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# Trend Analysis of Area, Production and Productivity of Coconut in Kerala

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***Abstract: Coconut is one of the principal crops in Kerala which occupies the largest area with 37.6 per cent and production of 31.9 per cent. Kerala ranks first in coconut area as well as production in India. Different linear and nonlinear trend models were estimated to understand the trends in area, production and productivity of coconut in Kerala for the period 1987-88 to 2016-17. The best model was selected based on adj. $R^2$, RMSE and criteria of randomness and normality. Cubic model is found to be the best fitted model for area, production and productivity of coconut in Kerala.***
***Keywords: Linear and nonlinear models, Adj. $R^2$, RMSE***

## I. INTRODUCTION

India ranks third on area under coconut next to the Philippines and Indonesia. In recent times India becomes the largest producer of coconut with the production of 22167 million nuts from acreage under plantation of about 2.09 million hectares. India contributes about 17.54 per cent in area and 33.02 per cent in terms of production of coconut in the world. In India, Kerala is the main coconut growing state with an area of 0.771 lakh hectares and production of 7449 million nuts, followed by Karnataka (514 thousand hectares and 6773 million nuts).

Tamil Nadu (461 thousand hectares and 6571 million nuts). Coconut occupies the largest area with 29.5 per cent coverage followed by rubber with 21.4 per cent in Kerala.(GOI,2017).

Trend analysis is a method of analysis that allows agricultural traders/policy makers to predict what will happen with a stock in the future. Trend analysis helps to form different trend equations such as, linear, power, exponential, logarithm and quadratic equations to predict the future aspects of data. This study mainly focused on computing the suitable linear and non-linear models which helps to know about trend in area, production and productivity of coconut in Kerala.

## II. MATERIALS METHODS

Annual data regarding coconut area (“000 ha), production (Million nuts) and productivity (Nuts $ha^{-1}$) in Kerala for the period of 1987-2017 were collected from coconut development board, ministry of agriculture and farmers welfare, Government of India. Regression coefficients were obtained with log values of area, production and productivity. There are eight models used for this study.

### A. *Goodness of fit of a Model*

Goodness of fit of a model was evaluated by computing the adjusted coefficient of determination (Adj $R^2$) and Root mean square error (RMSE).

### B. *Adjusted Coefficient Of Determination*

Adjusted coefficient of determination is defined as portion of significant variance explained by the estimated regression line.

$$\text{adj } R^2 = 1 - (1 - R^2)\left[\frac{n-1}{n-(k+1)}\right]$$

### C. *Root Mean Square Error (RMSE)*

Root Mean Square Error (RMSE) is defined as the square root of the average value of squared error.

$$RMSE=\sqrt{\frac{\sum_{i=1}^{n}(Y_i-\widehat{Y_i})^2}{n}}$$

Table.1 Equation of different model

| Name of the model | Model equation |
|---|---|
| Semi-log | $\ln Y = b_0 + b_1(t) + \varepsilon$ |
| Double logarithmic | $\ln(Y) = b_0 + b_1 \ln(t) + \varepsilon$ |
| Inverse | $\ln(Y) = b_0 + \frac{b_1}{t} + \varepsilon$ |
| Quadratic | $\ln(Y) = b_0 + b_1(t) + b_2 t^2 + \varepsilon$ |
| Cubic | $\ln(Y) = b_0 + b_1(t) + b_2 t^2 + b_3 t^3 + \varepsilon$ |
| Compound | $Y = b_0 b_1{}^t \varepsilon$ |
| Power | $Y = b_0 t^{b_1} \varepsilon$ |
| Exponential | $Y = b_0 e^{(b_1 t)}$ |

Where,
Y- dependent variable viz., area, production and productivity
t - time in years, independent variable
$b_{0,}$ $b_{1,}$ $b_2$ and $b_3$ are constants or parameters
$\varepsilon_t$ - error term

### D. *Assumptions of Error*

An important assumption of regression models is that the error term should follow the properties of normality and randomness.

