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Exploration of Different Functional Forms of Growth Models: A Censorious Analysis With Reference to Horticultural Sector in Karnataka

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Abstract: *The horticulture sector in Karnataka encompasses a wide range of crops, namely, fruits, vegetables, plantations, spices and flowers. In recent years, horticulture development has made rapid strides in Karnataka state as evidenced by increasing contribution to the State Agricultural Domestic Product. A significant shift towards horticulture is evident in the state with an increase in area and production. Horticulture sector is making inroads throughout the length and breadth of the state through higher unit productivity and great scope for value addition. The present study attempted to explore different linear and nonlinear growth models for the purpose of estimating the growth rate and fitting the best model, which would help better prediction. Keeping this in mind, we have estimated the parameters of the model to infer precisely. Results revealed that there is a clear shift in area from agriculture to horticulture as the latter is relatively more remunerative to farmers. Based on the estimated growth models, the projected area and production of horticultural crops in Karnataka by the year of 2030 would be 27.58 lakh ha and 201.30 m tonnes as against the present figures of 18.99 lakh ha and 147.80 lakh tonnes, respectively.*

Key Words*: Horticulture, Growth Models, MAE, RMS, MAPE, Run test, Shapiro-Wilk test.??*

INTRODUCTION

Although agriculture plays a vital role in the Indian economy, in the recent decades, there have been substantial changes in the patterns of production, consumption and trade in Indian agriculture. Horticulture sector creates opportunities for small farmers to raise their income by participating in the growing markets for horticulture goods. It plays an important role in country's nutritional security as well, including poverty alleviation and employment generation. India is now the second largest producer of fruits and vegetables in the world and is the leader in several horticultural crops. The changed economic order in the context of globalization and liberalization of world trade in agriculture has opened up new vistas of growth. Prajneshu and Chandran (2005) and Sadeesh et al. (2006) have analysed the trends in area, production and productivity of agriculture using linear and non linear growth models.

Largely in response to the growth in domestic consumption and, to a lesser degree, export opportunities, production of horticulture commodities has grown more quickly than that of traditional grain crops. To meet the changing demands, production systems are also moving towards horticulture crops, but the extent and pattern of such shifts vary across regions/states due to agro-climatic, socio-economic and demographic factors. What are factors responsible for such a growth of horticulture sector in Karnataka? On the one hand, there is a rising domestic demand for horticulture commodities, driven by rising incomes,

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urbanization, and perhaps changing preferences. On the other, trade liberalization has opened export markets in other countries where high-income consumers demand fruits, vegetables, and spices which has raised the demand for horticultural products.

?? Add a paragraph on why different models are tried in this study OR why different models need to be tried before selecting a particular model.

The present study has been undertaken to evaluate the growth in area, production and productivity of important horticultural crops in Karnataka using various linear, non-linear and linearisable growth models with a view to provide analytical approach of fitting appropriate growth model. Different linear and nonlinear regression growth models were used by Pradeep and Krishna (2002), Venugopalan and Shamasundaran (2003), Deka and Sarmah (2004) and Verma et al. (2009) and the best-fitted model was taken for future projection. The best-fit model which explains the underlying phenomenon, the Adjusted R^2 and Residual Mean Square (RMS) were estimated. Some important assumptions regarding randomness (using one sample run test), test for normality (Shapiro-Wilk test) was also checked in the present study and the effort was made in such a way that parameters of the best-fitted model have appropriate economical interpretation. The utility of such modeling efforts is that as different agricultural mechanisms follow distinct patterns, an overview of the selection criteria of model will provide an insight into the underlying mechanism. Moreover the knowledge of projected production and demand would help agriculture researcher, developmental agencies and policy makers to redirect their investigation towards the goal of sustainable development.

METHODOLOGY

The present study attempts two important aspects of horticultural sectors; one is to estimate district-wise growth in area, production and productivity of horticultural crops, and second is to analyze the best fitted linear and nonlinear growth models for projection of total horticultural area and production for 2030 AD.

