STATISTICAL MODELS FOR PREDICTION OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH

By

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B.Sc. (Ag.)

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(AGRICULTURAL STATISTICS)

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2020

DECLARATION

I, **N. PRIYANKA EVANGILIN** hereby declare that the thesis entitled **“STATISTICAL MODELS FOR PREDICTION OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH”** submitted to the Acharya N. G. Ranga Agricultural University for the degree of Master of Science in Agricultural Statistics is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

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Date:

CERTIFICATE

Mrs. **N. PRIYANKA EVANGILIN** has satisfactorily prosecuted the course of research and that thesis entitled **"STATISTICAL MODELS FOR PREDICTION OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Place: TIRUPATI
Date:

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CERTIFICATE

This is to certify that the thesis entitled **"STATISTICAL MODELS FOR PREDICTION OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH"** submitted in partial fulfilment of the requirements for the degree of "Master of Science in Agriculture Statistics" of the Acharya N. G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by Mrs. **N. PRIYANKA EVANGILIN** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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N. Priyanka Evangilin. . .

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
Etc.,	:	and so on; and other people/things
i.e.	:	That is
et al.	:	and others people
Viz.,	:	Namely
M ha	:	Million Hectares
t ha	:	tonnes Hectares
Kg/ha	:	Kilogram per Hectare
Mt	:	Metric Tonnes
AR	:	Auto Regressive
MA	:	Moving Average
ARIMA	:	Auto Regressive Integrated Moving Average
ACF	:	Auto Correlation Function
PACF	:	Partial Auto Correlation Function
MAPE	:	Mean Absolute Percentage Error
Qtls	:	Quintals
R^2	:	Coefficient of Determination
RMSE	:	Root Mean Squared Error
AD	:	Anno Domini

ABSTRACT

Name of the Author	:	**N. PRIYANKA EVANGILIN**
Title of the thesis	:	**STATISTICAL MODELS FOR PREDICTION OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH**
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The Present study entitled "**Statistical models for prediction of area, production and productivity of selected oilseeds in Andhra Pradesh**" has been undertaken to fit different trend equations like linear, non-linear and time series models for selected oilseeds like Groundnut, Niger, Sesame and Castor and also made the future forecast up to 2022-23 AD. The study was carried out for Andhra Pradesh state using time series data from 1965-66 to 2017-18.

For forecasting purpose ten linear and non-linear growth models viz., linear, logarithmic, inverse, quadratic, cubic, compound, power, s-curve, growth and exponential and time series models like ARIMA were fitted to the area, production and productivity of selected oilseed crops. The best-fitted model for future projection was chosen based upon highest coefficient of determination (R^2) with least RMSE and MAPE values.

The study revealed that the area, production and productivity of Groundnut marked fluctuating increasing and decreasing trend during the study period 1965-66 to 2017-18; for the forecasted period i.e. up to 2022-23 area and production showed decreasing trend, productivity increasing trend . In Niger there was decreasing trend in area and production whereas productivity showed an increasing trend; the forecasts exhibited an increasing trend in area and production, slightly increasing trend in productivity. The Sesame crop revealed that area and production marked decreasing trend but productivity slightly fluctuating increasing and decreasing trend; forecasts of area, production and productivity depict increasing trend. Whereas Castor crop area and productivity showed decreasing trend and production showed fluctuating increasingand decreasing trend during the study period; forecasts exhibited that area as decreasing trend but production and productivity increasing trend.

Chapter –I

Introduction

Chapter I

INTRODUCTION

India is an agrarian country and agriculture has been and will contribute to be the lifeline of the Indian economy as more than 60% of the population directly or indirectly depends on agriculture and allied sectors. The Oilseeds account for 13% of the Gross cropped area, 3% of the Gross National Product (GNP) and 10% value of all the agricultural commodities. Several crops are grown in our country such as wheat, rice, sugarcane, cotton and vegetables. Pulses and oilseeds are also sown across the country. Oilseed crops are the second most important determinant of agricultural economy, next only to cereals within the segment of field crops. Oilseeds plays indispensable role in day-to-day life, as they provide highly nutritious food and protein for human and livestock they are important component of semi-tropical and tropical agriculture. Fat and vitamin E for the population is mainly supplied through vegetable oil. Important by product of the oil milling industry, oilcakes are used as cattle feed and manure supplementing the chemical fertilizer. Most of the vegetable oils are contributed by soap, paint and varnish industries and are easy into incorporate into locally manufactured products.

Classification:-

The oilseed crops are classified according to the nature of oil produced as follows:

EDIBLE OILSEED CROPS	NON-EDIBLE OIL SEED CROPS
The most significant source of supply of consumable oils are the seeds known as edible oilseeds and the crops belong to this class are known as edible oil seed crops	The most important source of supply of non-edible oils are the seeds known as non-edible oil seeds and the crops belong to this category are known as non-edible oil seed crops.
E.g., Rapeseed & Mustard, Sesame, Groundnut, Niger, Sunflower, Safflower, Soybean etc.	E.g., Castor, Linseed etc.

The main purpose of growing oilseeds is for oil content. The blueprint adopted under Technology Mission on Oilseeds (TMO) played a crucial role during early 1990's.TMO aimed at increased production of oilseeds trigger "Yellow revolution" in the country (Source: Oilseed Situation, DOR, 2006-2007).

India is a global player in edible oil arena, being the 2nd largest importer, and 3rd largest consumer of edible oil as well as 4th largest oilseed producer. After USA, China & Brazil India is fourth largest country in vegetable oil economy, accounting for about 19% of the global area, 2.7% production, and in the agricultural economy of the country oilseed sector engrossed significant position. There is a quantum move in the production of oilseeds during 2017-2018 in comparison with the past two years. India is blessed with varied agro-ecological environments ideally suited for growing a variety of oilseeds India occupied the place of pride as the world's largest producer of groundnuts, sesame, linseed and castor seeds. With its rich agro-ecological diversity, India is ideally suited for growing all the major annual oilseed crops. Among the nine oilseed crops grown in the country, seven are of edible oils (soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower and niger) and two are of non-edible oils (castor and linseed).

In India precise choice for specific oils is made based upon the oils available in the regions. South and West people consume groundnut oil but in East and North inhabitant mustard/rapeseed oil. Coconut and Sesame oil is frequently preferred in many regions in the southern. People of northern plain are mostly hard fat eaters and therefore, prefers Vanaspathi, term used to denote a partially hydrogenated edible oil mixture. Its production is 1.2 million tonnes annually and shares 10% of the edible oil market. Vanaspathi do not find direct trade chance because of buyer's preference for customary oils like groundnut oil, mustard oil, sesame oil etc.

Contemporary oils like soybean, sunflower, rice bran and cottonseed and oil from oilseeds of trees and forest origin had endow their way to the edible puddle through vanaspathi route. Because of technological means such as refining, bleaching and de-odourisation all the oils have exhibited practically colourless, odourless and tasteless and, therefore, have simply replaceable in the kitchen. Newer oils like cotton, sunflower, palm oil or its fraction (palmolein), soybean and rice bran are favored by most traditional customers because of their strong and distinctive taste. The share of raw oil, refined oil and vanaspathi in the total edible oil market is estimated at 35%, 55% and 10% respectively.

Among the four major states in India Andhra Pradesh is important in area and production of oilseed crops. In Andhra Pradesh, area under oilseed 825.53 million hectares, production 1096.6 million tonnes and productivity 1328 kg/hectare (www.indiastat.com, 2017-18). The state's share in the total net sown area and production of the country is about 15.71% and 9.93% of the major oilseeds. Among the nine oilseeds crops grown, seven are of edible oils (groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and Niger) and two are of non-edible oils (castor and linseed). The districts in which oilseeds grown are Kurnool, Ananthapur, Kadapa, Chitoor, Srikakulum,Vijayanagaram etc.

Problem statement

In oilseeds the high degree of variation is due to, they are grown in dry lands which are distinguish with scanty and uneven rainfall, poor soil health etc. There is malfunction in the earlier developed varieties to bring the desired characters in oilseed production. Due to lack of technological breakthrough there is poor performance in the development of high-yielding varieties (HYV's). Due to limitation in production of oilseed in large scale resulted in low quality seed. There is a kind of virtual stagnation in the yield of oilseeds as farmers are uncertain to adopt improved varieties of seeds. The present study is about following crops.

Groundnut:

The peanut, also known as the groundnut taxonomically classified as *Arachis hypogaea* L. is a legume crop grown mainly for its edible seeds. It is an important commercial crop and ancillary food crop of the world, contributes about 40% of oil production in the India. Groundnut production, within the country, is mainly concentrated in five states including Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Maharashtra accounting for nearly 90% of the total production of groundnut in the country. In Andhra Pradesh it is predominantly cultivated in Rayalaseema districts viz., Anantapur, Kadapa, Kurnool, Chittoor districts followed by coastal districts.

Groundnut plays main role in the dietary requirement. Groundnut seed contain 47-53% oil and 26% protein and 11.5% starch. Peanut oil is often used in cooking, because it has a mild flavor and relatively high smoke points. Due to its high monounsaturated content, it is considered more healthful than saturated oils, and is resistant to rancidity. Groundnut cake which is obtained after extraction of oil, is used as valuable organic manure and feeding material for livestock. It consists of 7.3% N, 1.5% P_2O_5 and 1.3% K_2O. It is a good rotation crop, which builds up soil fertility by fixing atmospheric nitrogen through the root nodules bacteria and an efficient cover crop of lands exposed to soil erosion. Groundnut kernels are also used for the preparation of food products like chikkis, groundnut milk, butter, curd including different bakery products.

Niger:

Niger is native of Abyssinia (Ethiopia) .It is originated from *Guizotia abyssinica L.* and. Niger is a minor oilseed crop in world and meets economy of India. Niger crop is grown for seed used for extracting oil which is about 37 to 43 percent of the seed weight, which is pale yellow with nutty taste and a pleasant odour. The oil is used for culinary purposes. 75% of Niger seed produced is used for extraction of oil in India, and rest is used for food in confectioneries making, also exported to western countries as cage bird feed. Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha and West Bengal are the states where Niger is grown.

Castor:

Castor (*Ricinus Cummunis* L.) belongs to Euphorbiaceous family and is indigenous to Eastern Africa and native of Ethiopia. The crop is cultivated around the world for its non-edible oilseed. Castor seed contain 45-47 % non-edible oil. Castor oil is used as a lubricant in all moving parts of the machinery and particularly high speed engines and aero planes. Castor seed and castor cake are highly poisonous as it contains a toxic alkaloid ricinine and ricin. But the castor cake is a good source of organic manure as it contains nitrogen 4.5 %, P_2O_5 1.75 % and K_2O 1.5 % and also controls white ants and nematodes. Gujarat, Rajasthan and Andhra Pradesh are the leading producers in India. Castor is largely grown in Anantapur, Kurnool, Guntur and Nellore districts. Here it is mostly raised as a pure crop but mixtures of castor with jowar, bajra, groundnut and ragi are also to be found.

Sesame:

Sesame (*Sesame indicum* L.) crop is the oldest oil plant cultivated by man and native of India. More than 85% production of sesame comes from West Bengal, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Andhra Pradesh and Telangana. It is also known as Gingelly or Til. Among oilseed proteins, sesame seed proteins are more nutritious. It is rich in methionine and Tryptophane. Sesame seed protein content varies from 20-28% with an oil content ranging between 48-55%. Sesame oil has two constituents namely sesamin and sesamol. They are responsible for very high stability of oil at room temperature, and frying temperatures. The sesame seeds or powder and its oil are used as flavoring agent in Indian dishes. The seed has high food value because of the higher contents of good quality edible oil and nutritious protein. Sesame meal is an excellent high quality protein (40%) feed for poultry and livestock.

Area, Production and Productivity of selected oilseed crops in Andhra Pradesh (2017-2018)

Oil seed crops	Area (In ’000 Hectares)	Production (In ’000 Tonnes)	Productivity (In Kg/ Hectares)
Groundnut	735.00	1048.41	1426
Castor	32.00	20.96	655
Sesame	64.00	17.00	266
Niger	6.00	2.48	413

Source: (www.indiastat.com, 2017-2018)

There is an imbalance between demand and supply in edible oils due to low productivity of oilseeds. The crops grown are facing several risks regarding production and price instability. Production risk is due to oscillate in area, production and productivity. The risk faced by small and marginal farmers includes poor access to quality inputs and services, markets and technologies. Failure of hybridization and seed multiplication programmes in oil seed crops compared to cereals. Lack of suitable post harvest technology to prevent post harvest losses & also to avoid the deterioration of quality of oilseed. The oilseeds crops are cultivated mostly under rain fed conditions in many districts of Andhra Pradesh. So the yield of oilseeds crops is low when compared to the yield of the crops that is cultivated under irrigated conditions in some of the states in India. To achieve the high yield in oilseeds the in-depth studies on production, prices and markets are needed. Such studies make the farmer aware of price fluctuations, and able to sell their produce at right time.

Keeping in the view of above circumstances, the present study has been an attempt to investigate the scenario of trend by fitted suitable, Linear, Non-linear and Time series models i.e., ARIMA models and also to forecast the succeeding values of area, production and productivity of selected oilseed crops (Groundnut, Castor, Sesame and Niger) oilseed crops in Andhra Pradesh.

OBJECTIVES OF RESEARCH:

- To fit different linear, non-linear and time series models on area, production and productivity of selected oilseeds in Andhra Pradesh.
- To study and differentiate the performance of different linear, non-linear and time series models on area, production and productivity of selected oilseeds in Andhra Pradesh.
- To estimate the future values of area, production and productivity of selected oilseeds in Andhra Pradesh through best fitted model.

LIMITATIONS OF THE STUDY:

The secondary data required for the study pertaining to area, production and productivity of groundnut, niger, castor, sesame oilseed crops in Andhra Pradesh of 53 years period i.e., 1965-1966 to 2017-18 collected from the EPWRF (Economic and Political Weekly Research Foundation) India Time series, Directorate of Economics and Statistical and www.indiastat.com.

PLAN OF THESIS:

The report of the study is presented in five chapters.

- In the first chapter, it deals with importance of oilseed crops and objectives of the study.
- In the second chapter a brief Review of Literature relevant to the present problem is presented.
- The third chapter is devoted to the Materials and Methods followed with statistical procedures used are presented.
- In the fourth chapter Results and Discussions with respect to the objectives of the study are presented.
- In the fifth chapter brief Summary and Conclusions of the study are presented.

Literature cited is presented at the end.

STATISTICAL SOFTWARE USED FOR ANALYSIS:

SPSS V.22 and MS EXCEL-2007.

Chapter – II

Review of Literature

Chapter II

REVIEW OF LITERATURE

In this chapter, a comprehensive review of published literature has been presented so as to understand the issues considered and approach followed in past studies. This would enable the researchers to steer the study in right direction, collect the appropriate data and to draw meaningful results out of it. Keeping in the view the objectives of the study, the reviews are presented chronologically by the following headings.

2.1. Forecasting of area, production and productivity through linear and non-linear growth models

2.2. Forecasting through Time series models.

2.1. FORECASTING OF AREA, PRODUCTION AND PRODUCTIVITY THROUGH LINEAR AND NON-LINEAR GROWTH MODELS

Growth models are measures of performance of economic variables. They are describing the trends in variables over time. Hence, they are commonly used as indicators of trends in the Time series data. Price indices, productivity indices and output series are usually discussed in terms of the changing growth rates over a period of time.

Nimbrayan P.K *et al*. (2019) sued exponential function to study the trends of area, production and productivity of pulses in Haryana vis-à-vis India for a period from 1970-71 to 2016-17 and the results shown as, the growth trends of area in Haryana was negative. In 1971-72 maximum area under pulses was recorded while lowest area under pulses was recorded in 2015-16. In case of production growth trends was also negative in Haryana. In 2012-13 maximum production under pulses was estimated while lowest production was estimated in 2015-16 Compound growth rate for area and production during this period was -5.56 and -4.51 per cent, respectively i.e. declining in trend in pulses. Productivity growth trends were positive in Haryana. Compound growth rate (CGR) of productivity during 2015-16 was 0.64 per cent in Haryana. In India the area, production and productivity trends are positive. CGR of production and productivity was 1.09 and 0.97 per cent in India. Similarly, in productivity, CGR was 0.97 per cent which shows positive trends. In this study the author found that the daily intake of pulses was low as per requirement of institute of nutrition. Export and import compound growth trend was positive. From last few years export of pulses was increase there is decline in imports.

Sundar Rajan *et al*. (2018) investigated regression models for area, production and productivity growth trends of cotton in India for the period of 1951-52 to 2012-13. They concluded that cubic model was found to be the best fitted model for increasing future projection trends with respect to area, production and productivity of cotton in India.

Ramakrishna *et al*. (2017) made attempts to examine the trends and forecasting in area, production and productivity of Turmeric crop in India .The study is based on 65 years of data i.e., from 1950 to 2015 of Turmeric in India The future projections of area, production and productivity of Turmeric crop India up to 2018 were estimated upon the best fitted growth model used for fitting the trend equations. They had chosen coefficient of multiple determination R^2 or adjusted R^2 as the criterion of model selection. Non-parametric one sample run test is used to test the randomness of residuals. Regarding the area and productivity of turmeric Cubic function was found to be the best model with future projection of area under Turmeric by Logarithmic function by 2018 would be 215.97 thousand hectares which is in increasing trend, the projected productivity would be increasing to 5.3 tonnes/ha by 2018. The production of Turmeric Quadratic linear function was found to be the best model for future projections. The projected production would be increasing to1247.05 thousand tonnes by 2018.

Parmar *et al*. (2017) analyzed area, production and productivity trends and growth rates of maize crop in Panchmahal region of Gujarat from 1949-50 to 2007-08 based on parametric and nonparametric regression models. Their study revealed that the production had increased at a rate of 0.49 per cent per annum due to combined effect of increase in area and productivity at a rate of 0.30 and 0.21 per cent annum respectively.

Abhiram Dash *et al*.(2017) were fitted appropriate model to study growth rates and instability of mango production in India by dividing entire period into two sub groups 1992-93 to 2002-03 as sub period-I and 2003-04 to 2013-14 as sub-period-II and they concluded that in the year 2002-03 in area, production and yield of mango there was maximum percentage change. The best fit models are compound model without spline, Compound model with spline and linear model with spline. Each sub period and for the entire period of study. In case of area the growth rate is positively significant but for yield is significantly negative. Even though the production exhibits positive growth rate but it is insignificant for sub-period-I and also for the whole period. The instability in mango production is due to coefficient of variation, is affected by long term trend and, it is computed after eliminating trend from the data. From study of instability, it is judged that area under mango in India shows lesser instability than production and yield. Though there is increase in production of mango but the increase is mainly due to the positive growth in area under mango. The yield of mango is declining at a significant rate.

Shruthi *et al*. (2017) made an attempt to study the growth rates in area, production and productivity of groundnut crop in Telangana for the period of 2000-01 to 2014-15 by fitted of Exponential function. The results indicated that area, production and productivity of groundnut in Mahabubnagar district of Telangana were increased over the study period.

Greeshma *et al*. (2017) examined the trend in growth models on area, production and productivity of sugarcane crop in Coastal Andhra region of Andhra Pradesh State for the period of 1973-74 to 2012-13. They observed that quadratic function was the best fitted model for area and production where as linear function for productivity. And the results revealed that area, production and productivity of sugarcane crop would be increased during their study period.

Ganjeer.P.K *et al*. (2017) studied on trend in area, production and productivity of wheat crop in different districts of Northern Hills of Chhattisgarh State from period 1979-80 to 2012-13 by fitting linear, quadratic and exponential function, compound growth rate, coefficient of variation (CV), instability index and concluded that CV is less than 8.4 per cent and instability indices is low which proves that less risk in growing wheat in future. The growth rate showed positiveness and production and productivity had increased.

Kalpana (2016) applied different linear and nonlinear regression models to analyze the growth rates of area, production, yield and seeds of groundnut crop in India for the period 1990-91 to 2013-14. She observed that area, yield, production and seed growth rates are statistically significant and found that area and production growth rates as well as area and seeds growth rates are following opposite directions in most of the years.

Paland *et al*. (2015) fitted nonlinear growth models viz. Monomolecular, Logistic and Gompertz models for modeling of India's total groundnut production during the period 1950-51 to 2011-12. It has been observed that Monomolecular and Logistic models perform better than Gompertz model. Finally, forecasting of India's total groundnut production for the year 2014-15 to 2019-20 has been carried out by using Monomolecular and Logistic models.

Ramakrishna *et al*.(2014) selected ten growth models to fit the area, production and productivity of Rice crop in Andhra Pradesh from 1970-2012 and best- fitted model for future projection was chosen based upon least Residual Mean Square (RMS) and significant Adj R^2 Besides, the important assumption of randomness of residuals was tested using one sample run test . Logarithmic function is found to be best fit for area under rice in Andhra Pradesh. Linear function was found to be the best model for future projections of production and productivity. They concluded that the growth rate in area, production and productivity of rice were positive and showed increasing trend.

Josily Samuel *et al*. (2013) collected data of cotton from 1980 onwards for the nine major cotton growing states to analyze the trends in area, production and productivity of cotton. The study revealed that the productivity of cotton for the country as a whole increased. The production and productivity of Punjab, Haryana, Rajasthan, Madhya Pradesh, and Karnataka showed significant positive growth. The area under cotton in the states Karnataka, Punjab and Tamil Nadu has declined**.**

Bharti *et al*. (2012) estimated the Time series data on area, production and productivity of oilseeds crop in Uttar Pradesh pertaining to the period of 1970-71 to 2005-06 were used for the investigation of trend and growth of oilseeds and also impact of technological changes on oilseeds production. Statistical tools and techniques like regression analysis etc. have been used for the purpose of investigation. They observed that the production gains in oilseeds were largely due to the expansion in area during the first period (before the launch of technological mission) rather than in productivity. And the absence of growth in productivity was a result of adequate technological progress and or poor adoption of yield enhancing technologies. In addition favorable price situation created through the technological mission on oilseeds resulted in expansion of marginal areas. Thereby, causing a decline in average yields developing location specific technologies that enhance oilseeds productivity.

Rajarathinam *et al.* (2011) developed some parametric and non-parametric models to study area, production and productivity trends of castor crop grown in Anand district of middle Gujarat in India for the period of 1950 to 2008. The statistically most suited parametric models were selected on the basis of R^2 and adjusted R^2 to estimate relative growth rates of area, production and productivity trends on the best fitted model.

Ufuk Karadavut (2010) compared some statistical growth models *viz.*, Quadratic, square root, exponential and Weibull models for seedling growth in *Lolium Perenne* plants on the basis of Coefficient of determination and mean square errors as comparison criteria. Among these models, quadratic model explained better for describing early period seedling growth.