### E. *Shapiro-wilk Test*

Shapiro-Wilk test was used to test the normality of error terms. The test statistic value ranges from 0 to 1. When W=1 the given error data are perfectly normal in distribution ( Shapiro et al., 1968). When 'W' is significant assumption of error term will not met. The test statistic is

$$W = \frac{(\sum_{i=1}^{n} a_i x_{(i)})^2}{\sum_{i=1}^{n}(x - \bar{x})^2)}$$

### F. *Run Test*

The run test can be used to decide if a dataset is from a random process. The test statistic is

$Z = \frac{r-\mu_r}{\sigma_r}$ , Mean=$\mu_r = \frac{2n_1n_2}{n_1+n_2} + 1$

SD ($\sigma_r$) = $\sqrt{\frac{2n_1n_2(2n_1n_2-n_1\ -n_2)}{(n_1+n_2)^2(n_1+n_2-1)}}$

$n_1$=Number of positive values in the series
$n_2$= Number of negative values in the series
The run test rejects the null hypothesis, if $\frac{\propto}{2}$ $|Z|>Z_{1-\frac{\propto}{2}}$

## III. RESULT AND DISCUSSION

Eight different models were used for studying the area, production and productivity of coconut in Kerala state such as Semi-log, Double logarithmic, Inverse, Quadratic, Cubic, Compound, Power and Exponential models. The criteria for deciding best model was high $R^2$ least RMSE and criteria of randomness and normality. Area of coconut in Kerala showed a declining trend pattern during the study period. All the fitted models for area under coconut in Kerala are presented in table.2. Adj $R^2$ values for the entire models ranges from 0.2 per cent for power model to 76.5 per cent for cubic model with minimum RMSE of 0.0472 and estimated regression coefficients were significant. According to Shapiro-Wilk test and Runs test the residuals of cubic model were normal and random. The best model selected was cubic model and its trend values are presented in Fig.1. The estimated cubic model was

$Y_t$= 6.561+.066t-.004$t^2$+6.855 ×$10^{-5}t^3$ (Adj. $R^2$=0.765)

Production of coconut in Kerala showed an increasing pattern during the study period. All the fitted models for production of coconut in Kerala are presented in table.3. Adj $R^2$ values for the entire models ranges from 52.8 per cent for compound/exponential model to 75.6 per cent for cubic model with minimum RMSE of 0.0792 and estimated regression coefficients were significant. According to Shapiro-Wilk test and Runs test the residuals of cubic model were normal and random. The best model selected was cubic model and its trend values are presented in Fig.2. The estimated cubic model was

$Y_t$= 8.058+0.110t-.006$t^2$+1.18E×$10^{-4}t^3$ (Adj. $R^2$=0.756)

Productivity of coconut in Kerala showed a positive trend pattern during the study period. All the fitted models for productivity of coconut in Kerala are presented in table.4. Adj $R^2$ values for the entire models ranges from 41.7 per cent for inverse model to 89.1 per cent for cubic model with minimum RMSE of 0.0584 and estimated regression coefficients were significant. According to Shapiro-Wilk test and Runs test the residuals of cubic model were normal and random. The best model selected was cubic model and its trend values are presented in Fig.3. The estimated cubic model was

$Y_t$= 8.404+0.044t-.002$t^2$+5.043E×$10^{-5}t^3$ (Adj. $R^2$=0.891)

## IV. CONCLUSION

Different linear and nonlinear growth models were estimated to understand the trends in area, production and productivity of coffee. Among the estimated models, best model was selected based on highest adjusted $R^2$, least RMSE and criteria of randomness and normality. Cubic model found to be the best fitted model from the result of linear and nonlinear modelling of area, production and productivity of coconut in Kerala.

## V. ACKNOWLEDGEMENT

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Table.2. Parameters estimates of fitted linear and nonlinear models for coconut area ('000 ha) in Kerala for 1987-2017
**and * indicates significance value at 1% and 5% respectively and NS- Non significant
Values in [] and () indicates probability value and standard error respectively

