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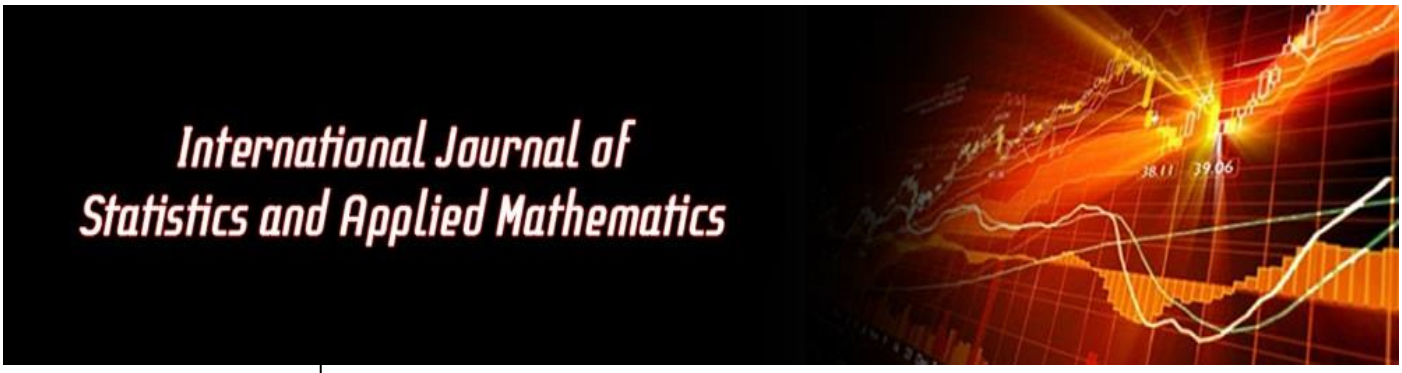

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Forecasting of area, production and productivity of sugarcane in Tamil Nadu using ARIMA model and correlating with weather parameters

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Abstract
For proper planning and policy making in the agriculture sector of the country crop yield forecasting and crop acreage estimation are the two important crucial components. This research is a study model of forecasting area, production and productivity of Sugarcane and sugarcane in Tamil Nadu. Data for the period of 2000-01 to 2022-23 were analysed by time series methods. Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) were calculated for the data. Appropriate Box- Jenkins Auto Regressive Integrated Moving Average (ARIMA) model was fitted. Validity of the model was tested using standard statistical techniques. For forecasting area, production and productivity ARIMA (0, 1, 1) model respectively were used to forecast five leading years. The forecasts for the next five years were made. We also correlated climate data *viz*., Temperature and Rainfall with Production. The results showed the area forecast for the year 2023 to be about 459682.31hectare with lower and upper limit 363638.87 and 555725.75hectares respectively, production forecast to be about 37136582.91 tonnes with lower and upper limit 25232180.91 and 49040984.90 tonnes respectively and productivity forecast to be about 99.07 tonnes per ha with lower and upper limit 86.97and 111.17 tonnes per ha respectively. Temperature was negatively correlated with production whereas Rainfall was positively correlated with production.

Keywords: ARIMA, sugarcane, auto correlation, partial auto correlation

Introduction
Required food production is necessary to be enhanced to provide food and nutritional security for the growing population. To make proper planning and policy making in the agriculture sector crop yield forecasting is necessary. The main objectives of the study research are:

- To predict and forecast the area, production, productivity of Sugarcane along with rainfall data
- To make time series analysis using data from the past 20 years and provide forecast for the next four years 2023-2027.
- To find the relation between climate data and production.

The gross cropped area in Tamil Nadu is around 58.43 lakh hectares of which the Gross Irrigated Area is 33.09 lakh hectares which is 57% and the balance 43% of the area are under rain fed cultivation. Out of these, Tamil Nadu has achieved a record coverage of Sugarcane in financial year (2022-23) as the total area stands at 22.05 lakh hectares. D.
Balanagammal *et al.* (2000) [2] utilized the ARIMA model to forecast the cultivable area, production, and productivity of several crops in the Indian state of Tamil Nadu based on data from 1956 to 1994 for the following years. Zahra N. *et al.* used the linear model, quadratic model and the exponential model to analyze the trends in rice area and yield in Punjab, Pakistan. Forecast of area, production and productivity of Paddy in Thanjavur, Tamil Nadu also done by M. Hemavathi *et al.* (2018) [5] with ARIMA model by analyzing the time series data. Senthamaraikannan K and KM Karuppasamy. (2020) [6] elaborated about Forecasting for Agricultural Production using ARIMA model. Amala Kaavya. C, A SahayaS udha (2022) [7] reported on analysis of long term sugarcane cultivation in Tamil Nadu.

