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Forecasting of Ragi Production in Koraput Districts of Odisha, India

Chinmayee Patra[1]* and Subrat Kumar Mahapatra[2]

[1]*Department of Agricultural Statistics, PalliSikshaBhavan, Visva Bharati University, West Bengal, India*
[2]*College of Agriculture, Orissa University of Agriculture and Technology, Odisha, India*

**Corresponding author*

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A B S T R A C T

Ragi is an important cereal crop in Koraput district of Odisha it is the richest source of Calcium, iron, and protein which makes it more important for health. This study aims the forecasting of Ragi production in Koraput district. Statistic data from 1985-86 to 2017-18 is used for forecasting purposes. For trend estimation, Auto-Regressive Integrated Moving Average (ARIMA) model was used. Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) were calculated for the knowledge. Appropriate Box-Jenkins ARIMA model was fitted. Validation of the model was tested by using Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE). ARIMA (0,1,1) model was used for forecasting of the subsequent 5 years' production. The result shows 52.75 tonnes of Ragi production in 2022.

Introduction

Eleusine coracana, or finger millet (Ragi) is an annual herbaceous plant widely grown as a cereal crop in the arid and semiarid areas in Asia. it's the foremost important small millet within the tropics covering 12% of the worldwide millet area. The specialty of those tiny ruby pearls is that the abundance of nutrients present in them. ragi may be a rich source of calcium, iron, protein, fiber, and other minerals and may be a gluten-free food. The cereal has low-fat content and contains mainly unsaturated fat. it's easy to digest and doesn't contain gluten; people that are sensitive to gluten can easily consume corakan. it's having high levels of methionine, an organic compound that's lacking within the diets of poor people that rely on starchy foods. it's considered jointly of the foremost nutritious cereals. Ragi could be a millet crop and their current use is restricted 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 realm, production, and consumption (Nagarajan and Smale, 2005). In Odisha major, Ragi producing districts are Koraput, Nabarangpur, Kalahandi, Bolangiri.

Koraput has the largest area under finger millet and is the biggest producer of ragi in India. Ragi, a staple food grain for the rural population of this District, has been cultivated here for thousands of years. Koraput is one of the poverty-stricken pockets of southern Odisha state in India and located in the Eastern Ghats region between 17o 40’ and 20o 7’ north latitude and 81 o 24’ and 84o 2’ east longitude, the District lies at altitudes varying from 1500 MSL to 3000 MSL. The average annual rainfall is 1,567 mm (based on measurements of the last 5 years). Out of this, 75% is received from June to September, 13% is received from October to February, and the rest is received from March to May. The environment is suitable for crop growth and often there is no substitute for millet crops. As of 2014, ragi production in Koraput District was 30,162 tonnes that account for 66.55% of India's ragi production. However, there was a deceleration in the area, the productivity of ragi showed an 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 take note of both the trend and fluctuations. In this context, the present study has been taken up to analyze and forecasting of area and production of Ragi. One of the most important and highly popularized time series models is the Box-Jenkins approach, commonly known as ARIMA (autoregressive integrated moving average). Qureshi *et al.*, (1992) analyzed the relative contribution of area and yield to the total production of wheat and maize in Pakistan. Fatoki *et al.*, (2010) applied the ARIMA model to the Nigeria Gross Domestic Production (GDP). For Rice forecasting (Dey, 1994), potato (Rahulamin, 2000) used the ARIMA model. This model has been frequently employed to forecast the future requirements in terms of internal consumption and export to adopt appropriate measures (Muhammed *et al.,* 1992; Shahur and Haque, 1993; Kahforoushan *et al.,* 2010; Sohail *et al.,* 1994).

Materials and Methods

Data sources

The Blockwise time series data for the period from 1985-86 to 2017-18 about production and productivity of ragi in Koraput district were collected from various volumes of Odisha Agricultural Statistics published by the Directorate of Economics and Statistics, Government of Odisha.

Analytical model

Forecasting of area, production and productivity using ARIMA Model

The annual data on ragi crop cultivated area, production and yield of koraput for the period from 1985-86 to 2017-18 were used for forecasting the future values using ARIMA models. The ARIMA methodology is also called as Box-Jenkins methodology. The Box-Jenkins procedure is concerned with fitting a mixed Auto Regressive Integrated Moving Average (ARIMA) model to a given set of data. The main objective in fitting this ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. These methods have also been useful in many types of situation which involve the building of models for discrete time series and dynamic systems. But, this method was not good for lead times or for seasonal series with a large random component (Granger and Newbold, 1970).

The first thing to note is that most time series are non-stationary and the ARIMA model refer only to a stationary time series. Since the ARIMA models refer only to a stationary time series, the first stage of Box-Jenkins model is reducing non-stationary series to a stationary series by taking first order differences.

Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) Models

Box-Jenkins methodology (Box and Jenkins of Time Series Analysis: Forecasting and Control) is used here for time series analysis which is technically known as the ARIMA methodology. The ARIMA Model Includes: The Autoregressive (AR) model, the Moving Average (MA) Model, the ARMA Model.