| Models | Regression coefficients | | | | Goodness of fit | | | |
|---|---|---|---|---|---|---|---|---|
| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | Adj. $R^2$ | Shapiro-wilk test | Runs test(z) | RMSE |
| Semi-log | 6.843** (0.035) | -.006* (0.002) | | | .205 | .983 NS [.890] | -4.631 NS [.000] | 0.0902 |
| Double logarithmic | 6.809** (0.060) | -.022 NS (0.023) | | | .003 | .976 NS [.712] | -4.645 NS [.000] | 0.1012 |
| Inverse | 6.763** (.024) | -.062 NS (.102) | | | .022 | .969 NS [.517] | -3.895 NS [.000] | 0.1022 |
| Quadratic | 6.674** (.036) | .026** (.005) | -.001** (.000) | | .651 | .947 [.139] | -.976 [.329] | 0.0586 |
| Cubic | 6.561** (.042) | .066** (.012) | -.004** (.001) | 6.85E-5** (.000) | .765 | .960 NS [.307] | -.908 [.364] | 0.0472 |
| Compound | 6.843** (.035) | .999** (.000) | | | .207 | .982 NS [.887] | -4.631 NS [.000] | 0.0903 |
| Power | 6.809** (.061) | -.003 NS (.003) | | | .002 | .976 NS [.717] | -4.645 NS [.000] | 0.1013 |
| Exponential | 6.843** (.035) | .001* (.000) | | | .207 | .983 NS [.890] | -4.631 NS [.000] | 0.0903 |

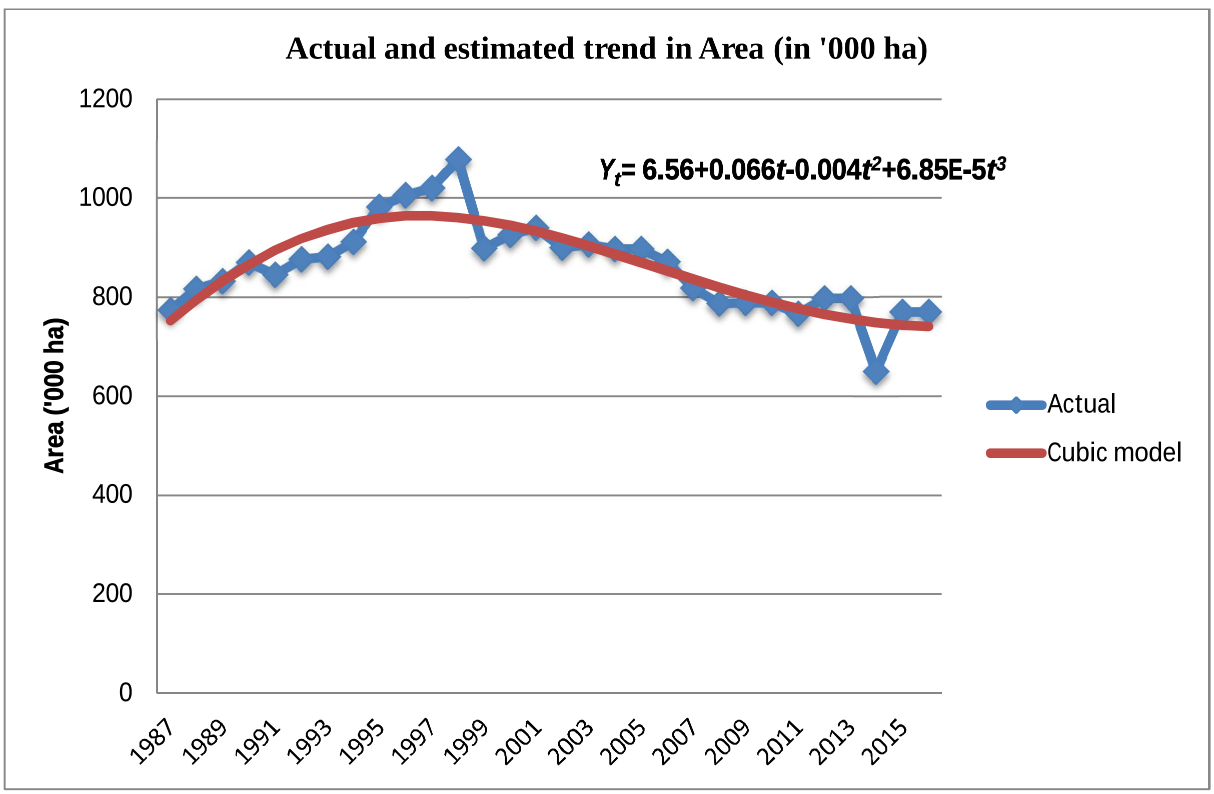

Fig.1 Graph for actual and estimated values of coconut area in Kerala

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Table.3. Parameters estimates of fitted linear and nonlinear models for coconut production (in Million nuts) in Kerala for 1987-2017
**and * indicates significance value at 1% and 5% respectively and NS- Non significant

