

**A STATISTICAL INVESTIGATION OF COCONUT YIELD
IN KARNATAKA STATE**

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**A STATISTICAL INVESTIGATION OF COCONUT
YIELD IN KARNATAKA STATE**

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By

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CERTIFICATE

This is to certify that the thesis entitled “ **A STATISTICAL INVESTIGATION OF COCONUT YIELD IN KARNATAKA STATE** ” submitted by **Mr. D. K. VINAY**, for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL STATISTICS** to the University of Agricultural Sciences, Dharwad, is a record of bonafide research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

**DHARWAD
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Introduction

1. INTRODUCTION

Botanically, the Coconut tree (*Cocos nucifera*) is a member of the family Arecaceae (palm family). Coconuts are known for their great versatility, as evidenced by many traditional uses, ranging from food to cosmetics. They form a regular part of diets of many people in the tropics and sub-tropics. Coconuts are distinct from other fruits for their large quantity of water (also called “juice”) and when immature, they are known as tender-nuts or jelly-nuts and may be harvested for their potable coconut water. When mature, they can be used as seed nuts or processed to give oil from the kernel, charcoal from the hard shell, and coir from the fibrous husk. The endosperm is initially in its nuclear phase suspended within the coconut water. As developmental continues, cellular layers of endosperm deposit along the walls of the coconut, becoming the edible coconut “flesh”. When dried, the coconut flesh is called copra. The oil and milk derived from it are commonly used in cooking and frying, as well as in soaps and cosmetics. The husks and leaves can be used as material to make a variety of products for furnishing and decorating. The coconut also has cultural and religious significance in certain societies, particularly in India, where it is used in Hindu rituals.

The coconut yield depends on variety and conditions under which it is grown. The average yield per hectare varies from 10,000 to 14,000 nuts per annum.

Several programmes are being planned and implemented by government from time to time to improve production and productivity. Besides improved techniques for the development of agricultural and higher agriculture production, timely and sufficient rainfall and weather conditions are also crucial factors. During the year 2009-10 report, the total cropped area has increased by about 5.0 lakh hectares due to sufficient rainfall (Directorate of Economics and Statistics Bangalore).

National scenario:

Traditional areas of coconut cultivation in India are the states of Kerala, Karnataka, Tamil Nadu, Puducherry, Andhra Pradesh, Goa, Maharashtra, Odisha, West Bengal and the islands of Lakshadweep and Andaman and Nicobar. As per 2014-2015 statistics from Coconut Development Board of Government of India, four southern states combined account for almost 90% of the total production in the country: Tamil Nadu (33.84%), Karnataka (25.15%), Kerala (23.96%) and Andhra Pradesh (7.16%). Other states, such as Goa,

Maharashtra, Odisha, West Bengal and those in the northeast (Tripura and Assam) account for the remaining productions. Though Kerala has the largest number of coconut trees, in terms of production per hectare, Tamil Nadu leads all other states.

State scenario:

Major coconut growing districts in Karnataka are Tumkur, Hassan, Dakshin Kannada, Chikamagalur and Chitradurga which together account for more than 85% of coconut growing area in state. The coconut production in Karnataka was 5141.15 million nuts in 2014-15. It is increased by 100 million nuts as compared to the coconut production of 5041.15 million nuts in the year 2013-14. The annual growth recorded in the year 2014-15 was 1.98 per cent. Tumkur district has the largest area under coconut production.

Approximately 60 per cent of the coconut produced in the state is utilized as raw nuts for domestic culinary purposes, social cultural and religious purposes. About 25 per cent of the nuts are converted into edible ball copra, desiccated coconut powder and the remaining 15 percent is utilized as tender coconut for drinking purpose. Prominently, around 60–70 per cent of the arrival of coconut is exported to other states i.e. Uttar Pradesh, Punjab, Maharashtra, Rajasthan, Madhya Pradesh, Jammu & Kashmir, etc., About 60 per cent of coconut production in Karnataka is used in domestic items and remaining is dried as copra, most of the copra arriving to the markets is dispatched to other state, where the Karnataka copra is in great demand. The coconut utilized for commercial product preparation is only to the extent of 35-40 per cent, while 55-60 per cent is consumed for food and beverage purposes (Coconut Development Board).

Decreasing the cost of production of nut is the most important criteria for increasing competitiveness. Cost effective management practices such as organic recycling of coconut biomass and other farm wastes or converting them into vermi-compost, addition of need based inputs at the appropriate level and time, adopting drip irrigation by providing subsidy for it, soil moisture conservation, basin management with organic mulching or growing green manures and incorporating them, need based plant protection measures using bio-control agents are also to be adopted for substantial growth in production and to increase the productivity of coconut.

The integrated pest and disease management approach allows pest and disease management without any adverse impact on ecological sustainability of the Agro ecosystem.

It is necessary that a massive and concerted programme be launched involving research and extension backed by suitable subsidy schemes. It is recommended that a massive programme should be launched to weed out the old unproductive and diseased coconut palms and replanting seedling of improved hybrid varieties of coconut palms as a measure of rehabilitation.

Adverse weather condition and the problem of disease infestation are the two major risk factors affecting coconut production and productivity which result in low income among farmers. In the absence of any effective mechanism for risk cover, the economy of coconut farmers suffers severely. Hence, the scope of National Agricultural Insurance Scheme should be effectively extended to provide risk coverage to coconut farmers.

Marketing data about a product line from both external and internal sources and assembles the data, thus helping in marketing decision making as it comprises of collection and storage of data, analysis, and interpretation of data and the dissemination of intelligence.

Thus, competitive data base market intelligence system should be developed to generate advance estimation of coconut production and copra with a view to generate reliable and consistent estimates

The consumers for organic foods are increasing and organic sales are growing by 20 per cent. Since consumer of organic food look for absence of pesticides/herbicides/synthetic fertilizers, coconut is the best option to satisfy all these preferences. Since coconut is largely raised in all the coconut growing areas under natural farming, it can be marketed as organic product.

Farmers growing coconut now a day's face many problems like fluctuating prices of coconut, even though the area under coconut and the production have been increasing over the years and farmers tend to take risk. The study related to aspects like whether increasing in production is due to increase in area or yield and the factors responsible for changes in area and yield, which in turn contributed to increase in output supply.

In view of importance of coconut, the present investigation on "A statistical investigation of coconut yield in Karnataka state" will give a clear scenario about the instability of the coconut productivity, impact of weather parameters on coconut production and estimation of production.

Specific objectives of study

1. To study the stability of productivity of coconut in Karnataka.
2. To study the impact of weather parameters on the production of coconut.
3. To estimate the production of coconut.

Review of Literature

2. REVIEW OF LITERATURE

A review of past research helps in developing a right understanding of the research problem and identifying the conceptual and methodological issues relevant to the present study. A review of studies is essential to look into the relevant studies conducted on the problems so far. This chapter deals with a brief review of the relevant research literature that has accumulated on the area of present study. Consistent with the objectives of the present study, the reviews of literature are presented under the following sub-headings.

2.1 Stability of productivity of coconut in Karnataka.

2.2 Impact of weather parameters on the production of coconut

2.3 Estimate the production of coconut.

2.1. To study the stability of productivity of coconut in Karnataka

Ghose (1993) analysed the trends in area, production and productivity of coconut in Assam state during the four decades from 1947-48 and 1987-88. In the decade followed (1967-68 to 1977-78 and 1977-78 to 1987-88) recorded steady and positive growth of coconut in state. In the last three decades the growth rate was positive and quite erratic.

Shibu *et al.* (2004) the annual compound growth of area was highest (5.97%) in period-I compared to whole period (2.22%) with declining trend in period-II (-1.82%). A positive significant growth rate of production was noticed (3.76%) in period-I with stagnation in production growth rate (0.02%) in whole period and showing a declining trend (-1.18%) in period-II.

Angels and Hosmani (2005) the instability in turmeric production were examined in terms of area and productivity in important states of South India *viz.* Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. The states contributed around 80 per cent of turmeric produced in India. Secondary data was used for the study, considering the period from 1979-80 to 1998-99. Hazell's decomposition model was used for the analysis. The instability in area and productivity of turmeric indicated that the area in the case of Andhra Pradesh and Tamil Nadu showed instability, while Kerala showed stability. But, in the case of yield, except Karnataka all other states showed instability. Decomposition analysis showed that yield instability was the dominant factor affecting production. The future development programmes should envisage stabilisation of yield, which would stabilize production. Evolving location specific

varieties, adoption of modern cultural practices and intensive cultivation were some of the suggestions for stabilizing productivity of turmeric

Lathika and Kumar (2005) analysed the growth trends in area, production and productivity of coconut in India of all the coconut producing states/union territories for which the period has been divided into two sub-periods as phase I (1951 to 1995) and phase II (1996 to 2002). Area shows positive growth in both phases for selected states except for the Andaman and Nicobar Islands where the growth was negative -9.69 per cent in II phase. Production also showed a positive growth in all the states in both the phases and Andhra Pradesh has highest growth in II phase 16.69 per cent. The growth rate of productivity showed negative growth in Kerala and Orissa in the I phase, Karnataka in the II phase.

Amarender and Devraj (2006) conducted a research study on “Growth and instability in Chickpea production in India: A state level analysis”. The results from Coppock’s instability index observed that overall instability was higher in production than area and yield at all India level. Instability was higher in second period than first period. Instability in yield was higher than area and it was contributing more to the production instability in both the periods. Instability of yield was increased and area was decreased in the second period compared to first period. However in some states like Tamil Nadu, Rajasthan, Haryana and Gujarat instability was higher than yield instability.

Lathika *et al.* (2007) examined the growth trends in coconut area, production and productivity in 1960-61 to 2004-05 and the performance of different districts of Kerala in coconut production and assess the relative role of area and yield in explaining the trend in coconut production. The study was based on secondary data of area in hectares under cultivation, production and productivity and the information provided in the official website of the coconut development board. The prestigious position that Kerala enjoyed in coconut area and production over the years, seems to be waning out. It should however gratifying to see the Kerala is on the path of regaining some of its glory in Indian coconut scenario.

Barman and Akter (2010) stated that in Bangladesh coconut is grown in all over the country and it is suited with the existing climate. The variety that has been extensively cultivated in Bangladesh is “typical” a long lived tall form. Economic life of the coconut trees usually ranges between 50-60 years. Presently Bangladesh has 0.41 million hectares of land area under coconut groves which is about more than 500 times higher than that was under

coconut in 1947-48 and about 60 per cent higher than the area coconut at the time of independence.

Mohammed (2011) worked on analysis of agricultural production instability in the Gezira scheme. The study used time series data from 1997 to 2008. The whole period was subdivided as the before the adoption of liberalization policy (1970-71 to 1991-92) and the period after the adoption of liberalization policy (1992-93 to 2007-08). The main crops included in the study were sorghum, wheat, cotton and groundnuts. The results of the study showed that sorghum, wheat and cotton witnessed a continuous increase in instability over the two periods, whereas there was a decrease in the instability of groundnut production during post-liberalization period. The instability in area and yield of all crops moved in the same direction and their increasing/decreasing trend resulted in increase/decrease in instability.