Narinc *et al.* (2010) fitted several nonlinear growth models to select the most appropriate model for age-related changes of body weight growth in Japanese quail and compared with other. The result revealed that three-parameter Gompertz model is the most appropriate model.

Rajarathinam.G *et al.* (2010) carried out a study on area, production and productivity trends and growth rates of tobacco crop grown in Anand region of Gujarat state for the period 1949-50 to 2007-08 based on parametric and nonparametric regression models. In parametric models different linear, nonlinear and Time series models were employed. The statistically more suited parametric models were selected on the basis of adjusted R^2, significant regression coefficients and coefficient of determination ($R^{2)}$. The statistically appropriate model was selected on the basis of various goodness of fit criteria *viz.*, Akaike's Information criteria, Bayesian Information Criteria, Root Mean Square Error, and Mean Absolute Error, assumptions of normality and independence of residuals. Residual analysis was carried out to test the randomness. Relative growth rates of area, production and productivity were estimated based on the best fitted trend function. None of the parametric model was found suitable to fit the trends in area, production and productivity of tobacco crop. Nonparametric regression was finally selected as the best fitted trend function for the area, production and productivity of tobacco crop based on lower values of root mean square and mean absolute error.

Ufuk Karadavut *et al*. (2010) developed five nonlinear models *viz.,* Richards, Logistic, Weibull, Morgan Mercer Flodin and Gompertz model to explain the fitting performance of five maize cultivars leaf growth data. Based on the four comparison criteria namely coefficient of determination (R^2), sum squares error (SSE), root mean squares error (RMSE) and mean relative error (MRE), Richards, Logistic and Gompertz models were found to be the most suitable models to fit with maize leaf growth data.

Khamis. A *et al*. (2005) studied the basic needs of parameters estimation for nonlinear growth model such as partial derivatives of each model, determination of initial values for each parameter. The parameters are estimated using the Marquardt iterative method of nonlinear regression relating oil palm yield growth data. The best model was selected based on the model performance and it can be used to estimate the oil palm yield at any age of oil palm. The result establish that the Gompertz, logistic, log-logistic, Morgan-Mercer-Flodin and Chapman-Richard growth models have the ability for quantifying a growth phenomenon that exhibit a sigmoid pattern over Time.

Angles *et al.* (2002) examined the performance of turmeric in terms of area, production and productivity in certain states of South India *viz.,* Andhra Pradesh, Tamil Nadu, Karnataka and Kerala, considering the period from 1979-80 to 1998-99.They used exponential form of growth function for analysis. They concluded that all the states registered significant growth in area, production and productivity except area in case of Tamil Nadu and Kerala, production in Tamil Nadu and productivity in Karnataka.

Prajneshu *et al.* (2000) applied number of nonlinear mechanistic growth models to critically examine the pattern of state wise wheat productivity data during the period 1973-74 to 1996-97 in respect of four major wheat growing States, *viz.*, Punjab, Haryana, Uttar Pradesh, Rajasthan as well as at the all India level. Logistic and Gompertz models were found to be quite successful in describing the path of wheat productivity. Forecast values were also computed on the basis of the selected models. A comparative study indicated that Haryana's performance was the best among the major wheat growing States.

2.2. FORECASTING THROUGH TIME SERIES MODELS

Başer *et al.* (2018) fitted ARIMA model for Forecasting Chestnut Production and Export of Turkey for the period of 1961-2016. They obtained ARIMA (1, 1, 1) and

ARIMA (1, 2, 1) models were best fitted models and they conclude that Turkey's chestnut production and export would be increased in the forecasted years.

Ramana Murthy *et al.* (2018) applied Box- Jenkins ARIMA model for forecasting of groundnut area, production and productivity of India by using the study period of 1949-50 to 2015-16. Their analysis found that ARIMA (2, 1, 3), ARIMA (3, 0, 3), and ARIMA (2, 1, 3) models were suitable models for future forecast. The forecasted results showed for area, production and productivity of groundnut for the year 2019-20 to be 3682 thousand hectare, 8320 thousand tonnes and 1589 in kg/hectare, respectively.

Ramana Murthy *et al*. (2018) research study was carried out to identify the appropriate Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) model for forecasting sunflower production in India for a period of 47 years (1970-71 to 2016-17) . The validity of the model was tested using standard statistical techniques R^2, RMSE, and MAPE. ARIMA (4, 1, 4) model was found to be a best fitted model to forecast sunflower production in India for further five years. The forecasted results showed for production of sunflower in India for the year 2017-18 to 2021-22 to be 220, 150, 114, 121 and 141 thousand tonnes respectively.

Ramakrishna and Vijaya Kumari (2017) applied ARIMA model for forecasting of rice production in India by using SAS for the period 1949-50 to 2016-17. They found that there is a significantly increased trend in the total rice production in India and the forecasted production would be increased to 112.90 million tonnes for 2020 AD by ARIMA (0, 1, 1) model.

Sundar Rajan and Palanivel (2017) aim at presenting models for the forecasting Time-series data of cotton (*Gossypium hirsutum)* Area, Production and Productivity of Tamil Nadu by using Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models of Time-series forecasting. The cotton data for (1970-2013) area, production and productivity were forecasted to five years staring from 2014-2018. Presence of trend in data was checked through Time series stationary through auto correlation and partial auto correlation functions ARIMA (1, 1, 2), (2, 1, 2) and (1, 1, 3) model performed better among other models of ARIMA family for modeling as well as forecasting purpose. To forecast the following "Forecast Criteria" are significant coefficient, the lowest Normalized BIC, Good R^2 and model fit statistics for Root Mean Square Error and Mean Absolute Percentage Error.

Ravita and Verma (2016) study deals with application of Time-series modeling in prediction of mustard yield in Haryana. Autoregressive integrated moving average (ARIMA) models have been fitted using the district-level Time series yield from 1966-67 to 2010-11 and the models have been validated for the post-sample periods 2011-12 to 2013-14. ARIMA (0, 1, 1) for Hisar, Bhiwani and Sirsa districts and ARIMA (1, 1, 0) for Mahendergarh and Gurgaon districts have been fitted for mustard yield estimation in Haryana.

Niranjan and Chouhan (2016) studied the past and future trends on area, production and productivity of onion in Madhya Pradesh by using ARIMA model for the period of 1975 to 2011. The results revealed that the forecasted area, production and productivity of onion will be increases to some extent in future.

Prabakaran *et.al* (2014) analyzed pulses area and production in India during the period from 1950-51 to 2011-12 by using ARIMA model and he was found that ARIMA (1, 1, 0) and ARIMA (2, 1, 1) models were best fitted to forecast area and production in India for four leading years.

Manoj and Madhu (2014) attempted to study forecasting of sugarcane production in India by using Time series modeling approach (Box-Jenkins ARIMA model). They found that ARIMA (2, 1, 0) model was best fitted model for forecasting of sugarcane production.

Keerthi and Naidu (2013) studied forecasting the monthly prices of tomato in Madanapalli market of Chittoor district through fitting of univariate Auto Regressive Integrated Moving Average (ARIMA) models. The authors concluded that ARIMA (2, 0, 2) (1, 0, 1) model was found suitable to produce price forecasts for tomato for subsequent years.

Badmus and Ariyo (2011) employed Autoregressive Integrated Moving Average (ARIMA) model for cultivated area and production of maize in Nigerian during the period 1970-71 to 2004-05. They found that ARIMA (1, 1, 1) and ARIMA (2, 1, 2) have appropriated models for future projection of area and production of Maize.

Suresh and Priya (2011) studied forecasting sugarcane area, production and productivity of Tamil Nadu through ARIMA models. The study revealed that ARIMA (1, 1, 1) model was found suitable for sugarcane area and productivity. ARIMA (2, 1, 2) was found appropriate for modeling sugarcane production. The performance of models is validated by comparing with actual values. Using the models developed, forecast values for sugarcane area, production and productivity are developed for subsequent years.

Iqbal *et al*. (2005) studied forecasting of wheat area and production in Pakistan by using ARIMA model. They developed models such as ARIMA (1, 1, 1) for area and ARIMA (2, 1, 2) for production by using data of 1950-2000 to forecast up to 2022. The forecasted production of wheat showed an increasing trend.

Saeed *et al*. (2000) made an empirical study to forecast Wheat Production in Pakistan from 1998-99 to 2012-13. The Box Jenkins ARIMA methodology has been used for forecasting. The diagnostic checking has shown that ARIMA (2, 2, 1) is appropriate and wheat production is increased. These forecasts would be helpful for the policy makers to foresee ahead of Time the future requirements of grain storage import and/or export and adopt appropriate measures in this regard.

Chapter – III

Material and Methods

Chapter III

MATERIAL AND METHODS

To realize the various objectives of the study, an appropriate methodology describing data collection and tools of analysis for the conduct of the study are inevitable. The main aim of this chapter is to provide a brief description of the materials which provide the necessary database for this study along with the important statistical tools employed in the analysis. The details of the materials and the methods used for this study are discussed under following headings.

3.1. Description of the study area

3.2. Selection of crops

3.3. Collection of data

3.4. Statistical tools employed in the analysis

3.1. DESCRIPTION OF THE STUDY AREA

The study was undertaken in Andhra Pradesh state.

3.2. SELECTION OF CROPS

The study pertains to the period of 53 years from 1965-66 to 2017-18. The important crops selected for the study are major coarse cereals viz., Groundnut, Niger, Castor and Sesame in Andhra Pradesh.

3.3. COLLECTION OF DATA

The secondary data required for the study pertaining to area, production and productivity of groundnut, niger, castor, sesame oilseeds in Andhra Pradesh of 53 years period i.e. 1965-1966 to 2017-2018 will be collected from the EPWRF (Economic and Political Weekly Research Foundation) India Time series, Directorate of Economics and Statistical and www.indiastat.com.

3.4. STATISTICAL TOOLS EMPLOYED IN ANALYSIS

Keeping in view of the objectives set for the study, following statistical tools and methods have been employed.

1. Statistical models to study the trend and to forecast the area, production and productivity through linear and non-linear growth models.
2. Forecasting through Time series models and identifying trend by using ARIMA.

3.4.1. Statistical models used in the study

The trend equations were fitted by using different linear, non-linear models, and Time series models for identifying the trend. Growth models are nothing but the models that describe the behavior of a variable varying with respect to Time. They are very quick to estimate and less expensive, although less efficient. They are very good in many situations for describing the growth pattern and the future movement of a Time series (Pindyck and Rubinfeld, 1991) these models are widely used to estimate the growth rate of Time series data. The growth models taken under consideration here are as follows.

3.4.1.1. Linear function

The function is given by

$$Y_t = a + bt$$

Where,

‘Y_t’ is the dependent variable i.e., area or production or productivity

‘t’ is the independent variable, Time in years

‘a’ is the intercept

‘b’ is the regression coefficient

3.4.1.2. Quadratic function

This function is useful when there is peak or trough in the data of past periods.

Quadratic function is

$$Y_t = a + bt + ct^2$$

Where,

‘Y_t’ is the dependent variable i.e., area or production or productivity

‘t’ is the independent variable, Time in years

‘a’ is the intercept

‘b’ and ‘c’ are the regression coefficients

3.4.1.3. Cubic function

This function is useful when there is, two peaks or two troughs in the data of past periods.

Cubic fit or third degree curve is given by the equation:

$$Y_t = a + bt + ct^2 + dt^3$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b', 'c' and 'd' are the regression coefficients

3.4.1.4. Compound function

This function is useful when it is known that there is increasing growth or decline in past periods. Compound fit is given by

$$Y_t = ab^t$$

(or)

$$\ln Y_t = \ln a + t \ln b$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'$\ln(a)$' is the intercept

'$\ln(b)$' is the regression coefficients

3.4.1.5. Inverse function

Inverse fit is given by the equation

$$Y_t = a + (b/t)$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

3.4.1.6. Logarithmic function

The function of this fit can be given by

$$Y_t = a + b \ln (t)$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

3.4.1.7. Power function

The function of this fit can be given by

$$Y_t = at^b$$

(or)

$$\ln (Y_t) = \ln (a) + b \ln(t)$$

Where,

'Yt' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

The fit is similar to exponential fit, but produces a forecast curve that increase or decreases at different rate.

3.4.1.8. Exponential function

The function of this fit can be given by

$$Y_t = ae^{bt} \quad \text{(or)}$$

$$\ln Y_t = \ln a + (bt) \log e$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

3.4.1.9. Growth function

This Growth function is given by

$$Y_t = \text{Exp}\ (a + bt)$$

(or)

$$\ln Y_t = a + bt$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

3.4.1.10. S-curve

S- Curve fit is given by

$$Y_t = \text{Exp}\ (a + b/t)$$

(Or)

$$\ln Y_t = a + b/t$$

Where,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, Time in years

'a' is the intercept

'b' is the regression coefficients

In the above functions the constants and coefficients are estimated by using OLS method.

3.4.2. TIME SERIES MODELS

Auto Regressive (AR) Model

A stochastic model that can be extremely useful in the representation of certain practically occurring series is the autoregressive model. In this model, the current value of the process is expressed as a finite, linear aggregate of previous values of the process and a shock ϵ_t. Let us denote the values of a process at equally spaced Time epochs t, t-1, t-2……by y_t, y_{t-1}, y_{t-2}, …., then y_t can be described by the following expression

The autoregressive process of first order AR (1) is given by

$$y_t = \emptyset_1 y_{t-1} + \varepsilon_t \qquad \text{---------------(1)}$$

The autoregressive process of second order AR (2) is given by

$$y_t = \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \varepsilon_t \qquad \text{---------------(2)}$$

And similarly, the autoregressive process of p- order AR (p) is given by

$$y_t = \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \ldots\ldots + \emptyset_p\, y_{t-p} + \varepsilon_t \text{ ---------------(3)}$$

Where y_t is the value of variable for forecasting at Time‘t’ (Area, Production and Productivity in the present case)

$\emptyset_1$ to $\emptyset_p$: Regression Coefficient

ε_t : Random error

Moving Average (MA) Model

Another kind of model of great practical importance in the representation of observed Time-series is the finite moving average process.

The moving average process of q^{th} order MA (q) model is defined as

$$y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots\ldots - \theta_q \varepsilon_{t-q} \text{ ------------(4)}$$

The moving average process of first order MA (1) is given by

$$y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} \qquad \text{---------------(5)}$$

The moving average process of second order MA (2) is given by

$$y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} \qquad \text{---------------(6)}$$

Where # y_t is the vSalue of the variable for forecasting at Time t (Area, Production and Productivity in the present case)

$\in_t$: Error term

$\theta_1 \; to \; \theta_q$: Partial regression coefficients

Auto Regressive Moving Average (ARMA) Model

To achieve greater flexibility in fitting of actual Time-series data, it is sometimes advantages to include both autoregressive and moving average process. This leads to the mixed autoregressive-moving average model

$$y_t = \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \ldots\ldots + \emptyset_p\, y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots\ldots \theta_q \varepsilon_{t-q}$$

This is written as ARMA (p, q) model. In practice, it is frequently true that adequate representation of actually occurring stationary Time-series can be obtained with autoregressive, moving average or mixed models.

Auto Regressive Integrated Moving Average (ARIMA) Model

In the above models it was assumed that the error ε_t is random error (white noise) i.e., the data is stationary. However, in general, the data is not stationary. For example, the data on economic variables such as area, production, productivity often exhibit trend. ARIMA model essentially require identification of three constants p, d, q i.e. the order of AR terms (p), order of differencing (d) and the order of MA terms (q).

The ARIMA methodology is also called as Box-Jenkins methodology (Box and Jenkins 1976). Box and Jenkins established that these parameters can be obtained through trial and error approach after examining the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF). The first step in developing ARIMA model is to examine data for stationarity. This can be identified through Auto Correlation Function (ACF) of actual data, if the auto correlation function does not die out rapidly, it indicate that the data are non-stationary. Under this situation, the auto correlation corresponding to most of lags are statistically significant. For reducing the data to stationarity, the data are therefore transformed by taking first order differences (d=1). If the auto correlation functions of differenced data indicate a rapid decrease, then it can be concluded that the transformed data is stationary. If not again the data has to be transformed by taking second order differences (d=2). Continuing in a similar way as that of d=1, the order of differencing i.e., d can be determined. After determining the differencing order‘d’, the order of auto regressive (p) and moving average (q) components, can be obtained as follows :

If the auto correlation function corresponding to the transformed data decays after the q^{th} lag, then it is taken as MA (q) model; likewise, if partial auto correlation function indicates a decaying after p^{th} lag, it indicates existence of AR (p) model i.e., the characteristics p and q are determined on the basis of PACF and ACF of the stationary data.

The Box-Jenkins procedure is concerned with fitting a mixed ARIMA model to a given set of data. The main objective in fitting ARIMA model is to identify the stochastic process of the Time series and predict the future values accurately. This methods have also been useful in many types of situations which involve the building of models for discrete Time series and dynamic systems. However the optimal forecast of future values of a Time series are determined by the stochastic model for that series.

The ARIMA (p, d, q) process is given by

$$y_t = \theta_0 + \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \ldots\ldots + \emptyset_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots\ldots \theta_q \varepsilon_{t-q}$$

Where y_t and ε_t are the actual value and random error at Time period t, respectively.

$\emptyset_i$ $(i = 1,2,\ldots\ldots,p)$ and θ_j (j=1, 2, …..,q) are model parameters. p and q are integers and often referred to as orders of the model. Random errors ε_t are assumed to be independently and identically distributed with a mean of zero and a constant variance of σ^2.

The main stages in setting up a Box-Jenkins forecasting model are as follows:

1. Identification
2. Estimating the parameters
3. Diagnostic checking
4. Forecasting

1. **Identification**: - The foremost step in the process of modeling is to check for the stationarity of the series, as the estimation procedures are available only for stationary series. There are two kinds of stationarity, viz., stationarity in ‘mean’ and stationarity in ‘variance’. A cursory look at the graph of the data and structure of autocorrelation and partial correlation coefficients may provide clues for the presence of stationarity. Another way of checking for stationarity is to fit a first order autoregressive model for the raw data and test whether the coefficient “$\emptyset_1$” is less than one or by using Dickey Fuller unit root test, to check the stationarity of the data.

2. **Estimation Stage**:-At the identification stage one or more models are tentatively chosen that seem to provide statistically adequate representation of the available data. Then we attempt to obtained precise estimates of parameters of the model by least square as advocated by Box and Jenkins. Standard computer packages like SAS, SPSS etc. are available for finding the estimates of relevant parameters using iterative procedures.

3. **Diagnostic checking**:-Having chosen a particular ARIMA model and having estimated its parameters, the next step is to check whether the chosen model fits the data reasonably well, as it is possible that another ARIMA model might do the job well. Here selection of model will be done by criteria like highest R-square (R^2), least RMSE (Root Mean Square Error) and least MAPE (Mean Absolute Percent Error).

R^2 Criteria

R^2 is a statistic that will give some information about the goodness of fit of a model. In regression, the R^2 or coefficient of determination is a statistical measure of how well; the regression line approximates the real data points. An R^2 of 1.0 indicates that the regression line perfectly fits the data. It provides a measure of how well future outcomes are likely to be predicted by the model.

The most general definition of the coefficient of determination is

$$R^2 = 1 - \frac{SS_{err}}{SS_{total}}$$

(or)

$$R^2 = 1 - \left[\sum_{i=1}^{n}(y_t - \hat{y}_t)^2 / \sum_{i=1}^{n}(y_t - \bar{y})^2\right]$$

(or)

$$R^2 = \frac{SS_{reg.}}{SS_{total}}$$

Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{100}{n}\sum_{i=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right|$$

Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_t - \hat{y}_t)^2}{n}}$$

Where,

y_t is the actual value and $\hat{y}_t$is the forecast value

Ljung-Box Q statistic: - The model verification (or) diagnosed by the Ljung-Box Q statistic. The Ljung-Box Q statistic is to check the overall adequacy of the model. The test statistic Q is given by

$$Q_n = nr(nr+2)\sum_{i=1}^{n}\frac{r_i^2(e)}{nr-l}$$

Where $r_l(e)$ is the residual autocorrelation at lag l, nr is the number of residual, n is the number of Time lags included in the test for model to be adequate, p-value associated with Q statistics should be large $(p-value > \alpha)$.

Test for randomness of residuals

Non-parametric one sample run test can be used to test the randomness of residuals. A ***run*** is defined as a succession of identical symbols in which the individual scores or observations originally were obtained. Let 'n_1', be the number of elements of one kind and 'n_2' be the number of elements of the other kind in a sequence of $N = n_1 + n_2$ binary events. For small samples i.e., both n_1 and n_2 are equal to or less than 20 if the number of runs 'r' fall between the critical values, we accept the H_0 (null hypothesis) that the sequence of binary events is random otherwise, we reject the H_0. For large samples i.e., if either n_1 or n_2 is larger than 20, a good approximation to the sampling distribution of r (runs) is the normal distribution, with mean

$$\mu_r = \frac{2n_1n_2}{N} + 1$$

And standard deviation

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

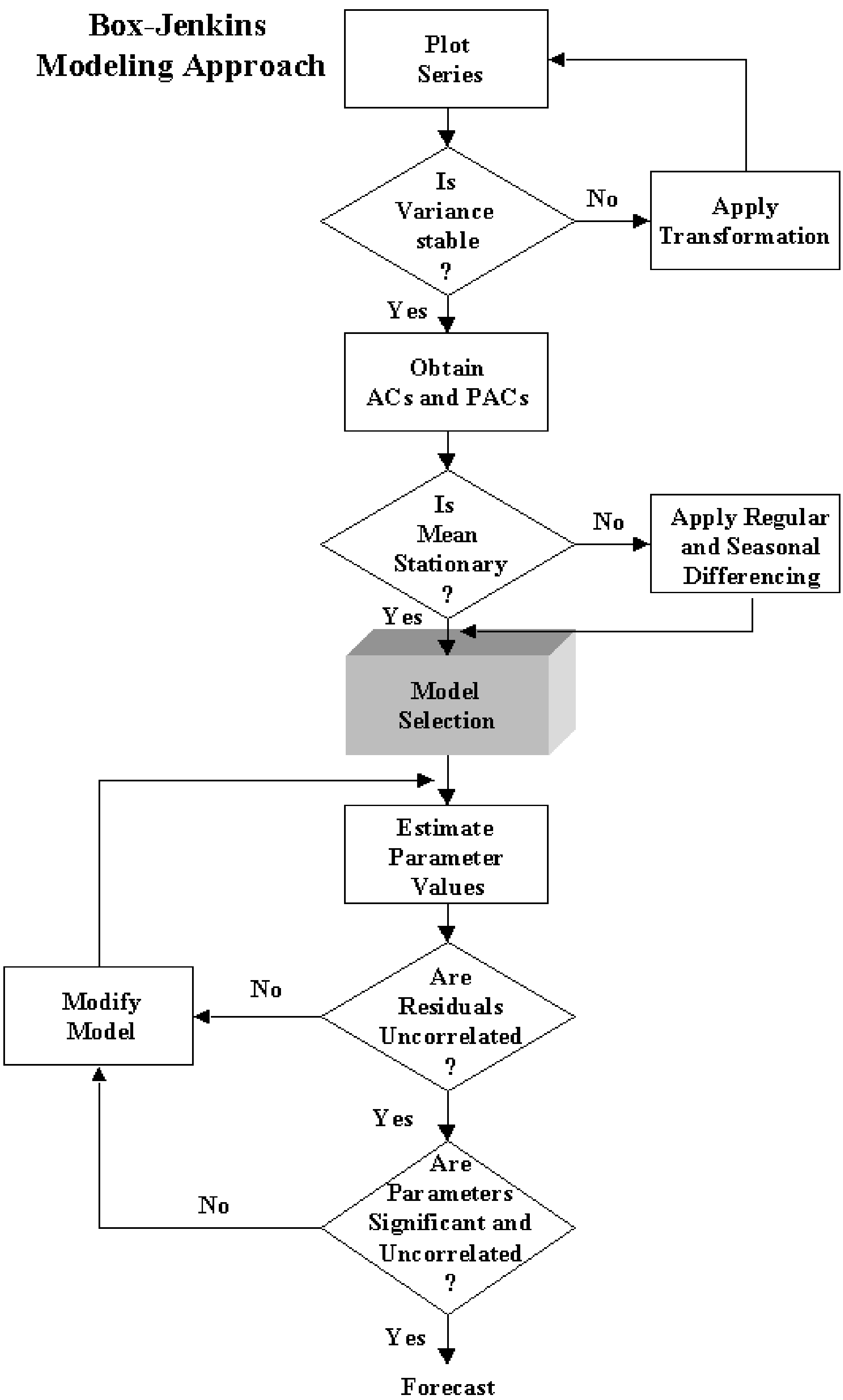
Then, H_0 may be tested by

$$Z = \frac{r - \mu_r}{\sigma_r}$$

The significance of any observed value of Z computed from the above formula may be determined by reference to the standard normal distribution table.