Devaki C, A Kachi Mohideen (2022) [8] reported on Sugarcane production in Tamil Nadu using a comparison of ARIMA, State space and linear mixed models.

Sugarcane is a renewable, natural agricultural resource because it provides sugar, besides biofuel, fiber, fertilizer and myriad of byproducts/co-products with ecological sustainability. Its juice is used for making white sugar, brown sugar (Khandsari) and jiggery (gur). Among the sugarcane growing states in India, Tamil Nadu ranks third in area (0.37 M. ha) and production (3.5Million tonnes) and first in productivity (105 t/ha) and sugarcane productivity is 40% higher than the national productivity (69.5 t/ha).

Materials and Methods

The secondary data of Sugarcane area, production and productivity was collected for the period from 2001 to 2022 from various sources like Directorate of Economics and Statistics, Season and Crop report and Tamil Nadu state website. George Box and Gwilym Jenkins studied ARIMA models extensively during 1968 that can be used for time series analysis and forecasting. ARIMA has three components, namely Auto regression (AR), Integrated (I) and Moving Average (MA). The ARIMA model can be expressed as (p, d, q) where p is the number of autoregressive terms, d is the degree of differencing, q is the number of forecast errors. For optimum forecast in ARIMA model, the time series should be stationary. The main stages in setting up a Box-Jenkins forecasting model are Identification, Estimating the parameters, diagnostic checking and Forecasting. This process is referred as ARIMA (p, d, q) where p and q refer to the number of AR and MA terms, and d refers to the order of differencing required for making the series a stationary. The accuracy of ARIMA model is measured using Mean square error (MSE) and Mean absolute percentage error (MAPE), (Markidakis and Hibbon, 1979 [4].

Results and Discussion

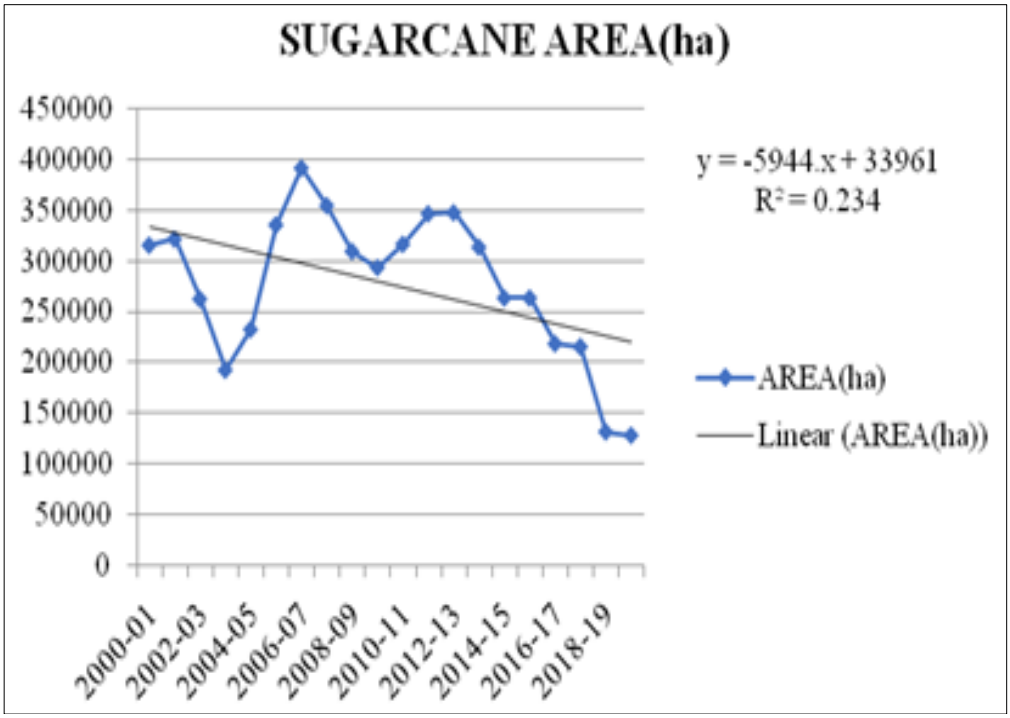
Time series data for Sugarcane crop cultivated area, production and yield for the period 2000-01 to 2022-23 has been employed in the Auto Regressive Integrated Moving Average (ARIMA) model in Gretl software.

