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Research Article

Analysis of Poultry Egg Production Growth of Karnataka State Using Statistical Models

Manjula R.[1], Amaresh[2*] and Manjunath V.[3]

[1]Department of Agricultural Statistics, University of Agricultural Sciences, GKVK, Bengaluru-560 065.

[2*]Assistant Professor, Discipline of Agricultural Statistics, College of Agriculture, Bheemarayanagudi, University of Agricultural Sciences, Raichur-584 104

[3]Associate Professor, Department of Agricultural Statistics, University of Agricultural Sciences, GKVK, Bengaluru-560 065

*Corresponding Author E-mail: amaresh.as13@gmail.com

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ABSTRACT

The study is aimed at analysing the growth of egg production using different statistical models. The secondary data on egg production of Karnataka state for the period of thirty years (1985 to 2014) and district wise data for the period of seventeen years (1998 to 2014) were used to analyse the growth in egg production. Poultry egg production in Karnataka has shown an increasing trend over the period with varied growth rates among the districts. This growth is not uniform across all the districts of the state. Hence a modest attempt has been made to construct statistical models separately by grouping the districts on their production as high, medium and low egg producing districts as well as based on administrative divisions for obtaining the appropriate growth models. Various polynomial and exponential regression models were fitted and the best fitted model was selected based on Coefficient of determination (R^2) and Root Mean Square Error (RMSE) criterion. Kalaburagi division had the highest egg production followed by Mysuru, Belagavi and Bengaluru divisions. The quadratic model was best fitted model for low and medium egg producing districts and linear model was best suitable for high egg producing districts. It was found that linear model was the appropriate model for the districts or division with higher egg production growth rates.

Keywords: *Poultry Egg production, Regression, Coefficient of determination and RMSE*

INTRODUCTION

Poultry is one of the important livestock activities and it plays an important role for the food security as the eggs and chicken meat are important and rich sources of protein, vitamins and minerals. It also provides rich organic manure, this is an important source of income and generates employment. Poultry farming is a major agricultural activity across Karnataka and the state is an important contributor to the overall production of egg and chicken meat of the country.

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India ranks third highest in egg production and the fourth highest in broiler production. In India, the leading egg producing states are Tamil Nadu, Andhra Pradesh, Tripura, Maharashtra, West Bengal, Haryana and Karnataka.

Karnataka is one of the progressive states in egg production as its climatic condition is very feasible for rearing the poultry throughout the year and ranks seventh in the country and contributing 5.6 per cent to India's egg production. Koppal district, with a share of about 17.27 per cent of the state, ranks first with about 7,000 eggs produced in year 2014-15. Mysuru, Davangere and Ballari are other leading egg producing districts in the state with a share of about 12.84 per cent, 11.78 per cent and 11.19 per cent respectively. The eco-friendly backyard layers production along with commercial layer farming is practiced in the state. The egg production has improved from 10,724 lakh eggs in 1985-86 to 43,948 lakh eggs in 2014-15 inferring a wide scope for poultry farming in the state.

The present investigation was carried out to know the egg production growth in Karnataka state for the period 1985-86 to 2014-15 and attempt to construct the models for different classes of egg production and administrative divisions for the period 1998-99 to 2014-15 in order to obtain the realistic overall growth. The suitable empirical models were selected based on significance of the estimates of regression global parameters.

MATERIALS AND METHODS

The secondary data on egg production of Karnataka state for the period of thirty years (1985 to 2014) and district wise data for the period of seventeen years from 1998 to 2014 were obtained from Department of Animal Husbandry and Veterinary Services, Government of Karnataka. The egg production data of the state includes both desi and improved layers.

Descriptive statistics

As study is empirical in nature, in order to understand the structure of the data estimates of the important parameters were obtained. On the basis of district wise egg production data, different descriptive measures such as Mean, Kurtosis, Skewness, Standard Error and Growth rate were computed and depicted in the tables for each divisions as well as classifying the districts as high, medium and low egg producing districts.

Classification of districts

In order to remove the heterogeneity in egg production due to regional as well as district disparity, the classification of districts is carried out by two methods. In first method, the districts were classified as high, medium and low egg producing districts using measure of central tendency and dispersion. This will provide a more meaningful characterization of various stages of production. In this method for relative comparison, it appears appropriate to assume the districts having egg production more than or equal to (Mean + 0.5*SD) as high egg producing districts and the districts having egg production less than or equal to (Mean – 0.5*SD) as low producing districts. Similarly districts with egg production lying between (Mean – 0.5*SD to Mean + 0.5*SD) are classified as medium egg producing districts. In the second method, districts were classified based on existing four administrative divisions i.e., Bengaluru division, Mysuru division, Belagavi division and Kalaburagi division.