The Autoregressive (AR) Model

The Simplest form of the ARIMA model is called the autoregressive model. Let Z_t stand for the value of a stationary time series at time t, that is, a time series that has no trend, but fluctuates about a constant value referred to as the level of the series. (We deal with trends below.) By autoregressive, we assume that current Z_t values depend on past values from the same series. In symbols, at any t,

$$z_t = c + \varphi_1 z_{t-1} + \varphi_2 z_{t-2} + \cdots + \varphi_p z_{t-p} + \epsilon_t$$

$$z_t = c + \epsilon_t + \sum_{i=1}^{p} \varphi_i z_{t-i}$$

Where C is the constant level, z_{t-1}, $z_{t-2,\ldots..,}z_{t-p}$ are past series values (lags), the φ 's are coefficients (similar to regression coefficients) to be estimated, and ε_t is a random variable with mean zero and constant variance. The ε_ts are assumed to be independent and represent random error. Some of the 's may be zero. If z_{t-p} is the furthest lag with a nonzero coefficient, the AR model is said to be of order p, denoted AR (p).

The Moving Average (MA) Model

z_t can also be modelled as a linear combination of white noise stochastic error terms. We call this type of model a moving average (MA) model. If z_t is considered as a weighted average of the uncorrelated ε_t's, MA(q) moving average component of order q, which relates each z_t value to the residuals of the q previous z estimates may be expressed as

$$z_t = e_t - q_1 e_{t-1} - q_2 e_{t-2} - \cdots - q_p e_{t-p}$$

The ARMA Model

The AR and MA models for stationary series to account for both past values and past shocks may be combined. Such a model is called an ARMA (p, q) model with p order AR terms and q order MA terms. Thus an ARMA (p, q) model is written as

$$z_t = c + \varphi_1 z_{t-1} + \varphi_2 z_{t-2} + \cdots + \varphi_p z_{t-p} + \epsilon_t - q_1 e_{t-1} - q_2 e_{t-2} - \cdots - q_p e_{t-p}$$

The main stages in setting up a Box-Jenkins forecasting model are Identification, Estimating the parameters, diagnostic checking and Forecasting.

In ARIMA modelling, the order of AR(p) is identified by partial autocorrelation function (PACF) while the order of MA(q) is identified by autocorrelation function (ACF) (Tsay, 2002).

The order of ARIMA (p, d, q) is also identified by model selection criteria's i.e. Schwarz Bayesian information criteria (SBIC) and Akaike's Information Criteria (AIC) (Casella, *et al.,* 2008). These criteria's are further explained in model specification section.

Model specification

One of the important issues in time series forecasting is to specify model. Time series model is specified on the basis of some information criteria's which includes AIC, BIC likelihood etc. Akaike's (1973) introduced AIC criteria for model specification. AIC is mathematically defined as;

AIC=–2log (maximum likelihood)+ 2k

Where k = p+q+1 (if model includes intercept) otherwise k = p+q. model specified well if its AIC value is minimum as other fitted models (Tsay, 2005).

Forecasting accuracy measuring techniques

After model selection, a next important step is to measure the accuracy to verify the reliability of forecasted value based selected model. Various tools are available in literature which includes Root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), mean error (ME) and mean percentage error (MPE). Further computation and literature of these accuracy measuring tools are given:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}|PE_t|$$

$$MSE = \frac{1}{n}\sum_{i=1}^{n} e_t^2$$

$$PE_t = \left(\frac{Y_t - F_t}{Y_t}\right) \times 100$$

Where Y_t is the present value for time t and F_t is the forecasted value for time t.

Results and Discussion

In this study, we used the data for ragi crop production for the period 1985-86 to 2017-18. As we have earlier stated that development of ARIMA model for any variable involves four steps: Identification, Estimation, Verification and Forecasting. Each of these four steps is now explained for ragi production as follows.

Model identification and validation

For forecasting ragi crop production ARIMA model estimated only after transforming the variable under forecasting into a stationary series. The stationary series is the one whose values vary over time only around a constant mean and constant variance. There are several ways to ascertain this. The most common method is to check stationarity through Augemented Dickey-Fuller test of the data. As result of Augemented Dickey-Fuller test the production data for koraput is not stationary, so one differencing is required to make the data stationary.

The next step is to identify the values of p and q. The Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) show that the order of p and q can. Basing on the p, d, q values from the ACF and PACF graph (figure 1) we entertained three tentative ARIMA models for production and chose that model which has minimum AIC (Akaike Information Criterion), RMSE (Root Mean Square Error)& MAPE. The models and corresponding AIC,RMSE & MAPE values are given in Table 1.

As the result of Augemented Dickey-Fuller the value of "d" is one, from the figure1 p and q values are taken. 3 different ARIMA models (1,1,1),(1.1.0) and (0,1,1) are tested and from the table 1 model (0,1,1) is having lowest AIC value, RMSE and MAPE value, so we have taken this model for forecasting of data.

For the validation of model last 7 years of data has taken. Table 2 shows ARIMA (0, 1, 1) is the best model for forecasting the Production data in koraput district with minimum, RMSE, MAPE and MAE value.

