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Trend analysis and forecasting coconut production in Assam

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In India coconut is grown in an area of 1894.57 thousands hectares producing 15729.75 million nuts per annum (Coconut Statistics, 2009). Although, major coconut production comes from the southern part of India, the production and productivity of some non-traditional areas like Assam is highly comparable. Traditionally found in smaller stands in many house-holds of Assam, this crop is mostly used for spiritual/*puja* purpose followed by tender nut. Being a small holder's crop, the economic importance of the crop is ignored by the growers and entrepreneurs. However, sustained efforts from the Indian Council of Agricultural Research (ICAR), the crop area has been constantly increasing with the passage of time. In 2009, the total area planted with coconut palms is around 18.7 thousands hectare with an approximate production of 1663.4 lakh nuts (Coconut Statistics, 2009).

Forecasting the coconut production is important for state agricultural planning and negotiating forward contracts. Various techniques (Magat *et al.*, 2004; Reynolds, 1979) were tried to forecast the coconut production or yield. Abeywardena (1968) developed a crop-forecasting formula for coconut based on rainfall with a multiple correlation coefficient of 0.94. However, the use of this formula is limited by the paucity of reliable climatic information. Some places like Assam, where the crop is grown in relatively smaller patches, it is practically difficult to forecast the production owing to disorganized management factors. Smith (1969) developed a method for recording potential fruit production on coconut palms with different levels of precision. At its simplest level, a count of the total number of fruit on each palm is an approximate measure of annual production. Muralidharan *et al.* (2008) provided an early forecast of coconut production in India for the year 2006-07 using stratified three stage sampling design and ratio estimator was used to forecast the coconut production at stratum level. This paper is attempts to forecast the coconut production in Assam based on last 34 years of data on production, area and productivity.

The fundamental hypothesis of any time series modeling is that some aspects of the past pattern are continued to future. And in this study, the time series process is often assumed to be based on the past values, tacitly assumed in form of numerical data, of the main variable but not on the explanatory variables (Venables and Ripley, 2002).

The auto regressive integrated moving average (ARIMA) model (Box-Jenkins, 1970; Brockwell and Davis, 1991) combining with regressors (Pierce, 1975) was applied to estimate the coconut production in Assam. ARIMA is a special type of regression model in which the dependent variable (production) is stationarized and the independent variables are all lags of the dependent variable and/or lags of the errors. In principle to extend an ARIMA model to incorporate the information provided by leading indicators and other exogenous variables: simply add one regressor (area) to the forecasting equation. Alternatively, a hybrid ARIMA/regression model (Pierce, 1975) exists which includes a correction for autocorrelated errors. If a multiple regression model is fitted and found that its residual auto-correlation function

(ACF) and partial auto-correlation function (PACF) plots (Enders, 2004) display an identifiable autoregressive or moving-average "signature" (*e.g.*, some significant pattern of autocorrelations and/or partial autocorrelations at the first few lags and/or the seasonal lag), then addition of ARIMA terms (lags of the dependent variable and/or the errors) to the regression model can be considered to eliminate the autocorrelation and further reduce the root mean square error (RMSE) value.

The general notation ARIMA (p, d, q) refers to the model with p-order of autoregressive (AR) terms, d is the order of non-seasonal differences and q, the order of moving average terms (MA). This model contains the AR (p) and MA (q) models,

$$Y_t = \mu + \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{i=1}^{q} \theta_i \in_{t-i} + \in_t \text{ .... (1)}$$

where $\phi_1, \phi_2, ..., \phi_p$ are the parameters of the model, μ is a constant and $\in_t$ is white noise. The constant term is omitted by many authors for simplicity. The error terms $\in_t$ are generally assumed to be independent identically-distributed (i.i.d.) random variables sampled from a normal distribution with zero mean: $\in_t \sim N(0, \sigma^2)$ where σ^2 is the variance.

The data of 34 years on coconut production, area and productivity were collected from different government sources like Coconut Development Board, Government of India and state government offices. After that, the ARIMA model was just re-fitted with a regressor for facilitating to eliminate the autocorrelation and reducing the RMSE. Then the appropriate AR and/or MA terms were found to fit the pattern of autocorrelation observed in the original residuals. The identified ARIMA model was ARIMA (2, 1, 0) with regressor (area) using SAS package. Diagnostic checks were applied to the obtained results. The model was passed through unit root test, popularly known as Dickey-Fuller Single Mean Test at α = 5% level of significance. The unit root test probability values were 0.0002, 0.0017 and 0.0024 corresponding to lag 0, 1 and 2. The autocorrelation function (ACF) probability values (0.7167 for lag 1 and 0.4906 for lag 2) were non-significant at α = 5% level of significance. Model having RMSE value 158.2055, Akaike Information Criterion (AIC) value 342.2171 and coefficient of determination (R^2) value 0.9054 was declared a good fit. Based on the results of ARIMA (2, 1, 0) with regressors (area), forecasts for coconut production in Assam from 2010 up to 2020 were made.

The data on area, production and productivity of coconut in Assam for last 34 years were used for forecasting and trend analysis. A critical glance of the data revealed that highest production of coconut; 2049.39 lakh nuts, was obtained during 2004 from an area of 19,057 hectares with a productivity level of 10754 nuts per hectare. Moreover, this is the highest productivity level achieved during the whole study period. The productivity was at its lowest minimum during 1976 with a figure of 5092 nuts per hectare. So, a 111.2 per cent increase in productivity level is achieved during the period. The current data on coconut statistics revealed that the area under coconut is 18.753 thousands hectares producing 147.10 million nuts with an average annual productivity of 9598 nuts per hectare against the initial year of the study where the area under coconut cultivation was 4,923 hectares with a production of 250.71 lakh nuts yielding 5092 nuts per hectare.