Polynomial and exponential regression models

Polynomial regression models play a very important role in understanding the complex inter-relationship among variables.

The n^{th} order polynomial model in one variable is given by

$$\hat{y}_i = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0$$

Then the model is multiple linear regression model in n explanatory variables and so the ordinary least square method can be used for fitting the polynomial regression model. The appropriate polynomial model is obtained by testing the significance of the model by analysis of variance technique.

Exponential model: $\hat{y}_i = a_0 e^{a_1 x_i}$

Where $\hat{y}_i$ is the i^{th} predicted value for the time period x_i and a_0 *and* a_1 are the parameters of the model to be estimated.

Several model selection criteria are available for the selection of the best model. In this study we have used the following criteria:

- Coefficient of determination (R^2)
- Root Mean Square Error (RMSE)

Coefficient of determination (R^2) is a statistical measure of how close the data are to the fitted regression line and it is the proportion of the total variation of the response variable explained by the regression model. One of the measures of goodness of fit of a regression is through R^2 value, which is defined as:

$$R^2 = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

Where, RSS is the regression sum of squares, ESS is Error sum of squares and TSS is total sum of squares computed from the regression model.

R^2 thus define, lies between the values 0 and 1. The closer it is to '1', the better is the goodness of the fit and vice versa.

The root mean square error (RMSE) or root mean square deviation is a frequently used measure of the differences between values predicted by a model or an estimator and the values actually observed. The RMSE represents the sample standard deviation of the differences between predicted values and observed values. The RMSE of predicted values $\hat{y}_i$ for times i of a regression's dependent variable y_i is computed for n different predictions as the square root of the mean of the squares of the deviations:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}{n}}$$

Further the test for significance of the regression co-efficient were carried out using student's t-test as,

$$T = \frac{a_i}{SE(a_i)}$$

Where, a_i is the regression co-efficient, $SE(a_i)$ is the standard error of the regression coefficient a_i and T is the calculated test statistics value which follows student's t distribution.

RESULT AND DISCUSSION

Karnataka state has considerable progress in egg production from last two decades. The total egg production in the state was 10,724 lakhs in 1985-86, whereas in 2014-15 the total egg production is 43,948 lakhs. The desi layers egg production is drastically reduced over the years from 2000-01 to 2014-15, whereas there is a rigorous increase was found in improved layers egg production. In 2014-15, the 86.11 per cent of egg production from the improved layers and only 13.89 per cent of eggs are from desi birds.

To know the egg production growth over the period, different regression models were constructed and analysed. Quadratic, Cubic and Exponential models were found suitable. The Fig 1 clearly depict the change in egg production growth in the state and also the best fitted model curves for the study period. The estimates of parameters of fitted models for egg production of Karnataka are presented in the Table 1. The result shows that the coefficients of exponential model are positive and highly significant with very low Root Mean Square Error (RMSE) value of 0.13 and R^2 value of 0.88. The analysis of variance indicates that model is significant with F value of 220.32. The coefficients of quadratic model are found to be significant with R^2 value of 0.89 and relatively high RMSE value compared to the other two models. The quadratic model was significant at 1 per cent level. The cubic model is also found to be significant with F calculated value of 202.45 and has the very high R^2 value of 0.95.

Among these good fitted models, the exponential model was found to be best fitted model with very less Root Mean Square Error and comparatively high R square value. Based on the t-test the model coefficients are significant at 1 per cent level of significance. Cubic model is the second best fitted model, compared to exponential model based on R square value and Root Mean Square Error. However, even the Quadratic model was adequate with significant F value, but it had relatively high Root Mean Square Error value compared to other two models.

By the inspection of the data it is clear that there is lot of difference in the growth of egg production in different districts of Karnataka. Hence a modest attempt has been made to make the data homogeneous by grouping the districts which are similar in production so as to know the realistic growth. The districts has been grouped based on their egg production as high, medium and low egg producing districts and separate models were constructed for each categories.

Table 1: Estimate of parameters for fitted egg production models pooled over districts of Karnataka during the period 1985-86 to 2014-15.

	Coefficients	t-stat	p-value	R^2 value	RMSE	F Test	Significant F (p)
Quadratic model							
a_0	14058.54	8.05	0.00	0.89	2977.08	117.39	0.00
a_1	-526.72	-2.02	0.05				
a_2	45.85	5.64	0.00				
Cubic model							
a_0	6974.24	4.38	0.00	0.95	1914.05	202.45	0.00
a_1	2010.01	4.59	0.00				
a_2	-155.41	-4.78	0.00				
a_3	4.32	6.27	0.00				
Exponential model							
a_0	9.19	185.16	0.00	0.88	0.13	220.32	0.00
a_1	0.04	14.84	0.00				

