), Hassan (8.18 %) and Chikkaballapura (9.81 %) districts. The variation in ragi production and productivity was found to be less in Mysuru (16.30 % and 18.37 %), Bengaluru Rural (17.30 % and 16.35 %) and Ramanagara (17.47 % and 16.11 %) next to Tumakuru district.

In period - II (1999-00 to 2014-15), concerning the instability of area (Table 4) Ramanagara (2.68%), Chikkaballapura (7.24%) and Chikkamagaluru (8.97%) districts were found be more stable districts in Karnataka. In Shivamogga (12.01%), Chikkamagaluru

(22.85%) and Chamrajnagara (26.49%) districts, the variation in production was found to be less indicating the stability in production. The percentage variation in ragi productivity was found to be less in Shivamogga (11.34%), Mysuru (17.67%) and Chikkamagaluru (17.74%) districts.

Table 3: Instability in area, production, and productivity of ragi during period –I (1984-85 to 1997-98) (In%)

S. No.	Districts	Area in (ha)	Production (tonne)	Productivity (Kg/ha)
1	Tumakuru	6.13	16.53	15.08
2	Hassan	8.18	20.88	18.52
3	Ramanagara	6.31	17.47	16.11
4	Kolar	14.91	29.14	22.05
5	Mandya	7.37	22.07	19.63
6	Mysuru	22.51	16.30	18.37
7	Chikkaballapura	9.81	21.81	22.36
8	Bengaluru	19.86	17.30	16.35
9	Chitradurga	50.57	50.58	23.69
10	Chikkamagaluru	22.72	41.28	27.25
11	Bengaluru Urban	17.52	25.15	18.83
12	Chamarajanagar	34.72	49.40	27.74
13	Davanagere	22.38	23.55	14.28
14	Bellary	31.69	40.15	25.85
15	Shivamogga	24.54	32.99	16.93
16	Karnataka	4.52	12.96	12.20
17	India	3.69	6.61	7.26

The instability in area, production and productivity were found to be high in period-II (1999-00 to 2014-15), compared to period-I (1984-85 to 1997-98) (Table 3 and 4). The percentage variation in area during period-II was less in Ramanagara (2.68%), Mysuru (15.62%), Chikkaballapura (7.24%), Chitradurga (16.65%), Chikkamagaluru (8.97 %), Bengaluru Urban (13.37%), Chamarajanagar (15.53%), Davanagere (14.10%) and Shivamogga (15.07%) districts. The instability analysis revealed that there was high variation in production during period-II except in Chitradurga (27.74%), Chikkamagaluru (22.85%), Chamrajnagara (26.49%) and Shivamogga (12.01 %) districts. On productivity, the instability was high in period-II except in districts namely Ramanagara (15.92%), Mysuru (17.67%), Chikkaballpura (21.44%), Chitradurga (21.35%), Chikkamagaluru (17.74%) and Chamarajanagar (20.70%).

The instability on area, production and productivity in period-II was found to be high when compared to the period-I in both Karnataka (10.73%, 23.97%, and 16.56% respectively) and India (7.57%, 17.57% and 12.07%, respectively). Therefore, period-II showed higher instability on area, production, and productivity when compared to the period-I. The findings are in conformity with the results of Paltasingh and Goyari (2013) and Swain (2014).

Table 4: Instability in area, production and productivity of ragi during period-II (1999-00 to 2014-15) (In%)

S. No.	Districts	Area (ha)	Production (tonne)	Productivity (Kg/ha)
1	Tumakuru	13.32	32.61	23.89
2	Hassan	13.17	27.96	24.86
3	Ramanagara	2.68	36.55	15.92
4	Kolar	25.28	42.54	25.24
5	Mandya	23.21	35.32	21.07
6	Mysuru	15.62	37.88	17.67
7	Chikkaballapura	7.24	42.98	21.44
8	Bengaluru rural	22.08	37.61	23.43
9	Chitradurga	16.65	27.74	21.35
10	Chikkamagaluru	8.97	22.85	17.74
11	Bengaluru urban	13.37	36.15	24.67
12	Chamarajanagar	15.53	26.49	20.70
13	Davanagere	14.10	29.26	25.27
14	Bellary	34.27	44.47	32.50
15	Shivamogga	15.07	12.01	11.34
16	Haveri	28.32	51.34	43.34
17	Belagavi	126.07	53.16	49.49
18	Kodagu	50.45	58.55	37.67
19	Dharwad	31.35	48.85	29.71
20	Gadag	62.12	65.78	36.40
21	Uttar Kannada	17.88	32.80	26.88
22	Karnataka	10.73	23.97	16.56
23	India	7.75	17.51	12.07