Vasudev *et al.* (2012) studied on “Growth in food grain production in India is technology led or policy led: special reference to Andhra Pradesh with district wise economic analysis”. The time series data for the period of 20 years from 1990-91 to 2009-10 was used. To reach their objective they applied Analytical tools like Hierarchical and K- Means Clustering, Compound Growth Rate, Coppock’s Instability Index (CII), Decomposition of change in average production. For analyzing Coppock’s instability index data period was subdivided into two periods each of 10 years viz. period I (1990-91 to 1999-2000) and period II (2000-01 to 2009-10). The result revealed that country as a whole, during the period -I, productivity variability had more influence on production fluctuations than by instability in area. During the period -II also instability in productivity has more influence on production variability than by instability in area. Inter period comparison revealed that instability in production and productivity during the period-II was less than period-I. State as a whole, during both periods, productivity variability had more influence on production fluctuations than by instability in area. Inter period comparison revealed that instability in production and productivity during the period-II was less than period-I. Among the regions, during the period -I, the lowest instability in area, production and productivity were recorded in Coastal Andhra. Highest instability in area and productivity were recorded in Rayalaseema. In 19 districts, out of 22, production fluctuation was more influenced by instability in productivity than variability in area.

Soumya *et al.* (2014) conducted study on growth and instability in production and export of selected spices of India. Three spices, pepper, cumin and coriander, were selected for the study as they have the foremost position in the world spices trade in value terms. For this study statistical tools namely, compound growth rate analysis and coefficient of variation were employed. The empirical results showed that area, production and productivity of pepper showed negative growth rate at national level. Pepper registered a positive but non-significant growth rate in terms of volume of export. At national level area under cumin showed only a meagre growth rate while production, productivity and export showed significant positive growth rate. Area, production and export of coriander showed significant and positive growth rate while productivity showed non-significant positive growth rate at national level. Area, production and productivity were found to be stable while export was found to be unstable in case of pepper. Similarly, at all India level, in case of cumin, area, production and productivity were found to be stable while export was found to be unstable. In case of coriander, area and productivity were found to be stable while production and export were found to be unstable.

Vinayaka *et al.* (2014) studied on Growth and Instability Analysis of fruits crops in India-An Economic Analysis. The study was based on secondary data from 2000-01 to 2010-11. The compound growth rate, coefficient of variation and instability index were employed to analyse instability. The result showed that in India growth rate of fruits crops productivity in India was positive (1.05%) and was associated with instability index of 10.16 per cent. In the same period a positive growth rate of area was observed (7.34%) with high instability index of 10.16 per cent, while a positive growth rate of production (8.48 %) with instability index of 0.10 per cent was observed for production. The average of area, production and productivity of fruits crops during this period were 5084.55 ('000 hectares), 55364.64 ('000 Million Tonnes) and 10.83 (Million tonne/ha).

Ganesan (2015) conducted research on Growth and Instability in Area, Production and Productivity of Turmeric in Selected States in India. The growth and instability in turmeric production in India was examined using secondary data for the period of 32 years, from 1979-80 to 2010-11 by employing Compound growth rate, Co-efficient of Variation and Decomposition model. It is also found from the analysis that the instability in area was reduced in Andhra Pradesh, production instability was reduced in Andhra Pradesh and Tamil Nadu, yield instability was reduced in Tamil Nadu and Karnataka.

2.2. To study the impact of weather parameters on the production of coconut

Prasad Rao (1986) reported that both high rainfall during the months of June, July and August as well as the absence of post-monsoon showers adversely affected the subsequent year's coconut yield in Kerala, India.

Prasad Rao (1991) has indicated the necessity of further studies of the climatic requirement of the coconut. These studies revealed that the crop response to major climatic variables, especially rainfall had to be further investigated and their effect should be based on distribution of rainfall and also on soil type. An identification of degree of influence of climatic factors for a given location would assist in short term yield forecasting and consequently in determining the potential yield in a given agro climatic region

Guruswamy *et al.* (2008) studied the mean annual and seasonal rainfall behaviour and the effects of weather parameters on coconut productivity in Thanjavur district, Tamil Nadu, India, during 1996-2005 and stated that southwest monsoon and winter rainfall had a negative correlation with coconut productivity, whereas summer and NEM rainfall had a positive correlation with coconut productivity. The per cent of barren nut production in coconut had a positive correlation with summer rainfall and negative correlation with winter, southwest and northeast monsoons. The maximum temperature, minimum temperature, relative humidity, pan evaporation and rainfall had a positive correlation with coconut productivity.

Kumar *et al.* (2008) reported that weather variables play an important role in determining the coconut palm growth, development and yield. The influence of nut yield in coconut starts from inflorescence initiation and lasts till nut maturity (44 months). Historical data on weather variables and coconut nut yield from different agro-climatic zones which are western coastal area hot sub-humid-per-humid (Kasaragod - Kerala; Ratnagiri - Maharashtra), hot semi- arid (Arisikere - Karnataka) and Eastern coastal plains - hot sub-humid (Veppankulam - Tamil Nadu; Ambajipeta - Andhra Pradesh) of India were used for developing models for prediction of coconut yield. The prediction models with 3- and 4-year lag had high R^2 values. The models differed for usage of parameters in different agro-climatic zones, indicating the relative importance of these parameters in respective conditions for realizing the nut yield in coconut. Interestingly, the parameters used in models for western coastal area- hot sub-humid -per-humid are temperature and relative humidity, as indicated

even in the classification of these areas. Models were verified for 2 years and prediction of yield during 1998-99 and 1999-2000 within 10% confidence level validated these models.

Mokashi *et al.* (2008) conducted an experiment on sorghum by using four different sowing windows to study the relationship between weather parameters and yield in *rabi* season. *Rabi* sorghum sown at MW 39 (24-30 Sept.) produced maximum pooled grain (850 kg ha⁻¹), fodder (29.06 q ha⁻¹) and total monetary returns (Rs.13781 ha⁻¹). However, the crop sown at MW 40 was also produced on par yields with crop sown at MW 39 and of high degree of sustainability. Tmax, Tmin, RH I, RH II, WS, rain and Epan had showed significant positive association with grain yield. Tmin at emergence to 4th leaf stage, Epan at panicle initiation to flag leaf stage BSS at soft dough to hard dough stage and Epan at hard dough to physiological maturity showed positive contribution in grain production of *rabi* sorghum.

Chikkeshkumar (2010) conducted study on association between weather parameters and crop yield. Among selected weather variables rainfall was positively and maximum temperature was negatively correlated with crop yield. The models were built in order to predict yield with the help of individual weather parameter. Best models were selected based on the significance of the variable and R², which explains the variation in dependent variable due to independent variables. Different nonlinear models were used for predicting yield using each weather parameter, among those, power, compound, cubic, s-curve, logarithmic and quadratic models were found significant.

Rankja *et al.* (2010) conducted a study to identify the quantitative relationship between weathers parameters and district level yield of cotton and to develop pre harvest forecast models for cotton yield. For this purpose 32 years weather and crop yield records of Banaskantha district were collected. It was found that the 26 week crop period model (using original weather variables, week wise approach) was recommended for pre harvest forecast due to higher R² value and lower simulated forecast error. The time trend, maximum temperature, morning and evening relative humidity have significantly affected on crop yield.

Suresh (2013) conducted research on the spatial analysis of influence of climate on chilli in Dharwad, Gadag and Haveri districts based on secondary data. Models were built in order to predict yield with the help of individual weather parameter. The cubic model was found to be significant and best suited for the trend of rainfall, temperature and relative humidity of selected districts, followed by quadratic model.

2.3 To estimate the production of coconut

Mastny (2001) used ARIMA models, also called Box and Jenkins models after their developers, is a group of models allowing the analysis of the time series with various features. The article demonstrates the possible usage of the Box-Jenkins methodology for the analysis of time series for agricultural commodities. The paper contains a basic mathematical explanation of ARIMA models together with a practical illustration of a price development forecast for a selected agricultural commodity.

Gangadharappa (2005) fitted ARIMA model to study the variation in arrivals and prices of potato in Bangalore, Belgaum, Kolar, Hassan markets of Karnataka during 1996-97 to 2003-04. Box –Jenkins method was applied for precise forecasting of arrivals and prices of potato for the monthly data to all selected markets. Of all the ten series, he found only two series, which yielded Box – Pierce ‘Q’ statistic which was significant and AIC was minimum.

Iqbal *et al.* (2005) used ARIMA (1, 1, 1) and ARIMA (2, 1, 2) for 20 years ahead forecasts for area and production of wheat. For 2000-2001 forecasts of wheat area was about 8,451.5 thousand hectares and that for the year 2022 was 8,475.1 thousand hectares. Forecasts of wheat production showed an increasing trend. For 2000-2001, forecast of wheat production was about 20,670.8 thousand tonnes and that for the year 2022 came to be about 29,774.8 thousand tonnes.

Satya pal *et al.* (2007) made an attempt to forecast milk production using statistical time series modelling techniques such as double exponential smoothing and Auto-Regressive Moving Average (ARIMA) for the study period of twenty five years (1980-81 to 2004-05). On validation of the forecast from these models, ARIMA model performed better than the other one.

Punitha (2007) attempted to fit ARIMA model to forecast the values of arrivals and prices of maize and groundnut for Davangere market and Hubli market. The forecasted values of groundnut arrivals and prices showed an increasing trend in Davangere market, but in Hubli market prices showed decreasing trend. The forecasted values of arrivals and prices of maize showed an increasing trend in both the markets.

Kaushik and Singh (2008) studied about the seasonal ARIMA model for forecasting of monthly rainfall and temperature. They analysed the data by using SPSS package. The study

concluded that Box-Jenkins ARIMA technique can be used to predict the seasonal and monthly mean rainfall and temperature, using rainfall and temperature time series as inputs. Previous 12 years mean monthly rainfall and temperature values were used to predict next years' values.

Padhan (2012) made a study on application of ARIMA model for forecasting agricultural productivity in India. The paper considered annual secondary data on 34 different agricultural products for forecasting. Data were collected from Centre for Monitoring Indian Economy (CMIE) prowess data base, Mumbai. Among the items considered, tea provided lowest Mean Absolute Percentage Error (MAPE) value, whereas cardamom provided lowest Akaike Information Criterion (AIC) value. Similarly, highest MAPE was obtained for papaya and highest AIC value was for sugarcane.

Singh *et al.* (2013) examined the application of ARIMA model for forecasting paddy production in Bastar division of Chhattisgarh. They used the annual data on paddy cultivated area and production for the period from 1974-75 to 2010-11 from Department of Agriculture, Govt. of Chhattisgarh, for forecasting the future values using ARIMA models. In their study, the developed model for paddy cultivated areas and production was found to be ARIMA (2, 1, 2) and ARIMA (2, 1, 0) respectively. From the forecast available by using the developed model, it could be seen that forecasted paddy cultivated areas and production increases the next four years.

