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Time series ARIMA model to forecast monthly precipitation for Balodabazar, Bemetara and Raipur (Chhattisgarh)

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Abstract
Weather forecasting is an important issue in meteorology and scientific research in this research, the Seasonal Auto Regressive Integrated Moving Average (ARIMA) model, which is based on Box-Jenkins method, was adopted to build the forecasting model. The Monthly Rainfall data for Balodabazar, Bemetara, Raipur city for the period (Jan. 1968 to Dec. 2018) was used. The autocorrelation and partial autocorrelation functions for time series data from years 1968 to 2018 were used to identify the most appropriate orders of the ARIMA models. To calculate the model's accuracy and compare among them, statistical criteria such as RMSE and R^2 were used. The model Balodabazar (1,0,1) (1,1,1), Bemetara (0,0,2) (0,1,1), Raipur (1,0,1) (0,1,1) gave the most accurate results and used to forecast the monthly rainfall for the period (2019 to 2025) for study regions. This long term prediction will help decision makers in efficient scheduling of urban planning, and rainwater harvesting and crop management.

Keywords: forecasting, ARIMA model, box-jenkins method, rainfall, RMSE and R^2

Introduction
Rainfall is very non-linear in nature and very complicated to predict. Due to adverse effects of climate change rainfall pattern has also been changing rapidly Short term and long term forecast of rainfall have significant relevance to agricultural, tourism, flood prevention and management strategy and water body management which influence the economy of a country. To predict such event, numerous techniques including numerical and machine learning processes have been adopted based on historical time series and radar data (Chander *et al*. 2002, Ingsrisawang *et al*. 2008) [3, 5]. Forecasts are generated by collecting data on current atmosphere and understanding atmospheric processes to decide how climate will change in future. In this research paper forecasting is done through ARIMA. It is a popular and widely used statistical method for time series forecasting. It stands for Autoregressive Integrated Moving Average.

Materials and Methods
Study Area
Baloda Bazar: The geographical location of Baloda Bazar is on the height of 270m from sea level. It belogs to Raipur division, the border of Baloda Bazar district touches Bemetara, Mungeli, Bilaspur, Jajgir, Raigarh, Mahasamund and Raipur districts. The city receives about 1031.8 millimetres of Annual rainfall.
Raipur: Raipur being Geographically Located almost at the centre of the Chhattisgarh state was made its capital. The geographical location of Raipur is on the height of 298m from sea level. The border of Raipur district touches Bilaspur, Dhamtari, Gariaband, Mahasamund and Durg District. The city receives about 1144.7 millimetres of Annual rainfall.
Bemetara: The geographical location of Bemetara is on the height of 278m from sea level. It belogs to Raipur division, the border of Baloda Bazar district touches Mungeli, Bilaspur, Kabirdham, Rajnandgaon, Balodabazar, Raipur and Durg districts. The city receives about 1091.6 millimetres of Annual rainfall.

Data Collection

Daily rainfall data (mm) for the past 51 years from 1968 to 2018 was collected from Department of Agrometeorology IGKV Raipur.

Software used

SPSS Auto Regressive Integrated Moving Average (ARIMA) models were selected using SPSS software to find the best fit of a time series to past values of this time series in order to make forecasts.

Methodology

Box and Jenkins (1976) [2] have effectively put together in a comprehensive manner, the relevant information required to understand and use time series ARIMA models. A detailed strategy for the construction of linear stochastic equation describing the behavior of time series was examined. Consider the function Zt represents forecasted rainfall and temperature at time t month. Yt is series of observed data of rainfall and temperature at time t. If series is stationary, then an ARIMA process can be represented as

$$\nabla pZ_t = \nabla qY_t \quad \text{.... (1)}$$

Where ∇ is a back shift operator. If series Y is not stationary then it can be reduced to a stationary series by differencing a finite number of times.