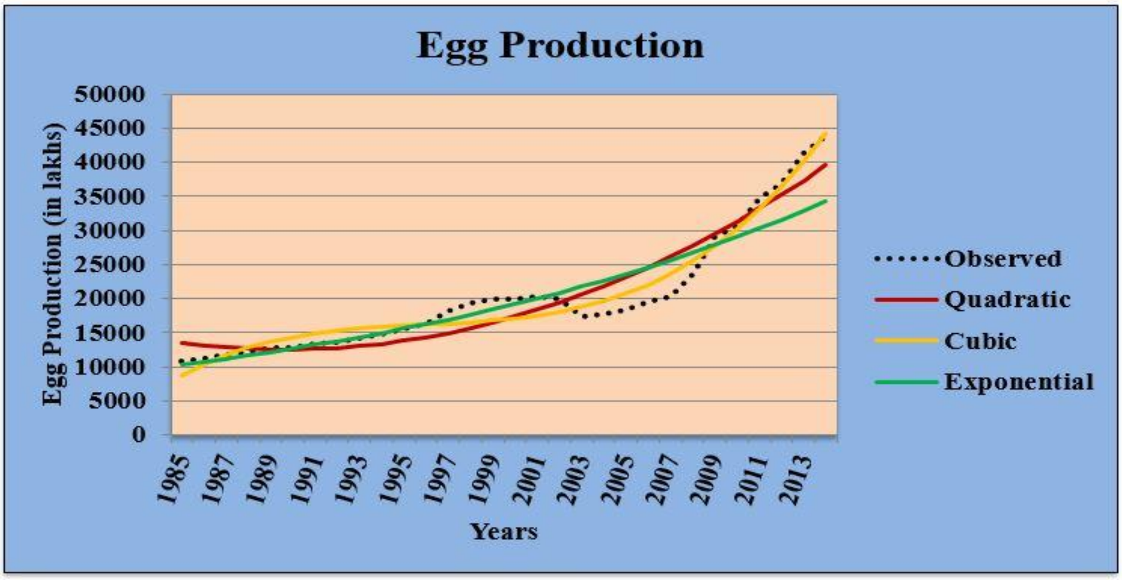

Fig. 1: Fitted models for egg production of Karnataka state for the period 1985-86 to 2014-15

Egg production analysis for high, medium and low egg producing districts

Districts were classified as high, medium and low egg producing districts based on the mean and standard deviation of egg production for the study period (1998-99 to 2014-15). Important descriptive measures were estimated and on that basis the districts having the average egg production greater than 24,834 lakhs are high egg producing districts, the average egg production from 7,308 to 24,834 lakhs are medium egg producing districts and average egg production is less than 7,308 lakhs are low egg producing districts. In Table 2 the districts falling in each category of classification are given.

The Standard deviation of low, medium and high egg producing districts is 542.79, 3674.83 and 6673.71 respectively, this shows that there is a more variation in an egg production among different classes. It is clear from the Table 3 the growth rate in high production class is very high value of 11.63 per cent compared to the medium with 1.66 per cent and very low growth rate in egg production in districts falling under low. This itself justifies the construction of different models for each of the classes.

Table 2: Number of districts under high, medium and low classification

Category	Districts	No. of Districts	Egg production (in Lakhs)
High	Ballari, Mysuru, Davangere, Koppal	4	> 24834
Medium	Bengaluru Urban, Bengaluru Rural, Belagavi, Bidar, Chitradurga, Kalaburagi, Hassan, Tumakuru, Kolar, Mandya, Raichur, Shivamogga, Uttara Kannada, Haveri, Bagalkot, Dakshina Kannada	16	7308 to 24834
Low	Vijayapura, Chikkamagaluru, Dharwad, Kodagu, Chamarajanagar, Gadag, Udupi	7	< 7308

Table 3: Descriptive statistics for the high, medium and low egg producing districts

Measures	Low	Medium	High
Mean	1943.59	11160.71	12406.71
Skewness	-0.08	0.28	0.22
Kurtosis	-1.64	-0.99	-1.40
Standard Error	205.15	918.71	3336.86
Growth rate (%)	0.64	1.66	11.63
Number of districts	7	16	4

The empirical models were fitted separately for each class i.e., high, medium and low egg producing districts and the estimates of the model parameters are presented in the Table 4. The quadratic, cubic and quartic model were good fitted to the districts falling under low egg producing class. It is observed from the Table 4 the coefficients of Quadratic model were found to be highly significant with R^2 value of 0.68 and very low RMSE of 48.31. In cubic model, the coefficients are not significant, whereas in quartic model the coefficients are significant and very high R^2 value of 0.81. For districts falling under medium egg producing the quadratic, cubic and quartic models were good fitted and quadratic model was found to be significant with the R^2 value 0.85 and RMSE is 1554.62. The very high R^2 value was found in quartic model and it gives very less RMSE value of

81.06. For districts falling under high egg producing class the linear model was best fitted with R^2 value 0.96 and RMSE value of 1400.12.