4. **Forecasting:-**The forecast of the variable in the t^{th} year (y_t) in ARIMA model is based on its past values. After the identification of the model and its adequacy check, it is used to forecast the future values. The forecasts can be obtained from the estimated ARIMA model.

Flow chart of Box-Jenkins Methodology



Chapter – IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

In this chapter, an attempt is made to discuss critically the results obtained from the study. The study aims to fit linear, non-linear and time series as well as to forecast area, production and productivity of selected oilseeds in Andhra Pradesh. The important findings of the research are well presented and discussed under the following in accordance.

4.1. To apply different Linear, Non-Linear and Time series models of selected oilseeds in Andhra Pradesh.

4.2. To forecast future values of area, production and productivity of selected oilseeds in Andhra Pradesh by using best fitted model.

4.1. TO APPLY DIFFERENT LINEAR, NON LINEAR AND TIME SERIES MODELS OF SELECTED OILSEEDSIN ANDHRA PRADESH

To attain the specified objectives, the present study had been carried out on the basis of Time series data pertaining to the period1965-1966 to 2017-2018 (53 years) collected from the EPWRF (Economic and Political Weekly Research Foundation) India Time series, Directorate of Economics and Statistical and www.indiastat.com.

In parametric models different linear (Montgomery et al., 2003), non-linear (Ratkowsky, 1990; Bard, 1974; Draper and Smith, 1998) and Auto-Regressive Integrated Moving Average (ARIMA) Time-series models (Box et al., 1976) were employed. The statistically most suited parametric models were selected on the basis of adjusted R^2, Root Mean Square Error (RMSE) and Mean Absolute Error (MAPE). The findings are discussed in sequence as under.

4.1.1. Groundnut:

Groundnut is one among the main sources of edible oil in India. Around one-fourth of country's total edible oil is produced from groundnut. After China with around 20 per cent of world's total production India is the second largest producer of groundnut in the world. Virtually every part *viz*., oil, kernels, shell and straw of groundnut is of economic worth. It's referred as the 'king' of oilseeds and accounts for nearly 25 percent of the total oilseed production of the nation. In India during 2017-18 the area under groundnut is 4.89 million hectares with annual production of 9.25 million tonnes and productivity 1893.03 kg/ha.

4.1.1.1. Groundnut Area

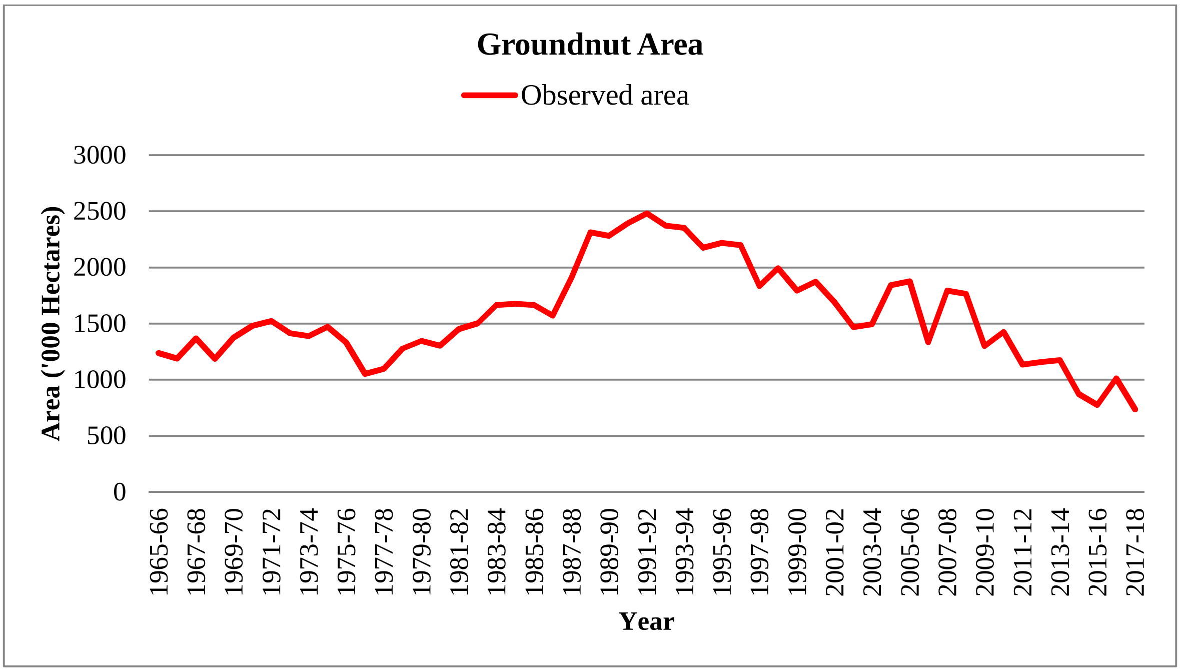


Figure 4.1. Observed Area of Groundnut in Andhra Pradesh

From the figure 4.1 it was recorded that the average area of groundnut crop during the study period (1965-66 to 2017-18) was 1578 thousand hectares in Andhra Pradesh, maximum area was 2481 thousand hectares in the year 1991 and minimum was 735 thousand hectares in 2017.

The time series data on area under groundnut for the study period of 1965-66 to 2017-18 was subjected to fitting of all the linear, non-linear growth models, time series models and the results were presented in the Table 4.1.

Table 4.1. Linear, Non-linear and Time series models of Groundnut Area in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	1592.50**	-0.53			0.00	433.04	24.99
Logarithmic	1304.60**	90.37			0.04	425.67	23.55
Inverse	1631.10**	-617.46			0.05	422.74	24.00
Quadratic	800.90**	85.82**	-1.60**		0.60**	274.95	15.71
Cubic	1209.36**	-0.92	2.38	-0.05**	0.70**	237.95	12.72
Compound	1583.54**	0.99**			0.01	438.33	23.75
Power	1340.26**	0.04			0.02	430.89	22.74
S-Curve	7.35**	-0.35			0.04	426.76	22.68
Growth	7.36**	-0.00			0.01	438.33	23.75
Exponential	1583.54**	-0.00			0.01	438.33	23.75
Time Series Models							
ARIMA (1, 0, 3)					0.83	192.18	10.11
ARIMA (1, 1, 3)					0.83	188.98	9.83
ARIMA (2, 1, 3)					0.84	187.16	9.61
ARIMA (2, 2, 2)					0.81	201.35	10.07
ARIMA (3, 0, 3)					0.83	194.24	9.92
ARIMA (3, 1, 3)					**0.85**	**185.68**	**9.46**
ARIMA (3, 2, 3)					0.81	205.05	10.08

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **, * indicate significant at 1% and 5% level of probability respectively.

Under groundnut area based on the model selection criteria among all the parametric models and ARIMA models, ARIMA (3, 1, 3) was found to be the best fitted model with highest R^2 (0.85) and minimal RMSE (185.68) and MAPE (9.46).

Among all the time series models ARIMA (3, 1, 3) is efficient when compared to linear and non-linear growth models.

4.1.1.2. Groundnut Production

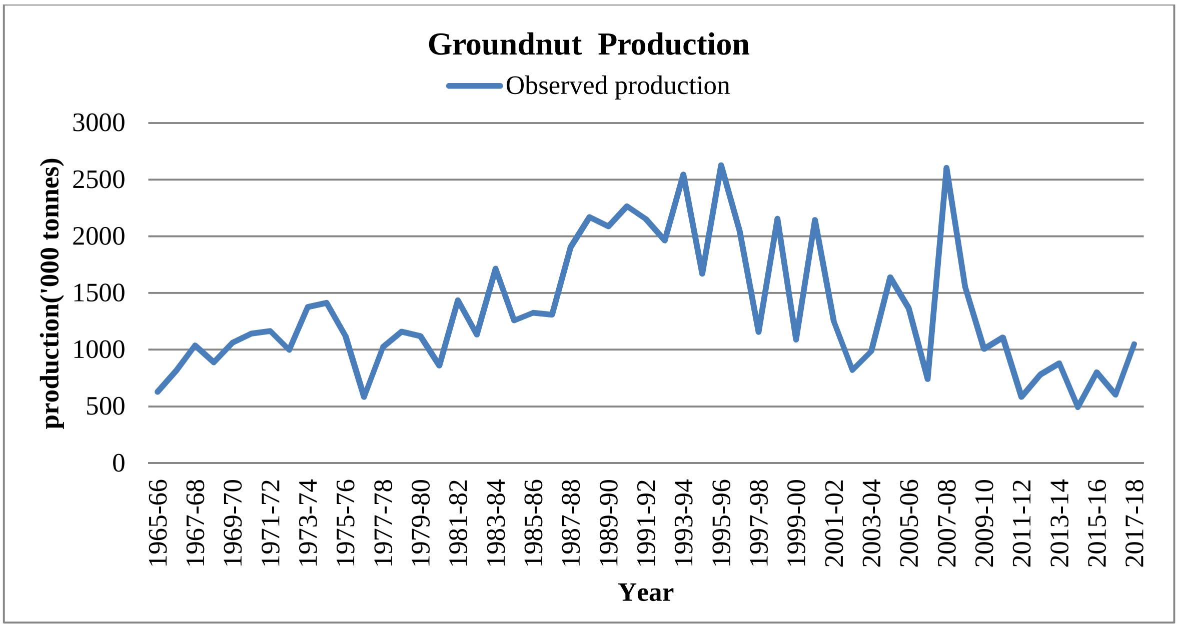


Figure 4.2. Observed Production of Groundnut in Andhra Pradesh

From the figure 4.2 it was found that the average production of groundnut in Andhra Pradesh for the complete period (1965-66 to 2017-18) was 1336.19 thousand tonnes. The data on production of Groundnut in Andhra Pradesh during the study period of 1965-66 to 2017-18 showed fluctuating trends.

The maximum production was 2625.80 thousand tonnes in the year 1995-96 and minimum production was 493 thousand tonnes in the year 2014-15. The results obtained for production of groundnut during the study period by fitting all the models were presented in Table 4.2.

Table 4.2. Linear, Non-linear and Time series models of Groundnut Production in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	1306.71**	1.09			0.01	558.76	40.05
Logarithmic	913.13**	139.84			0.05	545.15	38.43
Inverse	1422.26**	-1001.07*			0.08*	537.72	38.03
Quadratic	453.53*	94.16**	-1.72**		0.42**	446.86	29.28
Cubic	682.95*	45.44	0.51	-0.02	0.44**	439.78	28.22
Compound	1258.59**	0.99**			0.01	570.58	35.34
Power	941.49**	0.08			0.04	557.76	34.60
S-Curve	7.18**	-0.79*			0.09*	547.33	33.12
Growth	7.13**	-0.00			0.01	570.58	35.34
Exponential	1258.59**	-0.00			0.01	570.58	35.34
Time Series Models							
ARIMA (1, 0, 3)					0.41	455.30	28.67
ARIMA (1, 2, 2)					0.28	495.35	31.78
ARIMA (2, 0, 2)					0.41	455.41	29.16
ARIMA (1, 1, 3)					0.40	457.07	27.68
ARIMA (3, 1, 1)					**0.45**	**437.10**	**26.80**
ARIMA (2, 1, 1)					0.43	442.39	27.35
ARIMA (2, 2, 3)					0.30	500.73	32.09

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

It appears from the above Table 4.2 by model selection criteria, among all the models ARIMA (3, 1, 1) had highest percentage of R^2 (0.45) and least RMSE (437.10), MAPE (26.80) values. Hence ARIMA (3, 1, 1) model was chosen for forecasting purpose.

4.1.1.3. Groundnut Productivity

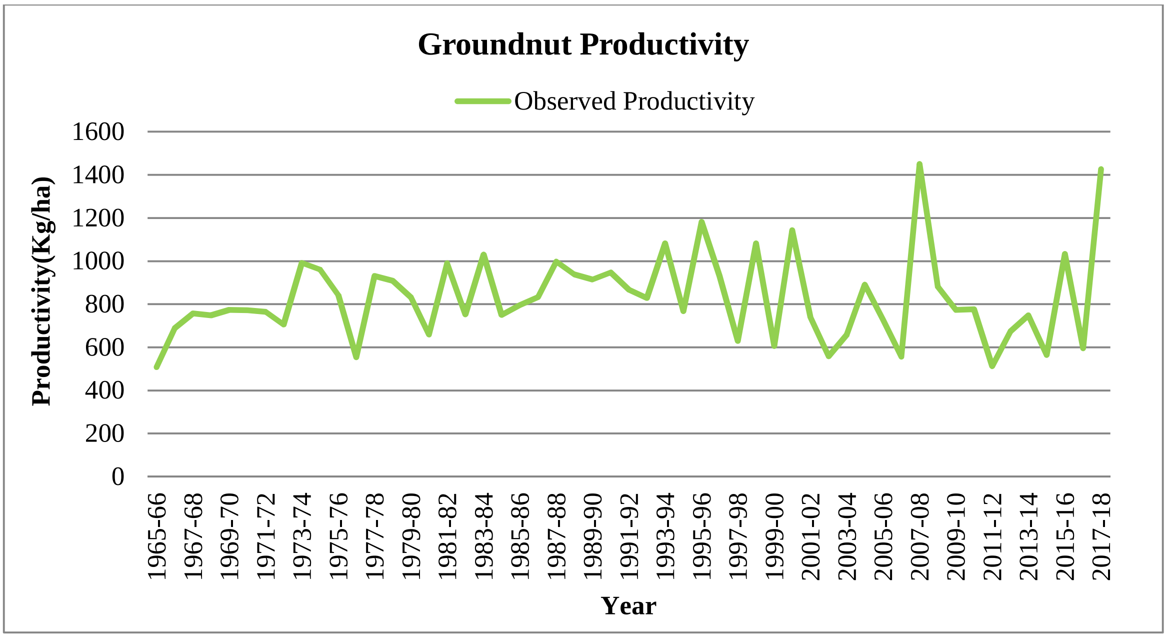


Figure 4.3. Observed Productivity of Groundnut in Andhra Pradesh

From the figure 4.3 it was revealed that, the average productivity of groundnut crop during the study period (1965-66 to 2017-2018) was 830.89 kg/ha. The data on productivity of groundnut in Andhra Pradesh during the study period appears that there is increasing and decreasing trend with maximum productivity 1450.7 kg/ha in 2007-08 and minimum productivity 508.31 kg/ha in 1965-66.

The results obtained for productivity of Groundnut during the study period by fitting all the models were presented in Table 4.3.

Table 4.3. Linear, Non-linear and Time series models of Groundnut Productivity in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	796.64**	1.26			0.01	201.37	19.80
Logarithmic	694.20**	45.18			0.04	198.32	19.11
Inverse	861.06**	-350.93*			0.07*	195.09	18.15
Quadratic	702.89**	11.49	-0.18		0.05**	197.44	18.38
Cubic	**570.44****	**39.62***	**-1.47**	**0.01**	**0.10****	**192.31**	**18.04**
Compound	794.79**	1.00**			0.00	203.04	19.01
Power	702.47**	0.04			0.03	199.91	18.65
S-Curve	6.73**	-0.44*			0.08*	196.38	17.72
Growth	6.67**	0.00			0.00	203.04	19.01
Exponential	794.79**	0.00			0.00	203.04	19.01
Time Series Models							
ARIMA (1, 0, 1)					0.05	204.69	19.99
ARIMA (1, 0, 2)					0.06	205.77	19.80
ARIMA (1, 1, 1)					0.03	204.52	18.85
ARIMA (2, 0, 1)					0.06	206.05	19.78
ARIMA (2, 1, 3)					0.08	205.52	18.79
ARIMA (2, 0, 3)					0.04	201.64	19.51
ARIMA (3, 0, 3)					0.09	208.85	19.59
ARIMA (3, 1, 1)					0.03	208.66	18.93

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

Forecasted Cubic model is *productivity* $\hat{Y}_{productivity}$= **570.44+ 39.62t - 1.47t^2 + 0.01t^3**

From the above Table 4.3 it was observed that all the deterministic models showing least R^2 except cubic model. Quadratic and Cubic models are significant at 1% level and, Inverse and S-curve models are significant at 5% level, but comparison with model selection criteria among all the models Cubic model was highest percentage of model accuracy R^2 (0.10) and has least RMSE (192.31) and MAPE (18.04). Accordingly the Cubic model is determined to forecast the productivity of Groundnut in Andhra Pradesh.

The model verification (or) diagnosed

The ARIMA models verification (or) diagnosed by the Ljung-Box Q statistic. The p-value associated with Q statistics should be large $(p - value > \alpha)$. The results of estimation are reported in the following Table 4.4.

Table 4.4. Estimates of the fitted ARIMA (3, 1, 3), ARIMA (3, 1, 1) and Cubic models for groundnut area, production and productivity respectively.

Groundnut	Model fit Statistics			Ljung-Box Q (18)	
	R-Square	RMSE	MAPE	Statistic	p-value
Area	0.85	185.68	9.46	12.80	0.38
Production	0.45	437.10	26.80	15.64	0.33
Productivity	0.10	192.31	18.04	1.74	0.17

**,* indicate significant at 1% and 5% level of probability respectively.

Test for randomness of residuals

Table 4.5. Test for randomness of the residuals for fitted models of Groundnut Area, Production and Productivity.

Model	Run Test for Residuals			
	Total Cases	No. of Runs	Z- Value	p-value
Area : ARIMA (3, 1, 3)	53	26	0.41	0.67
Production : ARIMA (3, 1, 1)	53	27	0.13	0.89
Productivity: Cubic model	53	28	0.14	0.88

4.1.2. Niger:

According to statista at the end of fiscal year 2017, India produced approximately 0.1 million metric tons of niger seeds. This was an increase of over 14 percent as compared to the production volume from the previous fiscal year. 1.1-2.1 lakh metric tonnes of niger seeds per annum was produced by India alone, out of the total production around 75% is used for oil extraction and remaining exported to countries like Europe, Japan, USA etc. In India states like Madhya Pradesh, Andhra Pradesh, Orissa, Karnataka etc., cultivate niger seeds. The area under niger in India was 0.22 Mha, production was 0.07 Mt and productivity was 321.24 kg/ha during 2017-18.

4.1.2.1. Niger Area

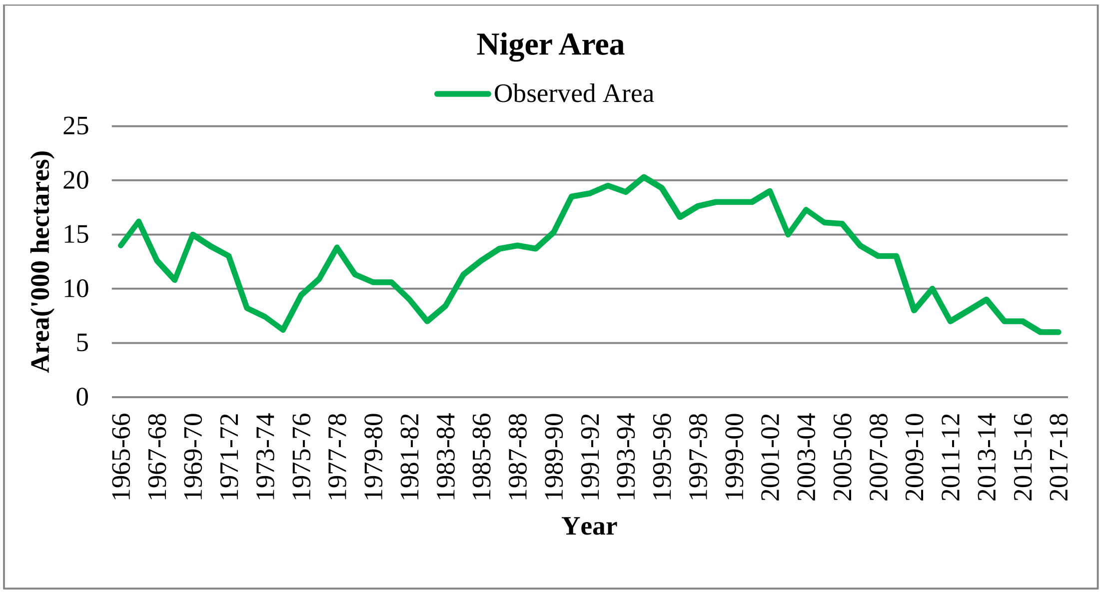


Figure 4.4.Observed Area of Niger in Andhra Pradesh

From the figure 4.4 it was recorder that the average area of niger in Andhra Pradesh in the course of study was 12.90 thousand hectares. Highest area was 20.3 thousand hectares in the year 1994-95 and lowest was 6.00 thousand hectares was observed in the two years 2016-17 and 2017-18.