In a study conducted by Prabakaran and Sivaprakasam (2014), ARIMA (1, 1, 1) was the developed model for forecasting both rice cultivated area and production. From the forecast available by using the developed model, it could be seen that forecast rice cultivated areas and production were to increase in the next four years. The model could be used by researchers for forecasting rice cultivated areas and production in India.

Ali *et al.* (2015) collected the production and yield data for sugarcane and cotton from various issues of economic survey of Pakistan and agricultural statistics of Pakistan. Time series data for 65 years (1948 to 2012) was used for the study. All the essential steps of ARMA and ARIMA modelling had been systematically followed to forecast productions and yields of selected crops from 2013 to 2030. These forecast values could be used for formulating agriculture policy especially for sugarcane and cotton crops by policy makers at national level.

Methodology

3. METHODOLOGY

The experimental material which served as the data base for the present study and the methods of data treatment are given in this chapter. The details of the material and the methods used for this study are discussed under the sections such as 3.1 to 3.4.

3.1 Description of the study area

3.2 Nature and source of data

3.3 Study period

3.4 Analytical tools and techniques applied

3.1 Description of the study area

Karnataka is a state in the south western region of India. It is seventh largest state in India. It consists of 30 districts. The state is situated in north of the equator between 12°58' to 12°97' north latitude and 77°30' to 77°50' east longitude. It is bordered by Goa to the northwest, Telangana to the northeast, Andhra Pradesh to the east, Maharashtra in the north, Tamil Nadu to southeast, Kerala to the south and Arabian Sea to the west. The state covers an area of 191,791 km² (74,051 sq. mi).

Karnataka has got past, pleasant present and bright future with respect to production of coconut. Major coconut growing districts in Karnataka are Tumkur, Hassan, Dakshin Kannada, Chikamagalur and Chitradurga which together account for more than 85% of coconut growing area in the state. Tumkur district has the largest area under coconut production. Study area was shown in the Fig.1.

3.2 Nature and source of data

The present study is based on the secondary data and data was collected from the following sources.

- Coconut Development Board
- www.indiastat.com.
- www.karnatakastat.com.
- Main Agriculture Research Station, Dharwad.

3.2.1 Different parameters considered for the research study are as follows:

Y : Production (Lakh nuts)

X₁: Rainfall (mm)

X₂: Temperature (Degree Celsius).

3.2.2 Crop Data

The secondary data was collected based on the parameters such as production (Lakh Nuts), productivity (Nuts/ha), rainfall (mm) and temperature (Degree Celsius).

3.3 Study period

The available data for area, production and productivity of selected districts of Karnataka were collected from 1990 onwards for 26 years.

3.4 Statistical tools employed

To examine the different objectives of the present study, the data were further processed, tabulated and classified. Different statistical tools were employed to respective objectives for analyzing and interpreting the results

3.4.1 To study stability of productivity of coconut in Karnataka.

It is necessary to know the variations in the productivity of coconut in Karnataka

3.4.1.1 Compound Growth Rate (CGR)

Compound growth rate was used to study the growth rate of productivity of coconut.

$$Y_t = Y_0 (1+r)^t e^u$$

Where,

Y_t = coconut productivity in year t

Y₀ = intercept

r = Growth rate

t = Time in years; 1, 2, 3... n

u = Random error-term

3.4.1.2 Coppock's Instability Index

This method involves a constant percentage changes from year to year and this is better measure than the constant absolute changes from year to year *i.e.* it is close approximation of the average. Coppock index is performed for any time series data. The Coppock's instability index is also called as the log variance method and is expressed algebraically in the following estimable form

$$\text{CII (per cent)} = [(\text{antilog } \sqrt{\log v} - 1)] * 100$$

Where,

$$\log v = \frac{\sum \left(\log \frac{X_{t+1}}{X_t} - m \right)^2}{n}$$

$\log v$ = logarithmic variance

n = number of years in the series.

X_t = coconut productivity in the year 't'

X_{t+1} = coconut productivity in the next year 't+1'

m = arithmetic mean of difference between log's of X_{t+1} , X_t

$$m = \frac{1}{n-1} \sum \log \left[\frac{X_{t+1}}{X_t} \right]$$

Steps for Calculating CII Percentage

1. Logarithms are obtained for each annual value of a variable for example productivity for Year 1, Year 2 *etc.*
2. The logarithm of the value for year 1 is subtracted from logarithms of the value for year 2 *etc.* in order to get first differences of logarithms.
3. The arithmetic mean of the logarithmic first differences is then obtained.
4. The logarithmic mean is subtracted from each year to year logarithmic first difference in order to obtain the logarithmic difference between the actual and average (trend) year to year logarithmic differences.

5. These logarithmic differences from trend some positive and some negative are then squared, summed up and divided by the number of years minus one. The resulting number is termed as “log - variance”
6. The next step is to take the square root of the log variance and obtain the antilog of the square root value. Unity is then subtracted from antilog and multiply with hundred. The resulting “instability index” is close approximation of the average year to year percentage variation adjusted for trend.

3.4.2 To study the impact of weather parameters on the production of coconut.

3.4.2.1 Polynomial and nonlinear models

Polynomial regression is a form of linear regression in which the relationship between the independent variable t and the dependent variable y is modelled as an n^{th} order polynomial. Polynomial regression fits a nonlinear relationship between the value of x and the corresponding conditional mean of y , denoted by $E(y/t)$. The parameters are estimated by OLS method. In present study, taking production as dependent variable and weather parameters i.e. rainfall and temperature as independent variables, non-linear and polynomial models were attempted (Reddy, 2013). Following models fitted to the data.

1. Linear model

$Y = b_0 + b_1(x)$ is the linear form of the model.

Y and x 's are coconut production and rainfall/temperature period respectively.

b_0 and b_1 's are constants to be estimated

2. Logarithmic model

The linear form of the model is:

$$Y = b_0 + b_1 \ln(x) + \varepsilon_i$$

Y is dependent variable and x 's are independent variables.

b_i 's are constants (where $i = 0 \& 1$) to be estimated and \ln is natural log and ε_i is the random error

3. Quadratic model

The form of the equation is:

$$Y = b_0 + b_1x + b_2x^2 + \varepsilon_i$$

Where,

Y is dependent variable and x's are independent variables.

b_i 's are constants (where $i = 0, 1$ & 2) to be estimated and ϵ_i is the random error.

The quadratic model was used to model a series that take off or a series that dampens.

4. Cubic model

Here the equation is:

$$Y = b_0 + b_1x + b_2x^2 + b_3x^3 + \epsilon_i$$

Y is dependent variable and x's are independent variables.

b_i 's are constants (where $i = 0, 1, 2$ & 3) to be estimated and ϵ_i is the random error.

5. Exponential model

Model under consideration is:

$$Y = b_0 * e^{(b_1 * x)} + \epsilon_i$$

or

$\ln(Y) = \ln(b_0) + (b_1 * x)$ where,

Y is dependent variable and x's are independent variables.

b_i 's are constants (where $i = 0, \&1$) to be estimated and \ln is natural log and " ϵ_i " is the exponential function

6. Growth model

It has the form:

$$Y = e^{(b_0 + (b_1 * x))} + \epsilon_i$$

On transformation,

$\ln(Y) = b_0 + (b_1 * x)$ which is a linear form of the model.

Y dependent variable and x's are independent variables.

b_i is a constant to be estimated, $i = 0, 1$ and \ln is natural log and " ϵ_i " is the exponential function.

7. Compound model

It has the form:

$$Y = b_0 b_1^x$$

On transformation,

$\ln(Y) = \ln(b_0) + (x) \ln(b_1)$ is obtained which is of the linear form

where,

Y is dependent variable and x_i 's are independent variables.

b_i is a constant to be estimated, $i = 0, 1$ and \ln is natural log.

8. Power model

$$Y = b_0X^{b_1} + e_i$$

Where,

Y: dependent variable.

X: independent variable.

b_0 & b_1 : Coefficients to be estimated.

e_i : Error component.

3.4.3 To estimate the production of coconut.

3.4.3.1 ARIMA (Autoregressive Integrated Moving Average) model

In statistics, Auto-Regressive Integrated Moving Average (ARIMA) models, sometimes called Box-Jenkins models are typically applied to time series data. In the current study, ARIMA method were adopted with the use of SPSS software to predict the availability of production of coconut for next decade.

ARIMA model is a tool for understanding and, perhaps, predicting future values in the series. The model consists of two parts, an autoregressive (AR) part and a moving average (MA) part. The model is usually then referred to as the ARMA (p, q) model where p is the order of the autoregressive part and q is the order of the moving average part.

The model is generally referred to as an ARIMA (p, d and q) model where p , d , and q are integers greater than or equal to zero and refer to the order of the autoregressive, integrated and moving average parts of the model respectively.

Given a time series of data X_t where t is an integer index and the X_t are real numbers, then an ARMA (p, q) model is given by

$$\left(1 - \sum_{i=1}^p \alpha_i L^i\right) X_t = \left(1 + \sum_{i=1}^q \theta_i L^i\right) \epsilon_t$$

Where L is the lag operator, the α_i are the parameters of the autoregressive part of the model, the θ_i are the parameters of the moving average part and the ϵ_t are error terms. The error terms are generally assumed to be independent, identically distributed variables sampled from a normal distribution with zero mean (Kallimath, 2009).

Results

4. RESULTS

In this chapter, the secondary data collected from various sources were analyzed using appropriate statistical tools. Results found through important statistical analysis for the following objectives are presented in this chapter.

4.1 Stability of productivity of coconut in Karnataka.

4.2 Polynomial models on impact of weather parameters on the production of coconut.

4.3 ARIMA model in estimate of coconut production.

4.1. Stability of productivity of coconut in Karnataka.

Different statistical models used to study the stability in the productivity of coconut is presented in Table 4.1.1 for period-I, Table 4.1.2 period-II and Table 4.1.3 whole period respectively. The Compound Growth Rate (CGR) was used to study the growth in coconut productivity for the study period-I (1990-91 to 2003-04) is presented in Table 4.1.1. The results revealed that the productivity of coconut in Bangalore rural was decreasing at the rate of -1.8088 per cent followed by Chikamagalur, Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar Kannada where in the production was decreasing at the rate of -1.8070, -1.8094, -0.0880, -1.8112, -1.7735, -1.8450, -1.8094, -1.8082 and -0.0875 per cent respectively.

To study the stability in the productivity of coconut for the study period-II (2004-05 to 2015-16) is presented in Table 4.1.2. The result revealed that the productivity of coconut in Bangalore rural was increasing at the rate of 10.3554 per cent, followed by Chikamagalur, Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar Kannada was increasing at the rate of 12.1255, 9.5269, 14.4223, 5.4548, 11.5715, 13.2824, 13.6668, 6.3446 and 6.4311 per cent, respectively.

To study the stability in the productivity of coconut for the study period taken as a whole (1990-91 to 2015-16) is presented in Table 4.1.3. The result revealed that the productivity of coconut in Bangalore rural was increasing at the rate of 2.8465 per cent, followed by Chikamagalur, Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar Kannada 3.9165, 2.4467, 5.5481, 0.8678, 3.6365, 4.4567, 4.5532, 1.0593 and 2.6409 per cent, respectively.