The data pertaining to area, production and productivity of horticultural crops of Karnataka were collected for the period of 26 years (1985-86 to2011-12) from the publications of the State Department of Horticulture, Government of Karnataka. The growth in area, production and productivity of horticultural crops were estimated for two sub periods, *viz.*, Period-I (1985 to 1997) and Period-II (1998 to 2011) by the following models and the best-fit model was finally selected for a particular crop group and period.

The compound growth rates were computed for area, production and productivity based on the following exponential function;

$$Y = a * b^x$$

Where,

Y = the variable for which growth rate is calculated

X = time variable

a = intercept

b = the regression coefficient

The log form of the above exponential equation can be expressed as

$$ln\ (Y) = ln\ (a) + X\ ln\ (b)$$

The compound growth rate (CGR) in percentage can be expressed as

$$\text{CGR } (\%) = [\text{Antilog } (b) - 1] * 100$$

The Student's '*t*' test was used to test the significance of CGR (Sadeesh et al., 2006), where in the null hypothesis (H_0) would be 'CGR is not significantly different from zero', while the alternative hypothesis(H_1) would be 'CGR is significantly different from zero'. The test statistic is:

t with (n-2) degrees of freedom

Where, $\text{SE}(r) = \dfrac{100 * b *}{0}$

r = Growth rate

n = number of observations (years)

The various functional forms of Growth models tested were:

Simple linear Regression	:	$Y_t = \beta_0 + \beta_1 t + \varepsilon$
Quadratic Regression	:	$Y_t = \beta_0 + \beta_1 t + \beta_2 t_2 + \varepsilon$
Logarithmic Regression	:	$Y_t = \beta_0 + \beta_1 \, ln\,(t) + \varepsilon$
Exponential Regression	:	$Y_t = \beta 0.\ \mathrm{Exp}\ (\beta 1t).\ \varepsilon$
Power	:	$lnY_t = ln\ a + b\ ln\ t + e$
Compound	:	$ln(Y) = ln(b0) + t\ ln(b1)$
Cubic	:	$Y_t = ax^3 + bx^2 + cx + d$

Assumptions

1) Errors are Random
2) Errors are independent and identically distributed (normal)
3) E (ε) = 0, E (ε ? ε) = σ2, ε ~ N (0, σ2)

Where,

Y_t is the dependent variable at time period '*t*'.

'*t*' is the time period.

β_0 is the intercept

β_1 and β_2 are the slopes, and

ε is the error.

For the detailed procedure for estimation of parameters of linear and non linear growth models, please refer Seber and Wild (1989).

Model Selection Criteria

The choice of fitting trend equation from amongst the available alternatives is very crucial. The coefficients are checked for the significance, if they are significant then based on highest R^2, models are selected. The most commonly used statistical criterion is the coefficient of determination, R^2 or Adjusted R^2.

R square

The coefficient of determination, R^2, is a statistic that will give information about the goodness of fit of a model. It gives the proportion of variability in a data set that is accounted for by the statistical model. It provides a measure of how well future outcomes are likely to be predicted by the model.

The value of R^2 lies between 0 and 1. An R^2 of 1.0 indicates that the model perfectly fits to the data. For linear models, the sums of the squared errors always add up in a specific manner: SS Regression + SS Error = SS Total. This seems quite logical. The variance that the regression model accounts for plus the error variance adds up to equal the total variance. Further, R-squared equals SS Regression / SS Total, which mathematically must produce a value between 0 and 100%. In nonlinear regression, SS Regression + SS Error do not equal SS Total! This completely invalidates R-squared for nonlinear models, and it no longer has to be between 0 and 100%.