Values in [] and () indicates probability value and standard error respectively

| Models | Regression coefficients | | | | Goodness of fit | | | |
|---|---|---|---|---|---|---|---|---|
| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | Adj. $R^2$ | Shapiro-wilk test | Runs test(z) | RMSE |
| Semi-log | 8.391** (.044) | .014** (.002) | | | .530 | .951 NS [.174] | -1.981 NS [.048] | 0.1140 |
| Double logarithmic | 8.186** (.053) | .172** (.020) | | | .714 | .960 NS [.304] | -1.282 [.200] | 0.0890 |
| Inverse | 8.710** (.024) | -.712** (.102) | | | .623 | .961 NS [.325] | -1.603 [.109] | 0.1021 |
| Quadratic | 8.253** (.062) | .040** (.009) | -8.32E-4* (.000) | | .629 | .972 NS [.604] | -2.675 NS [.007] | 0.0995 |
| Cubic | 8.058** (.071) | .110** (.019) | -.006** (.001) | 1.18E-4** (.000) | .756 | .926 NS [.139] | -1.301 [.193] | 0.0792 |
| Compound | 8.390** (.044) | 1.002** (.000) | | | .528 | .950 NS [.171] | -1.981 NS [.048] | 0.1144 |
| Power | 8.190** (.050) | .020** (.002) | | | .719 | .959 NS [.291] | -1.282 [.200] | 0.0893 |
| Exponential | 8.390** (.044) | .002** (.000) | | | .528 | .950 NS [.171] | -1.981 NS [.048] | 0.1144 |