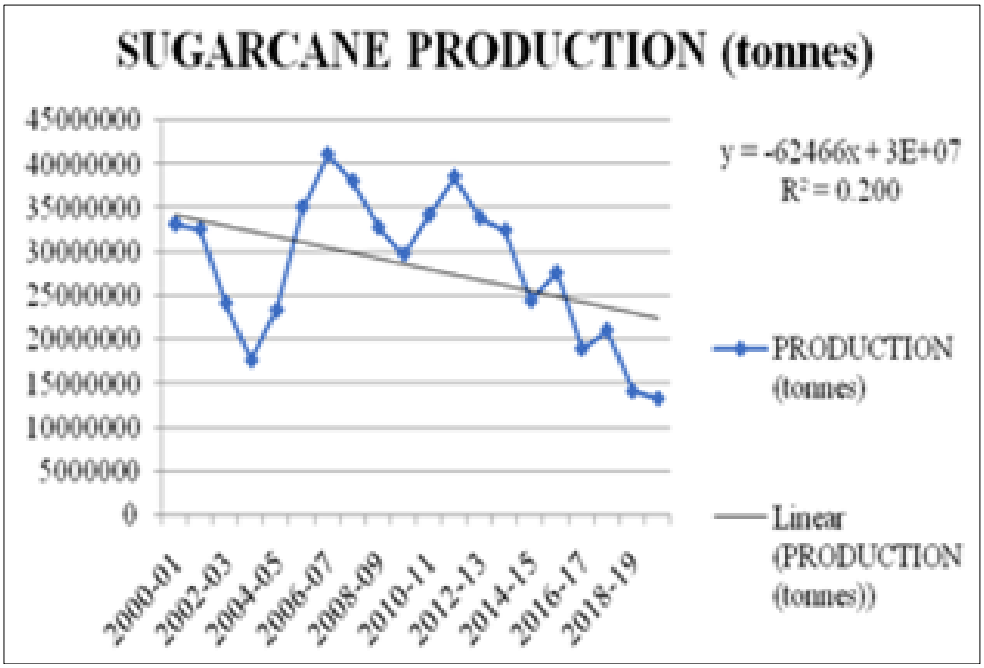
Model identification

ARIMA model estimates only stationary series, so it is important to check the stationary. In stationary series, the values vary over time only around a constant mean and constant variance. The common method used to check stationarity is through examining the graph or time plot of the data. From Fig 1, it is showed that the data are stationary. The next step is to identify the values of p and q. For this, the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) (Fig. 2, 3 and 4) showed that the order of p and q can at most be 0.5. We entertained eight tentative ARIMA models and chose that model which has minimum AIC (Akaike Information Criterion) and SBC (Schwartz Bayesian Criterion). The models and corresponding AIC and SBC values are given in (Table. 1). So, the most suiTable model is ARIMA (0, 1, 1) for Sugarcane area, ARIMA (0, 1, 1) for Sugarcane production and ARIMA (0, 1, 1) for Sugarcane productivity has the lowest AIC and SBC values.

Table 1: AIC and SBC values for tentative ARIMA models for sugarcane area, production and productivity in Tamil Nadu

Area	011	110	111	012	112
AIC	556.08	608.33	584.97	584.59	586.59
SBC	578.21	612.70	589.14	588.77	591.81
Production	011	110	111	012	112
AIC	632.33	634.46	661.33	661.33	662.92
SBC	651.47	667.59	665.51	665.51	668.14
Productivity	011	110	111	012	112
AIC	32.29	41.294	34.04	36.24	42.87
SBC	35.05	32.16	39.22	38.42	37.65