In the present study used to estimate the constants of non-linear models. Each of these trend equations imposes certain restrictions upon the character of the growth process. So in fitting trend equation the choice of trend equation from amongst the available alternatives is very crucial. The most commonly used statistical criterion is the coefficient of determination, R^2 or adjusted R^2. As R^2 is not an adequate measure for choice of nonlinear models, because the reduced linear model obtained through Linearization method or LM method are not having intercept term. In case of a model without intercept term, sum of residuals is not zero. It is possible only in case of intercept model as unit vector belongs to the column space. Keeping this in mind, adjusted R^2 and RMS are considered here for the purpose of choosing the best-fit model. Adjusted R^2 is calculated as,$R^2 = R^2 - (1 - R^2)$

Where, p is the number of constants in the equation, '*n*' is the total number of observations. This criterion, though a very powerful one as a test of goodness of fit, has several deficiencies under certain circumstances. For example, a power model may first be liberalized by using a logarithmic transformation and then fitted to empirical data by using Ordinary Least Square (OLS) method. The R^2 value is then often calculated using the logarithm of data points (log Yi_i). This R^2 is generally interpreted as a measure of goodness of fit of even the original non-linear model which is incorrect. So the best criterions to choose a model are the RMSE and MAE, which will also ensure accurate forecasting. To simplify, we assume that we already have n samples of model errors calculated as (ei, i = 1, 2, . . . , n). The uncertainties brought in by observation errors or the method used to compare model and observations are not considered here. We also assume the error sample set is unbiased. The RMSE and the MAE are calculated for the data set as

$$RMSE = \sqrt{1/n\sum_{i=1}^{n} ei^2}$$

$$MAE = 1/n\sum_{i=1}^{n} |ei|$$

The underlying assumption when presenting the RMSE is that the errors are unbiased and follow a normal distribution. Thus, using the RMSE or the standard error (SE)1 helps to provide a complete picture of the error distribution.

$$\text{Mean Squared Error (MSE)} = \frac{\sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2}{n-p}$$

Mean Squared Error is a measure to quantify the difference between actual values and forecasted values. Mean Squared Error is a risk function corresponding to the expected value of the squared error loss or quadratic loss.

Mean Absolute Percentage Error (MAPE) =

$$\sum_{i=1}^{n}\left|((Y_i - \hat{Y}_i)/Y_i) * 100)\right|$$

This measure is useful for imagining a worst-case scenario for your forecasts. Here n is the total number of observed values and p denotes the number of model parameters. The detail procedure for model criteria and parameters estimation was taken from Draper and Smith (1981), Gupta and Kapoor (2001), and Srivastava and Shobhit (2000). Before choosing a model one should be certain that the disturbance term satisfies all the conditions of randomness, non-autocorrelation, homoscedasticity and normality. The property of homoscedasticity is hardly checked perhaps on the assumptions that it is not a problem of time series data. In the present study an attempt has been made to verify two most important assumptions of normality and randomness of residuals.

Test of Randomness

Randomness of residuals can be tested by using non-parametric one sample run test (Siegel and Castellan, 1965). A run is defined as a succession of identical symbols in which the individual scores or observations originally were obtained. For example, suppose a series of binary events occurred in this order: + + - - - + - - - - + + - - +. If very few runs occur, a time trend or some bunching owing to lack of independence is suggested. If a great many runs occur, systematic short-period cyclical fluctuations seem to be influencing the scores.

Let '*m*' be the number of elements of one kind, and '*n*' be the number of elements of the other kind in a sequence of $N = m + n$ binary events. If both m and n are less than or equal to 20, then the number of runs, r if falls between the critical values, we cannot reject null hypothesis. Where null hypothesis is, H0 : The sequence is random.

For large samples if either '*m*' or '*n*' is large than 20, a good approximation to the sampling distribution of '*r*' is the normal distribution with.

$$\text{Mean } (\mu) = \frac{2mn}{m+n} + 1 \text{ and}$$

$$\text{var } (\sigma^2) = \frac{2mn(2mn - m - n)}{(m+n)^2(m+n-1)}$$

Then, H_0 may be tested by $Z = [(r \pm 0.5)-\mu_r]/?_r$

The significance of any observed value of z computed using the equation may be determined from a normal distribution table.