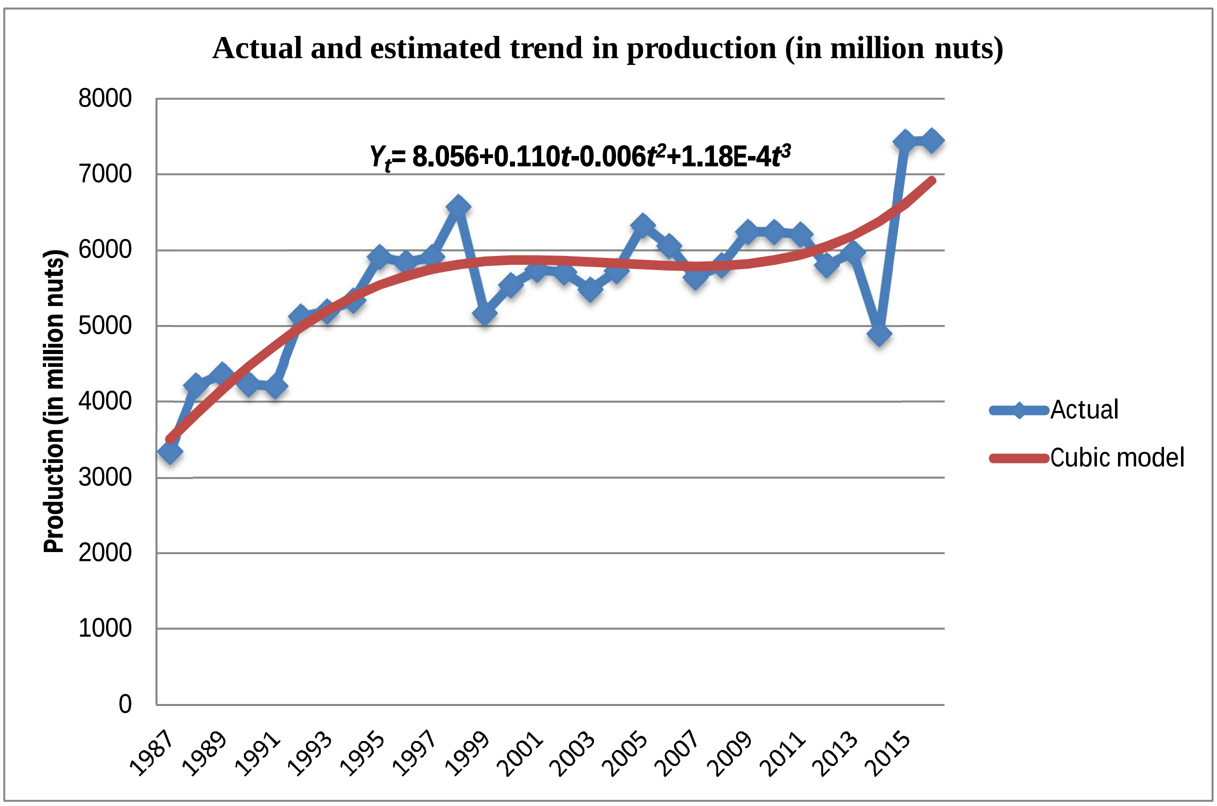



Fig.2 Graph for actual and estimated values of coconut production in Kerala

Table.4. Parameters estimates of fitted linear and nonlinear models for coconut productivity (in nuts $ha^{-1}$) in Kerala for 1987-2017
**and * indicates significance value at 1% and 5% respectively and NS- Non significant
Values in [ ] and ( ) indicates probability value and standard error respectively

| Models | Regression coefficients | | | | Goodness of fit | | | |
|---|---|---|---|---|---|---|---|---|
| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | Adj. $R^2$ | Shapiro-wilk test | Runs test(z) | RMSE |
| Semi-log | 8.455** (.025) | .020** (.001) | | | .874 | .966 NS [.429] | -1.301 NS [.193] | 0.0650 |
| Double logarithmic | 8.285** (.054) | .194** (.021) | | | .750 | .923 * [.032] | -2.287 NS [.022] | 0.0915 |
| Inverse | 8.855** (.032) | -.650** (.139) | | | .417 | .925* [.035] | -4.642 ** [.000] | 0.1399 |
| Quadratic | 8.487** (.039) | .014* (.006) | 1.91E-4 NS (.000) | | .874 | .975 NS [.689] | -1.301 NS [.193] | 0.0637 |
| Cubic | 8.404** (.052) | .044* (.014) | -.002 NS (.001) | 5.043E-5* (.000) | .891 | .946 NS [.131] | -1.301 NS [.193] | 0.0584 |
| Compound | 8.459** (.024) | 1.002** (.000) | | | .876 | .970 NS [.536] | -1.301 NS [.193] | 0.0647 |
| Power | 8.294** (.050) | .022** (.002) | | | .760 | .922* [.030] | -2.287 NS [.022] | 0.0905 |
| Exponential | 8.459** (.024) | .002** (.000) | | | .876 | .970 NS [.536] | -1.301 NS [.193] | 0.0647 |