A perusal of the data indicated that there was a linear trend in area expansion of coconut from 1976 to 2003 and after that it maintains 18,953 ± 0.126 thousand hectares. But the productivity showed an increasing trend up to 2004 corresponding to 7133.76 ± 1006.81 nuts per hectare with a maximum of 10,754 nuts per hectare during 2004. After that, it maintained a parallel productivity line with 8692.60 ± 1131.67 nuts per hectare. Considering the data on a five year term basis, it was found that a production increase of 44.8, 128.9, 190.5, 459.4, 418.2, 629.9 and 617.9 per cent was resulted during 1980, 1985, 1990, 1995, 2000, 2005 and 2009, respectively, over 1976. The corresponding figures for the increase in area was 10.7, 63.2, 109.8, 269.4, 324.8, 285.9 and 280.9 during 1980, 1985, 1990, 1995, 2000, 2005 and 2009, per cent, respectively.

Forecast of coconut production till 2020-2021

ARIMA (2, 1, 0) with regressor (area) model was applied to forecast the coconut production in

Assam for next 10 year ahead with the precision of α = 5% (level of significance). The resultant forecasts for coconut production are presented in Table 1. For diagnostic checking of the estimated models, different diagnostic checks like unit root test, popularly known as Dickey-Fuller Single Mean Test, Face Validity Test, series plot of residuals, histogram of the residuals, goodness of fits were applied at α = 5% (level of significance) for ascertaining whether these were properly fitted or not and it was best fitted. Final estimate of production parameters are presented in Table 2 along with forecasting (Fig. 1). The 2009-2010 forecast of coconut production was 1609 lakh nuts with lower and upper limits between 1278 and 1940 lakh nuts, respectively. Coconut production forecast for the year of 2020 comes to about 2056 lakh nuts which will show an increasing trend of 1.4 percent against 2009.

Table 1. Forecasts coconut production using ARIMA (2, 1, 0) along with area data till 2020-21

Calendar Year	Predicted production (in lakh nuts)	Prediction standard error
2010-11	1698	168.7547
2011-12	1696	198.1428
2012-13	1787	212.6567
2013-14	1813	238.1954
2014-15	1835	259.8575
2015-16	1879	277.0204
2016-17	1915	294.5416
2017-18	1948	311.3483
2018-19	1985	326.8124
2019-20	2021	341.6784
2020-21	2056	356.0211

Table 2. Final estimates of forecasting parameters

Parameters	Value	Standard error	t-value
Intercept	36.37763	20.888	1.7416
Autoregressive, Lag 1	-0.38468	0.1882	-2.0443
Autoregressive, Lag 2	-0.30574	0.1893	-1.6153
Area (in ha)	0.01501	0.0252	0.595

Model Variance (σ^2) is 28478

The production forecast for the year of 2020 is about 2056 lakh nuts. The results of this study may be used to formulate policy decisions. There is a broader scope to enhance and promote small as well as large scale coconut based industries for Assam and nearby states. The used methodology may also help to do forecasting as well as analyzing as a generic trend and forecasting research for other subject of interests.

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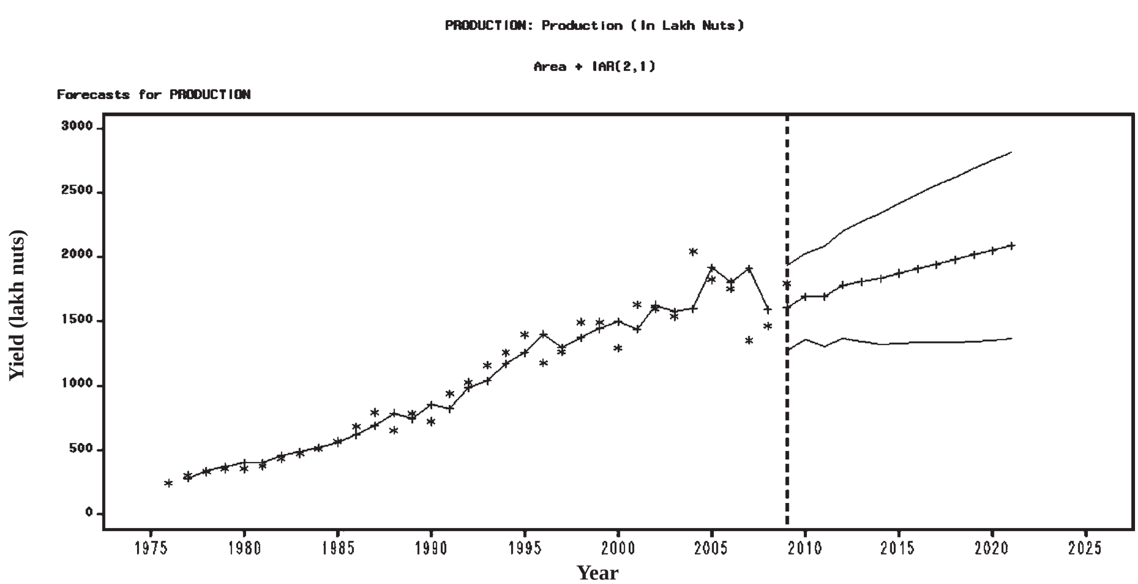

Fig. 1. Forecast of coconut production in lakh nuts

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