Test of Normality

It is important to note that for regression, the normality test should be applied to the residuals rather than the raw scores. However, this assumption is not so stringent while selecting non-linear models because residuals of non-linear models may not follow normal distribution. But it is must for linear models and linearised models. That is why in the present study normality check has been included. There is not a general agreement of the best way to test normality. Some popular tests for normality, viz., the Shapiro-Wilk (Shapiro and Wilk, 1965), the Kolmogorov–Smirnov test, Cramer Von Misses test and Anderson-darling test.

Shapiro-Wilk statistic 'W' is given as,

$$W = \frac{\left[\sum_{i=1}^{n} a_i X_i\right]^2}{\sum_{i=1}^{n}(X_i - \overline{X})^2}$$

Where, $i = 1, 2, ..., n$. X_i = ordered sample values

a_i = the constants generated from mean, variances and co-variances of the order statistics of a sample of size 'n' from a normal distribution. If the p-value is smaller than the level of significance, H_0 is rejected.

RESULTS AND DISCUSSION

District wise growth rates in area, production and productivity

Karnataka occupies a prominent place in the horticulture map of the country. Horticultural crops occupy an area of 18.99 lakh ha, with annual production 147.80 lakh tonnes. Although the area comprises only 14.44 per cent of the net cultivated area in the state, the total income generated from the horticulture sector accounts for over 40 per cent of total income derived from the combined agriculture sector and 17 per cent of the state's GDP.

The district wise growth performance of horticulture crops with respect three parameters, *viz.*, area, production and productivity is presented in Table-1. Majority of districts exhibited positive growth rates in period I. The highest and significant growth rate was observed in Gulbarga (6.80%), Bengaluru Rural (6.08%), Chitradurga (5.43%) and Bidar (5.33%) districts. Less than five per cent growth rate was registered in Mandya, Chikamagalur, Bellary, Bengaluru Urban, Belgaum, Bijapur, Mysore and Kolar districts. During Period-II, Bellary district (7.56%) recorded the highest growth rate in area followed by Dharwad (6.14%) and Raichur (5.54%) districts. Kolar, Bengaluru

Table 1
District wise Growth Rates of Horticulture Sector in Karnataka

[Per cent]

SN	*District*	*Area*		*Production*		*Productivity*	
		Period-I	*Period-II*	*Period-I*	*Period-II*	*Period-I*	*Period-II*
1	Bangalore(U)	4.03**	3.13**	8.31**	-2.67*	4.28**	2.22
2	Banglore (R)	6.08**	4.53**	5.39*	3.24 *	-0.69	-1.29
3	Belgaum	3.90**	3.10**	6.84**	1.24	2.94 *	3.84 *
4	Bellary	4.08*	7.56**	0.94	7.04 **	-3.13*	-0.52
5	Bidar	5.33*	1.99 *	9.74**	1.98 *	4.42 **	0.98
6	Bijapur	3.84*	1.79	9.44**	6.22 **	5.59 **	4.4 *
7	Chikmagalur	4.42 **	3.39**	3.21 **	9.77**	-1.2	6.38 **
8	Chitradurga	5.43**	3.21**	6.38**	0.73	0.95	1.66
9	D. Kannada	2.46	1.72 *	0.88	5.9	-1.58	4.18 *
10	Dharwad	0.6	6.14*	7.18**	9.43 **	6.58*	3.29
11	Gulburga	6.80**	1.08	5.74**	4.62 **	-1.06	3.54*
12	Hassan	1.99*	1.56 *	9.94 **	-2.98	7.95**	-4.54 *
13	Kodagu	-0.49	-0.71	6.03 *	-3.73 *	6.52*	-2.97
14	Kolar	3.21*	4.67*	4.10**	6.10**	0.89	1.42 *
15	Mandya	4.58**	4.03**	12.15**	7.08 **	7.57**	3.05*
16	Mysore	3.37*	2.27*	13.36**	4.34 **	9.99**	2.07 *
17	Raichur	1.81*	5.54**	0.22	12.96 **	-1.59	7.42 **
18	Shimoga	0.91	1.97 *	0.9	0.61	2.17	-1.35
19	Tumkur	0.3	3.08**	-1.16	7.89 **	-1.45	4.81 **
20	U.Kannada	1.02	1.44 *	0.21	-0.43	-0.82	-1.47

Note: **and * Indicates significant at one per cent and five per cent probability level, respectively

Rural and Mandya districts registered moderate but statistically significant growth rates.