Table 4.1.1: Compound growth rate and Coppack's instability index for productivity of coconut for period-I

(Values in percentage)

Districts	CGR	CII
Bangalore rural	-1.8088	3.50
Chikamagalur	-1.8070	3.50
Chitradurga	-1.8094	3.50
Dakshin kannada	-0.0880	0.21
Hassan	-1.8112	3.50
Mandya	-1.7735	3.51
Mysore	-1.8450	3.51
Shimoga	-1.8094	3.50
Tumkur	-1.8082	3.50
Uttar Kannada	-0.0875	0.21

Period-I: 1990-91 to 2003-04

Table 4.1.2: Compound growth rate and Coppack's instability index for productivity of coconut for period-II.

(Values in percentage)

Districts	CGR	CII
Bangalore rural	10.3554	7.02
Chikamagalur	12.1255	8.64
Chitradurga	9.5269	12.18
Dakshin kannada	14.4223	9.96
Hassan	5.4548	11.16
Mandya	11.5715	13.03
Mysore	13.2824	16.13
Shimoga	13.6668	11.20
Tumkur	6.3446	5.94
Uttar Kannada	6.4311	4.84

Period-II: 2004-05 to 2015-16

Table 4.1.3: Compound growth rate and Coppack's instability index for productivity of coconut for 26 years.

(Values in percentage)

Districts	CGR	CII
Bangalore rural	2.8465	5.86
Chikamagalur	3.9165	6.94
Chitradurga	2.4467	8.82
Dakshin kannada	5.5481	7.23
Hassan	0.8678	8.12
Mandya	3.6365	9.55
Mysore	4.4567	11.58
Shimoga	4.5532	8.54
Tumkur	1.0593	5.02
Uttar Kannada	2.6409	3.53

Period: 1900-91 to 2015-16

The result as per Fig.2 year wise productivity of coconuts in Bangalore district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

From the Fig.3 the result revealed that, year wise productivity of coconuts in Chikamagalur district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

The result presented in Fig.4 year wise productivity of coconuts in Chitradurga district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

Fig.5 depicted the result of year wise productivity of coconut in Dakshin Kannada district has constant from the year 1990 to 2006 for 17 years, started increasing trend from 2007 to 2015.

The result as per Fig.6 year wise productivity of coconuts in Hassan district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

The result noticed in Fig.7 described, year wise productivity of coconuts in Mandya district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

Fig.8 reported that result of year wise productivity of coconuts in Mysore district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

Fig.9 represented that year wise productivity of coconuts in Shimoga district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

The Fig.10 revealed that year wise productivity of coconuts in Tumkur district has constant from the year 1990 to 1999 for 10 years, started declining during the year 2000 to 2006 and further started increasing trend from 2007 to 2015.

The result as per Fig.11 year wise productivity of coconuts in Uttar Kannada district has constant from the year 1990 to 2005 for 16 years, started increasing trend from 2007 to 2015.