$$\nabla pZ_t = \nabla q\ (1\text{-}B)\ d\ Y_t \quad \text{.... (2)}$$

Where d is a positive integer, and B is back shift operator on the index of time series so that
$B\ Y_t = Y_t\text{-}1$; $B2Y_t = Y_t\text{-}2$ and so on. Thus further equation (2) can be simplified into following equation.

$$(1\text{-}\Phi 1B\text{-}\Phi 2B2\text{-}.......\text{-}\Phi pBp)\ Z_t = \theta 0+ (1\text{-}\theta 1B\text{-}\theta 2B2\text{-}\ ....\text{-}\theta qBq)\ at \quad \text{..... (3)}$$

Where a_t's a sequence of identically distributed uncorrelated deviates, referred to as "white noise". Combining equations (2) and (3) yields the basic Box-Jenkins models for non stationary time series (1-Φ1B-Φ2B2-…….-ΦpBp) (1-B)d Yt =θ0+ (1-θ1B-θ2B2- ………-θqBq) at ….(4) Equation (4) represents an ARIMA process of order (p,d,q). Seasonal ARIMA model represented as follows for a stationary series i.e. differencing parameters (d &ds = 0) equal to Zero, used for forecasting rainfall.

$$\nabla ps\ \nabla pZ_t = \nabla\ qs\ \nabla q\ Y_t \quad \text{....(5)}$$

Where ps and qs are the seasonal parameters corresponding to AR and MA process. Model of type of equation (5) was fitted to given set of data using an approach consists of mainly three steps (a) identification (b) estimation (c) application (forecasting) or diagnostic checking. At the identification stage tentative values of p, d, q and ps, ds, qs were chosen. Coefficients of variables used in model were estimated. Finally diagnostic checks were made to determine, whether the model fitted adequately describes the given time series. Any inadequacies discovered might suggest an alternative form of the model, and whole iterative cycle of identification, estimation and application was repeated until a satisfactory model was obtained.

Results and discussion

The practical application of the Box and Jenkins technology contains three main steps which are data preparation, developing the mathematical model and apply the suitable forecasting model. In this study, the time series of monthly rainfall from Jan. 1968 to Dec. 2018 was used to represent an ARIMA model for forecasting future values of Balodabazar, Bemetara and Raipur (Chhattisgarh). From the pattern of the ACF and PACF plots as shown in Figures 2 to 7, the monthly rainfall series respectively were non-stationary. The patterns exhibited a very slow decay which was an indication of possible non-stationarity. Besides some of the spikes were outside the confidence interval and some very close to it. This indicated the values were significant and were not white noise [HUANG *et al.* 2016] [1]. The model that gives the minimum Bayer's Information Criterion (BIC) is selected as best fit model, as shown in Table 1. Obviously, model ARIMA Balodabazar (1, 0, 1) (1, 1, 1), Bemetara (0, 0, 2) (0, 1, 1), Raipur (1, 0, 1) (0, 1, 1) has the smallest values of BIC. Observed and predicted values of next five years are determined and plotted as shown in figure: 8,9,10