With respect to horticulture production, high growth rates were observed in almost all districts of the state except Tumkur district which registered negative growth during Period-I. The highest growth rate was observed in Mysore (13.36%) followed by Mandya district (12.15%). During Period-II, higher growth rates were registered in Raichur (12.96%), Chikamagalur (9.77%), Dharwad (9.43%) and Tumkur (7.89%) districts. While production was decreasing in Kodagu, Bengaluru Urban and others districts. Productivity growth performance of horticultural crops (Table-1) revealed that Mysore, Hassan, Mandya, Dharwad and Kodagu districts registered impressive growth rates ranging from 6.5 per cent to 10 per cent, with significant negative growth rate in Bellary district during Period-I. On the other hand, during Period-II, Raichur and Chikamagalur districts exhibited significant growth rates of 7.42 per cent and 6.38 per cent, respectively. Slightly lower than five percent growth rate was observed in Tumkur, Bijapur, Dakshina Kannada, Belgaum and Gulbarga districts; productivity was on decreasing trend in the Hassan, Kodagu and Bangalore rural districts.

Sector-wise Growth Rates of Area, Production and Productivity

The diverse agro-ecological conditions prevailing in the state facilitates growth of a variety of horticulture crops covering fruits, vegetables, flowers, spices, plantations, roots and tuberous crops, aromatic crops, medicinal crops, oil palm, etc. There has been a significant development in horticulture sector since the last two to three decades. There is an increase in area under horticulture sector due to less labour intensive and highly remunerative nature. Karnataka state at the national level stands first in floriculture, second in spice and plantation crops, third in coconut and fifth in fruits and vegetable production.

The sector wise summary of growth rates is furnished in Table-2. Almost all the sectors showed positive growth in area with respect to overall horticulture sector (2.53%) in the state. Majority of horticultural sub-sector exhibited positive growth rates during Period-I. The highest and significant growth rate was observed in vegetables sector (4.44%) followed by flower (4.00%), spices (2.40%) and fruits (2.00%) sector. While growth rate analysis during Period-II revealed that vegetables (5.35%) recorded the highest growth rate followed by flower sector (5.08%). Little higher than three per cent growth was recorded for the overall horticultural sector. Interestingly spices had positive growth rate in the first period but showed negative in second period.

Growth in production of horticultural sub-sectors depicted in Table-2 revealed that during Period-I, flowers sector (9.45%) recorded the highest growth rate followed by vegetables (6.30%), fruits (4.40%), spices (2.19%) and plantation (2.10%) sectors. During Period-II also, production in all the sub-sectors of horticulture increased except for spice, which recorded 1.70 per cent decrease in production. Among the various sectors, vegetables (7.14%) showed the highest growth rate followed

Table 2
Sector wise Growth Rates of Horticulture in Karnataka

SN	*Sectors*	*Period I (1985 to 1997)*			*Period II (1998 to 2011)*		
		Area	*Prodn.*	*Yield*	*Area*	*Prodn.*	*Yield*
1	Fruits	2.00*	4.40**	2.41**	2.45**	5.12**	2.55**
2	Vegetables	4.44**	6.30**	1.90**	5.35**	7.14**	2.10*
3	Plantation	1.02*	2.10**	1.04*	2.51**	2.71**	-0.08
4	Spices	2.40**	2.19**	-0.40	-1.35	-1.70	-0.04
5	Flower	9.00**	9.45**	0.05*	5.08**	4.48**	3.04**
	Overall	2.53**	4.71**	2.10**	3.14**	5.20**	1.71*

Note: **and * Indicates significant at one per cent and five per cent probability level, respectively by fruits (5.12%) and flowers (4.48%). The growth rates of area and production under horticultural sector was positive during both the periods but per cent growth rates were higher during Period-II compared to Period-I and reverse was true with respect to productivity growth rate.