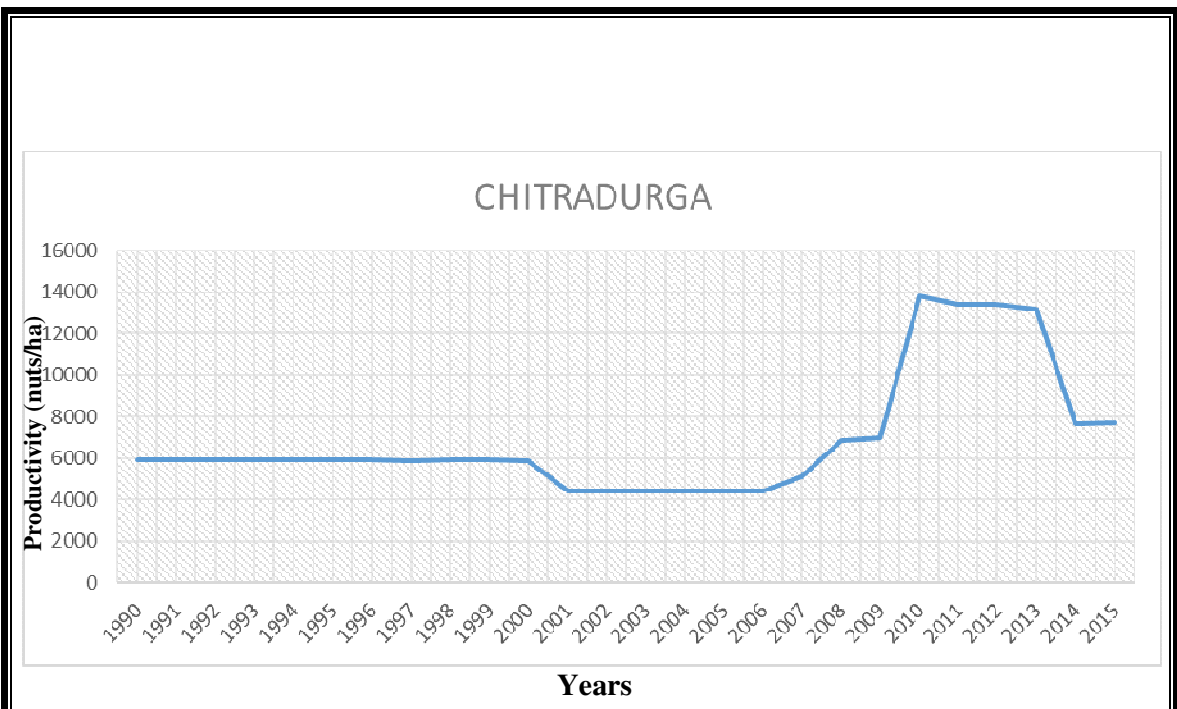


Fig.4: Year wise productivity of coconut in Chitradurga district

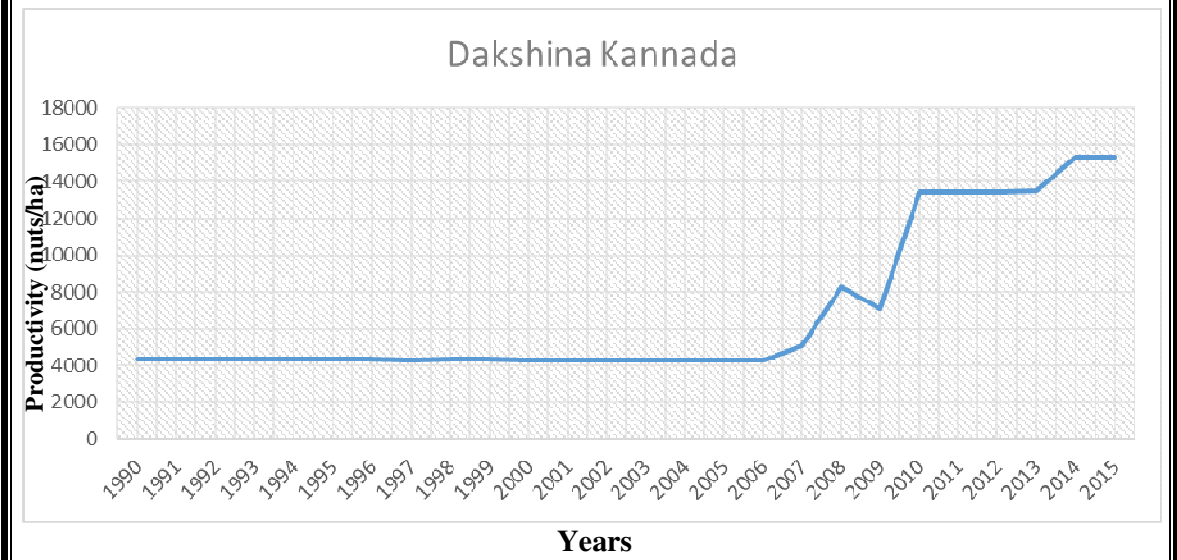


Fig.5: Year wise productivity of coconut in Dakshin Kannada district

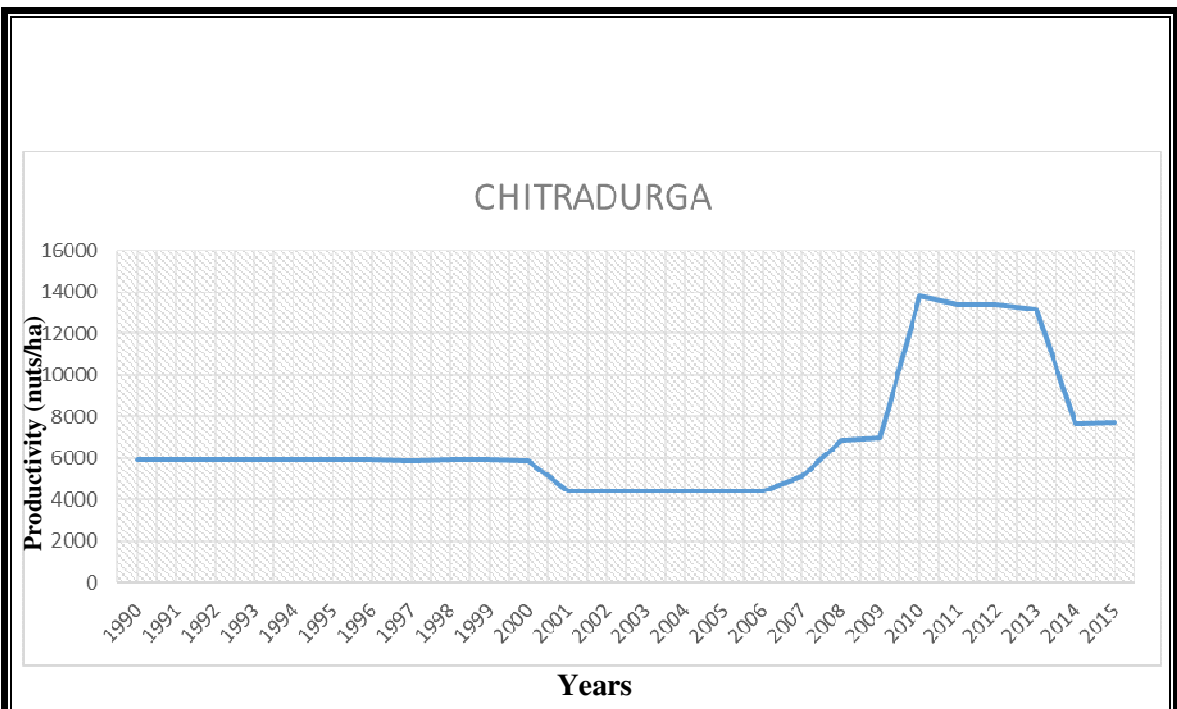


Fig.4: Year wise productivity of coconut in Chitradurga district

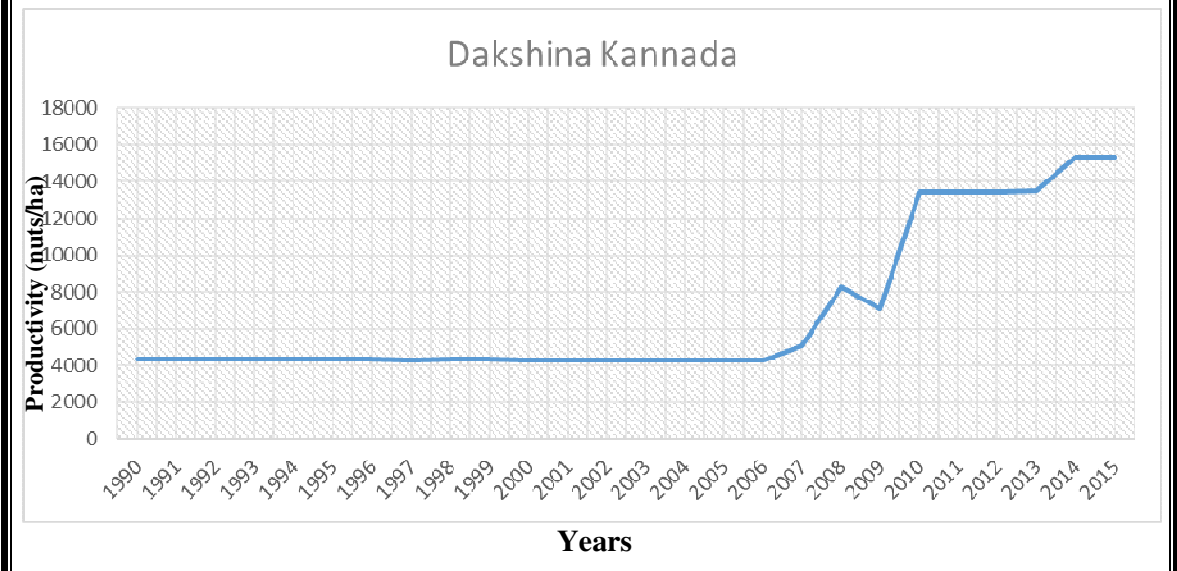


Fig.5: Year wise productivity of coconut in Dakshin Kannada district

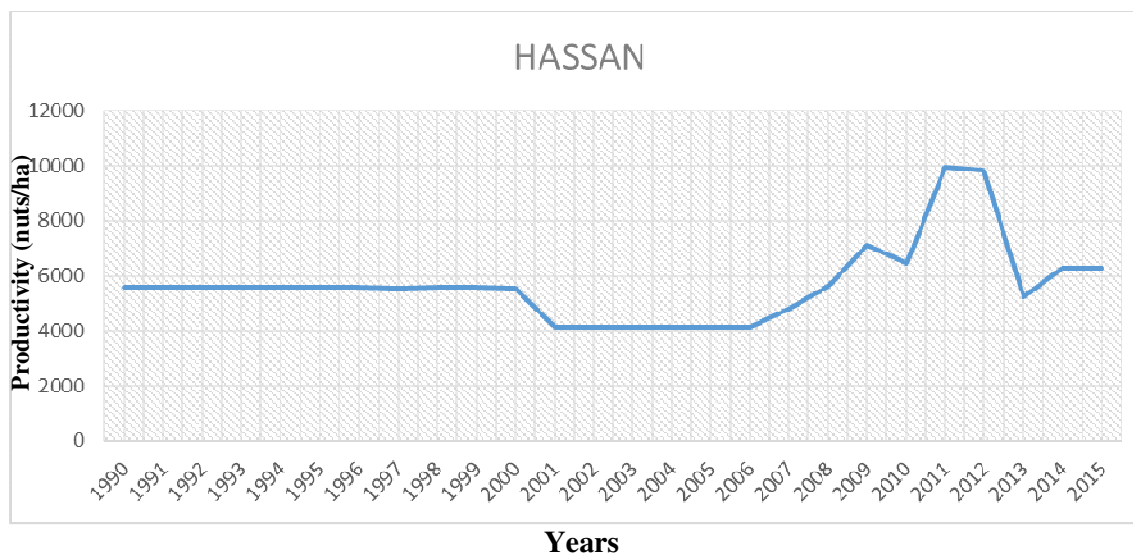


Fig.6: Year wise productivity of coconut in Hassan district

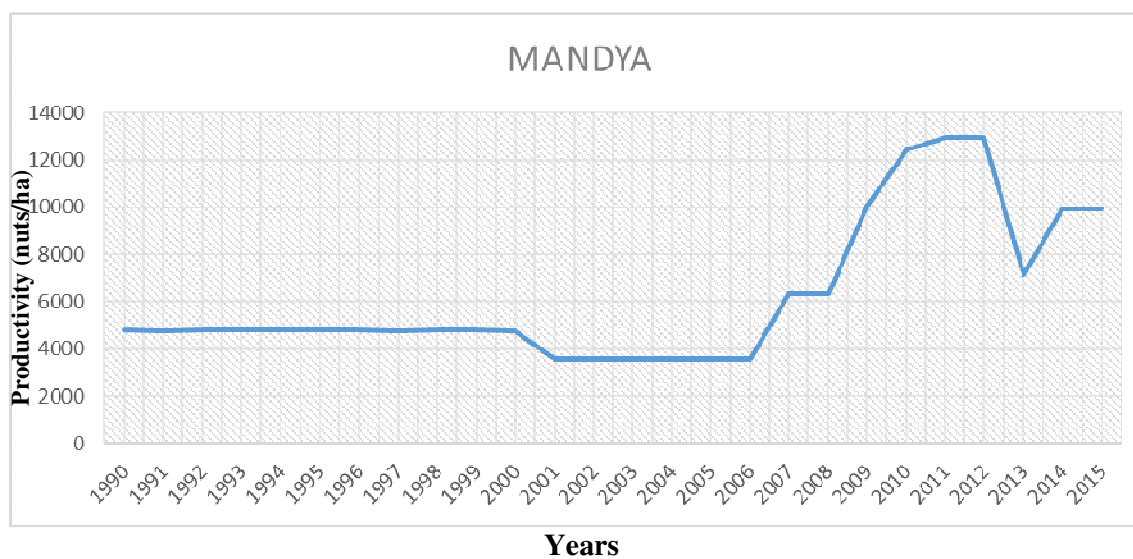


Fig.7: Year wise productivity of coconut in Mandya district

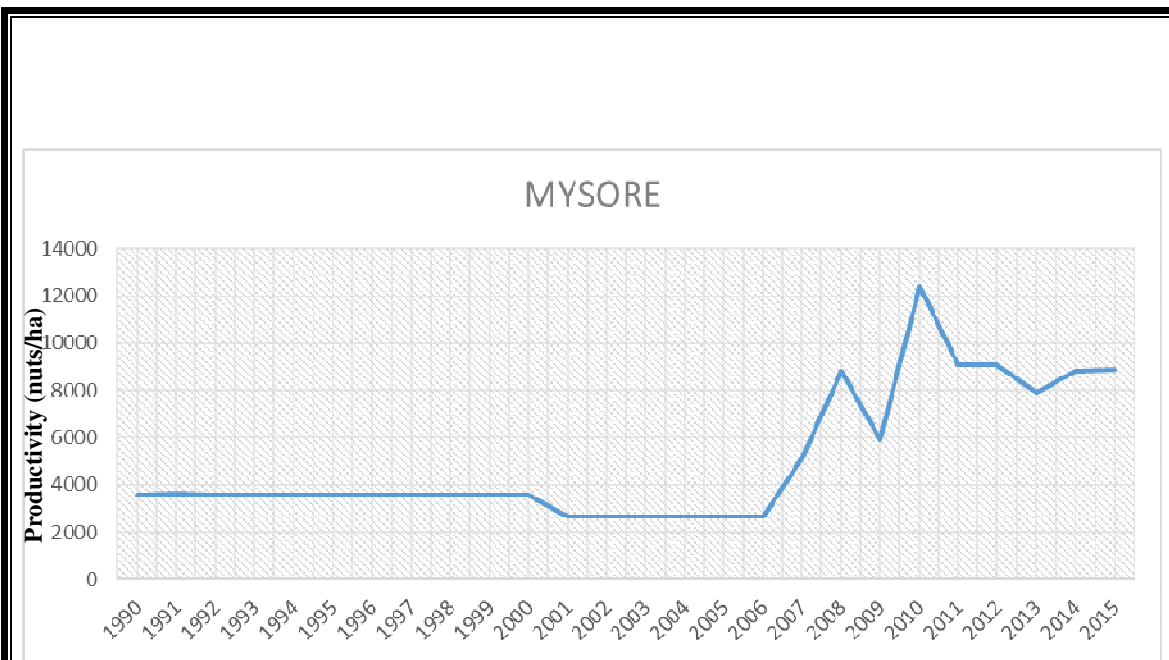


Fig.8: Year wise productivity of coconut in Mysore district

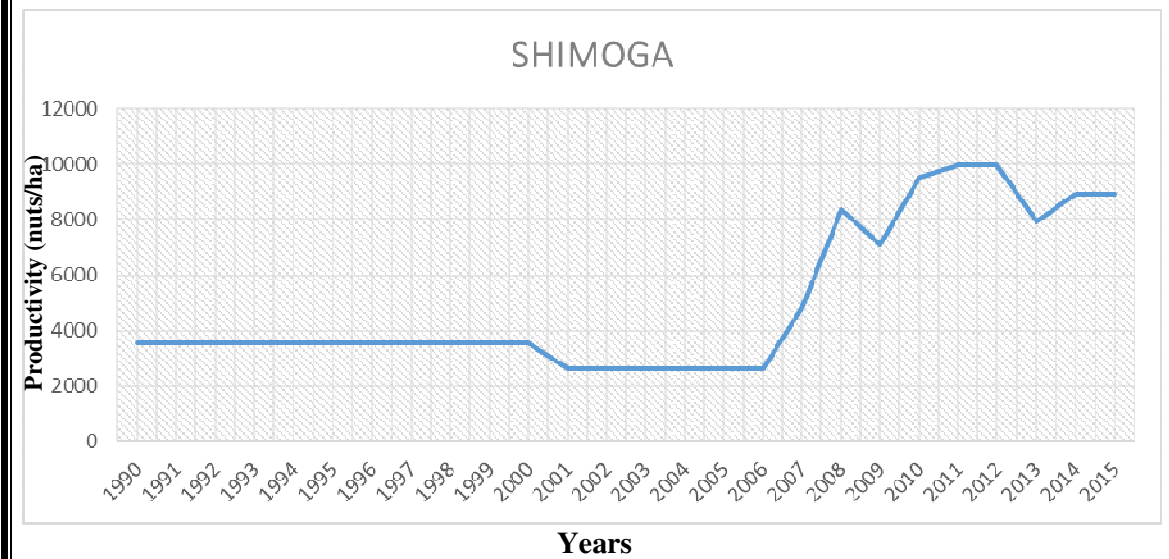


Fig.9: Year wise productivity of coconut in Shimoga district

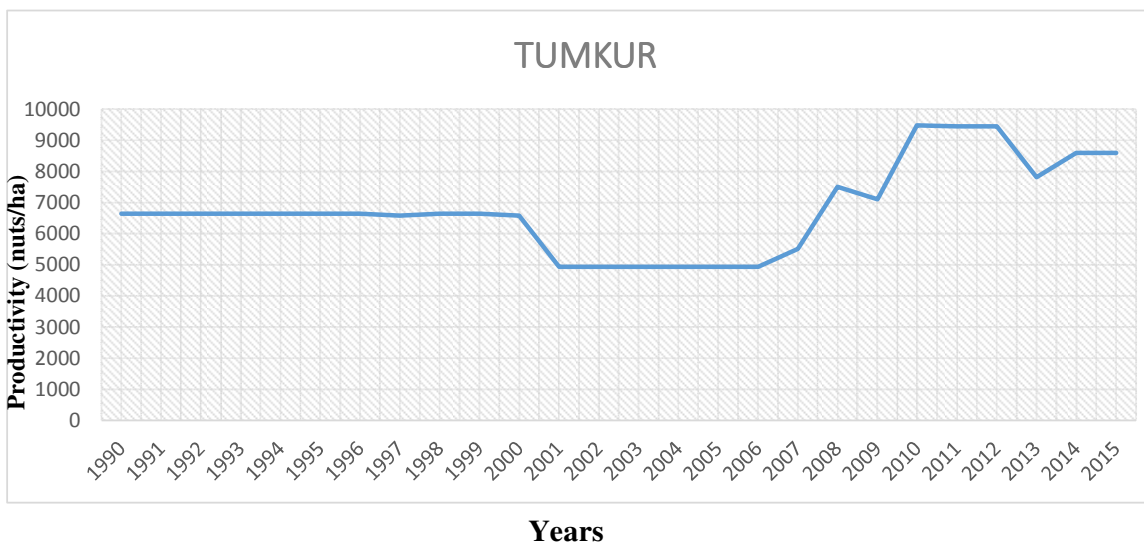


Fig.10: Year wise productivity of coconut in Tumkur district

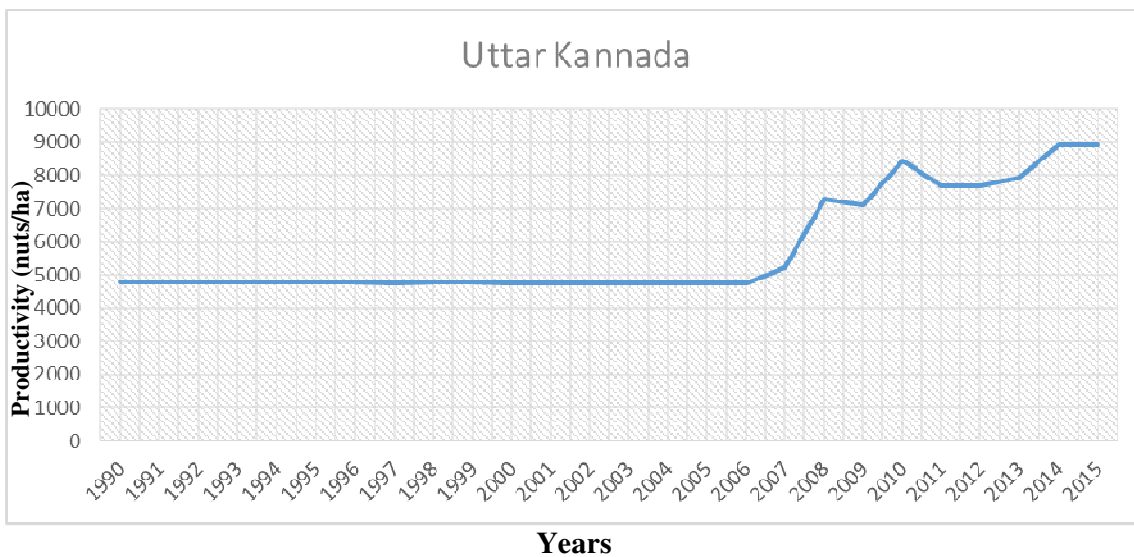


Fig.11: Year wise productivity of coconut in Uttar Kannada district

Coppock's instability index was measured by dividing the overall study period into two sub-periods. Instability in the productivity of coconut for the study period-I (1990-91 to 2003-04), period-II (2004-05 to 2015-16) and whole period (1990-91 to 2015-16) is presented in Table 4.1.1, Table 4.1.2 and Table 4.1.3 respectively.

The results pertaining to Coppock's instability index (CII) during period-I (Table 4.1.1) revealed that, productivity of coconut in the districts of Bangalore rural, Chikamagalur, Chitradurga, Hassan, Shimoga and Tumkur was 3.50 per cent.

The result reported in productivity of coconut in Dakshin Kannada district and Uttar Kannada district was 0.21 per cent.

The productivity of coconut in Mandya district and Mysore district was 3.51 per cent.

The results pertaining to Coppock's instability index (CII) during period-II (Table 4.1.2) reveals that, among the 10 districts, Mysore district has highest CII of 16.13 per cent followed by Mandya district having 13.03 per cent and the third highest was Chitradurga district with CII value of 12.18 percent. However the least CII value of 4.84 per cent was observed in Uttar Kannada district followed by Tumkur with CII value 5.94 per cent.

The results pertaining to Coppock's instability index (CII) during period 1990-91 to 2015-16 (Table 4.1.3) reveals that, among the 10 districts, Mysore district has highest CII of 11.58 per cent followed by Mandya district having 9.55 per cent and the third highest was Chitradurga district with CII value of 8.82 percent. However the least CII value of 3.53 per cent was observed in Uttar Kannada district followed by Tumkur with CII value 5.02 per cent.

4.2 Polynomial models on impact of weather parameters on the production of coconut.

4.2.1 Selected best models for coconut production with average rainfall as independent variable

The coconut production recorded during 1990-91 to 2015-16 can be regarded as the combined influence of weather parameters. The effort was made to find the influence of weather parameters on the production of coconut. The weather parameters considered for the study are average rainfall and average temperature.

Table 4.2.1: Selected best models for coconut production with average rainfall as independent variable

District	Model	R²	MSE	SE of estimate
Bangalore rural	Inverse	0.197*	37488.209	193.619
Chikamagalur	Quadratic	0.385*	3447779.503	589.728
Chitradurga	Compound	0.302*	0.102	.320
Dakshin kannada	Compound	0.233*	0.208	.456
Hassan	Compound	0.205*	0.068	.260
Mandya	Linear	0.181*	773190.455	879.312
Mysore	Cubic	0.401*	406439.183	637.526
Shimoga	Quadratic	0.479*	11690.620	108.123
Tumkur	Inverse	0.207*	1.013	3182.242
Uttar Kannada	Compound	0.291*	0.102	0.319

Note: * = significant @ 5 %

The relationship between weather parameters on coconut production was measured using by appropriate models were fitted in the analysis. As a part of it nearly nine models were tried and the suitable models were fitted to investigate the impact of weather parameters on the coconut production.