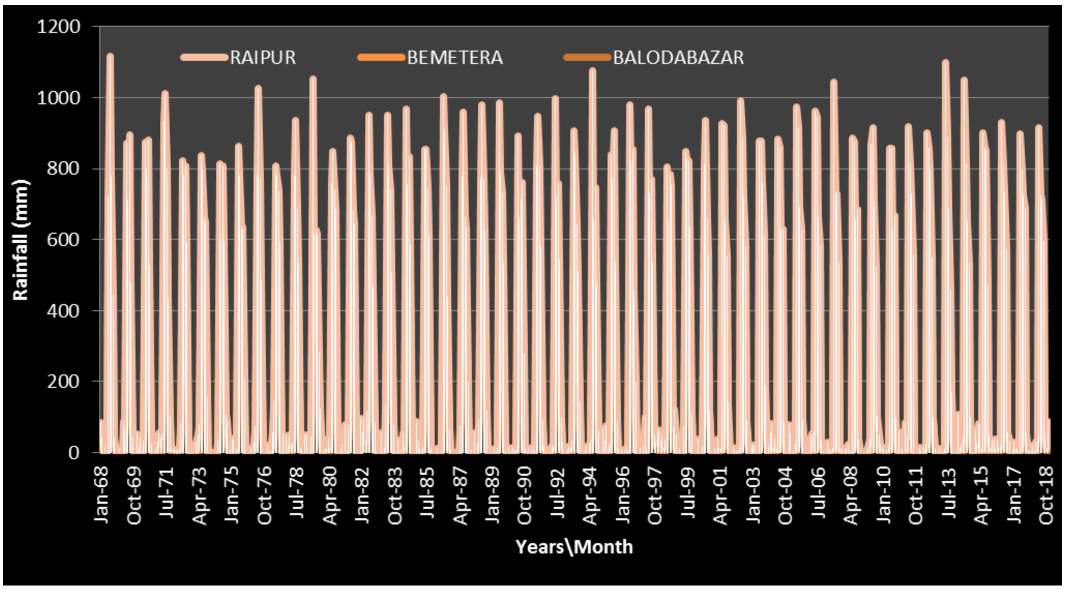

Fig 1: Observed rainfall of Balodabazar, Bemetara & Raipur districts (Jan1968-Dec2018)

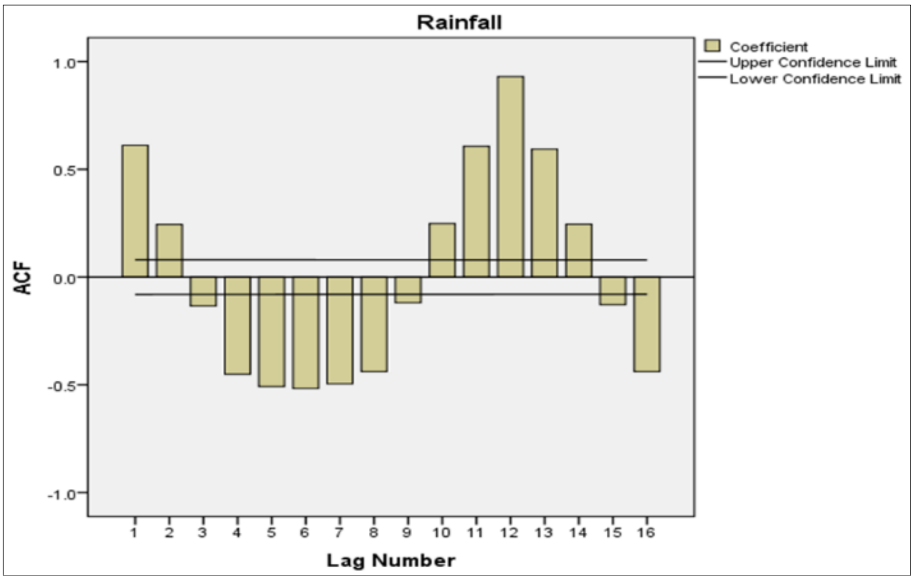

Fig 2: Autocorrelation function of rainfall Balodabazar.