The analysis of growth rates of productivity of horticultural crops (Table-2) revealed that spices posted negative growth rates during both the study periods. Significant and high growth rates were observed in fruits (2.41%), Vegetables (1.90%) and overall horticultural crops (2.10%) during Period-I. However, the growth rates during Period-II were higher for fruits (2.55%), followed by vegetable (2.10%) and flower (3.04%) sub-sectors. The growth in overall production of horticulture crops during both the periods was largely yield-led.

Estimated Growth Models for Area, Production and Productivity

Tests for Randomness and Normality

@@@Randomness of residuals was tested by using non-parametric one-sample run test outlined in the methodology section. The results presented in Table-3 reveals that the sample is normal shaped, the population from which it came is normally distributed. As one could see from the table the non-significant tests for Randomness and Normality, H_0 [observed distribution fits the normal distribution] is accepted and concluded that the data follows normality.

Statistical Criteria for Model Selection

Different linear and nonlinear growth models were examined for area, production and yield of horticulture crops in Karnataka for the time series data from 1985 -86 to 2011-12 to arrive at the best model for better prediction. The major criteria of choosing best model and results of the growth functions are presented in Table-4. The R^2 quantifies how well a model fits the data, so it seems as though it would be an easy way to compare models. It surely sounds easy to pick the model with the larger R^2.

The problem with this approach is that there is no penalty for adding more parameters. So the model with more parameters will bend and twist more to come nearer the points, and so almost always has a higher R^2. If you use R^2 as the criteria for picking the best model, you'd almost always pick the model with the most parameters. After analysing the several growth functions, the quadratic growth function was the best fit for area of fruit crops, with high R^2 (0.716) and adjusted R^2 (0.702) values, significant slope and intercept coefficients (Table-4). Our first indicator of generalizability is the adjusted R^2 value, which is adjusted for the number of variables (33 obervation) included in the regression equation. This is used to estimate the expected shrinkage in R^2 that would not generalize to the population because our solution is over-fitted to the data set by including too many independent variables. If the adjusted R^2 value is much lower than the R^2 value, it is an indication that our regression equation may be over-fitted to the sample, and of limited generalizability. For the present study we are analyzing, R^2=0.716 and the adjusted R^2=0.702. These values are very close, anticipating minimal shrinkage based on this indicator. The adjusted R^2 always has a lower value

Table 3
Tests for Randomness and Normality for Different Enterprises of Horticultural Sector

Sub-sector	*Area*					*Production*				
	Growth Model	*Run test*	*P value*	*Shapiro-wilk test*	*P value*	*Growth Model*	*Run test*	*P value*	*Shapiro-wilk test*	*P value*
Fruits	Quadratic	-0.89NS	0.51	0.94NS	0.41	Compound	-1.89NS	0.12	0.62NS	0.23
Vegetable	Cubic	-1.60NS	0.10	0.97 NS	0.57	Exponential	-0.87NS	0.85	0.96NS	0.33
Plantation	Cubic	-1.88NS	0.41	0.96 NS	0.51	Cubic	-1.60NS	0.52	0.65NS	0.15
Spices	Power	-1.47NS	0.56	0.97NS	0.72	Logarithmic	-1.47NS	0.16	0.96 NS	0.38
Flower	Compound	-0.45NS	0.64	0.86NS	0.12	Cubic	-0.45 NS	0.64	0.86 Ns	0.29
Overall	Linear	-1.03NS	0.49	0.84NS	0.65	Compound	-0.72 NS	0.47	0.95 NS	0.18

Table-4
Growth Models in Area and Production of Horticultural Sectors in Karnataka State