The results obtained for area of niger by fitting all the models throughout the study period were presented in the Table 4.6.

Table 4.6. Linear, Non-linear and Time series models of Niger Area in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	13.24**	-0.01			0.00	4.20	33.74
Logarithmic	12.52**	0.12			0.00	4.20	33.86
Inverse	12.83**	0.74			0.00	4.20	33.69
Quadratic	7.74**	0.58**	-0.01**		0.30**	3.50	27.52
Cubic	15.47**	-1.05**	0.06**	-0.00**	0.69**	2.33	17.97
Compound	13.02**	0.99**			0.01	4.28	32.23
Power	12.66**	-0.01			0.00	4.28	32.52
S-Curve	2.48**	0.15			0.00	4.27	32.23
Growth	2.56**	-0.00			0.01	4.28	32.23
Exponential	13.02**	-0.00			0.01	4.28	32.23
Time Series Models							
ARIMA (1, 0, 2)					0.78	2.04	14.11
ARIMA (1, 1, 3)					0.78	2.06	14.13
ARIMA (1, 2, 1)					0.74	2.24	15.14
ARIMA (2, 0, 3)					0.79	2.05	14.11
ARIMA (2, 1, 3)					0.79	2.06	12.95
ARIMA (2, 2, 3)					0.74	2.31	14.64
ARIMA (3, 0, 2)					**0.79**	**2.03**	**13.93**
ARIMA (3, 2, 2)					0.74	2.30	14.95

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

From the Table 4.6 it was noted ARIMA (2, 0, 3), ARIMA (2, 1, 3), ARIMA (3, 0, 2) shows highest R^2 i.e., (0.79) but least RMSE (2.03) and MAPE (13.93) has in ARIMA (3, 0, 2). Hence ARIMA (3, 0, 2) was considered for forecasting purpose.

Among the time series models ARIMA (3, 0, 2) was best fitted model based on model selection criteria when compared to model.

4.1.2.2. Niger Production

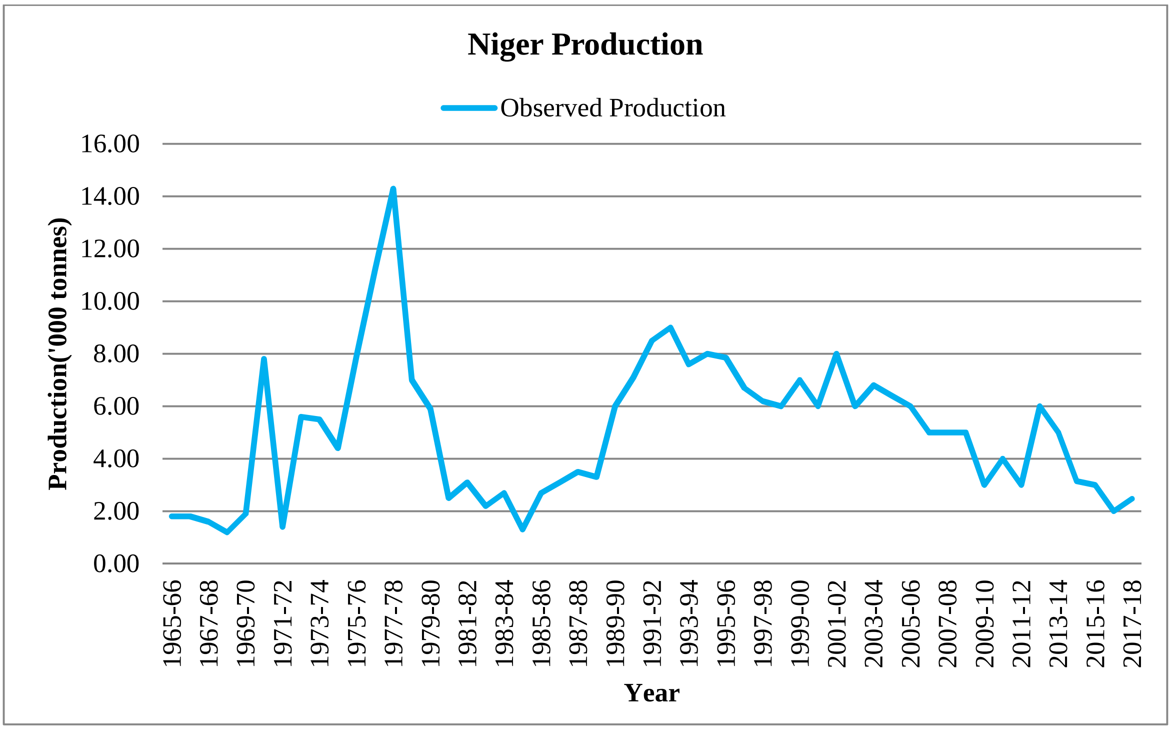


Figure 4.5.Observed Production of Niger in Andhra Pradesh

It was evident from the figure 4.5 that the average production of niger for the study period (1965-66 to 2017-18) was 5.08 thousand tonnes in Andhra Pradesh. It was observed that in decreasing trend from 2012-13 onwards. Maximum production was 14.30 thousand tonnes in the year 1977-78 and minimum was 1.20 thousand tones in the year 1968-69.

The analysis secure for production of niger in the course of study period by fitting linear, non-linear and time series models were presented in Table 4.7.

Table 4.7. Linear, Non-linear and Time series models of Niger Production in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	4.84**	0.00			0.003	2.68	66.19
Logarithmic	3.07*	0.66			0.05	2.6	60.54
Inverse	5.53**	-5.19*			0.09*	2.5	61.02
Quadratic	2.0	0.31**	-0.00**		0.19**	2.4	49.95
Cubic	2.45	0.23	-0.00	-0.00	0.19*	2.41	49.65
Compound	3.53**	1.00**			0.04	2.81	55.41
Power	2.06**	0.24**			0.14**	2.74	50.65
S-Curve	1.60**	-1.53**			0.16**	2.64	52.09
Growth	1.26**	0.00			0.04	2.81	55.41
Exponential	3.53**	0.00			0.04	2.81	55.41
Time Series Models							
ARIMA (1, 0, 2)					0.47	2.05	38.38
ARIMA (1, 1, 3)					0.46	2.08	37.03
ARIMA (2, 0, 2)					0.47	2.07	39.23
ARIMA (2, 1, 2)					0.45	2.10	36.28
ARIMA (2, 2, 1)					0.30	2.33	35.92
ARIMA (3, 1, 3)					0.48	2.09	35.95
ARIMA (3, 2, 2)					0.31	2.36	35.91
ARIMA (3, 0, 1)					**0.49**	**2.02**	**35.90**

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

To select the best model, model selection criteria will be helpful. It is evident from Table 4.7 that the value R^2 (0.49) is higher for ARIMA (3, 0, 1) compared to the other models. The value of RMSE (2.02) and MAPE (35.90) also lower for ARIMA (3, 0, 1) model compared to other models. Thus the ARIMA (3, 0, 1) is seemed to be the best for making forecast with minimum forecast error.

Among all Time series models ARIMA (3, 0, 1) was identified as the best fitted model based on the model selection criteria.

4.1.2.3. Niger Productivity

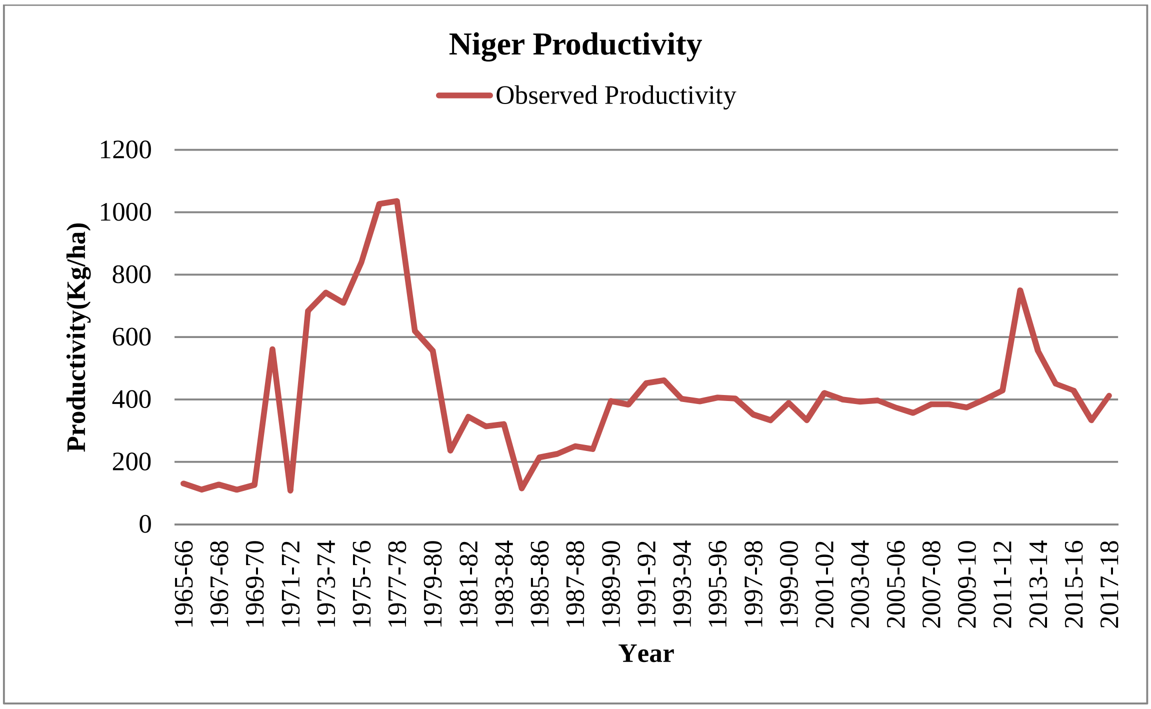


Figure 4.6.Observed Productivity of Niger in Andhra Pradesh

From the figure 4.6 it was obvious that the average productivity of niger for the entire period was 409.56 kg /ha. Maximum productivity was 1036.23 kg/ ha in the year 1977-78 and minimum productivity was 107.69 kg /ha in the year 1971-72.

By fitting all the parametric and ARIMA models the results of productivity of niger in Andhra Pradesh were presented in the Table 4.8.

Table 4.8. Linear, Non-linear and Time series models of Niger Productivity in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	395.44**	0.52			0.00	206.77	53.00
Logarithmic	298.57**	36.69			0.02	204.37	49.58
Inverse	442.90**	-387.68*			0.08*	198.29	47.64
Quadratic	377.26**	2.50	-0.03		0.00	206.63	52.80
Cubic	158.60	48.94*	-2.16*	0.02*	0.13	193.01	49.78
Compound	271.67**	1.01**			0.08*	217.66	39.91
Power	163.23**	0.25**			0.17**	215.81	35.62
S-Curve	6.02**	-1.67**			0.23**	203.48	37.33
Growth	5.60**	0.01*			0.08*	217.66	39.91
Exponential	271.67**	0.01*			0.08*	217.66	39.91
Time Series Models							
ARIMA (1, 0, 3)					0.51	153.32	29.99
ARIMA (1, 1, 3)					0.26	187.36	31.04
ARIMA (2, 0, 3)					**0.68**	**124.04**	**29.79**
ARIMA (2, 1, 3)					0.56	146.28	26.63
ARIMA (3, 0, 0)					0.42	164.61	30.91
ARIMA (3, 0, 1)					0.58	141.49	32.31
ARIMA (3,1 ,3)					0.56	147.37	26.50
ARIMA (3, 1 ,2)					0.27	187.45	30.67

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

It is shown from the above table 4.8 highest R^2 (0.68), minimal RMSE (124.04) and MAPE (29.79) was obtained in ARIMA (2, 0, 3) when compared to the other linear and non-linear models. So ARIMA (2, 0, 3) was chosen to predict the future values of productivity of niger in Andhra Pradesh.

The model verification (or) diagnosed

The ARIMA models verification (or) diagnosed by the Ljung-Box Q statistic. The p-value associated with Q statistics should be large $(p - value > \alpha)$. The results of estimation are reported in the following Table 4.9.

Table 4.9. Estimates of the fitted ARIMA (3, 0, 2), ARIMA (3, 0, 1) and ARIMA (2, 0, 3) models for Niger Area, Production and Productivity respectively.

Niger	Model fit Statistics			Ljung-Box Q (18)	
	R-Square	RMSE	MAPE	Statistic	p-value
Area	0.79	2.03	13.93	13.28	0.426
Production	0.49	2.02	35.90	9.15	0.821
Productivity	0.68	124.04	29.79	13.95	0.377

**,* indicate significant at 1% and 5% level of probability respectively.

Test for randomness of residuals

Table 4.10. Test for randomness of the residuals for fitted models of Niger crop Area, Production and Productivity

Model	Run Test for Residuals			
	Total Cases	No. of Runs	Z- Value	p-value
Area : ARIMA (3, 0, 2)	53	21	1.75	0.07
Production : ARIMA (3, 0, 1)	53	25	0.69	0.48
Productivity: ARIMA (2, 0, 3)	53	22	1.52	0.12

4.1.3. SESAME:

According to FAOSTAT (2020) in 2018 the area under sesame in India was 1730 thousand hectares, production and productivity are 746 thousand $MTha^{-1}$, 431 Kg/ha respectively with 12.40% of world production.

Sesame can survive in a harsh environment, it requires limited fertilizer, water, and litter, because of natural tolerance for diseases and insects there is no need for the use of pesticides in large quantity. Indian people revere sesame and both the oil and seeds are used in traditional cooking methods, religious rituals, Ayurvedic medicine, and topically for skin nourishment.

4.1.3.1. Sesame Area:

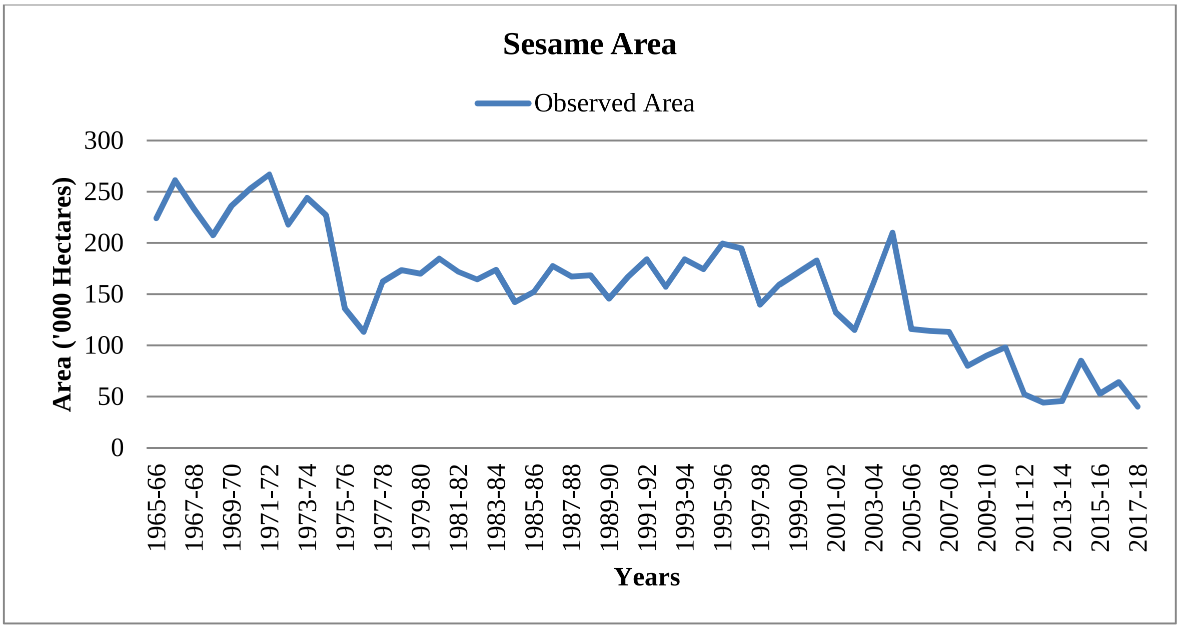


Figure 4.7.Observed Area of Sesame in Andhra Pradesh

From the figure 4.7 it was observed that the average area under sesame in Andhra Pradesh during the study period was 156.61 thousand hectares. It was also showed that the area of sesame has decreased from 224.2 thousand hectares in 1965 to 40 thousand hectares in 2017.

The results obtained for area of sesame by fitting all the linear, non-linear and time series models were presented in Table 4.11.

Table 4.11. Linear, Non-linear and Time series models of Sesame Area in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	240.65**	-3.11**			0.68**	33.02	21.07
Logarithmic	302.73**	-48.30**			0.54**	39.14	29.85
Inverse	141.57**	175.04**			0.21**	51.42	41.86
Quadratic	221.31**	-1.00	-0.03		0.70**	31.99	18.92
Cubic	269.98**	-11.33**	0.43**	-0.00**	0.78**	28.34	17.90
Compound	276.27**	0.97**			0.63**	37.03	22.68
Power	408.35**	-0.34**			0.43**	48.60	31.02
S-Curve	4.86**	1.15**			0.14**	57.91	41.32
Growth	5.62**	-0.02**			0.63**	37.03	22.68
Exponential	276.27**	-0.02**			0.63**	37.03	22.68
Time Series Models							
ARIMA (1,0,3)					0.78	28.20	17.53
ARIMA (1, 1,1)					0.76	29.28	17.67
ARIMA (1, 2, 1)					0.66	34.29	19.79
ARIMA (3, 0, 0)					**0.79**	**27.71**	**17.49**
ARIMA (2, 0, 3)					0.78	29.19	18.71
ARIMA (2, 2, 2)					0.71	32.26	18.76
ARIMA (3, 2, 2)					0.72	31.98	17.83
ARIMA (3, 1, 3)					0.78	29.49	17.91

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **, * indicate significant at 1% and 5% level of probability respectively.

From the above Table 4.11, it was observed that all the models fitted well. In comparison with all the models ARIMA (3, 0, 0) has high R^2 (0.79) and low RMSE (27.71) and MAPE (17.49).Hence ARIMA (3, 0, 0) model was chosen for future forecasts of sesame area.

Among the linear, non-linear models Cubic model identified as the best fitted model by model selection criteria, but ARIMA (3, 0, 0) model was best model when compared to Cubic model.

4.1.3.2. Sesame Production

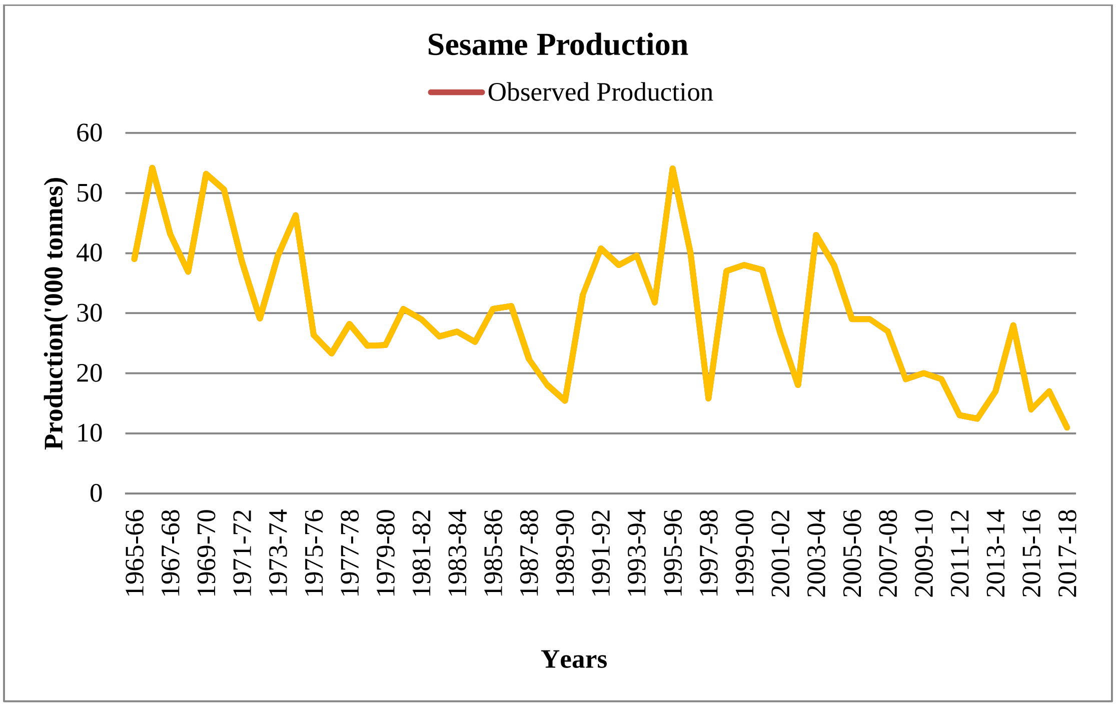


Figure 4.8. Observed Production of Sesame in Andhra Pradesh

From the figure 4.8 it was recorded that the average production of sesame in Andhra Pradesh during the study period (1965-66 to 2017-18) was 30.184 thousand tones. It showed increase in production in the first few years and then decreased in the last years. The production decline from 39 thousand tonnes in 1965-66 to 10.96 thousand tonnes in 2017-18.

The results obtained for production of sesame during the study period by fitting all the models were presented in Table 4.12.

Table 4.12. Linear, Non-linear and Time series models of Sesame Production in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	40.85**	-0.39**			0.29**	9.28	30.05
Logarithmic	50.77**	-6.80**			0.29**	9.29	30.96
Inverse	27.79**	27.83**			0.15**	10.23	34.18
Quadratic	39.83**	-0.28	-0.00		0.29**	9.27	29.71
Cubic	53.81**	-3.25**	0.13**	-0.00**	0.48**	7.98	24.78
Compound	41.91**	0.98**			0.33**	9.43	28.28
Power	57.64**	-0.23**			0.28**	9.63	29.27
S-Curve	3.25**	0.91**			0.13**	10.88	32.50
Growth	3.73**	-0.01**			0.33**	9.43	28.28
Exponential	41.91**	-0.01**			0.33**	9.43	28.28
Time Series Models							
ARIMA (1, 1, 2)					0.50	8.25	23.56
ARIMA (1, 2, 3)					0.39	8.93	24.01
ARIMA (2, 0, 3)					0.58	7.72	22.83
ARIMA (2, 1, 3)					0.51	8.33	23.35
ARIMA (2, 2, 3)					0.37	9.14	24.41
ARIMA (3, 0, 3)					**0.62**	**7.40**	**20.88**
ARIMA (3, 1, 2)					0.51	8.34	23.33
ARIMA (3, 2, 3)					0.39	9.10	24.09

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

From the above Table 4.12 ARIMA (3, 0, 3) was obtained best fitted model with highest R^2 (0.62), least RMSE (7.40) and MAPE (20.88) in correspondence with the other models. Thus ARIMA (3, 0, 3) was employ to forecasts the production of sesame in subsequent years.