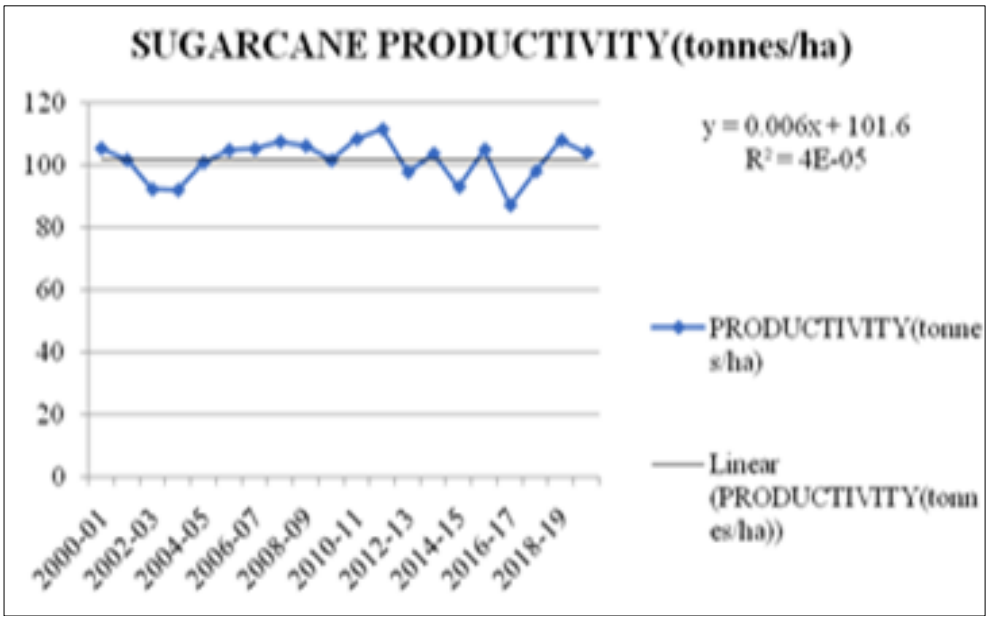


Fig 1: Time series plot for area, production and productivity of