Sub-Sectors	*Area*							*Production*						
	Model	R^2	*Adj* R^2	Parameter Estimation *Constant*	b_1	b_2	*b3*	*Model*	R^2	*Adj* R^2	Parameter Estimation *Constant*	b_1	b_2	*b3*
Fruits	Quadratic	0.716	0.702	0.416	1.758**	1.018**	0.16**	Compound	0.616	0.597	23.717	1.027**	0.811**	
Vegetables	Cubic	0.979	0.977	1.351	-.070**	0.011**	0.001*	Exponential	0.970	0.969	17.127	0.046**		
Plantation	Cubic	0.972	0.969	2.797	-0.350*	0.036	-0.001	Cubic	0.972	0.969	2.797	-0.350	0.036	-0.001
Spices	Power	0.791	0.768	3.253	1.29**	0.00	0.00	Logarithmic	0.704	0.677	20.033	-0.037	0.480	
Flower	Compound	0.862	0.858	.024	0.652**	0.00	0.00	Cubic	0.881	0.869	0.193	0.009	0.003	4.502
Overall	Linear	0.711	0.698	10.152	0.655**	0.00	0.00	Compound	0.834	0.831	55.512	1.029	0.00	0.00

Note: **and * Indicates significant at one per cent and five per cent probability level, respectively

than R^2 (unless you are fitting only one parameter). The R^2 quantifies the linear relationship in the sample of data you are analyzing. Even if there is no underlying relationship, there almost certainly is some relationship in that sample.

The appropriate function for production of fruit crops was compound growth function. For the vegetable area, cubic and exponential models were the best models as R^2 was higher and slope and intercept coefficients were significant. The plantation crops' area and production were best explained by cubic model. Similarly the spices' area and production are best explained by Power and Logarithmic growth model. However, the flower and overall horticultural sector were explored by Compound, Cubic and Linear growth functions which satisfied the above mentioned criteria and were the best fitted for the future forecasting and hence these functions were used for forecasting up to 2030 AD.

Tests for Goodness of Fit

Accurately measuring of forecast and its attributes at past, present, and future points in time has been of great interest of present study. Within discussions of forecast accuracy, often been criticized for their inaccurate prognostications of the future value. The Discussions of methods and data are usually at the centre of these criticisms, along with suggestions for providing an idea of forecast uncertainty. The measures used to evaluate the accuracy of forecasts also have received attention and while accuracy is not the only criteria advocated for evaluating forecasts, it is generally acknowledged to be the most important. One of the main objectives of present study is to figure out how to choose the right statistic to estimate actual and forecasted values. Of course, we need some measure of being right something that which shows likely to be close to actual and forecasted values could be interpreted in many ways, and we have to pick major criteria.

The most common measures, namely, Mean Square Error (or MSE), MAE, RMS and MAPE, were analysed for several growth models. Among these models, the one which gives the least value in terms of these criteria has been chosen as the best model for forecasting purposes. Table-5 presents the results of goodness of fit for different sub-sectors of horticulture.

With respect to horticultural production, growth function was highly impressive in all the models. Majority of growth functions observed the least and significant values of major criteria. The compound and exponential growth models were fitted well for fruits and vegetable production. Similarly the cubic and logarithmic growth functions gave the least values of the criteria for plantation, spices and flower production, respectively. However the compound growth function was good fit for the overall horticultural production (Table-5).