4.1.3.3. Sesame Productivity

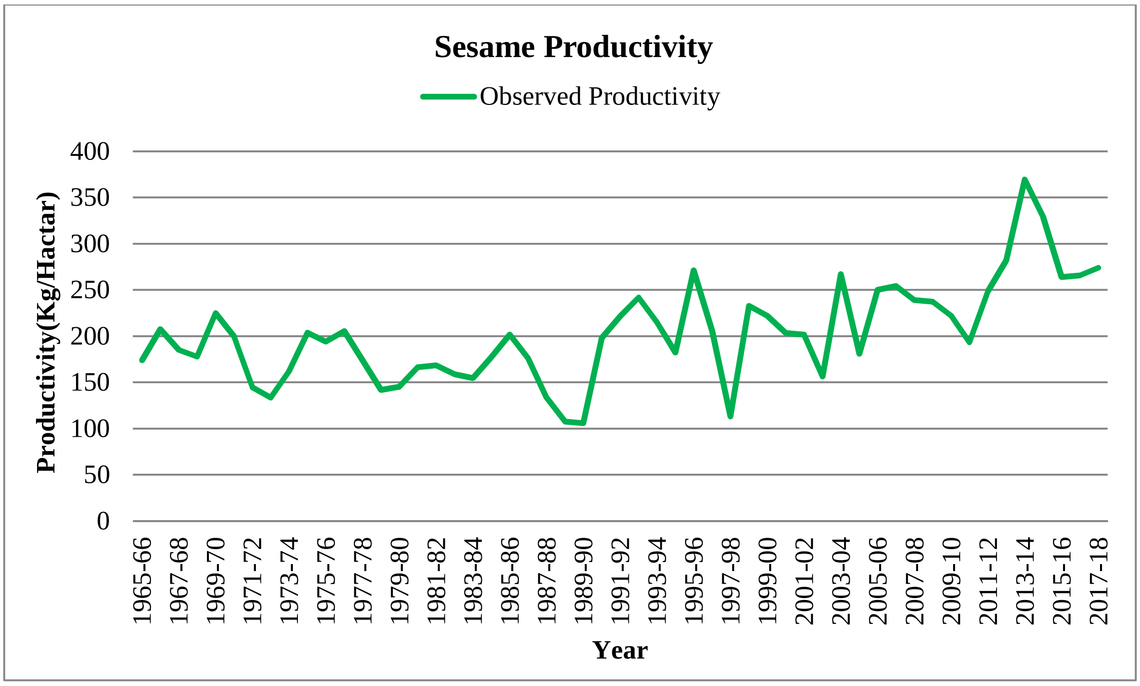


Figure 4.9. Observed Productivity of Sesame in Andhra Pradesh

From the figure 4.9, it revealed that the 203.17 Kg/ha is the average productivity of sesame for the entire period study 1965-66 to 2017-18.The data on productivity of sesame in Andhra Pradesh during the study plan exhibits an increasing trend. The maximum productivity was 274 kg/ha in the year 2017-18 and minimum was 173.95 kg/ha in 1965-66.

The results appeared for productivity of sesame during the study work by fitting all the models were presented in the Table 4.13.

Table 4.13. Linear, Non-linear and Time series models for Productivity of Sesame crop in Andhra Pradesh.

	Parameter				**Criteria**		
Model	**a**	**b**	**c**	**d**	**R2**	**RMSE**	**MAPE**
Linear	146.74**	2.09**			0.37**	41.99	17.95
Logarithmic	128.54**	24.66**			0.17**	48.05	21.13
Inverse	208.20**	-58.59			0.03	52.01	21.95
Quadratic	195.06**	-3.18*	0.09**		0.52**	38.69	15.60
Cubic	200.82**	-4.40	0.15	-0.00	0.52**	38.64	15.59
Compound	151.71**	1.01**			0.31**	41.49	17.44
Power	141.16**	0.10**			0.14	48.03	20.33
S-Curve	5.30**	-0.23			0.02**	52.44	21.17
Growth	5.02**	0.01**			0.31**	41.49	17.44
Exponential	151.71**	0.01**			0.31**	41.49	17.44
Time Series Models							
ARIMA (1, 0, 1)					0.47	39.70	16.20
ARIMA (1, 1, 2)					0.53	38.22	14.77
ARIMA (1, 2, 1)					0.25	48.40	19.17
ARIMA (2, 1, 3)					0.52	39.60	15.36
ARIMA (3, 0, 3)					0.54	38.87	15.48
ARIMA (3, 1, 1)					**0.55**	**37.84**	**14.34**
ARIMA (3, 2, 1)					0.30	47.65	18.46
ARIMA (2, 2, 3)					0.32	47.67	18.29

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **, * indicate significant at 1% and 5% level of probability respectively.

Based on model selection criteria out of all the models ARIMA (3, 1, 1) model was noted to be best fit because of highest R^2 (0.55), minimum RMSE (37.84) and MAPE (14.34). Therefore, ARIMA (3, 1, 1) was taken to predict the future values of sesame productivity in Andhra Pradesh.

The model verification (or) diagnosed

The ARIMA models verification (or) diagnosed by the Ljung-Box Q statistic. The p-value associated with Q statistics should be large $(p - value > \alpha)$. The results of estimation are reported in the following Table 4.14.

Table 4.14. Estimates of the fitted ARIMA (3, 0, 0), ARIMA (3, 0, 3) and ARIMA (3, 1, 1) models for Sesame Area, Production and Productivity respectively.

Sesame	**Model fit Statistics**			**Ljung-Box Q (18)**	
	R-Square	RMSE	MAPE	Statistic	p-value
Area	0.79	27.711	17.48	6.95	0.95
Production	0.62	7.40	20.87	14.95	0.24
Productivity	0.55	37.842	14.34	22.57	0.06

**,* indicate significant at 1% and 5% level of probability respectively.

Test for randomness of residuals

4.15. Test for randomness of the residuals for fitted models of Sesame crop Area, Production and Productivity

Model	**Run Test for Residuals**			
	Total Cases	No. of Runs	Z- Value	p-value
Area : ARIMA (3, 0, 0)	53	31	0.97	0.33
Production : ARIMA (3, 0, 3)	53	30	0.69	0.48
Productivity: ARIMA (3, 1, 1)	53	21	0.96	0.33

4.1.4. CASTOR:

Castor is cultivated all over the world because of its non-edible nature with wide lucrative use. India is the biggest exporter of castor seed. Solvent Extractors Association (SEA) conducts castor crop survey for crop estimation in major growing states like Gujarat, Rajasthan, Andhra Pradesh and Telangana. According to the castor crop survey conducted by the Solvent Extractors Association (SEA) total area under castor in India for the year 2018-19 is estimated to be 769570 hectares. Average yield for year 2018-19 is estimated slightly down, -12.6% to 1520 Kg/ha compared to 1740 Kg/ha, the total production in India in 2018-19 is estimated to be down by 20% to 11.26 lakh tonnes in 2018- 19 from 14.16 lakh tonnes, estimated in 2017-18.

4.1.4.1. Castor Area

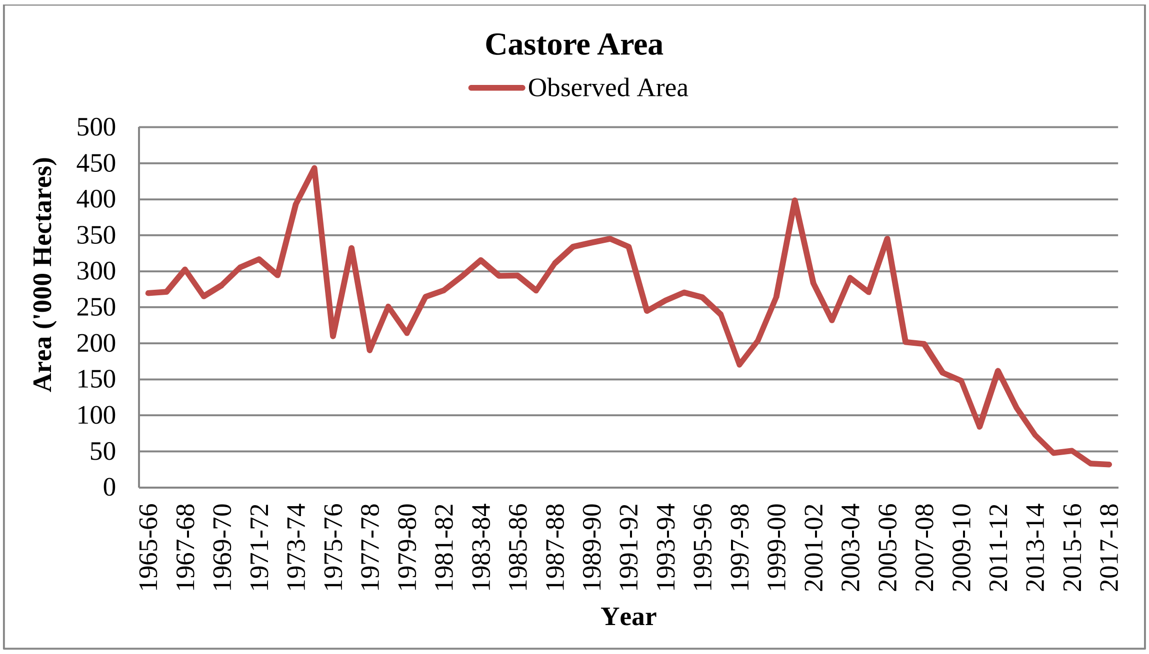


Figure 4.10. Observed Area of Castor in Andhra Pradesh

From the figure 4.10, it was set out that in Andhra Pradesh the average area of castor over the study period (1965-66 to 2017-18) was 246.28 thousand hectares, with maximum and minimum area 443.50 thousand hectares (1974-75), 32.00 thousand hectares (2017-18) respectively. There is decreasing fashion in area of castor from 2012-13.

The results analyzed for area of castor across the study data by fitting all parametric and ARIMA were displayed in Table 4.16.

Table 4.16. Linear, Non-linear and Time series models of Castor Area in Andhra Pradesh

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	352.71**	-3.94**			0.41**	71.03	42.36
Logarithmic	388.45**	-46.99**			0.20**	83.39	56.78
Inverse	237.08**	107.04			0.03	91.73	66.07
Quadratic	248.75**	7.39**	-0.21**		0.64**	55.82	21.93
Cubic	306.89**	-4.94	0.35	-0.00	0.67**	52.26	18.40
Compound	433.39**	0.97**			0.43**	86.81	40.89
Power	540.82**	-0.30**			0.20**	97.98	52.48
S-Curve	5.31**	0.73			0.03	98.02	61.38
Growth	6.07**	-0.02**			0.43**	86.81	40.89
Exponential	433.39**	-0.02**			0.43**	86.81	40.89
Time Series Models							
ARIMA (1, 0, 2)					0.63	59.05	24.04
ARIMA (1, 1, 1)					0.66	56.55	19.32
ARIMA (2, 0, 2)					0.64	59.38	23.82
ARIMA (2, 1, 2)					**0.68**	**52.15**	**18.36**
ARIMA (2, 2, 1)					0.59	63.51	21.10
ARIMA (3, 0, 3)					0.64	59.96	23.45
ARIMA (3, 1, 2)					0.67	57.09	18.37
ARIMA (3, 2, 2)					0.63	61.83	19.03

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively.

Above Table 4.16, from among all the models ARIMA (2, 1, 2) disclose that it has highest R^2 (0.68), smallest RMSE (52.16) and MAPE (18.36) with respect to selection criteria. Hench forth ARIMA (2, 1, 2) is relevant for forecasting purpose.

Even though Cubic model was best fitted model in time series models but it is less reasoned when ARIMA (2, 1, 2) is taken into consideration based on model selection criteria.

4.1.4.2. Castor Production

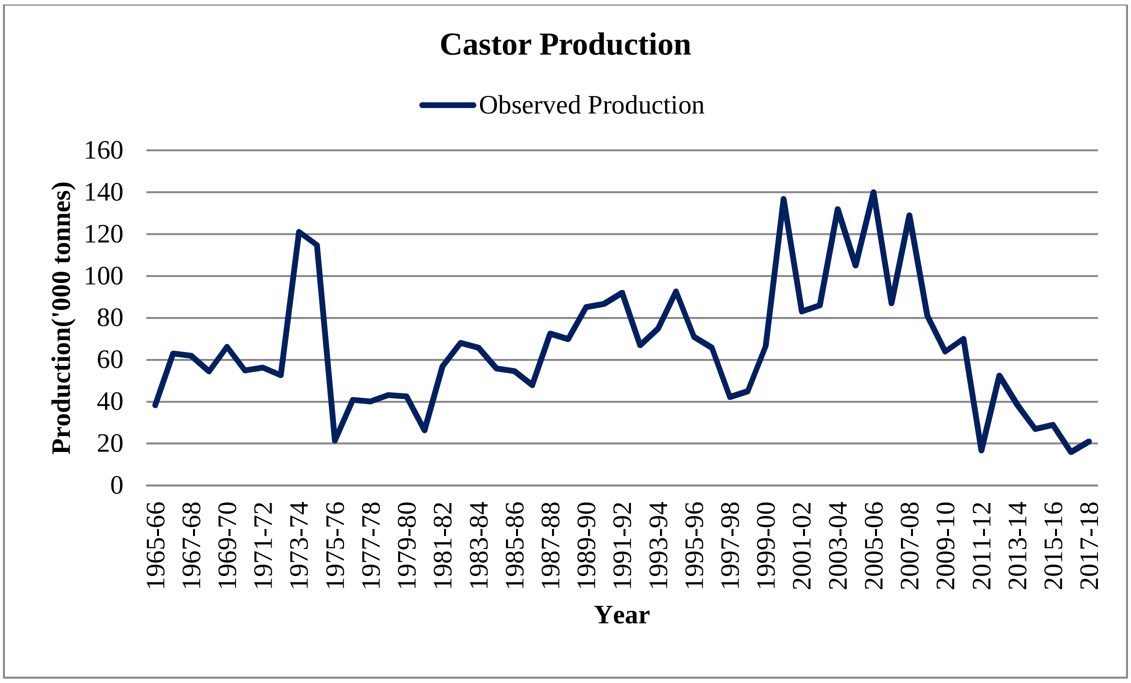


Figure 4.11. Observed Production of Castor in Andhra Pradesh

It is discernible from the figure 4.11 that 65.90 thousand tonnes was the mean production of castor for the study period (1965-66 to 2017-18) in Andhra Pradesh. It was noticeable that the was increasing and decreasing range in the production. Maximum production 140 thousand hectares in the year 2005-06 and minimum production 16 thousand hectares in the year 2016-17.

The results derived from linear, non-linear and ARIMA models were bestowed in the following Table 4.17.

Table 4.17. Linear, Non-linear and Time series models of Castor Production in Andhra Pradesh.

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	62.80**	0.11			0.00	30.41	51.30
Logarithmic	52.31**	4.49			0.01	30.20	51.20
Inverse	68.37**	-28.68			0.02	30.14	50.68
Quadratic	36.52**	2.98**	-0.05**		0.13*	28.31	44.85
Cubic	78.90**	-6.01*	0.36**	-0.00**	0.40**	25.43	33.90
Compound	62.37**	0.99**			0.00	31.51	45.69
Power	55.38**	0.01			0.00	31.21	46.05
S-Curve	4.09**	-0.30			0.00	31.06	45.88
Growth	4.13**	-0.00			0.00	31.51	45.69
Exponential	62.37**	-0.00			0.00	31.51	45.69
Time Series Models							
ARIMA (1, 0 ,2)					0.31	26.44	38.69
ARIMA (1, 1, 2)					0.33	26.10	35.29
ARIMA (2, 0, 3)					0.37	25.82	35.59
ARIMA (2, 1, 3)					0.39	25.53	36.03
ARIMA (2, 2, 3)					0.28	28.04	36.39
ARIMA (3, 0, 3)					**0.40**	**25.00**	**33.74**
ARIMA (3, 1, 2)					0.38	25.78	33.28
ARIMA (3, 2, 3)					0.31	27.78	35.95

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **,* indicate significant at 1% and 5% level of probability respectively

To pick the foremost model, model selection criteria will be aid .It is perceptible from the Table 4.17, that the value of R^2 (0.40) is higher for ARIMA (3, 0, 3) when compare to the other models. The value of RMSE (25.00) and MAPE (33.74) also lower as well for ARIMA (3, 0, 3). Whence ARIMA (3, 0, 3) was reckon to be appropriate to evaluate the future values of production of castor crop in Andhra Pradesh.

4.1.4.3. Castor Productivity

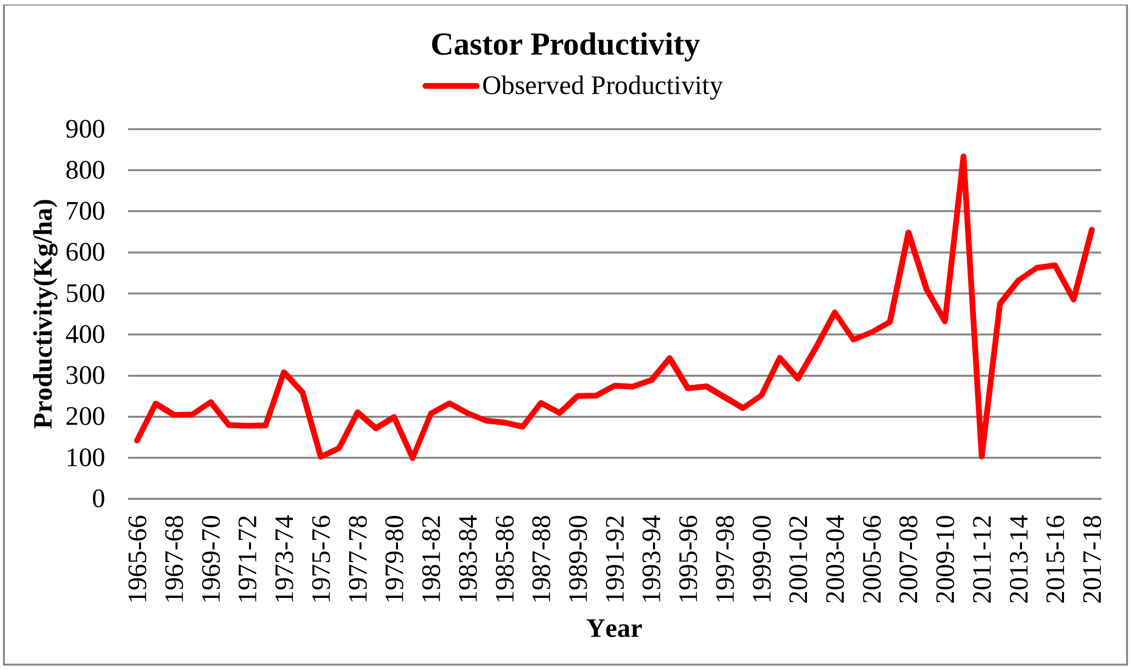


Figure 4.12. Observed Productivity of Castor in Andhra Pradesh

From the figure 4.12 the average productivity of castor crop considered to be 303.85 Kg/ha for the entire period 833.33 Kg/ha, 99.51 Kg/ha were the maximum and minimum productivity during the interlude 2010-11 and 1980-81 respectively. Though the area and production showed declining trend but productivity is on increasing trend.

The results acquire for the productivity of castor for the study period by fitting all the models were presented in Table 4.18.

Table 4.18. Linear, Non-linear and Time series models of Castor Productivity in Andhra Pradesh.

	Parameter				Criteria		
Model	**a**	**b**	**c**	**d**	**R^2**	**RMSE**	**MAPE**
Linear	95.67**	7.71**			0.56**	102.68	31.22
Logarithmic	-6.08	102.45			0.33**	127.44	42.25
Inverse	330.59**	-311.04*			0.09*	148.99	47.64
Quadratic	211.20**	-4.89	0.23**		0.66**	90.33	23.11
Cubic	**228.21****	**-8.50**	**0.39**	**-0.00**	**0.66****	**90.15**	**23.04**
Compound	143.92**	1.02**			0.54**	99.45	25.25
Power	102.40**	0.32**			0.34**	125.98	33.88
S-Curve	5.68**	-1.03*			0.10*	151.61	38.51
Growth	4.96**	0.02**			0.54**	99.45	25.25
Exponential	143.92**	0.02**			0.54**	99.45	25.25
Time Series Models							
ARIMA (1, 0, 3)					0.62	101.76	26.73
ARIMA (1, 1, 3)					0.64	98.49	25.35
ARIMA (2, 0, 2)					0.64	98.99	26.09
ARIMA (2, 1, 2)					0.64	98.64	25.31
ARIMA (2, 2, 3)					0.52	117.20	33.01
ARIMA (3, 0, 3)					0.67	97.34	26.12
ARIMA (3, 1, 2)					0.64	100.76	25.85
ARIMA (3, 2, 3)					0.45	126.46	35.63

1. *Source: Secondary data collected from Ministry of Agriculture, Govt of India, EPWRF and www.indiastat.com*

2. The value of the criterion for a model with bold numerals shows that the model is better than the other models with respect to that criterion.

3. **, * indicate significant at 1% and 5% level of probability respectively

Forecasted Cubic model is *Productivity* $\hat{Y}_{Productivity}$ = 228.21-8.50t +0.399t^2-0.002t^3

It is perceive from the Table 4.18, the cubic model is pertinent when compared with other growth models as it has highest R^2 (0.66), lowest RMSE (90.15) and MAPE

(23.04). Thus cubic model is taken as best fitted model to forecast the future values of productivity of castor in Andhra Pradesh.

The model verification (or) diagnosed

The ARIMA models verification (or) diagnosed by the Ljung-Box Q statistic. The p-value associated with Q statistics should be large $(p-value > \alpha)$. The results of estimation are reported in the following Table 4.19.

Table 4.19. Estimates of the fitted ARIMA (2, 1, 2), ARIMA (3, 0, 3), Cubic models for Castor Area, Production and Productivity respectively.