sugarcane in Tamil Nadu

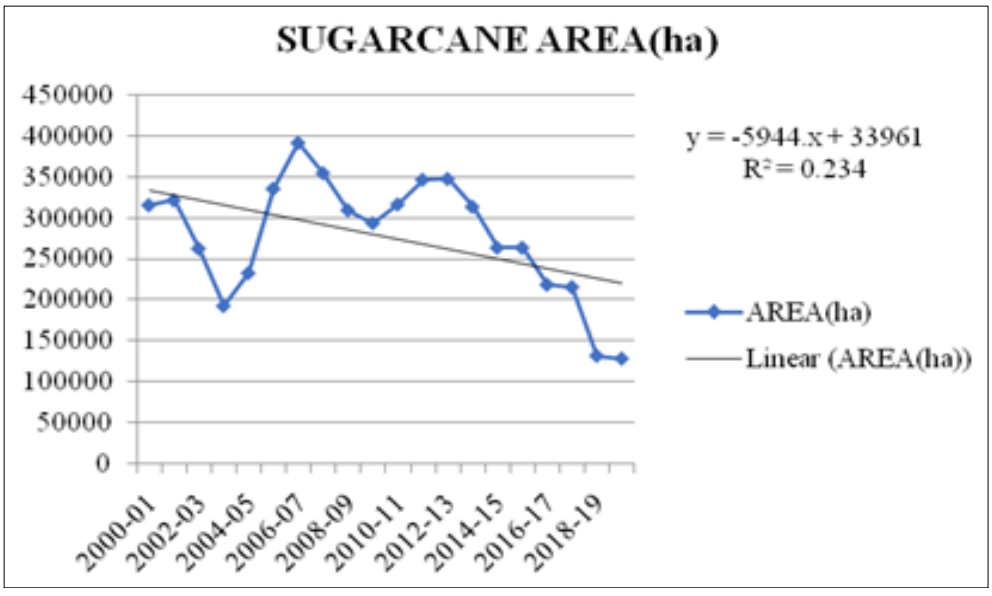
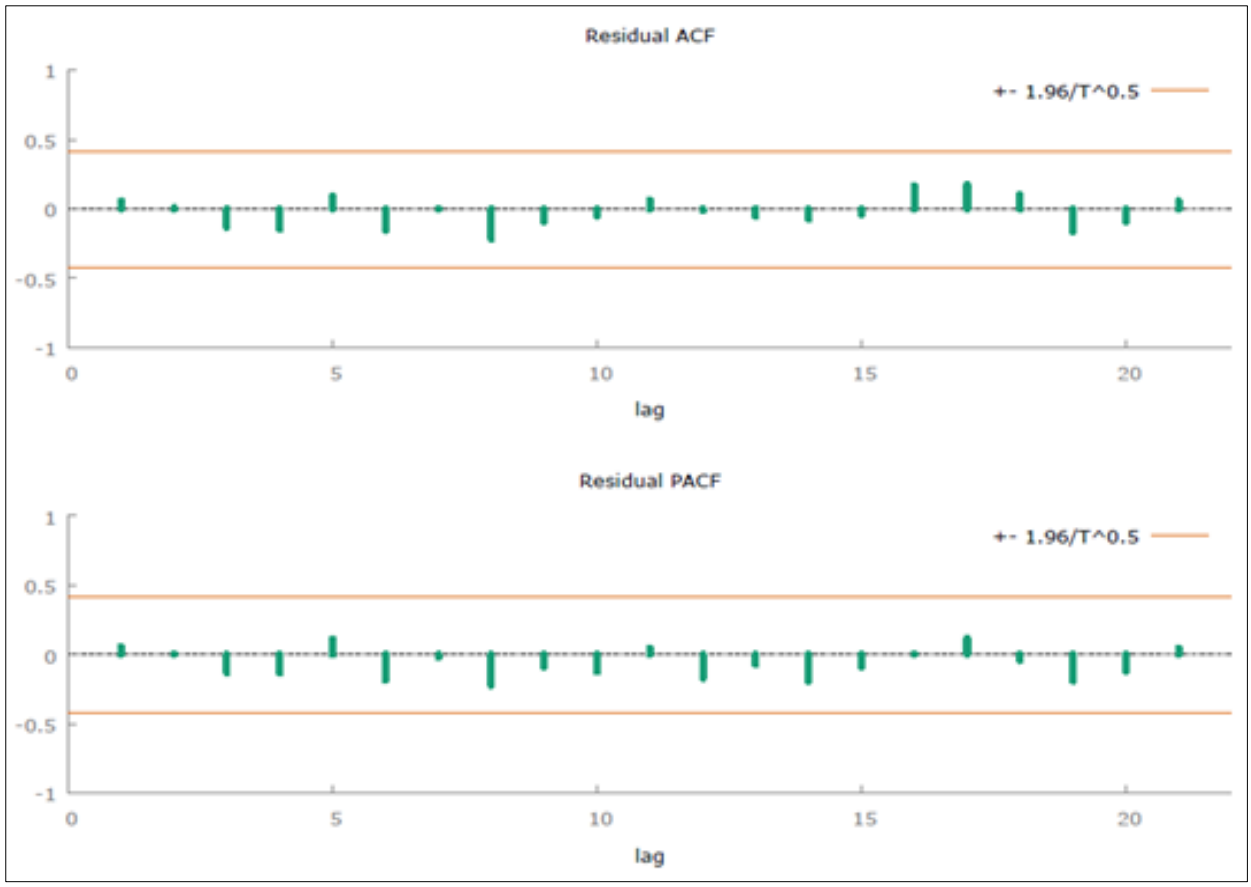