From the Table 4 it can be inferred that among the suitable models fitted quadratic model is superior (Fig 2) for districts under low classification based on the low RMSE value of 48.31 even though its R square value is little less than the quartic model. All the coefficients of quadratic model were significant with a negative linear term and a positive quadratic term this may due to decline in egg production in the initial stage of study period that is 1998 to 2004 and it had shown an increasing trend in the districts falling under this class. For the districts falling under medium class also indicated quadratic model fits better than the other models. Medium class also showed a similar trend as in the case of low class with a negative growth trend till 2003 and increasing in egg production thereafter (Fig 3). But the rate of growth is higher by 1.02 per cent compare to low class. Whereas districts falling in high class indicated linear increasing trend (Fig 4).

Table 4: Fitted models for low, medium and high egg producing districts

Category	Fitted model	a_0	a_1	a_2	a_3	a_4	R^2	RMSE
Low	**Quadratic**	**451.44****	**-54.24****	**2.99****	**-**	**-**	**0.68**	**48.31**
	Cubic	414.83**	-32.83^{NS}	0.10^{NS}	0.11^{NS}	-	0.69	48.89
	Quartic	1892.14**	666.49^{NS}	-208.80*	18.49**	-0.49**	0.81	279.14
Medium	**Quadratic**	**17518.63****	**-2447.05****	**149.19****	**-**	**-**	**0.85**	**1554.62**
	Cubic	1059.34**	-132.14*	6.52^{NS}	0.10^{NS}	-	0.85	100.23
	Quartic	759.17**	133.80^{NS}	-55.65*	5.37*	-0.14*	0.91	81.06
High	**Linear**	**386.74^{NS}**	**1335.55****	**-**	**-**	**-**	**0.96**	**1400.12**