Table 5: Best-fit models for forecasting

Particulars	Karnataka						India					
	Model	R^2	Parameter Estimation				Model	R^2	Parameter Estimation			
			Constant	b_1	b_2	b3			Constant	b_1	b_2	b3
Area	Cubic	0.840	1128700	1733.99 **	-1174.7**	21.00**	Cubic	0.954	2534142	-57263 **	-342.99 **	25.68**
Production	Cubic	0.121	1054920	62051.3 **	-2828.8**	32.10*	Quadratic	0.487	2605758	-12934**	-445.26**	-
Productivity	Cubic	0.511	971.671	66.26**	-2.83**	0.54**	Cubic	0.603	948.337	52.75**	-2.41**	0.04**

Note: ** indicate significant at 5 per cent level.

Estimated growth models for area, production and productivity of ragi in Karnataka and India

Different growth functions were examined separately for the area, production and productivity of ragi in Karnataka and India considering the time series data from 1984 -85 to 2014-15.

Both linear and nonlinear growth models were explored for the purpose of estimating best model and the growth rate which would help in better future prediction. The results of the growth functions are presented in Table 5. The cubic growth function was the best fit for area, production and productivity in Karnataka, with high R^2 (0.840, 0.121 and 0.511) value respectively with a significant slope, intercept and coefficients. The appropriate function for area and productivity of ragi in India was cubic growth function with R^2 value was 0.954 and 0.603 respectively. For the ragi production in India, quadratic model was the best fit as R^2 was higher with slope, intercept and coefficients significant. These findings are in line with the results of Vilas (2012).

Forecasted area and production of ragi for Karnataka and India

The forecasted area and production of ragi crop values were presented in Table 6. The results showed that, presently the area under ragi in Karnataka is 6.72 lakh hectares with a production of 12.60 lakh tonnes. The projections based on the estimated growth models are expected to be 13.79 lakh tons with a decrease in area of 2.70 lakh ha in the year 2030. In India, Presently the area under ragi is 12.25 lakh hectares with a production of 18.65 lakh tonnes. The projections based on the estimated growth models are expected to be 29.18 lakh tons with decrease in area of 7.33 lakh ha in the year of 2030. The results showed that there was a increase in production both in Karnataka and India even though there was decrease in area under ragi, the increase in production was attributed to increase in productivity due to use of high yielding varieties.

Table 6: Forecasted area and production of ragi using different growth models up to 2030 in Karnataka and India

Year	Karnataka		India	
	Area	Production	Area	Production
2016	609475	1377114	1059469	1879541
2017	586930	1377338	1031963	1895031
2018	564051	1377550	1005171	1917746
2019	540839	1377749	979074	1948138
2020	517293	1377938	953655	1986658
2021	493414	1378117	928896	2033756
2022	469201	1378287	904780	2089883
2023	444655	1378449	881290	2155490
2024	419775	1378602	858410	2231029
2025	394562	1378748	836123	2316950
2026	369016	1378888	814416	2413703
2027	343136	1379021	793272	2521740
2028	316922	1379148	772677	2641512
2029	290376	1379269	752616	2773470
2030	263495	1379386	733077	2918064

Conclusion and policy implications

There was a positive and significant growth in production in major ragi growing districts in period I (1984-85 to 1997-98) such as Tumakuru, Hassan, Kolar, Bengaluru rural and Chikkamagaluru districts showed accelerated growth in production.

The summary of growth rate for the three variables namely, area, production, and productivity across the districts showed negative growth rate in the area. However, in respect of productivity growth, almost positive trend was seen in both the periods. Growth rate analysis in production of ragi crop was mostly productivity led than area contribution.

Ragi production exhibited higher degree of instability when compared to area and productivity during period-I (1984-85 to 1998-99). The variation in ragi production compared to area was found to be higher across all the ragi growing districts of Karnataka, except for Mysore and Bengaluru rural districts.

The instability on area, production and productivity in period- II was found to be high when compared to period -I in both Karnataka and India, therefore period-II showed higher instability on area, production and productivity when compared to period–I. Hence, causes and remedies for such high degree of uncertainty need to be researched for improving the welfare of ragi growing farmers.

The forecasting of ragi area and production using different linear and non-linear growth models showed that, there was increase in production even though there was a decrease in area under ragi, this may be attributed to acceleration in productivity. Hence, in order to increase the production, there is a scope to release new varieties which are high yielding.

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