Fig 2: Auto correlations and partial auto correlations for sugarcane area



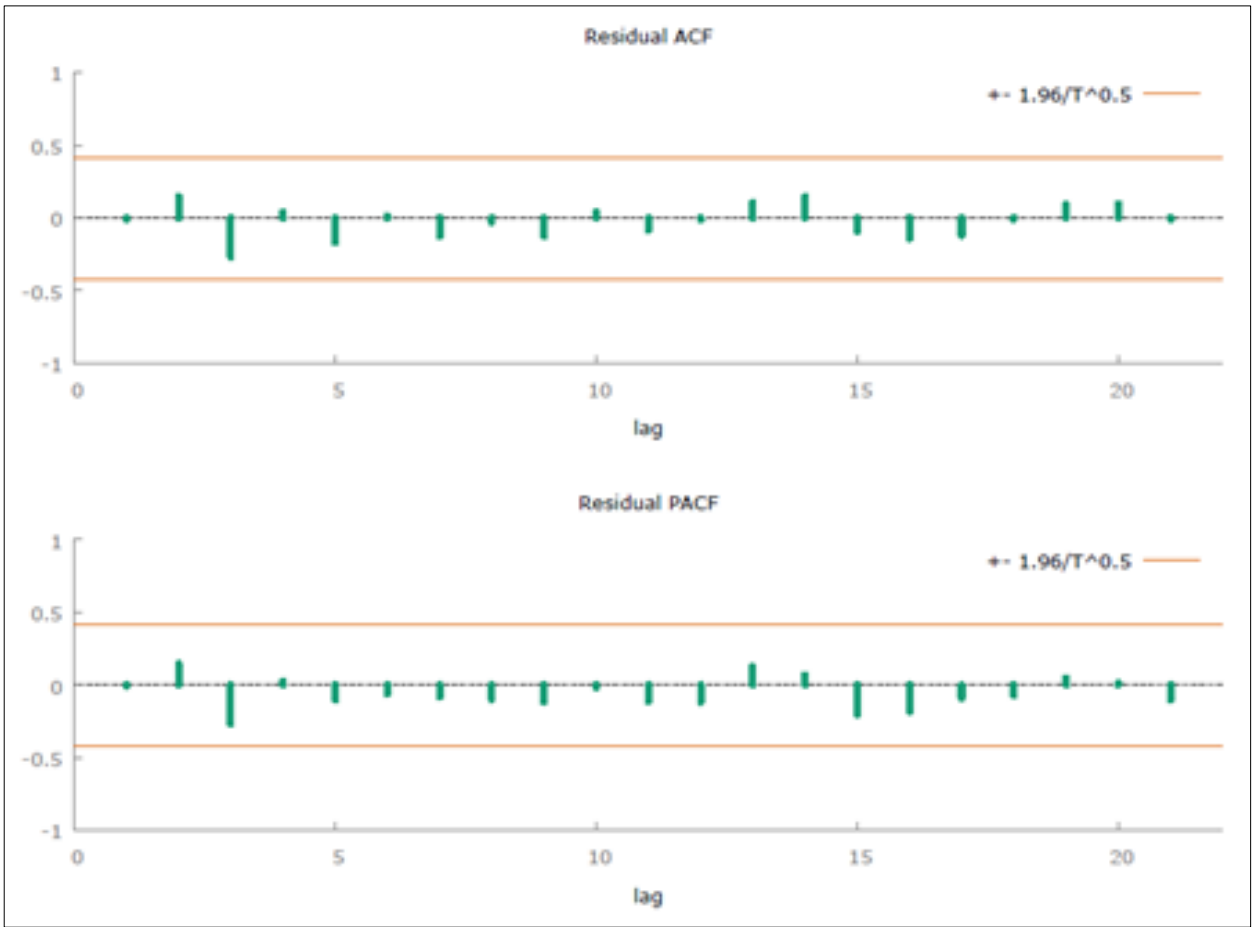


Fig 3: Auto correlations and partial auto correlations for sugarcane production

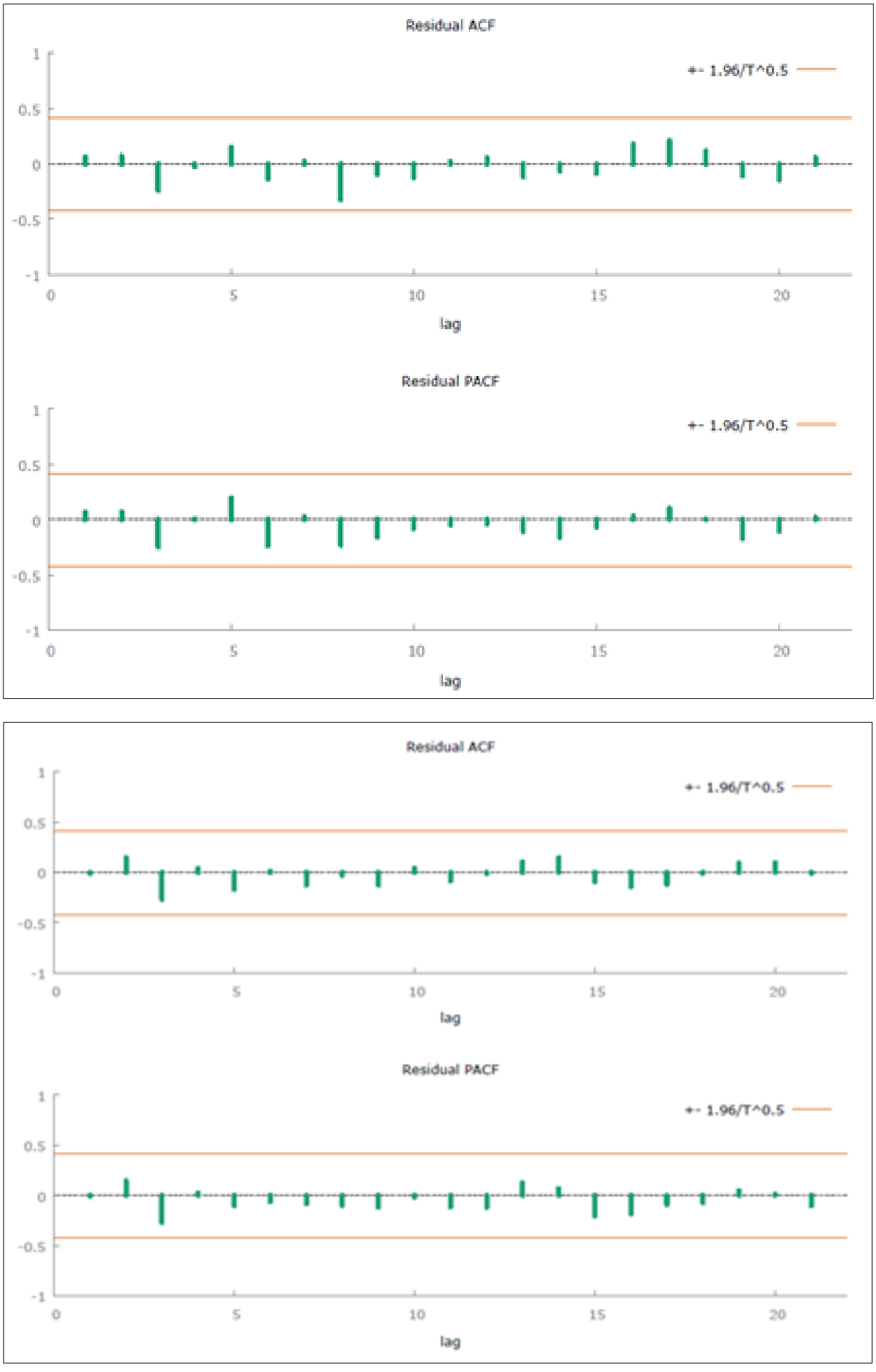


Fig 4: Auto correlations and partial auto correlations for sugarcane productivity

Forecasting and verification

Sugarcane area, production and productivity are forecasted for the year 2023 to 2027 using SPSS package. Results of estimation are reported in the Table 2. The results showed the forecasted area decreases 459682.31 ha to 287048.50 ha, production decreases from 37136582.91tonnes to 29162203.86 tonnes whereas productivity increases from 102 tonnes/ha to 102.11 tones/ha.

Table 2: Forecasted values of area, production and productivity of sugarcane in Tamil Nadu

Year	Area(Ha)	Production Tonnes)	Productivity Prediction (Tonnes/ha)
2023	459682.31	37136582.91	102.00
2024	348860.86	33066320.73	102.03
2025	307845.98	30909918.10	102.06
2026	292666.43	29767467.78	102.08
2027	287048.50	29162203.86	102.11