In the table 4.2.1 production was considered as dependent variable and independent variable as average rainfall. All models were found to be significant at 5 per cent level of significance. So the best model was selected based on highest R- square and least MSE values.

In case of production and average rainfall, compound model was found to be best fit for the following districts such as Chitradurga, Dakshin Kannada, Hassan and Uttar Kannada with the highest R^2 value of 0.302, 0.233, 0.205 and 0.291, MSE values were of 0.102, 0.208, 0.068 and 0.102 respectively.

Inverse model was found to be best fit for the districts of Bangalore rural and Tumkur with their highest R^2 values 0.197 and 0.207, MSE values were 37488.209 and 1.013 respectively. Quadratic model was found to be best fit for the districts Chikamagalur and Shimoga with their highest R^2 values 0.385 and 0.479, MSE values were of 347779.503 and 11690.620 respectively. Linear model was best fit for Mandya district with the highest R^2 value of 0.181 and MSE value of 773190.455. Cubic model was best fit for Mysore district with their highest R^2 value of 0.401 and MSE value of 406439.183.

4.2.2 Selected best models for coconut production with average temperature as independent variable

In the table 4.2.2 production was considered as dependent variable and independent variable as average temperature. All models were found to be significant at 5 per cent level of significance. So the best model was selected based on highest R- square and least MSE values.

In case of production and average temperature, compound model was found to be best fit for the following districts. Such as Chikamagalur, Chitradurga and Mandya with the highest R^2 value of 0.181, 0.180, 0.204 and MSE values were of 0.271, 0.120 and 0.314 respectively.

Table 4.2.2: Selected best models for coconut production with average temperature as independent variable

District	Model	R²	MSE	SE of estimate
Bangalore rural	S-curve	0.219*	0.233	0.472
Chikamagalur	Compound	0.181*	0.271	0.521
Chitradurga	Compound	0.180*	0.120	0.347
Dakshin kannada	S-curve	0.257*	0.120	0.448
Hassan	Cubic	0.334*	8855462.510	924.912
Mandya	Compound	0.204*	0.314	0.560
Mysore	Cubic	0.338*	449476.861	670.430
Shimoga	Inverse	0.190*	17404.739	131.927
Tumkur	Inverse	0.207*	1.012	3181.318
Uttar Kannada	S-curve	0.202*	0.114	0.338

Note: * = significant @ 5 %

Inverse model was found to be best fit for the districts of Shimoga and Tumkur with their highest R^2 values 0.190 and 0.207 and MSE values were 17404.739 and 1.012 respectively. S-curve model was found to be best fit for the districts of Bangalore rural, Dakshin Kannada and Uttar Kannada with their highest R^2 values 0.219, 0.257 and 0.202, MSE values are 0.233, 0.201 and 0.114 respectively. Cubic model was found to be best fit for the districts of Hassan and Mysore with their highest R^2 values 0.334 and 0.338, MSE values were 8855462.510 and 449476.861 respectively.

Significant average rainfall and average temperature was shown over the twenty six years in the case of production of coconut in the Table.4.2.1 and Table 4.2.2 respectively.

4.3. ARIMA model in estimate of coconut production.

4.3.1 ARIMA model

As Box-Jenkin methodology was preferred to be the multiplicative time series model for forecasting purpose. The detailed analysis of forecasting of production of coconut in selected districts of Karnataka has been presented as under.

4.3.2 Diagnostic checking

From the different (p, d, q) models, ARIMA (2, 1, 0) model was selected based on the lowest MAPE (19.784) and normalised BIC (9.630) values for forecasting the production of coconut in Bangalore rural district, followed by Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur, Uttar Kannada district with their MAPE values are 11.302, 13.659, 9.914, 18.901, 23.527, 16.800, 8.062, 5.523 and their normalised BIC values are 13.461, 11.397, 13.529, 12.492, 12.736, 9.118, 14.213, 7.654 respectively, the model fitted for Chikamagalur district are ARIMA (1, 1, 0) the lowest MAPE 6.545 and normalised BIC value was 10.280. The model parameters were estimated using SPSS software and hence it was taken as best fitted model and forecast has been done. The result were presented in the Table 4.3.2.