Castor	**Model fit Statistics**			**Ljung-Box Q (18)**	
	R-Square	RMSE	MAPE	Statistic	p-value
Area	0.68	52.15	18.36	8.17	0.88
Production	0.40	25.00	33.74	7.01	0.85
Productivity	0.66	90.15	23.04	24.36**	0.00

****, * indicate significant at 1% and 5% level of probability respectively**

Test for randomness of residuals

Table 4.20. Test for randomness of the residuals for fitted models of Castor crop Area, Production and Productivity

Model	**Run Test for Residuals**			
	Total Cases	**No. of Runs**	**Z- Value**	**p-value**
Area : ARIMA (2, 1, 2)	53	22	1.52	0.12
Production : ARIMA (3, 0, 3)	53	27	0.13	0.89
Productivity: Cubic model	53	26	0.41	0.67

4.2. FORECASTING OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED OILSEEDS IN ANDHRA PRADESH BY USING BEST FITTED MODEL

In this section, based upon model selection criteria viz., R^2, RMSE and MAPE the best fitted model was chosen for future forecasts up to 2022-23 AD of area, production and productivity of selected oilseeds in Andhra Pradesh were presented. The forecasts were presented crop wise as follows.

4.2.1. Groundnut

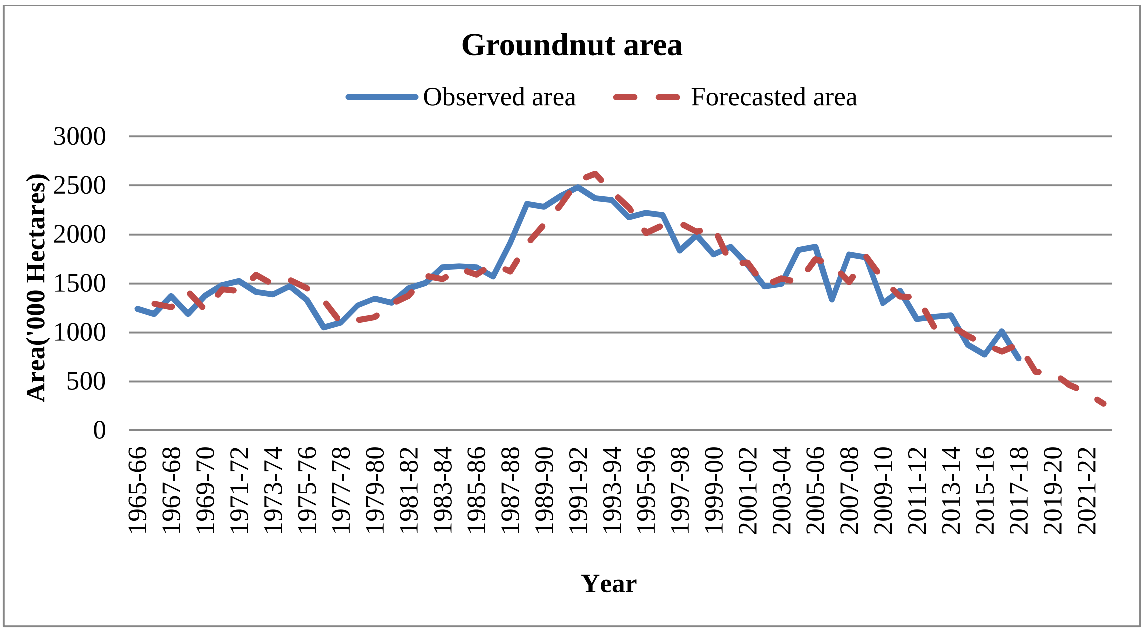
The future forecasts of area, production and productivity of groundnut by 2022-23 AD were calculated based on the best identified fitted model in linear, non-linear models and time series models and the results were presented as follows.

With the help of the knowledge on criteria selection i.e., highest R^2, minimal RMSE and MAPE, ARIMA (3, 1, 3) model was used to forecast the area for future years of groundnut in Andhra Pradesh. The forecasted area of groundnut by 2022-23 AD would be 274.7 thousand hectares which showed decreasing trend from the study period. Based up on the best analyzed model ARIMA (3, 1, 3) the area of groundnut was forecasted and tabulated in the Table 4.21.

Table 4.21. Forecasted values of Groundnut Area by ARIMA (3, 1, 3)

Year	Forecasted Area ('000 hectares)
2018-19	598.60
2019-20	597.20
2020-21	464.00
2021-22	388.00
2022-23	274.70

Figure 4.13. Observed and Forecasted Trends of Groundnut Area in Andhra Pradesh (1965-66 to 2022-23)

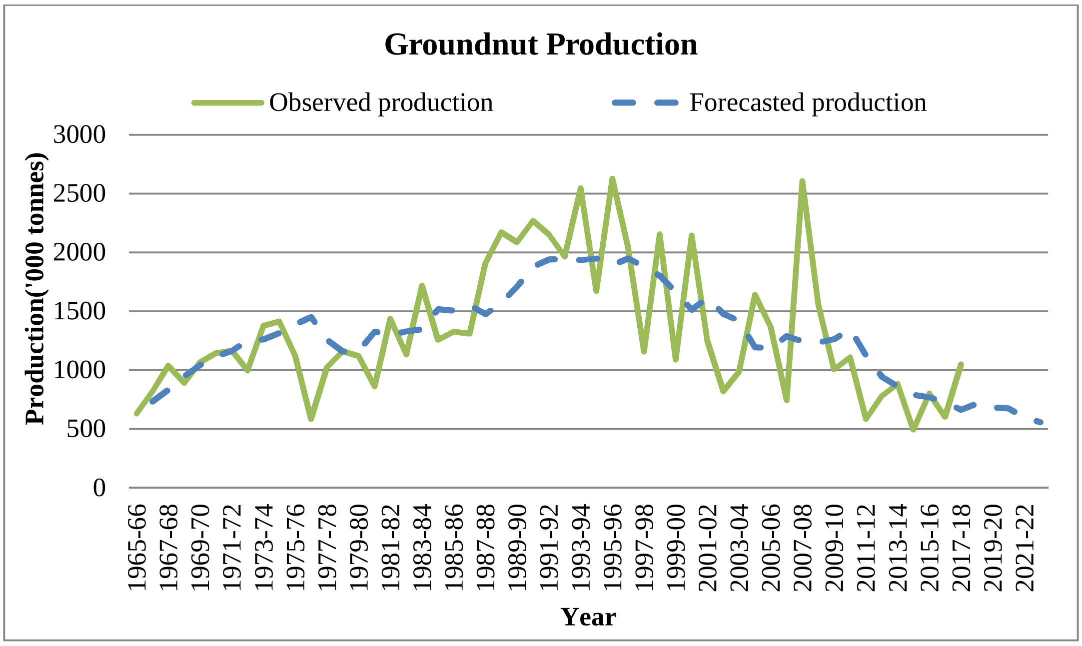


For the production also ARIMA (3, 1, 1) model was taken as the best fitted model for future prediction by 2022-23 AD as it has highest R^2 and least RMSE and MAPE values. By using this model the forecasted production would be 558.1 thousand tonnes which showed a decreasing trend by 2022-23 AD. The forecasted production of groundnut is presented in the Table 4.22 based on ARIMA (3, 1, 1) model.

Table 4.22. Forecasted values of Groundnut Production by ARIMA (3, 1, 1)

Year	Forecasted Production ('000 tonnes)
2018-19	714.40
2019-20	684.12
2020-21	675.00
2021-22	595.60
2022-23	558.03

Figure 4.14. Observed and Forecasted Trends of Groundnut Production in Andhra Pradesh (1965-66 to 2022-23)



Among all linear, non-linear and time series models productivity of groundnut was forecasted by using cubic model which had exhibited highest R^2, least RMSE and MAPE values. By applying this model, the predicted productivity would be 999.13 kg/ha which shows an increasing trend by 2022-23 AD. With the help of best suited model, the forecasted productivity of groundnut is tabulated in the below Table 4.23.

Table 4.23. Forecasted values of Groundnut Productivity by Cubic model

Year	Forecasted Productivity (Kg/ha)
2018-19	903.83
2019-20	924.11
2020-21	946.70
2021-22	971.67
2022-23	999.13

Figure 4.15. **Observed and Forecasted Trends of Groundnut Productivity in Andhra Pradesh (1965-66 to 2022-23)**

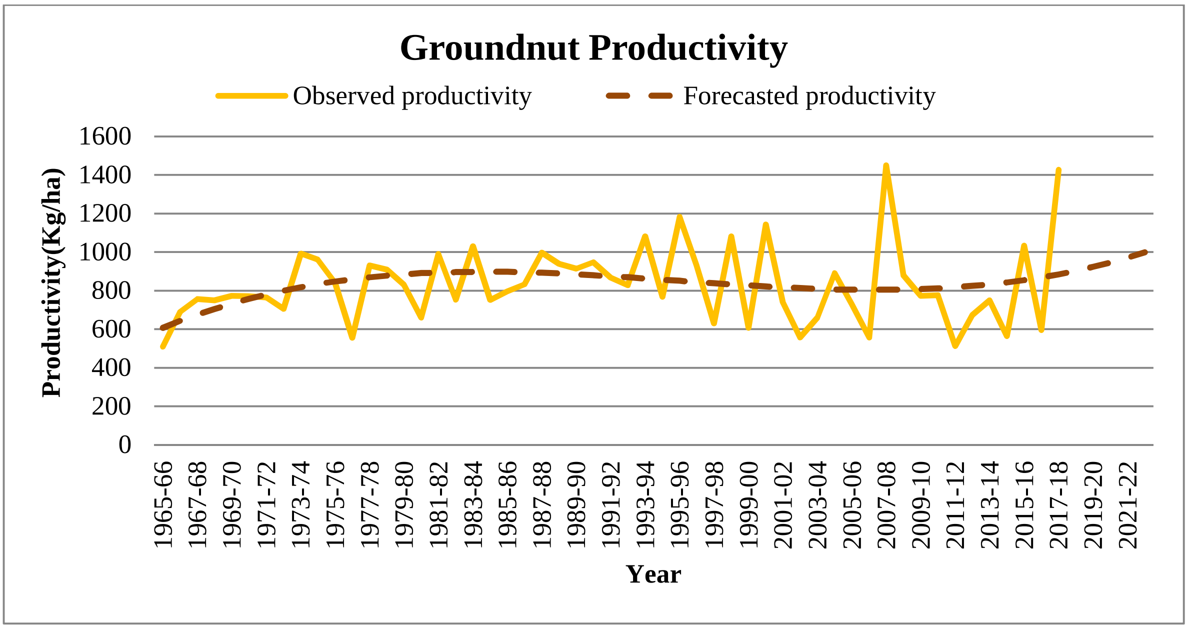
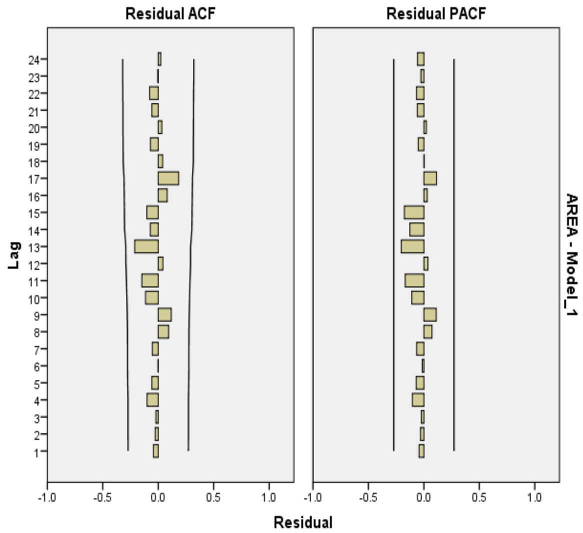
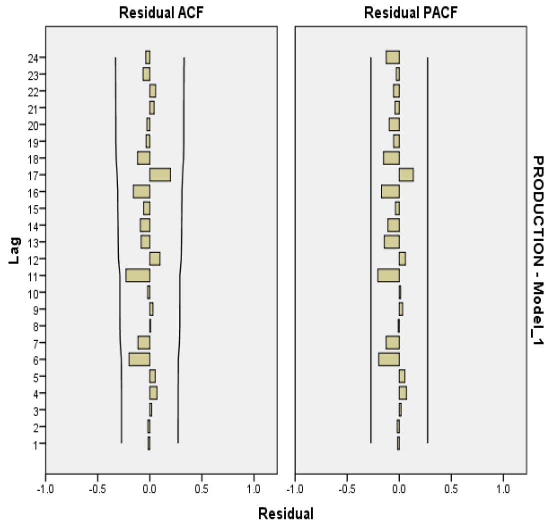


Figure 4.16. The ACF and PACF of residuals of fitted ARIMA (3, 1, 3) and ARIMA (3, 1, 1) models for Groundnut area and production

Groundnut area



Groundnut production



4.2.2. Niger

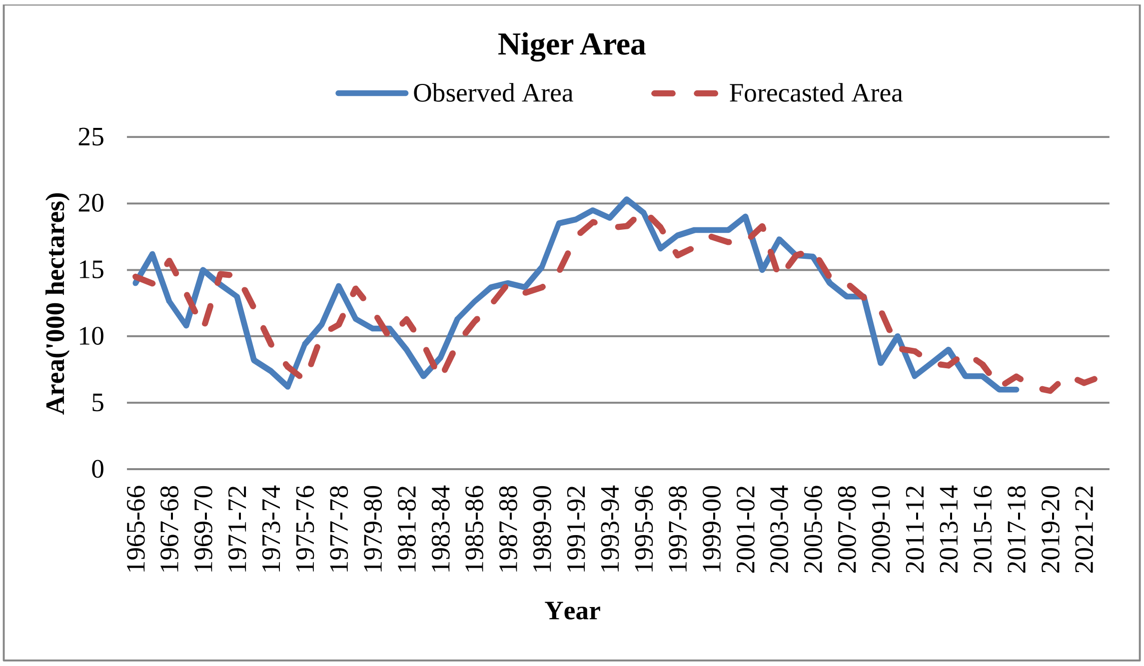
The future forecasts of area, production and productivity of niger by 2022-23 AD were analyzed based on the most appropriate fitted models and the results are presented as follows.

ARIMA (3, 0, 2) model is the best identified model to predict the area of niger in Andhra Pradesh because of highest R^2 and minimum RMSE and MAPE. The forecasted values depict slightly increasing trend by 2022-23 AD. By 2022-23 AD the area would be 7 thousand hectares. With respect to the fitted model ARIMA (3, 0, 2) the estimated values are compile in the Table 4.24.

Table 4.24. Forecasted values of Niger Area by ARIMA (3, 0, 2)

Year	Forecasted Area ('000 hectares)
2018-19	6.24
2019-20	6.00
2020-21	7.16
2021-22	6.50
2022-23	7.00

Figure 4.17. Observed and Forecasted Trends of Niger Area in Andhra Pradesh (1965-66 to 2022-23)

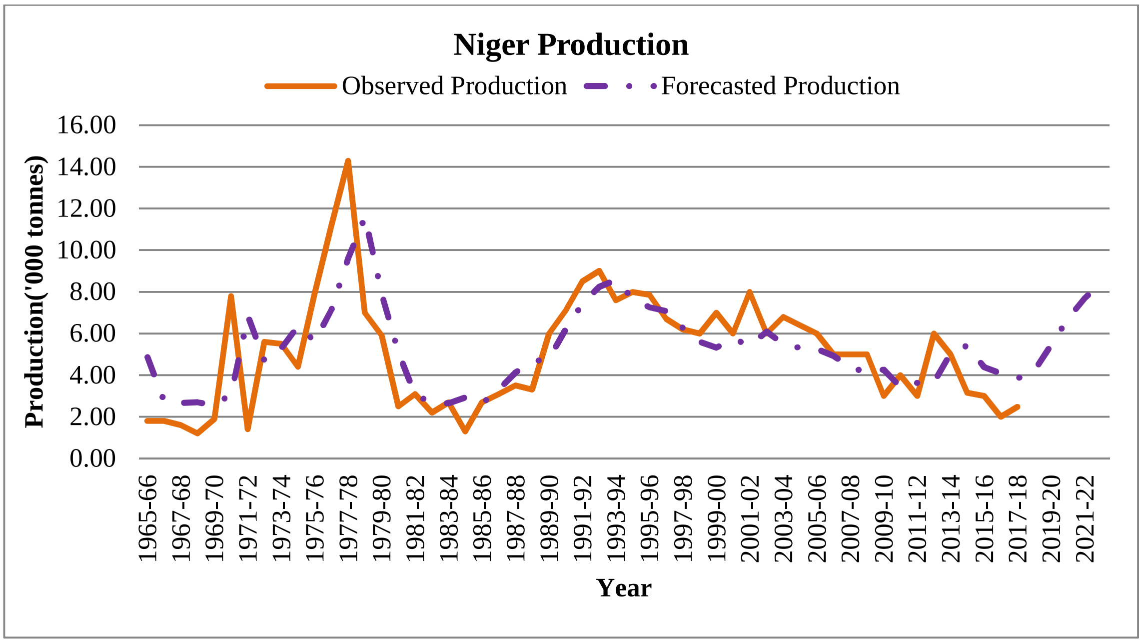


As for production ARIMA (3, 0, 1) is apt for forecasting the succeeding values, since this model have highest R^2, minimal RMSE and MAPE values. Mean while by 2022-23 AD the production set forth increasing trend 8.41 thousand tonnes as the area exhibits slight increasing trend. The forecasted values of niger production arranged in the below Table 4.25 based on ARIMA (3, 0, 1) model.

Table 4.25. Forecasted values of Niger Production by ARIMA (3, 0, 1)

Year	Forecasted Production ('000 tonnes)
2018-19	4.25
2019-20	5.47
2020-21	6.71
2021-22	7.69
2022-23	8.41

Figure 4.18. Observed and Forecasted Trends of Niger Production in Andhra Pradesh (1965-66 to 2022-23)



The productivity of niger in Andhra Pradesh outline slight increasing trend of 375.50 Kg/ha by 2022-23 AD. The estimated values are blag from best fitted model i.e., ARIMA (2, 0, 3), as this model relate highest R^2, lowest RMSE and MAPE criteria's. Table 4.26 showing the forecasted values is presented below

Table 4.26. Forecasted values of Niger Productivity by ARIMA (2, 0, 3)

Year	Forecasted Productivity (Kg/ha)
2018-19	345.01
2019-20	349.32
2020-21	349.85
2021-22	358.39
2022-23	375.05

Figure 4.19. Observed and Forecasted Trends of Niger Productivity in Andhra Pradesh (1965-66 to 2022-23)

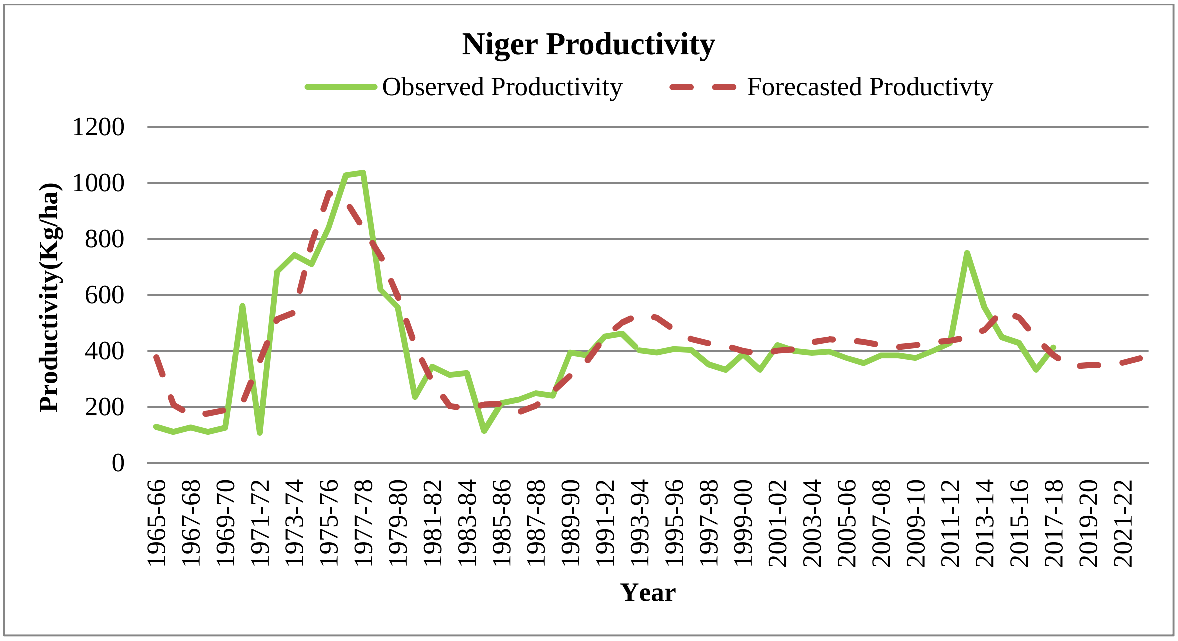
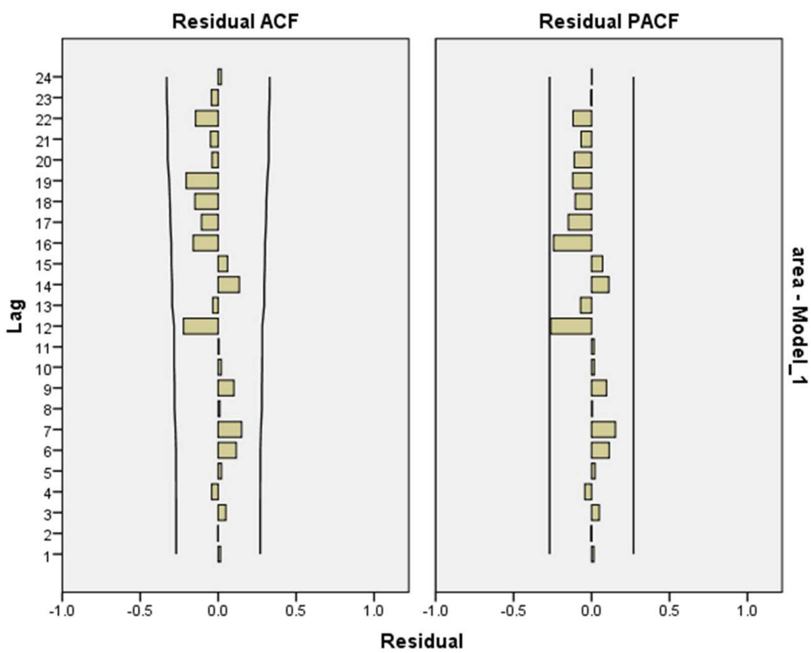
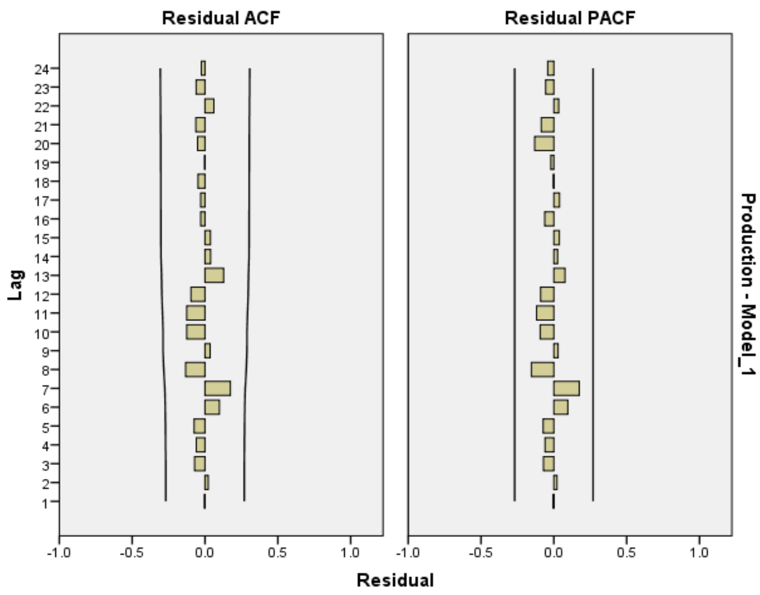


Figure 4.20. The ACF and PACF of residuals of fitted ARIMA (3, 0, 2), ARIMA (3, 0, 1) and ARIMA (2, 0, 3) models for Niger area, production and productivity.