** Significance at 1% level, * Significance at 5% level

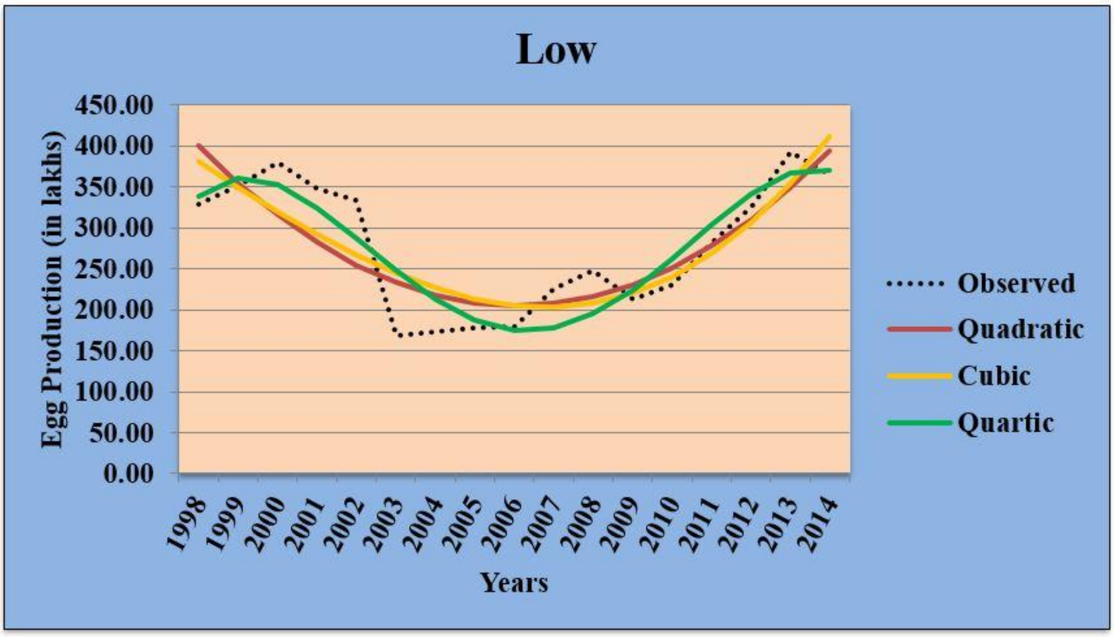

Fig. 2: Fitted models for low egg producing class

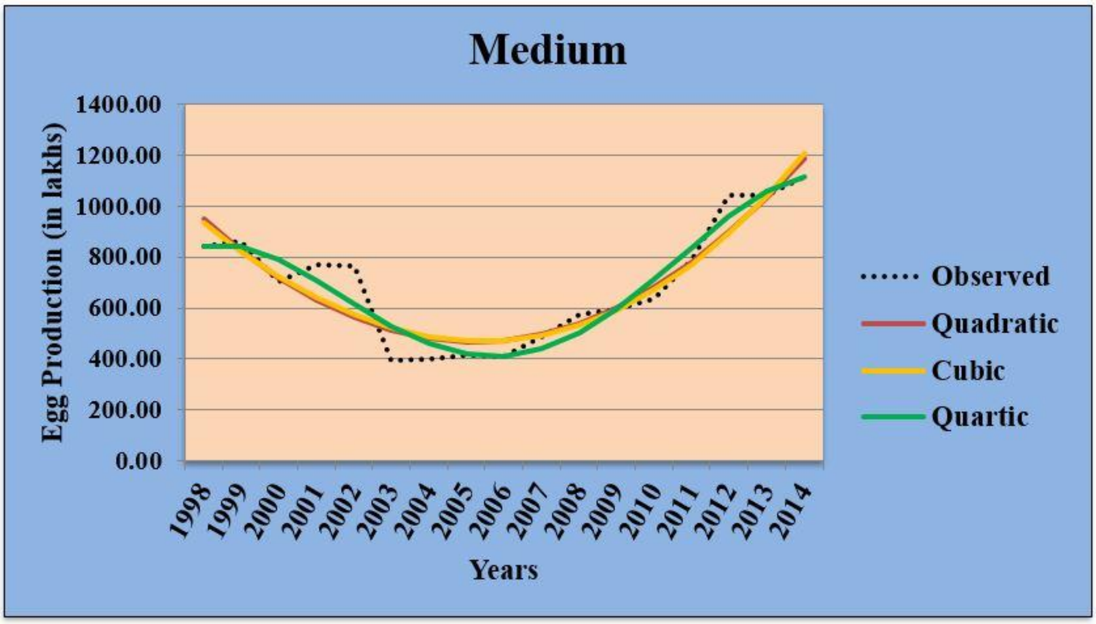

Fig. 3: Fitted models for medium egg producing class

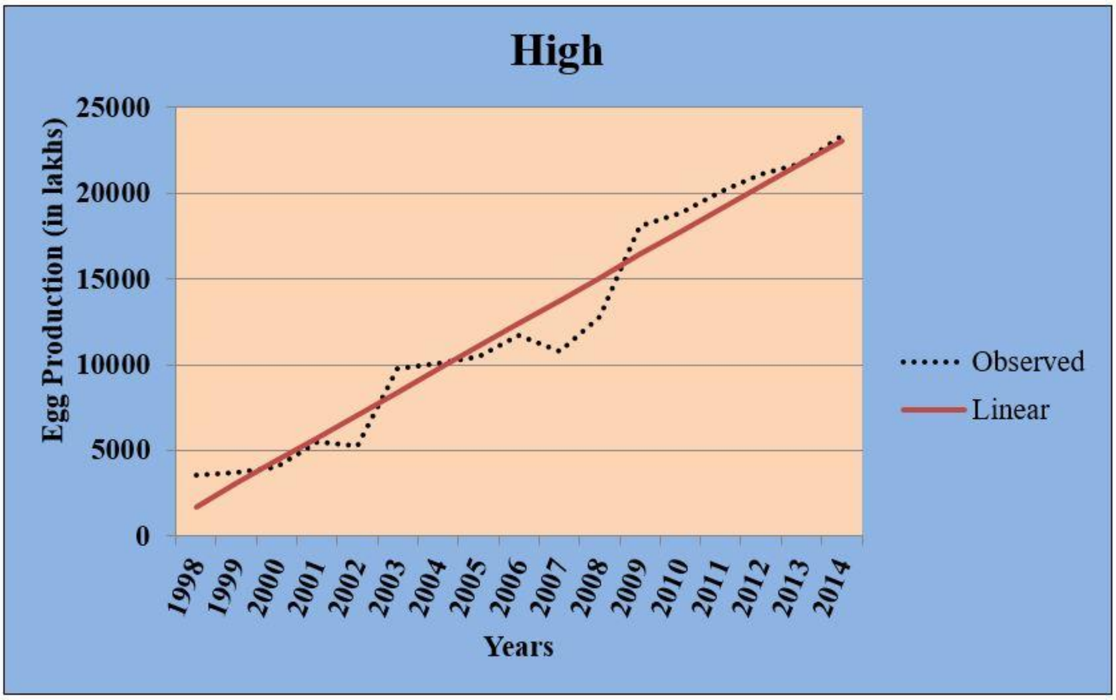

Fig. 4: Fitted models for high egg producing class

Egg production analysis for administrative divisions of Karnataka

An attempt was also made to study the growth of egg production by pooling data of different districts falling under four administrative divisions. The districts falling under different administrative divisions of Karnataka are shown in Table 5. To understand the nature of the data important descriptive measures for egg production for each division is estimated. The Table 6 reveals that the average egg productions of Bengaluru, Belagavi, Kalaburagi and Mysuru divisions are 5498.06, 2963.12, 7923.35 and 2899.24 lakhs respectively.