Table.1 ARIMA models with AIC, RMSE& MAPE values

Production of Ragi	ARIMA (p,d,q)	AIC	RMSE	MAPE
	1,1,1	779.64	11.527	17.123
	1,1,0	782.24	11.928	718.162
	0,1,1	776.28	11.057	17.057

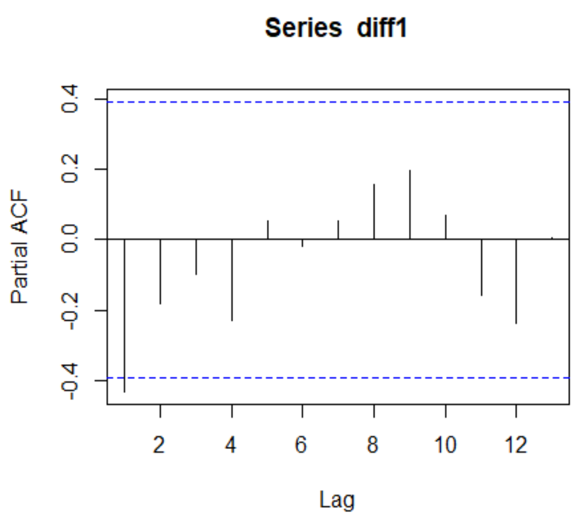
Table.2 ARIMA models with RMSE, MAPE & MAE values for validation of data

Model	RMSE	MAPE	MAE
ARIMA(1,1,1)	10.826	18.781	9.283
ARIMA(1,1,0)	13.022	22.783	11.295
ARIMA(0,1,1)	**10.772**	**18.653**	**9.214**

Table.3 Forecasted values of Ragi production with 95% Confidence Level (CL)

Ragi production in Koraput					
year	**Production**	**90% LCL**	**90% UCL**	**95% LCL**	**95% UCL**
2018	49.98811	35.99193	63.98428	28.58281	71.39341
2019	50.98691	34.50758	65.46863	26.31269	73.66353
2020	51.76825	33.15361	66.82261	24.24196	75.73426
2021	49.98811	31.9007	68.07551	22.32581	77.65041
2022	52.75423	30.72913	69.24708	20.53405	79.44217

Figure.1 ACF & PCF graph for production of ragi



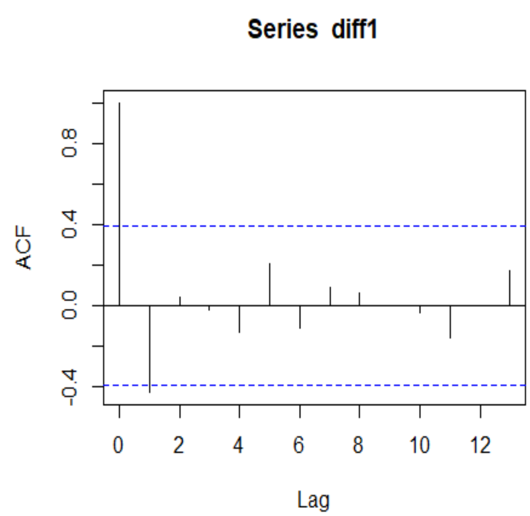
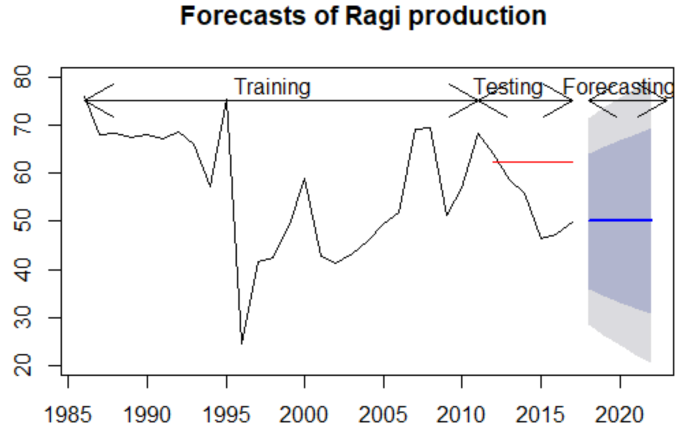


Figure.2 forecasts of ragi production



By using ARIMA (0,1,1) the forecast value of ragi production are given in the table 3. From the table it shows that the ragi production will increase in the year 2022, it will reach to 52.75 tonnes. In this table along with forecast value lower and upper confidence level values of 90% confidence and 95% confidence values are shown. The production may increase as per the application of inputs and package of practices but the production will lie between the forecasted limits.

In conclusion, the forecasting of Ragi production in Koraput district shows that there was an increase in the production, out of all the models of ARIMA(0,1,1) is a suitable model for the forecasting of ragi production in this district. The production of ragi can be increased if the supply of inputs timely to the farmers because Koraput is a backward district and the farmers are small and marginal. Only a timely supply of inputs and good varieties of ragi seed will help to increase the production of ragi in this district. It is useful for planning different practices and recommended different strategies to improve ragi production, also useful for the Government for preparing budget & implementing new policies.

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