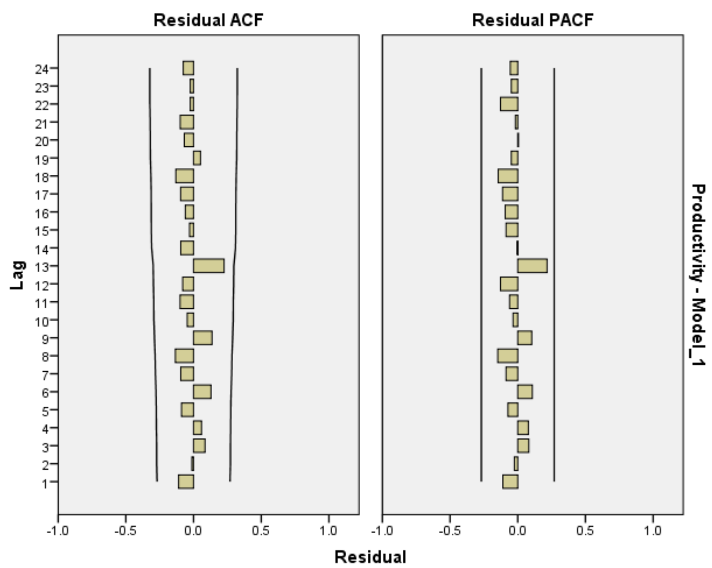
Niger area



Niger Productivity



Niger Productivity



4.2.3. Sesame

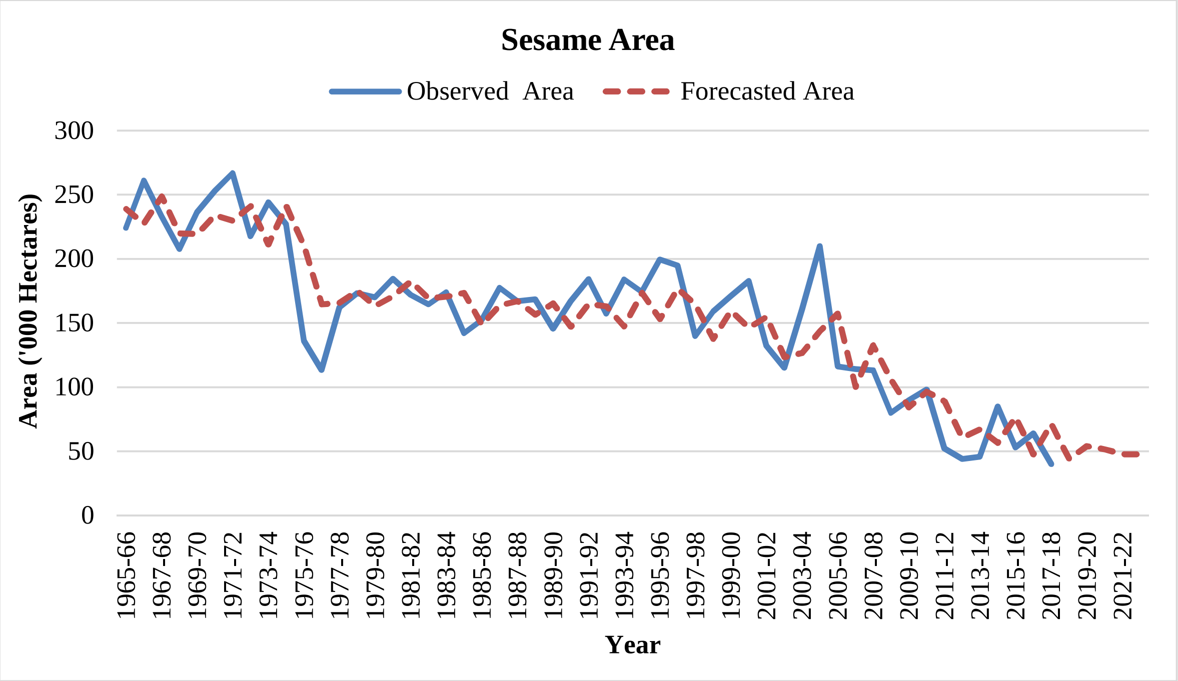
Based on the best fitted model area of sesame in Andhra Pradesh was forecasted. On the best identified model in linear, non-linear models and time series models the sesame area was forecasted and tabulated in the Table 4.27.

ARIMA (3, 0, 0) was selected on the basis of highest R^2, least RMSE and MAPE criteria's and was the best fitted model in ARIMA time series. In present study area of sesame was forecasted for 5 years from 2018-19 to 2022-23 AD. The forecasted area is expected to be 47.72 thousand hectares which resulted a fluctuating trend by 2022-23 AD.

Table 4.27. Forecasted values of Sesame Area by ARIMA (3, 0, 0)

Year	Forecasted Area ('000 hectares)
2018-19	44.23
2019-20	54.19
2020-21	51.66
2021-22	47.87
2022-23	47.72

Figure 4.21. Observed and Forecasted Trends of Sesame Area in Andhra Pradesh (1965-66 to 2022-23)

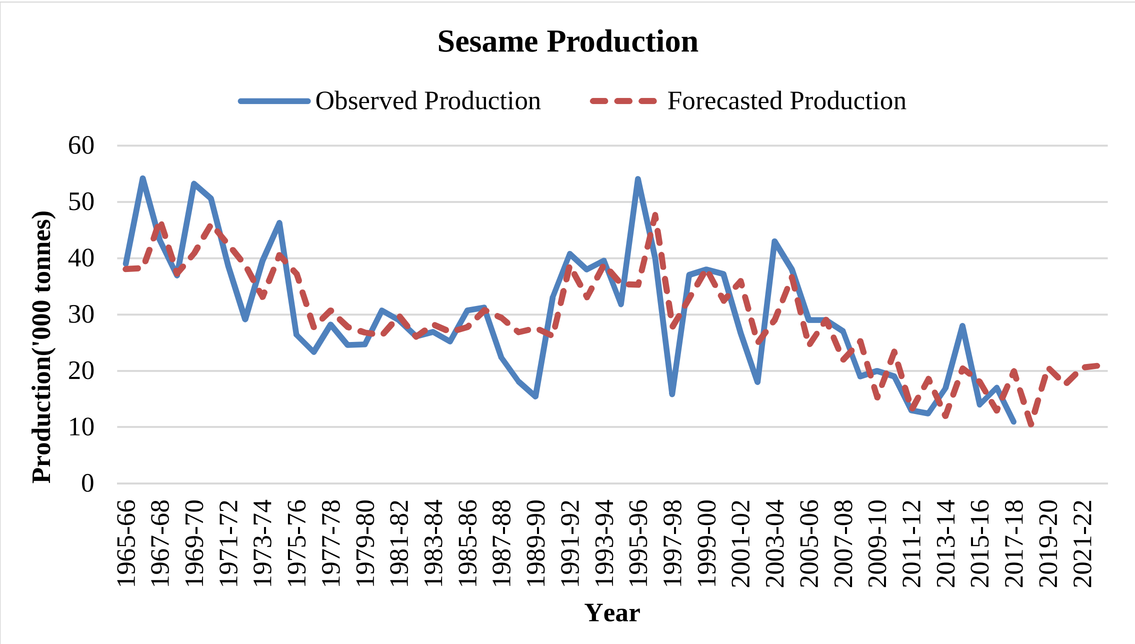


Regarding the production of sesame ARIMA (3, 0, 3) was analyzed as the best fitted model for future forecasts by 2022-23 AD as it has highest R^2, minimum RMSE and MAPE values. ARIMA (3, 0, 3) model forecasted production would be 20.95 thousand tonnes in 2022-23 AD, results a fluctuating trend in production. Based on the best identified fitted model the sesame production was forecasted and tabulated in the Table 4.28.

Table 4.28. Forecasted values of Sesame Production by ARIMA (3, 0, 3)

Year	Forecasted Production ('000 tonnes)
2018-19	10.50
2019-20	20.63
2020-21	17.64
2021-22	20.58
2022-23	20.95

Figure 4.22. Observed and Forecasted Sesame Trends of Production in Andhra Pradesh (1965-66 to 2022-23)



Productivity of sesame in Andhra Pradesh was forecasted by ARIMA (3, 1, 1) which exhibited highest R^2, lowest RMSE and MAPE. The forecasted value shows an increasing trend with 330.61 Kg/ha by 2022-23 AD. Based on the best related fitted model the sesame productivity was forecasted and tabulated in the Table 4.29.

Table 4.29. Forecasted values of Sesame productivity by ARIMA (3, 1, 1)

Year	Forecasted Productivity (Kg/ha)
2018-19	304.86
2019-20	318.67
2020-21	323.43
2021-22	325.29
2022-23	330.61

Figure 4.23. Observed and Forecasted Trends of Sesame Productivity in Andhra Pradesh (1965-66 to 2022-23)

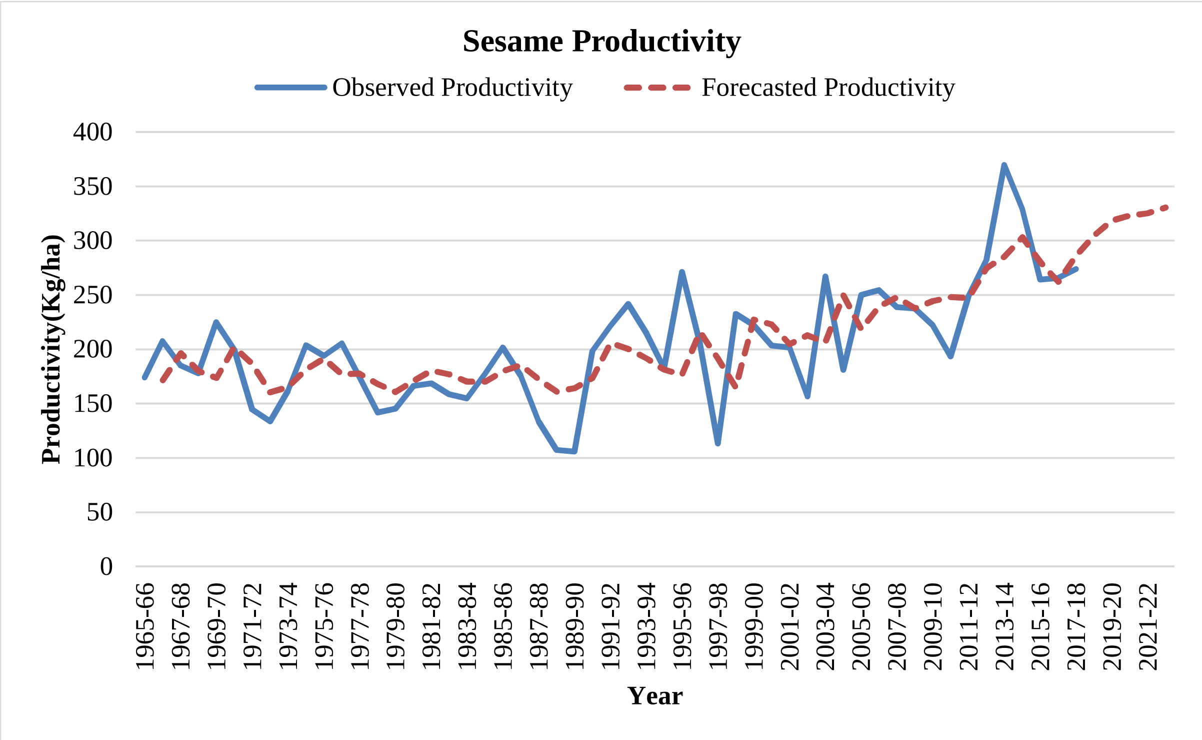
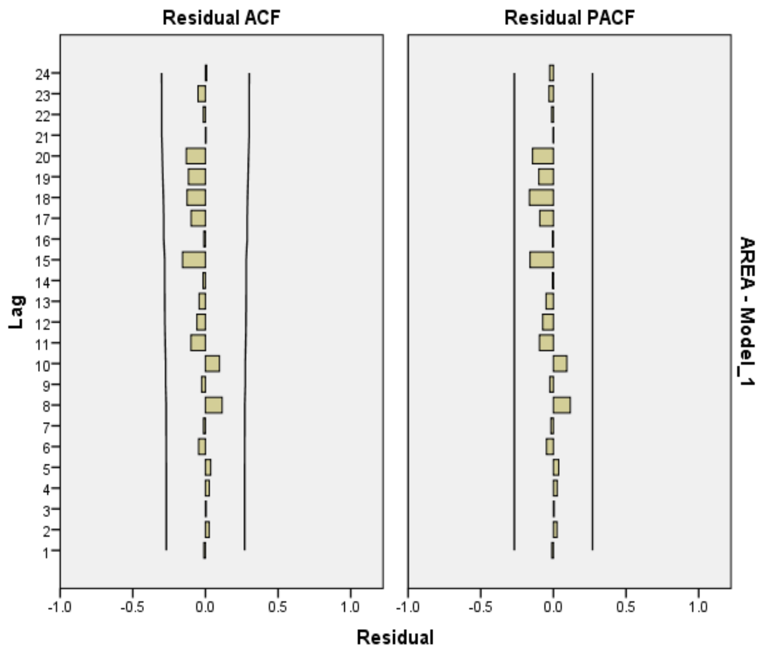
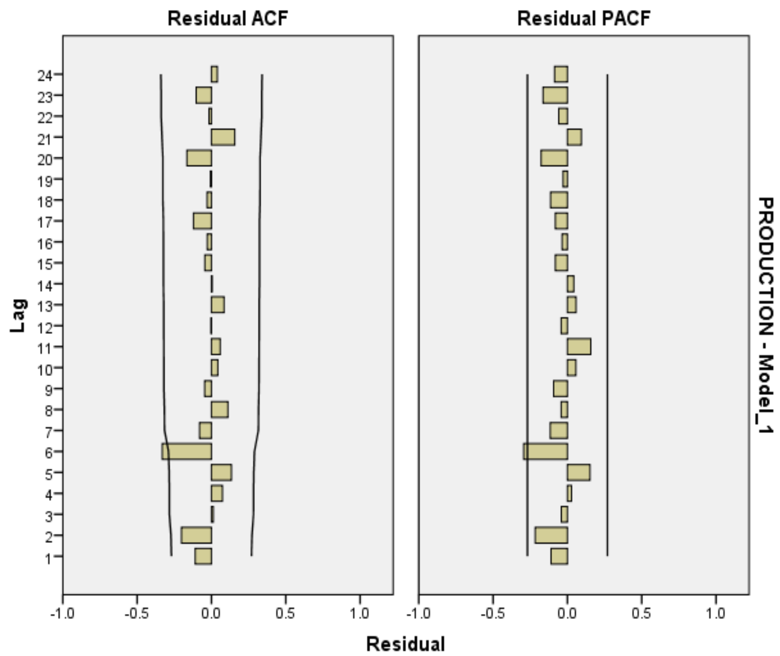


Figure 4.24. The ACF and PACF of residuals of fitted ARIMA (3, 0, 0), ARIMA (3, 0, 3) and ARIMA (3, 1, 1) models for sesame area, production and productivity.

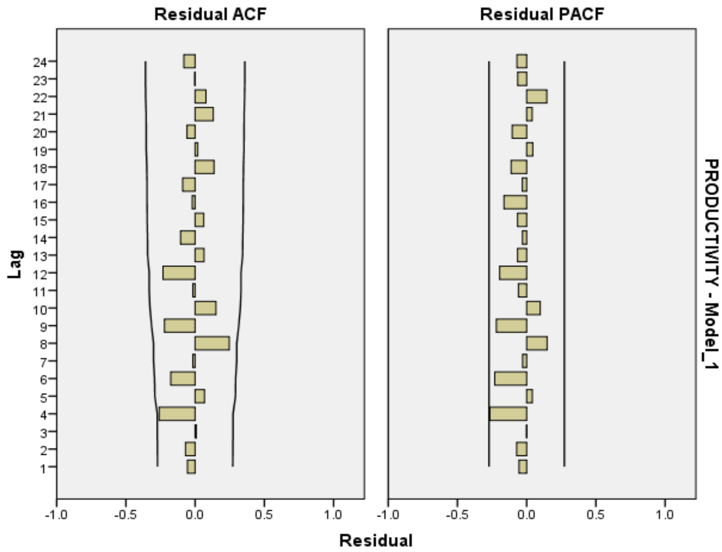
Sesame Area



Sesame Production



Sesame Productivity



4.2.4. Castor

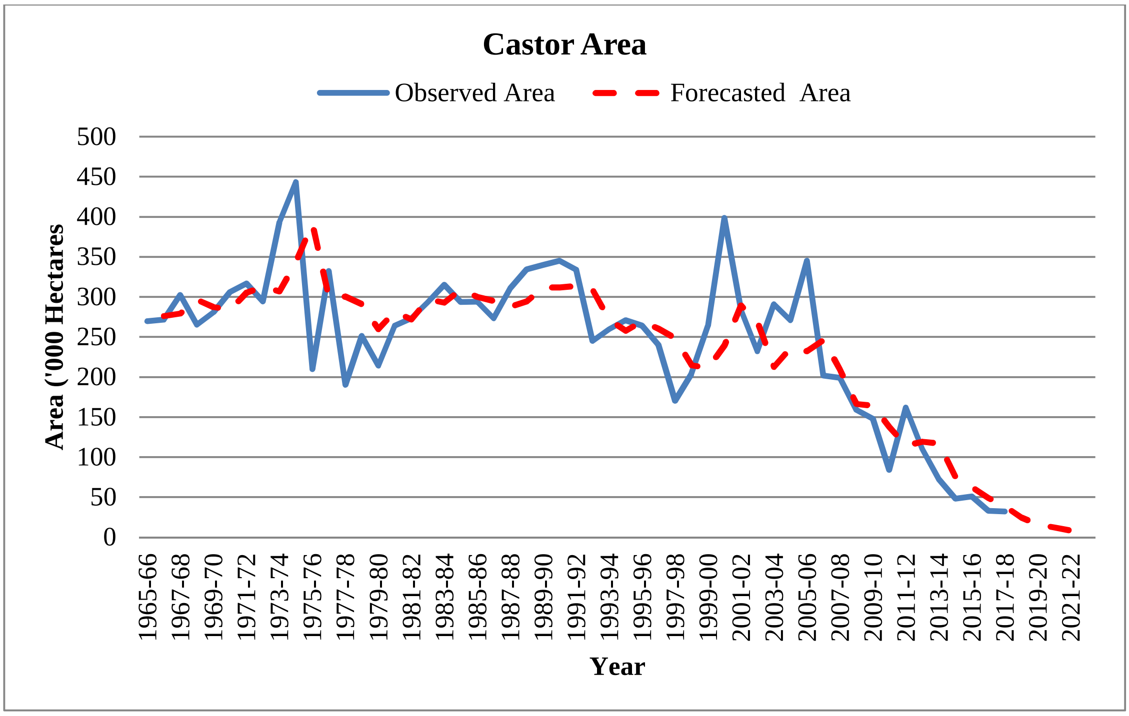
The calculations of the future values of area, production and productivity of castor in Andhra Pradesh were presented as follows

Taking in to account the model selection criteria ARIMA (2, 1, 2) was to the point to forecast the area of castor in Andhra Pradesh since this model has highest R^2 and minimum RMSE and MAPE. The forecasted values exhibit decreasing tendency by 2022-23 AD. The predicted values were presented in Table 4.30 as below

Table 4.30. Forecasted values of Castor area by ARIMA (2, 1, 2)

Year	Forecasted Area (‘000 hectares)
2018-19	24.70
2019-20	16.20
2020-21	12.30
2021-22	8.60
2022-23	6.10

Figure 4.25. Observed and Forecasted Trends of Castor area in Andhra Pradesh (1965-66 to 2022-23)

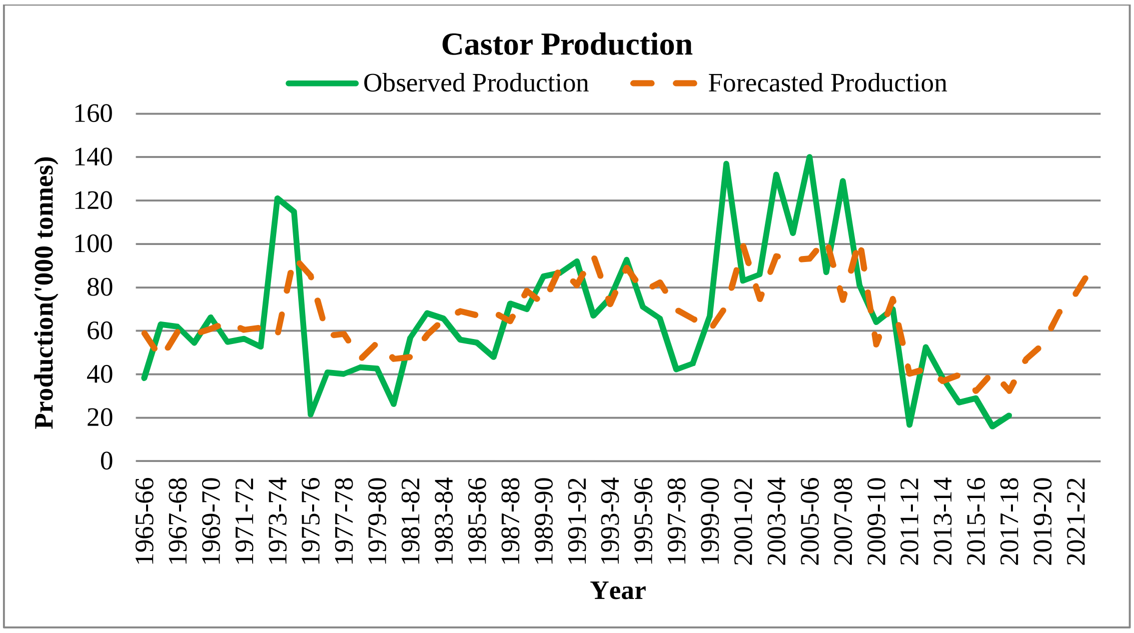


Considering the production of castor it also represents increasing curve by 2022-23 AD correspondingly with area. Production is forecasted by ARIMA (3, 0, 3) model because of its nature of having highest R^2, lowest RMSE and MAPE. The forecasted values were furnished in Table 4.31 as below.