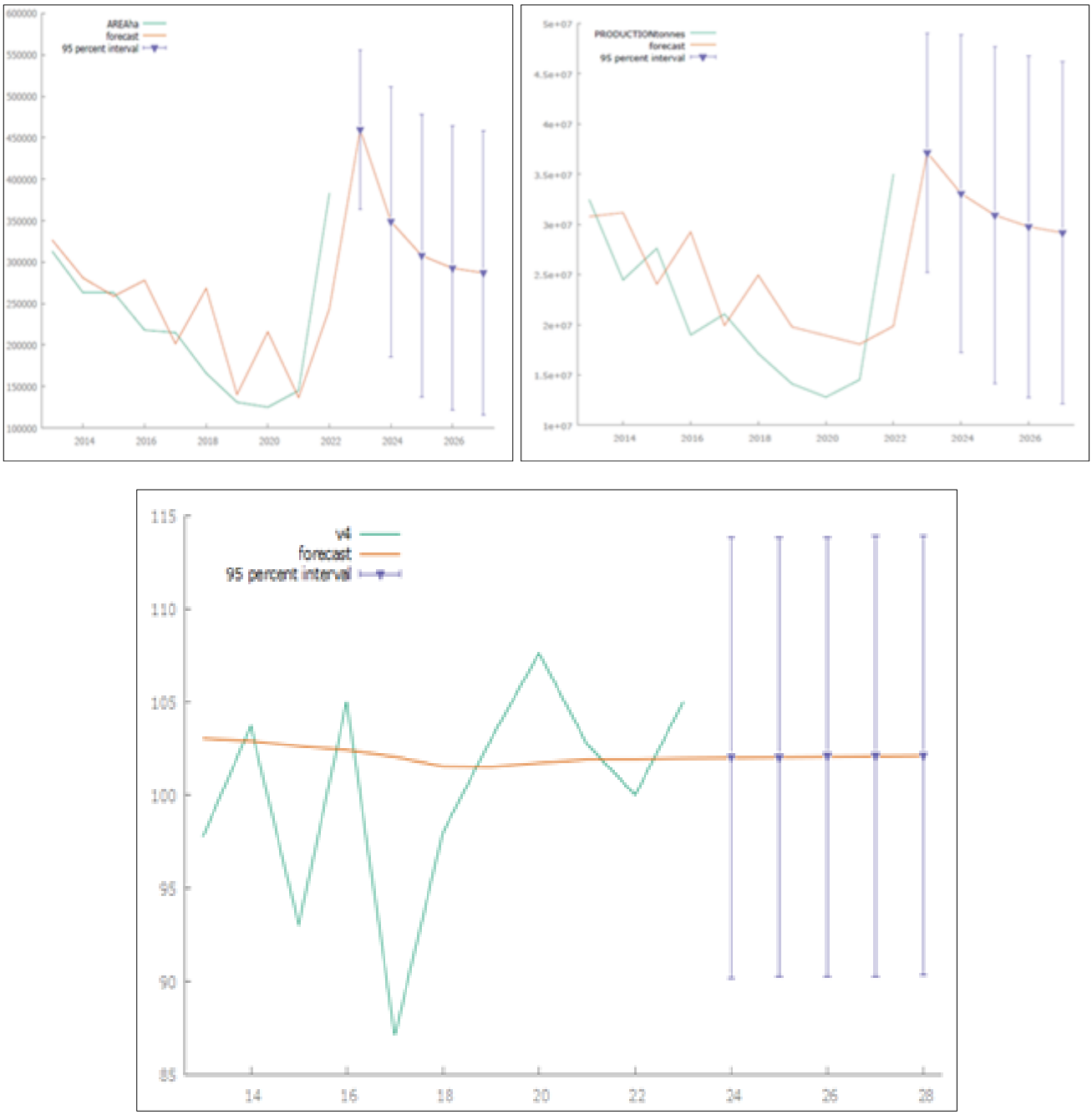


Fig 5: Forecast of sugarcane area, production and productivity in Tamil Nadu

The graphs of predicted domains Fig. 5 shows that as the year goes on, there is continuous decreasing trend in rice area due to which production and yield both resulted in decreasing trend. The Mean Absolute Percentage Error (MAPE) for rice cultivated area, production and productivity is found to be 23, 30.6 and 4.6 respectively. This measure indicates that the forecasting inaccuracy is low.

Correlation of yield with climate data

The correlation of Area, Production and Productivity of sugarcane with weather parameters like rainfall and temperature values are presented in the Table 3. If the

correlation coefficient is greater than 0, they are positively correlated and if it is less than zero, they are negatively correlated. The Temperature and production are positively correlated whereas Rainfall and production are negatively correlated.

Table 3: Correlation Coefficient

	Rainfall	Temp	Production
Rainfall	1		
Temp	-0.142297	1	
Production	-0.085958	0.1822591	1

Conclusion

ARIMA forecasting and climate correlation enhance strategic planning for sugarcane cultivation in Tamil Nadu.

References

1. Box GE, Jenkins GM, Reinsel GC, Ljung GM. Time series analysis: Forecasting and control. John Wiley & Sons; c2015.
2. Balanagammal D, Ranganathan CR, Sundaresan R. Forecasting of agricultural scenario in Tamil Nadu: A time series analysis. J Indian Soc Agricult Stat. 2000;53(3):273-86.
3. Zahra N, Akmal N, Siddiqui S, Raza I, Habib N, Naheed S. Trend analysis of rice area and yield in Punjab, Pakistan. Pakistan J Agric. Res. 2015;28:4.
4. Makridakis S, Hibbon M. Accuracy of forecasting: An empirical investigation, J Roy. Stat. Soc. A. 1979;41(2):97-145.
5. Hemavathi M, Prabakaran K. ARIMA Model for forecasting of area, production and productivity of rice and its growth status in Thanjavur district of Tamil Nadu, India; c2018.
6. Senthamaraikannan K, Karuppasamy KM. Forecasting for Agricultural Production using ARIMA Model; c2020.
7. Kaavya AC, Sudha AA. Analysis of Long Term Sugarcane Cultivation in Tamil Nadu; c2022.
8. Devaki C, Mohideen KA. Sugarcane production in Tamil Nadu using a comparison of ARIMA, State space and linear mixed models; c2022.
9. Tamil Nadu Agricultural University - PDF - Season and crop report. https://agritech.tnau.ac.in.
10. Tamil Nadu Government Portal - https://www.tn.gov.in crop - Season and Crop Report-2019-20.
11. Agricultural Statistics at a glance 2014 & Annual Report 2015-2016, Government of India, Department of Agricultural, Cooperation and Farmers welfare, Ministry of Agricultural and Farmers welfare.
12. Agricultural Statistic. Government of India, Department of Agricultural, Cooperation and Farmers welfare, Ministry of Agricultural and Farmers welfare; c2015.