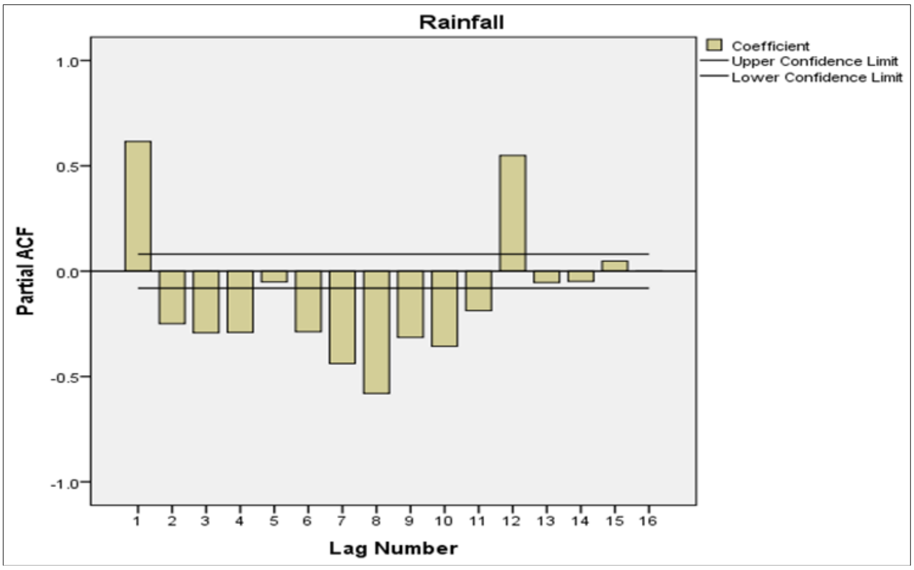

Fig 3: Partial Autocorrelation function of rainfall Balodabazar.

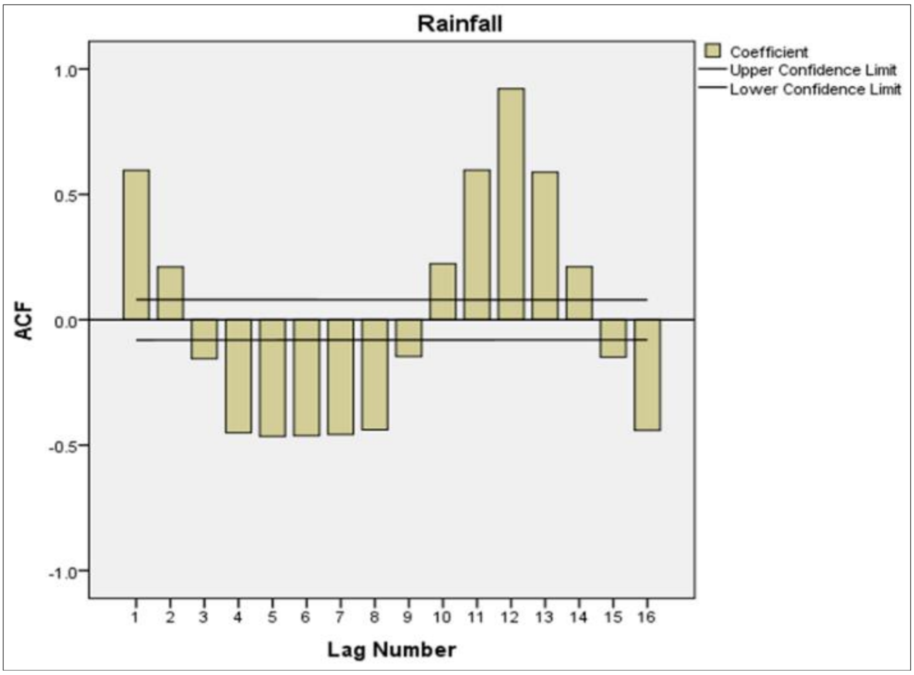

Fig 4: Autocorrelation function of rainfall Bemetara.