4.3.3 Forecasting of production

The predicted values of production of coconut for the next five years (2016, 2017, 2018, 2019 and 2020) are presented in the Table 4.3.3.1 to Table 4.3.3.10 and also seen in the Fig. 12 to 21.

The Bangalore rural district has shown decrease in observed and predicted coconut production over the period from 1990-91 to 2020-21 (Table 4.3.3.1). Highest observed

Table 4.3.2: Result of ARIMA model to the production of coconut

District	Fitted models	R²	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalised BIC
Bangalore rural	(2,1,0)	0.985	115.683	19.784	58.662	236.734	477.920	9.630
Chikamagalur	(1,1,0)	0.952	160.047	6.545	72.838	48.970	689.430	10.280
Chitradurga	(0,1,0)	0.637	785.330	11.302	372.600	75.456	2.774	13.461
Dakshin kannada	(0,1,0)	0.848	279.790	13.659	161.409	115.302	919.975	11.397
Hassan	(0,1,0)	0.453	812.504	9.914	363.627	95.990	3.070	13.529
Mandya	(0,1,0)	0.747	483.686	18.901	282.979	90.992	1.359	12.492
Mysore	(0,1,0)	0.532	546.462	23.527	305.530	78.677	1.783	12.736
Shimoga	(0,1,0)	0.613	89.546	16.800	58.190	90.369	211.771	9.118
Tumkur	(0,1,0)	0.892	1.144	8.062	668.277	27.890	3.245	14.213
Uttar Kannada	(0,1,0)	0.928	43.067	5.523	25.493	26.199	143.556	7.654

production of 786.14 lakh nuts was observed during the year 2001-02 followed by 767.44 lakh nuts during the year 2002-03 and the recent production during the year 2015-16 was 203.46 lakh nuts. Result can also be seen in the Fig.12.

The result from the Table 4.3.3.2 revealed that for Chikamagalur district the observed production of coconut increased in the year 1990-91 to 2000-01 and decreased in the year 2001-02 and remains constant up to 2006-07 and sudden increase in the year 2007-08 to 2015-16.

For the predicted production of coconut, started increasing trend in the year 1990-91 to 2001-02 and there was declining trend appeared in the year 2002-03 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards. Result can also be seen in the Fig.13.

Observed and predicted production of coconut in Chitradurga district over the period from 1990-91 to 2020-21 (4.3.3.3) has shown increase in trend. Highest observed production of 5831.65 lakh nuts was observed during the year 2010-11 followed by 5712.48 lakh nuts during the year 2011-12 and the recent production during the year 2015-16 was 2992.14 lakh nuts. Result can also be seen in the Fig.14.

The Dakshin Kannada district has shown increase in observed and predicted coconut production over the period from 1990-91 to 2020-21 (Table 4.3.3.4). Highest observed production of 2831.26 lakh nuts was observed during the year 2015-16 followed by 2821.27 lakh nuts during the year 2014-15 and the recent production during the year 2015-16 was 2831.26 lakh nuts. Result can also be seen in the Fig.15.

In the Table 4.3.3.5 for Hassan district the observed production of coconut increased in the year 1990-91 to 2000-01 and slight decrease in the year 2001-02 to 2006-07 and sudden increase in the year 2007-08 to 2012-13 and sudden decrease in the year 2013-14 to 2015-16.

Similar manner predicted production of coconut started increasing trend in the year 1990-91 to 2001-02 and there was slight declining trend appeared in the year 2002-03 to 2007-08 and increase in the year 2008-09 to 2013-14 and sudden decrease in the year 2014-15 to 2017-18 and increase in the year 2018-19 onwards. Result can also be seen in the Fig.16.

Table 4.3.3.1: Prediction of coconut production for the next five years by using ARIMA model for Bangalore rural

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	541.72	
1991-92	594.15	528.18
1992-93	603.29	580.61
1993-94	612.74	589.75
1994-95	625.87	599.20
1995-96	650.42	612.33
1996-97	660.06	636.88
1997-98	660.06	646.52
1998-99	674.05	646.52
1999-20	702.35	660.51
2000-01	719.99	688.81
2001-02	786.14	706.45
2002-03	767.44	772.60
2003-04	721.06	753.90
2004-05	708.81	707.52
2005-06	689.54	695.27
2006-07	693.33	676.00
2007-08	201.88	679.79
2008-09	158.46	188.34
2009-10	320.24	144.92
2010-11	430.46	306.70
2011-12	401.58	416.92
2012-13	227.65	388.04
2013-14	220.72	214.11
2014-15	201.23	207.18
2015-16	203.46	187.69
2016-17		189.92
2017-18		176.39
2018-19		162.86
2019-20		149.33
2020-21		135.80

Table 4.3.3.2: Prediction of coconut production for the next five years by using ARIMA model for Chikamagalur

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	631.97	
1991-92	632.25	631.97
1992-93	646.17	632.38
1993-94	646.81	652.88
1994-95	670.06	647.11
1995-96	670.97	681.28
1996-97	720.01	671.40
1997-98	756.69	743.68
1998-99	757.20	774.39
1999-20	760.20	757.44
2000-01	760.22	761.64
2001-02	587.50	760.22
2002-03	588.33	504.13
2003-04	589.53	588.73
2004-05	588.49	590.10
2005-06	714.17	587.98
2006-07	717.05	774.83
2007-08	1,407.87	718.44
2008-09	1,844.78	1,741.31
2009-10	2,032.39	2,055.66
2010-11	2,111.77	2,122.94
2011-12	2,078.27	2,150.08
2012-13	2,304.46	2,062.10
2013-14	2,395.53	2,413.63
2014-15	2,380.89	2,439.48
2015-16	2,396.86	2,373.82
2016-17		2,404.56
2017-18		2,408.28
2018-19		2,410.08
2019-20		2,410.95
2020-21		2,411.37

Table 4.3.3.3: Prediction of coconut production for the next five years by using ARIMA model for Chitradurga

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	2,027.28	
1991-92	2,068.55	2,101.41
1992-93	2,139.73	2,144.19
1993-94	2,147.59	2,217.97
1994-95	2,289.19	2,226.12
1995-96	2,349.43	2,372.89
1996-97	2,452.62	2,435.34
1997-98	2,474.77	2,542.30
1998-99	2,142.68	2,565.26
1999-20	2,177.60	2,221.03
2000-01	2,233.58	2,257.22
2001-02	1,725.62	2,315.25
2002-03	1,739.10	1,788.72
2003-04	1,898.70	1,802.69
2004-05	1,903.09	1,968.13
2005-06	1,785.19	1,972.61
2006-07	1,835.80	1,850.46
2007-08	2,164.88	1,902.93
2008-09	2,915.91	2,244.04
2009-10	2,950.08	3,022.53
2010-11	5,831.65	3,057.95
2011-12	5,712.48	6,044.89
2012-13	5,711.81	5,921.37
2013-14	5,042.71	5,920.67
2014-15	2,979.15	5,227.10
2015-16	2,992.14	3,088.08
2016-17		3,101.55
2017-18		3,214.97
2018-19		3,332.53
2019-20		3,454.39
2020-21		3,580.71

Table 4.3.3.4: Prediction of coconut production for the next five years by using ARIMA model for Dakshin Kannada

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	881.55	
1991-92	898.58	947.12
1992-93	910.44	965.42
1993-94	948.73	978.16
1994-95	968.35	1,019.30
1995-96	988.40	1,040.38
1996-97	1,004.00	1,061.92
1997-98	1,097.30	1,078.68
1998-99	547.57	1,178.92
1999-20	595.90	588.30
2000-01	633.16	640.22
2001-02	658.99	680.26
2002-03	666.29	708.01
2003-04	668.17	715.85
2004-05	669.53	717.87
2005-06	673.33	719.33
2006-07	687.03	723.41
2007-08	820.86	738.13
2008-09	1,334.27	881.92
2009-10	1,144.45	1,433.52
2010-11	2,149.56	1,229.58
2011-12	2,156.49	2,309.46
2012-13	2,168.03	2,316.91
2013-14	2,198.77	2,329.30
2014-15	2,821.27	2,362.33
2015-16	2,831.26	3,031.14
2016-17		3,041.87
2017-18		3,268.16
2018-19		3,511.27
2019-20		3,772.48
2020-21		4,053.11

Table 4.3.3.5: Prediction of coconut production for the next five years by using ARIMA model for Hassan

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	2,344.56	
1991-92	2,344.56	2,403.95
1992-93	2,374.64	2,403.95
1993-94	2,375.64	2,434.03
1994-95	2,483.85	2,435.03
1995-96	2,539.44	2,543.24
1996-97	2,552.01	2,598.83
1997-98	2,612.37	2,611.40
1998-99	2,704.10	2,671.76
1999-20	2,711.80	2,763.49
2000-01	2,717.05	2,771.19
2001-02	2,285.96	2,776.44
2002-03	2,403.42	2,345.35
2003-04	2,494.35	2,462.81
2004-05	2,536.83	2,553.74
2005-06	2,564.94	2,596.22
2006-07	2,565.47	2,624.33
2007-08	2,968.79	2,624.86
2008-09	3,471.67	3,028.18
2009-10	4,426.51	3,531.06
2010-11	4,040.12	4,485.90
2011-12	6,221.56	4,099.51
2012-13	6,208.83	6,280.95
2013-14	3,198.23	6,268.22
2014-15	3,826.29	3,257.62
2015-16	3,829.30	3,885.68
2016-17		3,888.69
2017-18		3,948.07
2018-19		4,007.46
2019-20		4,066.85
2020-21		4,126.24

Table 4.3.3.6: Prediction of coconut production for the next five years by using ARIMA model for Mandya

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	642.11	
1991-92	653.69	726.28
1992-93	651.86	737.86
1993-94	658.23	736.03
1994-95	732.77	742.40
1995-96	759.99	816.94
1996-97	770.00	844.16
1997-98	780.52	854.17
1998-99	800.63	864.69
1999-20	810.00	884.80
2000-01	814.29	894.17
2001-02	610.76	898.46
2002-03	640.68	694.93
2003-04	644.37	724.85
2004-05	650.82	728.54
2005-06	684.75	734.99
2006-07	655.55	768.92
2007-08	1,134.46	739.72
2008-09	1,453.48	1,218.63
2009-10	2,550.56	1,537.65
2010-11	3,281.12	2,634.73
2011-12	3,454.58	3,365.29
2012-13	2,768.37	3,538.75
2013-14	1,493.54	2,852.54
2014-15	2,736.82	1,577.71
2015-16	2,746.59	2,820.99
2016-17		2,830.76
2017-18		2,914.94
2018-19		2,999.12
2019-20		3,083.30
2020-21		3,167.48

Table 4.3.3.7: Prediction of coconut production for the next five years by using ARIMA model for Mysore