Table 4.31. Forecasted values of Castor production by ARIMA (3, 0, 3)

Year	Forecasted Production ('000 tonnes)
2018-19	47.04
2019-20	53.74
2020-21	68.65
2021-22	77.12
2022-23	89.45

Figure 4.26. Observed and Forecasted Trends of Castor Production in Andhra Pradesh (1965-66 to 2022-23)



Productivity of castor in Andhra Pradesh is on the other side of the coin by depicting increasing trend as it rally highest R^2, lowest RMSE and MAPE. The future values for 2022-23 AD are predicted to be 678.28 kg/ha. The following Table 4.32 details the forecasted values of castor productivity in Andhra Pradesh.

Table 4.32. Forecasted values of Castor productivity by Cubic model

Year	Forecasted Productivity (Kg/ha)
2018-19	610.53
2019-20	627.30
2020-21	644.187
2021-22	661.185
2022-23	678.28

Figure 4.27. Observed and Forecasted Trends of Castor Productivity in Andhra Pradesh (1965-66 to 2022-23)

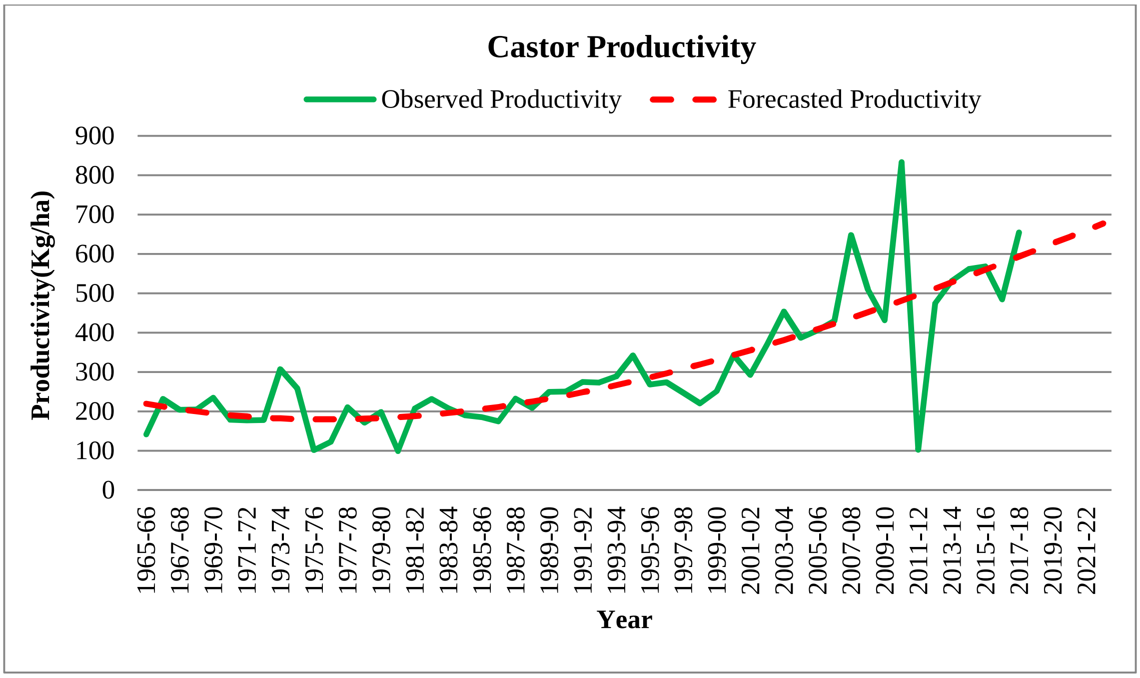
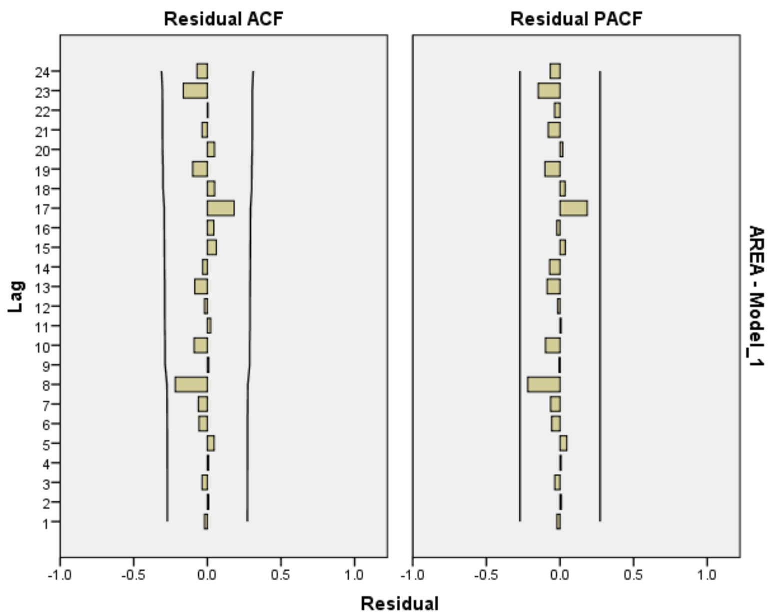
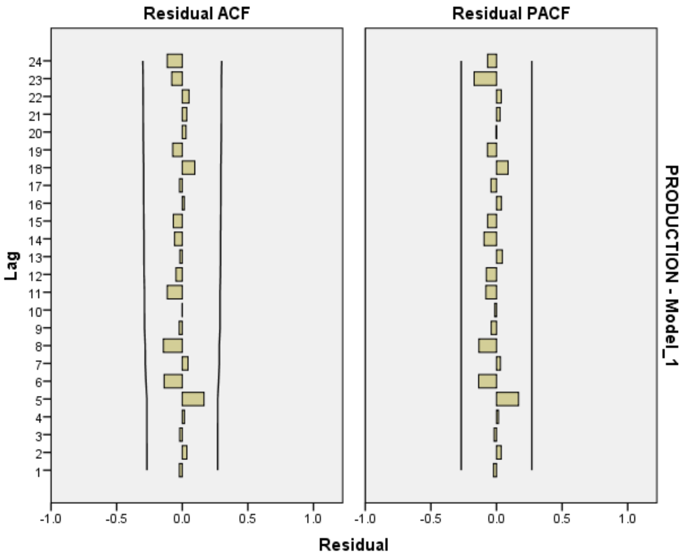


Figure 4.28. The ACF and PACF of residuals of fitted ARIMA (2, 1, 2), ARIMA (3, 0, 3) models for Castor area and production

Castor Area



Castor Production



Chapter – V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSION

This chapter vouchsafes the summary and conclusion of the study and suggestions for future endeavours.

PROLOGUE:

Andhra Pradesh is one of the major states in India in the scenario of oilseed area and production.There is a spurt in the vegetable oil consumption in recent years in respect of both edible as well as industrial usages. This research study disclose the growth of area, production and productivity of selected oilseeds in Andhra Pradesh, by spotting the best Linear and Non-Linear models, Time series models like ARIMA, to speculate the future forecasts (up to 2022-23 A.D).The data pertaining to the selected oil seeds viz., Groundnut, Niger, Sesame, Castor on area, production and productivity for the study period from 1965-66 to 2017-18 was collected from EPWRF and www.indiastat.com websites. The best fitted model was chosen based on the performance of goodness of fit criteria like highest R^2 with least RMSE and MAPE values for the purpose of future forecast up to 2022-23 A.D.

This study aimed to create a long-run forecast analysis on crop production and so give the general public, researchers, and decision-makers with basal knowledge on crop production within the future. The results can facilitate folks to understand attainable changes in crop production, create selections for agricultural management and food commerce etc. The backbone of research was to develop apt models to elucidate predicted forecasts values by using different linear, non-linear models like linear, logarithmic, inverse, quadratic, cubic, compound, S-curve, growth, power, exponential and logistic and time series models like ARIMA.

The model that showed comparatively the very best modal accuracy the highest R^2 having minimal RMSE and MAPE was chosen for the aim of forecasting of area, production and productivity of selected oilseed crops up to 2022-23 A.D.

Here the analysis of area, production and productivity of selected oilseed crops in Andhra Pradesh unconcealed the following features over a period of time. The highlights of the results which are enumerated below:

- In case of Groundnut crop the average area, production and productivity in Andhra Pradesh over the study period were 1578 thousand hectares, 1336.192 thousand tonnes, 830.89 kg/ha respectively. The future forecasts of area and production by ARIMA indicated that there would be substantial decreasing trend and the future forecasts of productivity by cubic model was indicated that there would be substantial increasing. The forecasted area, production and productivity of groundnut by 2022-23 AD would be 274.70 thousand hectares, 558.03 thousand tonnes, 999.13 kg/ha respectively.

- With regard to Niger crop 12.90 thousand hectares, 5.08 thousand tonnes and 409.56 kg /ha were the average area, production and productivity in Andhra Pradesh during the study period respectively. The future forecasts were worked out by ARIMA model revealed that there would be substantial increase in area, production and productivity of Niger crop. The predicted area, production and productivity by 2022-23 A.D respectively would be 7.00 thousand hectares, 8.41 thousand tonnes and 375.05 Kg/ha.

- The average area, production and productivity under Sesame crop in Andhra Pradesh for entire study period were 156.61 thousand hectares, 30.18 thousand tones and 203.17 Kg/ha respectively. Among all linear, non-linear and time series models the future forecasts were calculated by time series ARIMA model revealed that there would be fluctuating trend in area, production and increasing trend in productivity of sesame. The estimated area sesame by 2022-23 AD would be 47.72 thousand hectares, forecasted production would be 20.95 thousand tonnes and forecasted productivity is expected to be 330.61 kg/ha by 2022-23 AD.

- The average area, production and productivity of Castor in Andhra Pradesh during the study period were 246.28 thousand hectares, 65.90 thousand tonnes and 303.85 Kg/ha respectively. The forecasts indicated that there would be considerable decrease in area. But regarding production and productivity of castor crop, there would be an increasing trend. The forecasted values respectively for area, production and productivity were 6.10 thousand hectares, 89.45 thousand tonnes and 678.28 Kg/ha.

Conclusion

- The study reveals that the Cubic model was best fitted model for the productivity of Groundnut and Castor.
- ARIMA (3, 1, 3) and ARIMA (3, 1, 1) was considered as the best fitted model for Groundnut area and production.
- ARIMA (3, 0, 2), (3, 0, 1), (2, 0, 3) were evaluated as best suitable models for Niger area, production and productivity respectively.
- In case of Sesame ARIMA (3, 0, 0), (3, 0, 3), (3, 1, 1) models were studied as best for area, production and productivity respectively.
- For Castor ARIMA (2, 1, 2) and (3, 0, 3) models assessed to be best fitted for area and production respectively.

Implications:

The issues and concerns brought about the oilseed up in this investigation have been deliberately analyzed to distinguish the hidden causes and to define proper reactions.Territory development in oilseed crops offers just a restricted extension for significant production gains. Significant area gains are acknowledged under oilseed crops by following the distinguished techniques for area expansion.

- Oilseed cultivation in rice-fallows and non-traditional areas.
- Incorporating oilseed crops in intercropping sequence.
- Inclusion of oilseed crops as a component in crop diversification plans.

The key components of the productivity enhancement approach include

- Ensure timely availability of quality seed of improved varieties.
- Provide incentives to promote balanced crop nutrition.
- Promote efficiency in water use, e.g., protective irrigation.
- Effective crop management techniques need to popularize.
- Adoption of integrated pest and nutrient management.
- Selective farm mechanization in oilseed cultivation, especially in groundnut digging.

- Use of resource conservation technologies, precision farming and crop contingency.

Forecasts would be helpful for the policy makers to foresee ahead of time the future requirements of grain storage import and/or export and adopt appropriate measures in this regard.

Literature Cited

LITERATURE CITED

Abhiram Dash, Dhakre, D. S and Bhattacharya, D. 2017. Fitting of appropriate model to study growth rate and instability of mango production in India. *Agricultural Science Digest*. 37(3): 191-196.

Angles, S and Hosamani, S. B. 2002. Growth in area, production and productivity of turmeric in selected South Indian states. *Karnataka Journal of Agricultural Science*. 15(4): 657-662.

Badmus, M. A and Ariyo, O. S. 2011. Forecasting cultivated areas and production of maize in Nigerian using ARIMA model. *Asian Journal of Agricultural Sciences.* 3(3): 171-176.

Bard, Y.1974. *Nonlinear Parameter Estimation*. Academic Press, New York.

Başer, U., Bozoğlu, M., Alhas Eroğlu, N., Kilic Topuz. K. 2018. Forecasting chestnut production and export of Turkey using ARIMA model. *Turkish Journal of Forecasting*. 2(2):27-33.

Bharti, A. K., Sharma, M. K., Sharma, H. L., Sisodia, B. V. S., Dube, L. K. 2012. Pattern of growth and technological impact on oilseeds production in Uttar Pradesh. *Journal of Crop and Weed*. 8 (2): 1-6.

Box, G. E. P and Jenkins, G. M. 1976. *Time Series Analysis, Forecasting and Control*. San Francisco, Holden–Day, California, USA.

Draper, N. R. and H. Smith, 1998. *Applied Regression Analysis*. 3rd edition., John Wiley and Sons, New York, USA.

EPWRF. Economic and Political Weekly Research Foundation. *http://epwrfits.in/ Agriculture_All_India_State.aspx*

Ganjeer, P. K., Kaushik, D and Lakhera, M. L. 2017. A review on trend in area, production and productivity of wheat crop in different districts of northern hills of Chhattisgarh state. *Bulletin of Environment, Pharmacology and Life Sciences*. 6 (1): 302-304.

Greeshma, R., Bhave, M. H. V., Kumar, P. S. 2017. Application of growth models for area, production and productivity trends of sugarcane crop for Coastal Andhra region of Andhra Pradesh. *International Journal of Agricultural Science and Research*. 7(1): 7-14.

Indiastat. Socio-Economic Statistical Information About India. https:// www.indiastat.com / agriculture-data /2/ agricultural production /225/ oilseeds / 17204/stats.aspx

Iqbal, N., Bakhsh, K., Maqbool, A., Ahamad, A. S. 2005. Use of the ARIMA model for forecasting wheat area and production in Pakistan. *Journal ofAgriculture and Social Sciences.* 1 (2): 120-122.

Josil Samuel., Basavaraja, H., Puspanjali., Rejani. R. 2013. Trends in area, production and productivity of cotton across the major states in India. *International Journal of Humanities, Arts, Medicine and Sciences***.**1(2): 97-102.

Kalpana, P. 2016. Statistical modeling on growth rates of Groundnut crop from 1990 to 2014, in India. *International Journal of Engineering & Scientific Research.* 4 (10): 1-7.

Keerthi Kumuda, P and Mohan Naidu, G. 2013. Forecasting monthly prices of tomato in Madanapalli market of Chittoor district. *Bioinfolet.* 10 (1B): 201-203.

Khamis, A., Ismail, Z., Haron, K., Mohammad, A. T. 2005. Nonlinear growth models for modeling Oil Palm yield growth. *Journal of Mathematics and Statistics*. 1(3): 225-233

Manoj, K and Madhu, A. 2014. An Application of Time Series ARIMA forecasting model for predicting sugarcane production in India. *Studiesin Business and Economics Journal.* 9 (1): 81-94.

Montgomery, D. C., Peck. E., Vining, G. G. 2003. *Introduction to Linear Regression Analysis. John Wiley and Sons*, USA.

Narinc, D., Karaman, E., Firat, M. Z. and Aksoy, T. 2010. Comparison of nonlinear growth models to describe the growth in Japanese quail. *Journal of Animal and Veterinary Advances*. 9(14): 1961-1966.

Nimbrayan, P. K., Salinder and Tripathi.R. K. 2019. Trends of area, production and productivity of pulses in Haryana vis-à-vis India. *Journal of Pharmacognosy and Phytochemistry* 8(1): 1724-1729.

Niranjan. H. K and Chouhan. R. S. 2016. Past and future trends using ARIMA model in area, production and productivity of Onion in Madhya Pradesh .*International Journal of Agricultural Science and Research* .6:189-194.

Paland, S and Mazumdar, D. 2015. Forecasting Groundnut production of India using nonlinear growth models. *Journal Crop and Weed.* (11):67-70.

Parmar, R.S., Bhojani, S.H. and Chaudhari, G.B. 2017 . Application of regression models for area, production and productivity trends of maize (Zea mays) crop for Panchmahal region of Gujarat state, India. *International Journal of Trend in Scientific Research and Development*, 1(3):18-22.

Pindyck, R.S and Rubinfeld. D. L. 1991. *Econometric Models and Economic Forecasts.*

Prabakaran, K., Nadhiya, P., Bharathi, S., Isaivani, M. 2014. Forecasting of pulses area and production in India- an ARIMA approach. *Indian Streams Research Journal.* 4 (3): 1-8.

Prajneshu and Das, P. K.2000. Growth models for describing state wise wheat productivity. *Indian Journal of Agricultural Research*. 34(3): 179-181.

Rajarathinam and Parmar, R. S. 2011. Application of parametric and non-parametric regression models for area, production and productivity trends of castor (*Ricinus communis* L.) crop. *AsianJournal of Applied Science.* 4(1): 42-52.

Rajarathinam, A., Parmar. R. S. and Vaishnav. P. R. 2010. Estimating models for area, production and productivity trends of Tobacco (*Nicotiana tabacum*) crop for Anand region of Gujarat state, India. *Journal of Applied Sciences.* 10: 2419-2425.

Ramakrishna, G and Kumari, R.V. 2017. ARIMA model for forecasting of rice production in India by using SAS. *International Journal of Applied Mathematics & Statistical* Science. 6: 67-72.

Ramakrishna, G and Bhave, M. H. V. 2017. Temporal variations in area, production and productivity of Turmeric crop in India. *International Journal of Research in Business Management* .5(7): 83-90.

Ramakrishna, G., Mukherjee, D. N., Srikanth. B., Bhave ,M. H. V. 2014. Modeling rice production and forecasting in Andhra Pradesh *Society for Scientific Development in Agric. and Tech.* Progressive Research 9 (Conf. Spl.): 1200-1203.

Ramana Murthy, B., Mohan Naidu, G., Ravindra Reddy, B., Nafeez Umar, Sk. 2018. Forecasting Groundnut area, production and productivity of India using ARIMA Model. *International Journal of Agricultural and Statistical Sciences*. 14 (1): 153-156.

Ramana Murthy, B., Nafeez Umar, Sk., HariBabu. O. 2018. Arima model for forecasting Sunflower production in India. *International Journal of Pure and Applied Biosciences*. 6(6):1121-11226.

Ratkowsky, D. A. 1990. *Handbook of Non-linear Regression Models*. Marcel Dekker, New York.

Ravita and Verma, U. 2016. Application of ARIMA modeling for mustard yield prediction in Haryana. *International Journal of Applied Mathematics & Statistical Sciences*.5 (4): 23-28.

Saeed, N., Saeed, A., Zakria, M., Bajwa, T. M. 2000. Forecasting of wheat production in Pakistan using ARIMA models. *International Journal of Agriculture and Biology*. 2 (4): 352-353.

Shruthi, G., Rao, B. D and Masih, J. 2017. Analysis of area, production and productivity of groundnut crop in Telangana. *Agricultural Science Digest.* 37(2):151-153.

Sundar Rajan, M and Palanivel, M. 2018. A Time Series analysis of Cotton (*Gossypium Hirsutum)* in Tamil Nadu state India. *International Journal of Education and Science Research Review*. 4 (3):1-9.

Sundar Rajan, M and Palanivel, M. 2018. Application of regression models for area, production and productivity growth trends of Cotton crop India .*International Journal of Statistical Distributions and Applications*. 4(1):1-5.

Suresh, K. K and Krishna Priya, S. R. 2011. Forecasting sugarcane yield of Tamil Nadu using ARIMA models. *Sugarcane Technology*. 13(1): 23-26.

Ufuk Karadavut, Palta, C., Kokten, K., Bakoglu. A.2010. Comparative study on some non-linear growth models for describing leaf growth of maize. *International Journal of Agriculture and Biology.* 12(2): 227-230.

Ufuk Karadavut. 2010. Comparison of some statistical models for describing seedling growth of *Lolium perenne plants* in early period. *Journal of Animal and Veterinary Advance. 9(1): 190-194.*