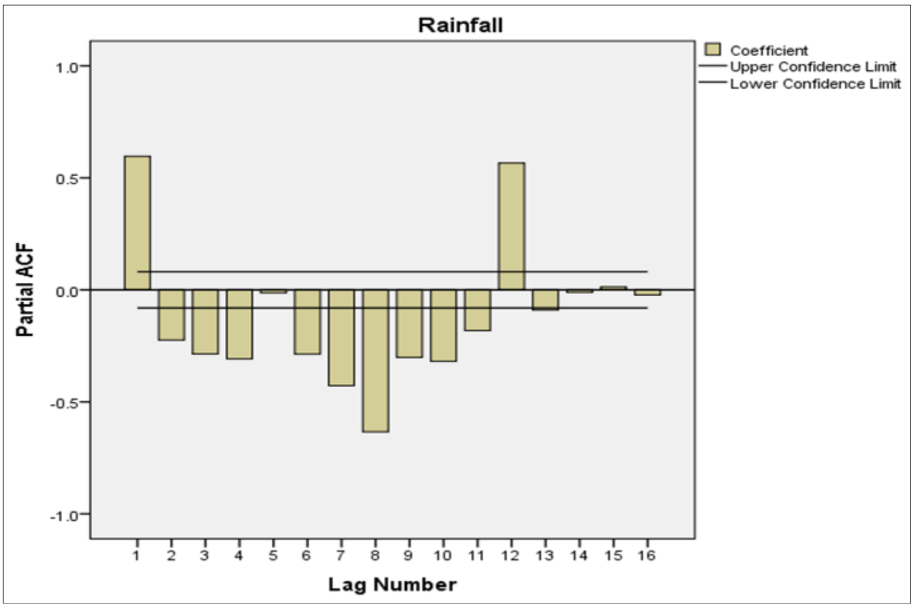

Fig 5: Partial Autocorrelation function of rainfall Bemetara.

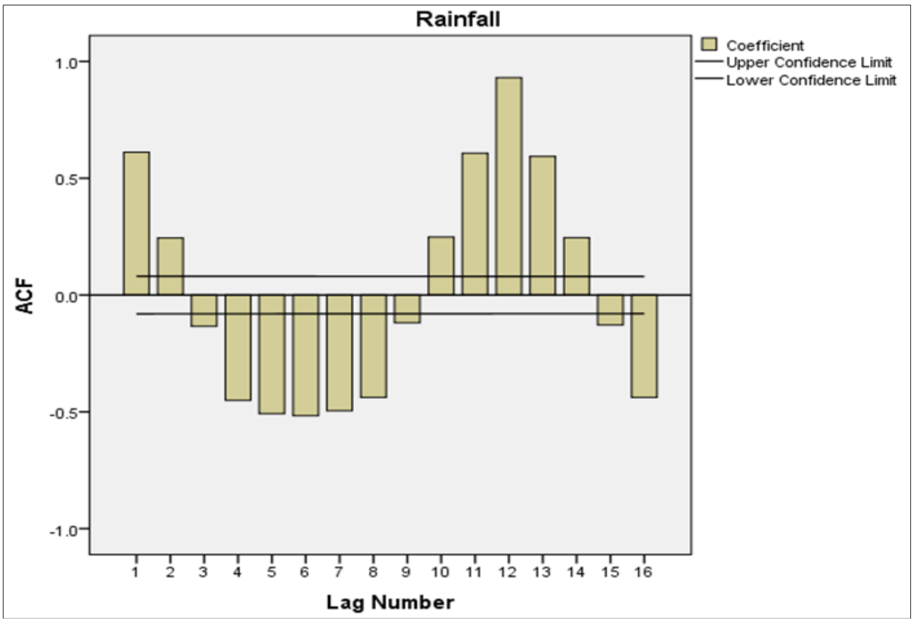

Fig 6: Autocorrelation function of rainfall Raipur.