Forecasts for area and production of horticulture crops upto 2030AD

Presently, the area under horticulture crops in Karnataka is 18.99 lakh ha with a production of 147.80 lakh tonnes. The projections based on the estimated growth models are expected to be 201.30

Table 5
Tests for Goodness of fit for Different Enterprises of Horticultural Sector

Sub-Sectors	Area					Production				
	Growth Model	MAE	MSE	RMSE	MAPE	Growth Model	MAE	MSE	RMS	MAPE
Fruits	Quadratic	0.362	0.284	0.533	4.199	Compound	0.326	0.295	0.543	12.381
Vegetable	Cubic	0.117	0.024	0.157	3.186	Exponential	0.510	4.683	2.164	12.514
Plantation	Cubic	0.450	0.290	0.539	9.303	Cubic	0.780	1.787	1.337	3.881
Spices	Power	0.266	0.746	0.864	5.551	Logarithmic	0.338	1.839	1.356	8.947
Flower	Compound	0.015	0.019	0.137	9.056	Cubic	0.015	0.068	0.262	9.056
Overall	Linear	0.984	0.922	0.960	6.742	Compound	0.851	0.968	0.983	8.918

Table 6
Forecasts for Area and Production of Different Sectors Using Different Growth Models up to 2030 in Karnataka State

Years	Fruits sector		Vegetables		Plantation		Spices		Flowers		Overall	
	Area quadratic	Prodn. compound	Area cubic	Prodn. Exponential	Area cubic	Prodn. cubic	Area power	Prodn. logarithmic	Area compound	Prodn. cubic	Area linear	Prodn. Compound
2015	3.53	60.36	5.16	76.15	8.86	4.84	2.79	3.99	0.32	2.12	19.95	156.73
2016	3.62	61.64	5.34	78.39	9.26	4.98	2.85	3.97	0.34	2.20	20.39	159.70
2017	3.71	63.30	5.53	80.66	9.66	5.12	2.91	3.93	0.36	2.28	20.83	162.67
2018	3.81	65.00	5.72	82.96	10.08	5.27	2.98	3.90	0.38	2.36	21.28	165.64
2019	3.91	66.75	5.92	85.28	10.51	5.41	3.44	3.86	0.40	2.44	21.75	168.61
2020	4.02	68.55	6.12	87.64	10.95	5.55	3.62	3.83	0.42	2.52	22.22	171.58
2021	4.12	70.39	6.32	90.01	11.40	5.69	3.97	3.79	0.45	2.60	22.71	174.55
2022	4.23	72.28	6.53	92.42	11.86	5.83	3.93	3.76	0.48	2.68	23.20	177.52
2023	4.34	74.22	6.73	94.85	12.32	5.97	3.90	3.73	0.50	2.76	23.71	180.49
2024	4.46	76.22	6.95	97.31	12.80	6.11	3.86	3.70	0.53	2.85	24.23	183.46
2025	4.58	78.27	7.16	99.79	13.29	6.25	3.83	3.67	0.57	2.93	24.76	186.43
2026	4.70	80.37	7.39	102.30	13.79	6.39	3.79	3.64	0.60	3.02	25.30	189.40
2027	4.82	82.53	7.61	104.84	14.31	6.53	3.76	4.12	0.64	3.11	25.85	192.37
2028	4.95	84.75	7.84	107.40	14.83	6.68	3.73	4.08	0.67	3.20	26.41	195.35
2029	5.08	87.03	8.07	109.99	15.36	6.82	3.70	4.04	0.71	3.29	26.99	198.32
2030	5.21	89.37	8.30	112.61	15.90	6.96	3.67	4.00	0.76	3.38	27.58	201.29

Note: A: Area in lakh ha and P: Production in lakh tonnes

m tonnes with an area of 27.58 lakh ha by the year 2030. Forecasts of area and production were made for major horticulture sectors up to the year 2030 using appropriate growth models as depicted in Table-5 and results are presented in Table-6. Area under fruits would likely to be 5.21 lakh ha with a production of 89.37 lakh tonnes by 2030. In the case of vegetable sector, the respective figures would be 8.30 lakh ha and 112.61 lakh tonnes. For plantation crops, the area and production could likely be 15.9 lakh ha and 6.96 lakh tonnes. It would be useful to test the adequacy of these forecasts based on the likely demand by 2030 taking into consideration the demand elasticity, population growth and other forecasts. Then only we can infer the adequacy of the forecasts. However, in the present study this was not attempted. But these figures suggest that if present situations prevail in 2030, the forecasts could be valid.

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