It is observed that the egg productions are positively skewed in all the divisions but in Kalaburagi division the value of skewness is nearer to zero. The value of Kurtosis in Mysuru division is positive and leptokurtic, whereas in other divisions the kurtosis is negative and platykurtic. From the Table 6 it is clear that in each of the division district egg production is homogeneous by similar standard error except in Kalaburagi division due to very high egg production districts falling under it. The Kalaburagi division had the highest rate of growth of 10.97 per cent which was higher by 1.32 compared with Mysuru division, higher by 3.31 per cent of Belagavidivision and more than 6.61 per cent higher of Bengaluru division.

Table 5: Districts falling under different administrative divisions of Karnataka

Name of the Administrative Division	Districts
Bengaluru division	Bengaluru Urban, Bengaluru Rural, Chikkaballapura, Chitradurga, Davangere, Kolar, Ramanagara, Shivamogga and Tumakuru
Mysuru division	Chamarajanagar, Chikkamagalur, Dakshina Kannada, Hassan, Kodagu, Mandya, Mysuru and Udupi
Belagavi division	Bagalkot, Belagavi, Vijayapura, Dharwad, Gadag, Haveri and Uttara Kannada
Kalaburagi division	Ballari, Bidar, Kalaburagi, Koppal, Raichur and Yadgir

Table 6: Descriptive statistics of Egg production in administrative divisions

Divisions	Bengaluru	Belagavi	Kalaburagi	Mysuru
Mean	5498.06	2963.12	7923.35	2899.24
Skewness	0.92	0.96	0.09	2.46
Kurtosis	-0.14	-0.20	-1.37	6.91
Standard Error	873.65	545.12	1789.71	619.19
Growth rate (%)	4.36	7.66	10.97	9.65
Number of districts	7	7	5	8

The empirical models were fitted for the all four divisions of Karnataka state separately and the good fitted models based on the R^2 and RMSE values are presented in the Table 7. For Bengaluru division the quadratic and cubic models were found to be suitable. It is found that the quadratic model is highly significant with positive coefficient for constant term (6776.89), negative coefficient of linear term (-1010.34) and positive coefficient for quadratic term with R^2 value of 0.95 and Root Mean Square Error is 511.74. In cubic model the cubic term is not significant and it is negative (-0.61) but remaining coefficients are positively significant. Quadratic, cubic and quartic models were fitted to Belagavi division among these models, the quartic model had relatively high R^2 value of 0.95 and less Root Mean Square Error is 362.53. In cubic model the coefficient for constant term is positive and highly significant (1991.52) and remaining coefficient for linear term (-199.96), quadratic term (29.64) and cubic term (-0.25) are not significant. The linear model is found to be suitable model for Kalaburagi division with R^2 value of 0.98 and Root Mean Square Error is 664.06. Appropriate models for Mysuru division are quadratic and cubic. In cubic model the coefficient for constant term and linear term are positive but not significant. The remaining coefficients are significant with R^2 value of 0.93 and Root Mean Square Error is 514.88.

Table 7: Estimates of global parameters for fitted model for Bengaluru, Belagavi, Kalaburagi and Mysuru division

Divisions	Fitted model	a_0	a_1	a_2	a_3	a_4	R^2	RMSE
Bengaluru Division	**Quadratic**	**6776.89****	**-1010.34****	**74.42****			**0.95**	**511.74**
	Cubic	6987.09**	-1133.26**	91.02*	-0.61		0.96	527.22
Belagavi Division	Quadratic	1906.91**	-150.48	22.96**			0.91	471.14
	Cubic	1991.52**	-199.96	29.64	-0.25		0.91	488.25
	Quartic	**363.75**	**1242.19***	**-307.49***	**28.31****	**-0.79****	**0.95**	**362.53**
Kalaburagi Division	**Linear**	**584.29**	**820.63****				**0.98**	**664.06**
Mysuru Division	**Quadratic**	**3087.85****	**-550.89****	**45.42****			**0.86**	**713.26**
	Cubic	1332.46	475.65	-93.16*	5.13**		0.93	514.88

** Significance at 1% level, * Significance at 5% level

Among the fitted models for Bengaluru division quadratic model was found suitable with low RMSE value and with high R square. All the coefficients of the model were highly significant. The coefficient of the linear term was negative the other two term had a positive coefficient. This indicates that in Bengaluru division there was a decline in egg production in the initial stage up to 2003 and there was a gradual increase thereafter (Fig 5). In Belagavi division quartic egg production model found to be more appropriate. In this model quadratic and quartic term were negative and other terms were positive which indicates egg production trend is cyclic in nature having an increasing trend initially till 2003, then declined up to 2007 and once again indicating an increase in trend (Fig 6). The Kalaburagi division had the highest growth rate indicated the linear trend which indicates egg production rate is increasing in a constant rate during the study period (Fig 7). The Mysuru division had second highest growth in egg production indicated quadratic trend. In this division all the coefficients of quadratic model were significant and only the linear term had negative sign. From the Fig 8 it can be clearly seen that there is a negligible change in egg production up to 2007 and there is a rapid increase in egg production thereafter.