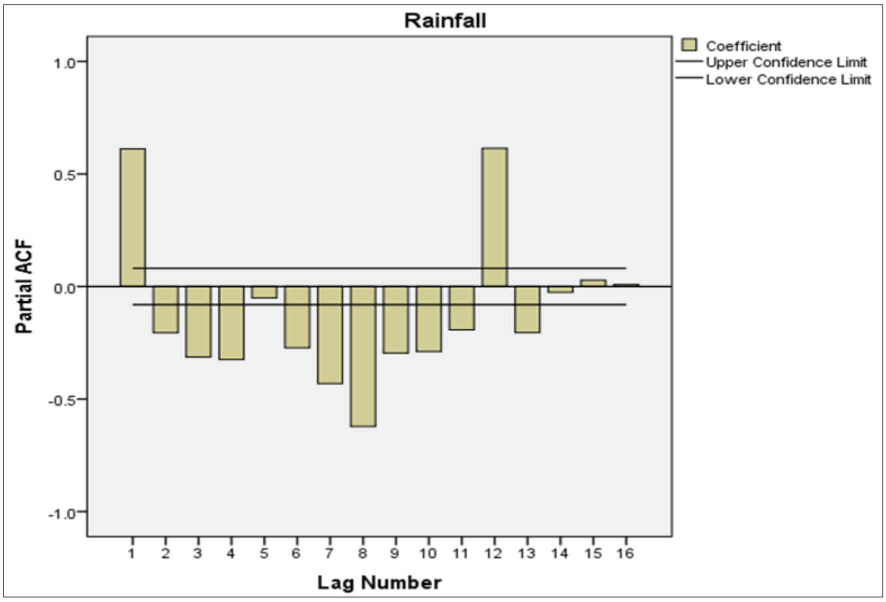

Fig 7: Partial Autocorrelation function of rainfall Raipur.

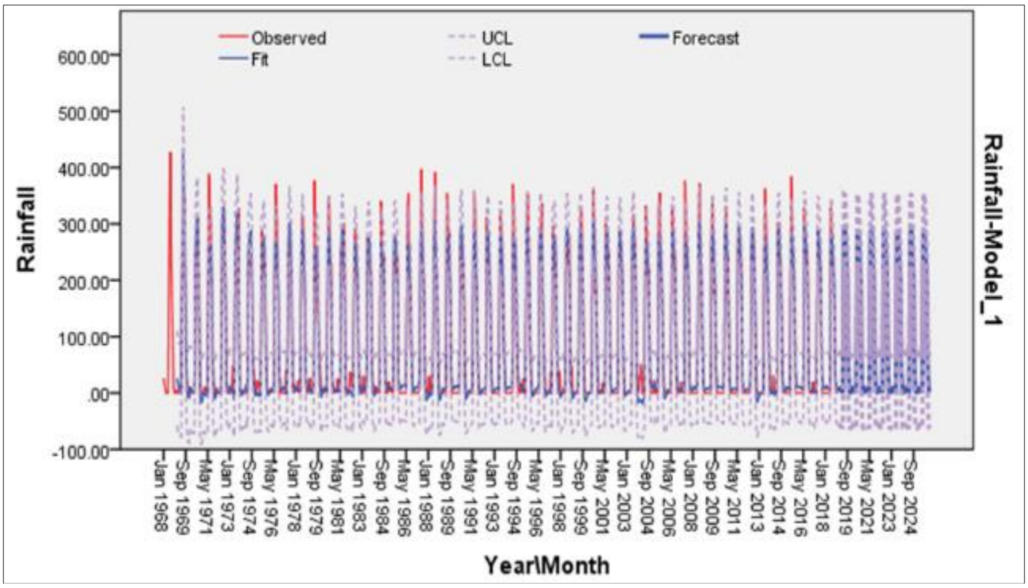

Fig 8: Observed and fitted values of rainfall for Balodabazar.