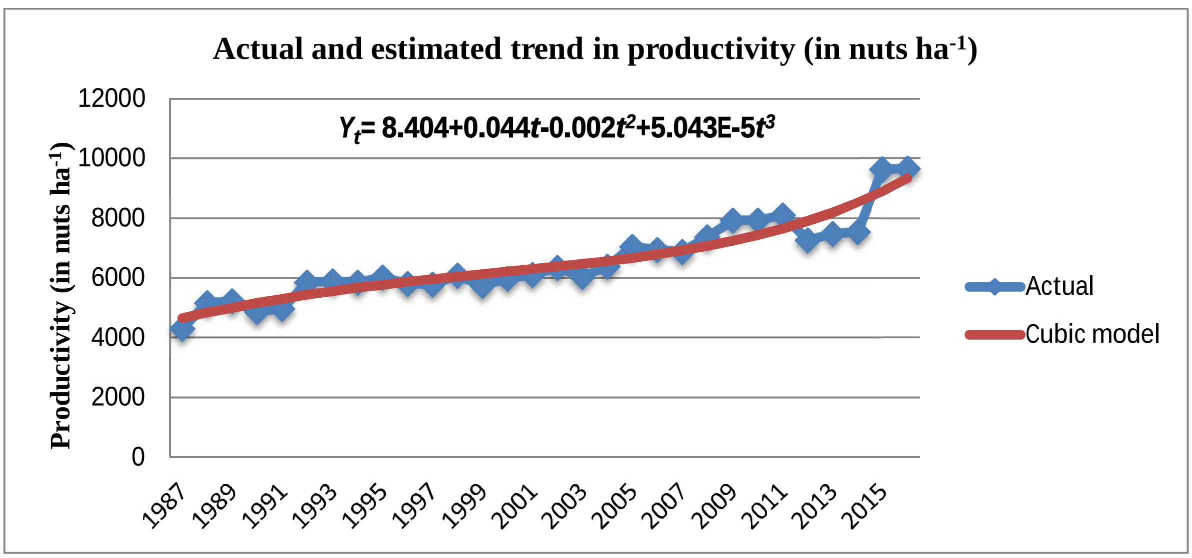
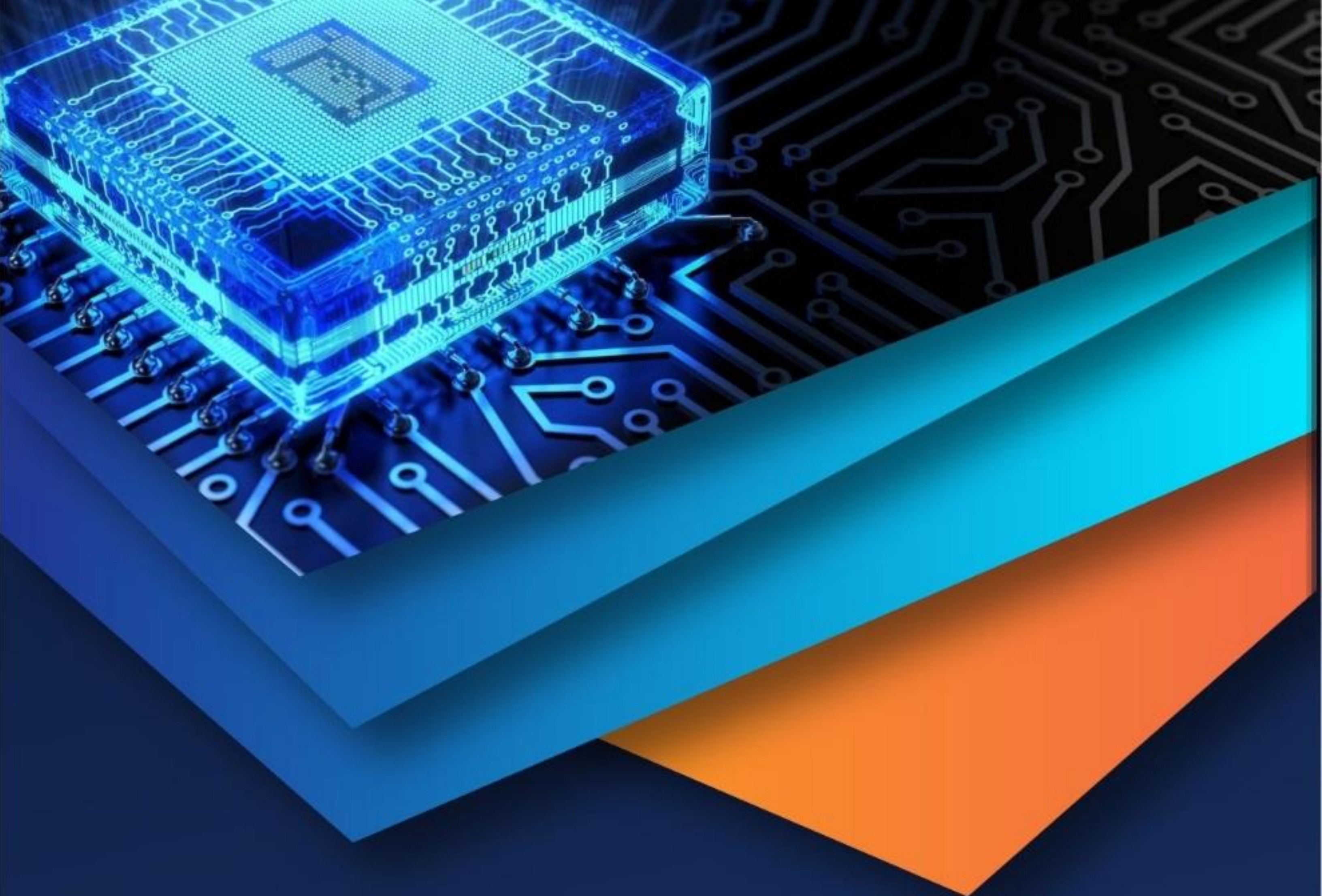



Fig.3 Graph for actual and estimated values of coconut productivity in Kerala

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