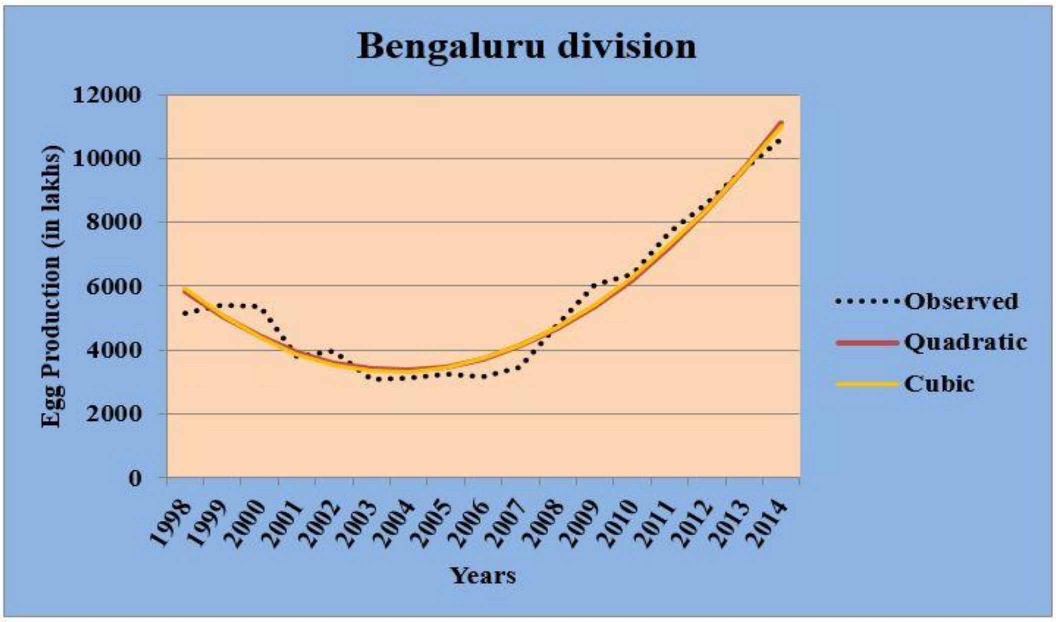

Fig. 5: Fitted models for Bengaluru division

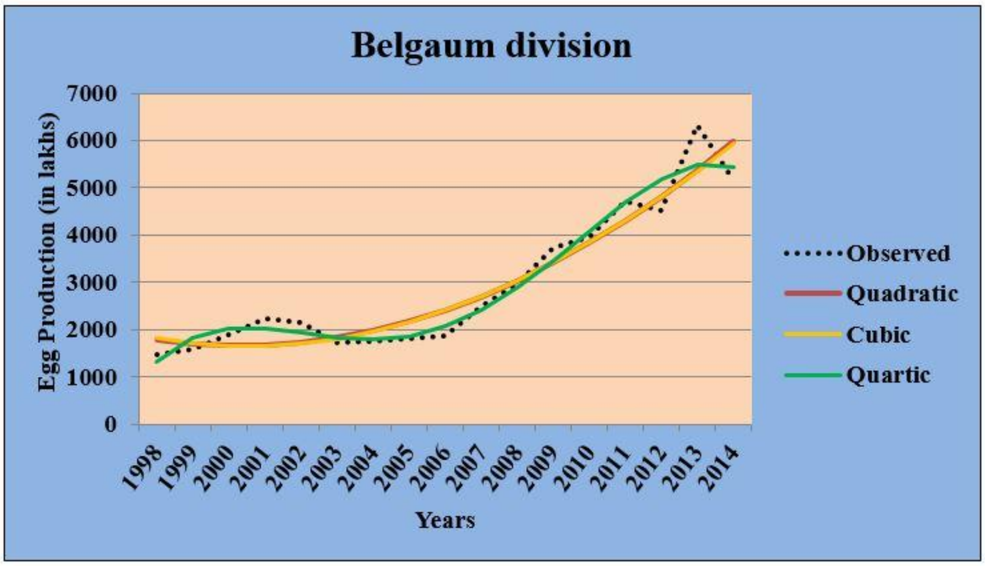

Fig. 6: Fitted models for Belagavi division

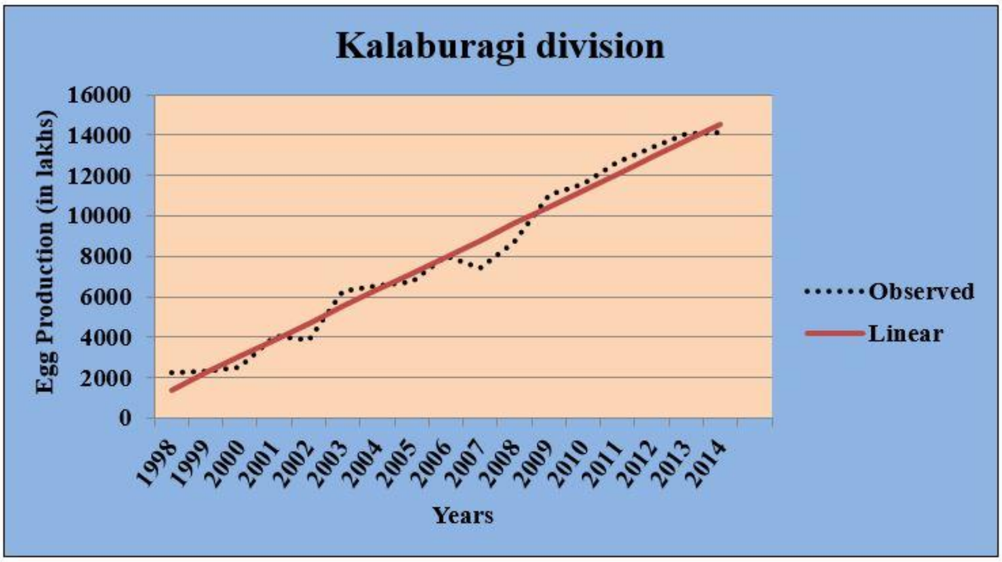

Fig. 7: Fitted model for Kalaburagi division

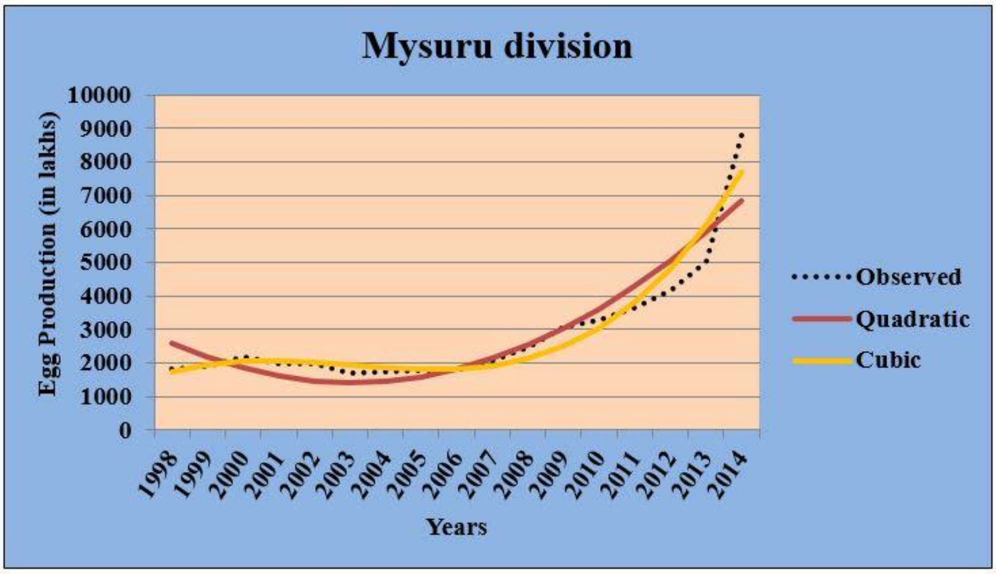

Fig. 8: Fitted models for Mysuru division

CONCLUSION

A steady increase in egg production till 2008 and thereafter a rigorous increase were seen in Karnataka state. Of all the models tested the exponential model explained better the egg production of Karnataka for the study period 1985-86 to 2014-15. To overcome the variation from district to district in egg production which hindered to assess the real growth an attempt has been made to group the districts based on two criterions and analysed the growth using appropriate models. The quadratic, cubic and quartic models are appropriate for districts falling under low and medium egg producing class. Among them the quadratic model was best fitted model. The linear model was best suitable for districts falling under high egg producing class. For the data analysed by grouping the districts on the basis of administrative divisions the quadratic model was best fit for Bengaluru division. For Belagavi division, the best fitted model is quartic. Linear model was found to be best fitted model for Kalaburagi division and Cubic model was best fitted model for Mysuru division. It was found that linear model was the appropriate model for the districts or division with higher egg production growth rates.

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