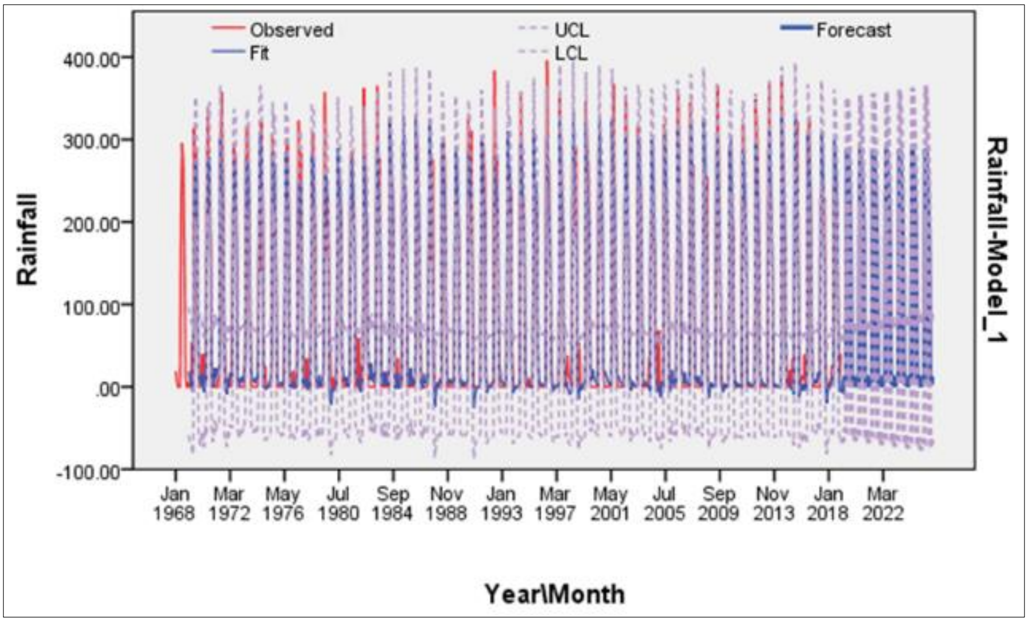

Fig 9: Observed and fitted values of rainfall for Bemetara.

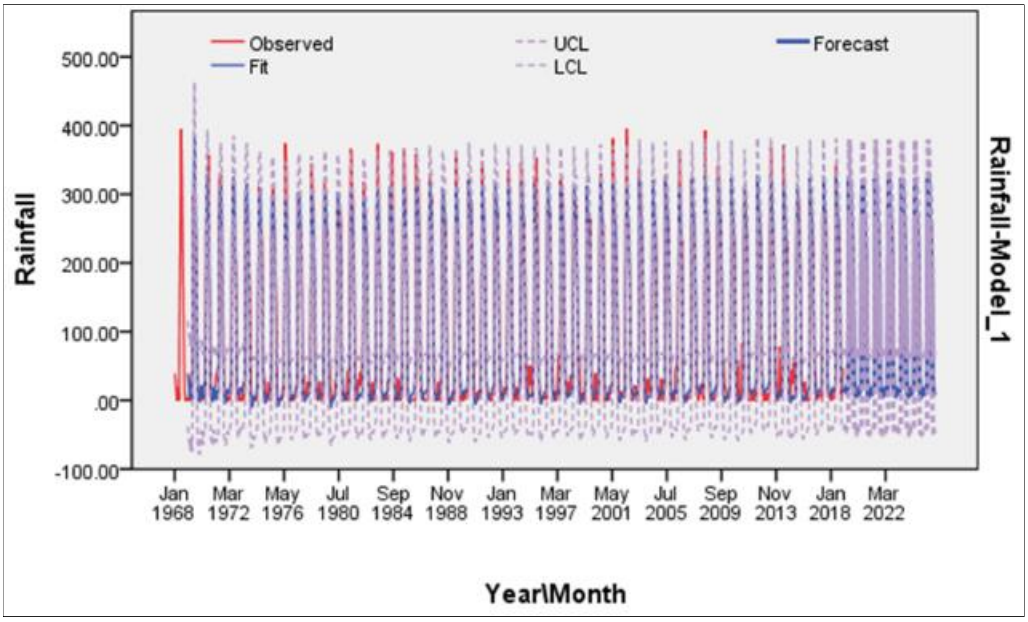

Fig 10: Observed and fitted values of rainfall for Raipur.

Table 1: Table show Balodabazar Bemetara Raipur

	Balodabazar	Bemetara	Raipur
Rainfall model	(1, 0, 1) (1, 1, 1),	(0, 0, 2) (0, 1, 1),	(1, 0, 1) (0, 1, 1)
R^2	0.928	0.931	0.945
RMSE	32.6	31.60	28.83

Conclusion

In this paper we have shown the study of weather forecasting with the help of ARIMA. It is very useful for understanding weather condition. By using ARIMA time series analysis we predicted the weather condition on the basis Rainfall. Here we have forecasted rainfall for upcoming 7 years for Balodabazar, Bemetara and Raipur. ARIMA is a forecasting technique that projects the future values of a series based entirely on its own inertia.

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