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	472.00	
1991-92	493.72	527.50
1992-93	514.23	551.77
1993-94	540.20	574.69
1994-95	579.69	603.72
1995-96	605.02	647.85
1996-97	652.01	676.16
1997-98	673.00	728.68
1998-99	420.95	752.13
1999-20	401.70	470.44
2000-01	445.56	448.93
2001-02	501.22	497.95
2002-03	528.89	560.15
2003-04	480.92	591.08
2004-05	518.28	537.47
2005-06	351.45	579.22
2006-07	493.12	392.77
2007-08	1,126.36	551.10
2008-09	1,938.57	1,258.81
2009-10	1,308.99	2,166.52
2010-11	3,246.30	1,462.91
2011-12	2,387.60	3,628.03
2012-13	1,962.86	2,668.36
2013-14	1,778.53	2,193.67
2014-15	1,976.74	1,987.66
2015-16	1,986.74	2,209.18
2016-17		2,220.36
2017-18		2,481.45
2018-19		2,773.25
2019-20		3,099.36
2020-21		3,463.82

Table 4.3.3.8: Prediction of coconut production for the next five years by using ARIMA model for Shimoga

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	209.54	
1991-92	285.85	223.08
1992-93	289.10	304.33
1993-94	290.84	307.79
1994-95	320.19	309.64
1995-96	357.38	340.89
1996-97	381.01	380.48
1997-98	419.02	405.64
1998-99	234.34	446.11
1999-20	238.66	249.49
2000-01	244.93	254.09
2001-02	183.39	260.76
2002-03	180.61	195.24
2003-04	177.43	192.28
2004-05	175.13	188.90
2005-06	181.22	186.45
2006-07	181.78	192.93
2007-08	331.67	193.53
2008-09	555.67	353.11
2009-10	450.71	591.59
2010-11	607.12	479.85
2011-12	592.86	646.37
2012-13	571.16	631.19
2013-14	429.94	608.08
2014-15	482.16	457.73
2015-16	488.21	513.33
2016-17		519.77
2017-18		553.38
2018-19		589.15
2019-20		627.25
2020-21		667.80

Table 4.3.3.9: Prediction of coconut production for the next five years by using ARIMA model for Tumkur

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	3,610.77	
1991-92	3,647.32	3,983.32
1992-93	3,914.16	4,019.87
1993-94	4,117.06	4,286.71
1994-95	4,292.36	4,489.61
1995-96	4,851.98	4,664.91
1996-97	5,036.01	5,224.53
1997-98	5,577.84	5,408.56
1998-99	5,514.84	5,950.39
1999-20	5,809.30	5,887.39
2000-01	6,632.83	6,181.85
2001-02	5,477.67	7,005.38
2002-03	5,490.26	5,850.22
2003-04	5,401.18	5,862.81
2004-05	5,474.91	5,773.73
2005-06	6,054.94	5,847.46
2006-07	6,194.16	6,427.49
2007-08	6,837.65	6,566.71
2008-09	9,945.66	7,210.20
2009-10	9,858.98	10,318.21
2010-11	13,477.00	10,231.53
2011-12	13,495.86	13,849.55
2012-13	13,888.04	13,868.41
2013-14	11,397.18	14,260.59
2014-15	12,836.92	11,769.73
2015-16	12,924.64	13,209.47
2016-17		13,297.19
2017-18		13,669.75
2018-19		14,042.30
2019-20		14,414.86
2020-21		14,787.41

Table 4.3.3.10: Prediction of coconut production for the next five years by using ARIMA model for Uttar Kannada

Year	Observed production (in lakh nuts)	Predicted production (in lakh nuts)
1990-91	261.67	
1991-92	261.05	273.16
1992-93	265.52	272.51
1993-94	268.40	277.18
1994-95	266.38	280.18
1995-96	271.23	278.07
1996-97	269.01	283.14
1997-98	273.37	280.82
1998-99	267.48	285.37
1999-20	276.10	279.22
2000-01	280.93	288.22
2001-02	288.64	293.26
2002-03	293.06	301.31
2003-04	296.01	305.93
2004-05	298.48	309.01
2005-06	342.29	311.58
2006-07	355.70	357.32
2007-08	387.38	371.32
2008-09	547.95	404.39
2009-10	539.02	572.01
2010-11	651.07	562.69
2011-12	587.22	679.66
2012-13	590.38	613.01
2013-14	616.30	616.31
2014-15	694.63	643.36
2015-16	699.27	725.13
2016-17		729.98
2017-18		762.04
2018-19		795.51
2019-20		830.45
2020-21		866.93

In the Table 4.3.3.6 for Mandya district the observed production of coconut increased in the year 1990-91 to 2000-01 and slight decrease in the year 2001-02 to 2006-07 and sudden increase in the year 2007-08 to 2015-16.

Same way predicted production of coconut started increasing trend in the year 1990-91 to 2001-02 and there was slight declining trend appeared in the year 2002-03 to 2007-08 and increasing trend noticed after 2010-11 onwards. Result can also be seen in the Fig.17.

In the Table 4.3.3.7 for Mysore district the observed production of coconut increased in the year 1990-91 to 1997-98 and decrease trend appeared in the year 1998-99 to 2006-07 and sudden increasing trend noticed after 2007-08 onwards.

The same way predicted production of coconut started increasing trend in the year 1990-91 to 1998-99 and there was declining trend appeared in the year 1999-20 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards. Result can also be seen in the Fig. 18.

In the Table 4.3.3.8 for Shimoga district the observed production of coconut increased in the year 1990-91 to 1997-98 and decrease trend appeared in the year 1998-99 to 2006-07 and sudden increasing trend noticed after 2007-08 onwards.

The similar way predicted production of coconut started increasing trend in the year 1990-91 to 1998-99 and there was declining trend appeared in the year 1999-20 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards. Result can also be seen in the Fig. 19.

In the Table 4.3.3.9 for Tumkur district the observed production of coconut was increasing trend from 1990-91 to 2015-16. The same way predicted production of coconut started increasing trend in the year 1990-91 to 2020-2021. Result can also be seen in the Fig. 20.

In the Table 4.3.3.10 for Uttar Kannada district the observed production of coconut was increasing trend from 1990-91 to 2015-16. The same way predicted production of coconut started increasing trend in the year 1990-91 to 2020-2021. Result can also be seen in the Fig. 21.

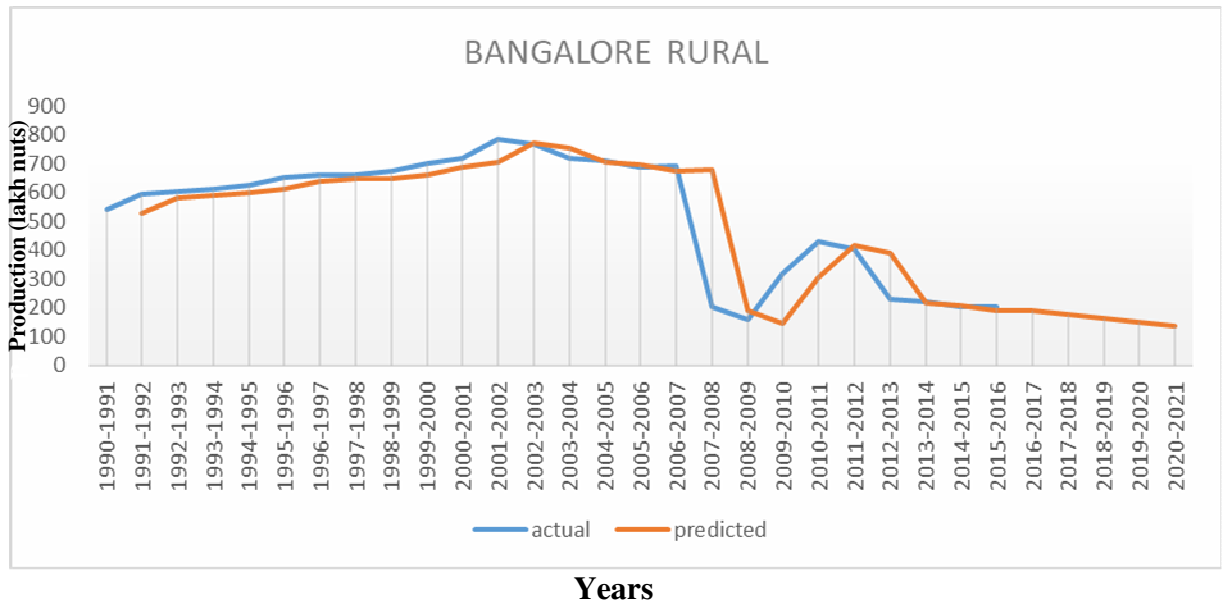


Fig.12: Observed and predicted production of coconut in Bangalore rural district

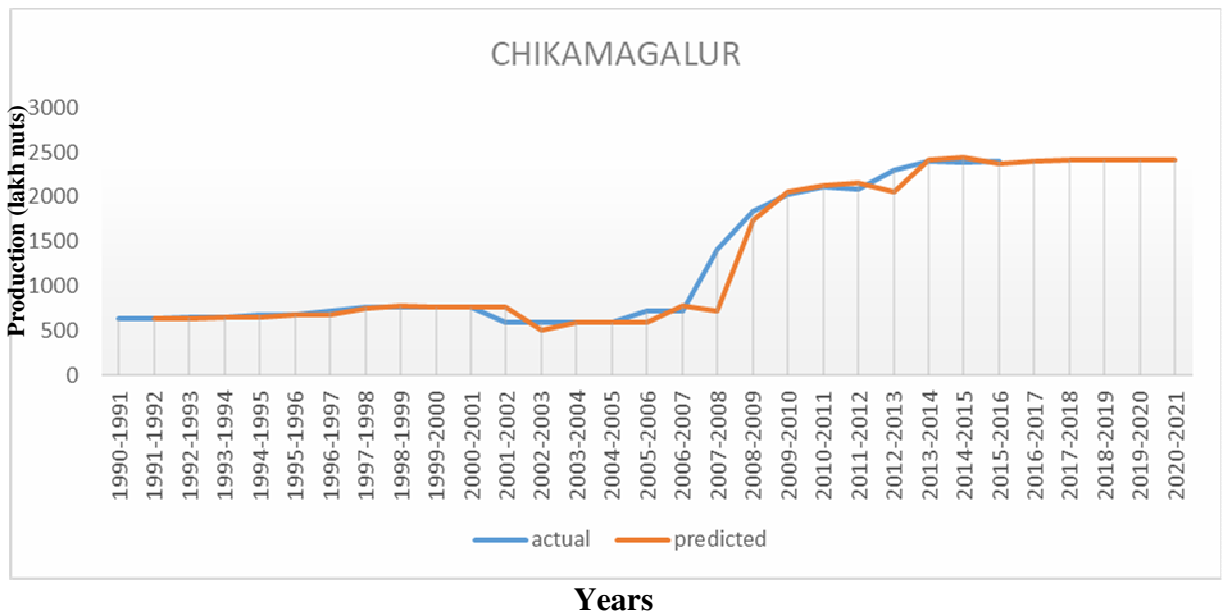


Fig.13: Observed and predicted production of coconut in Chikamagalur district

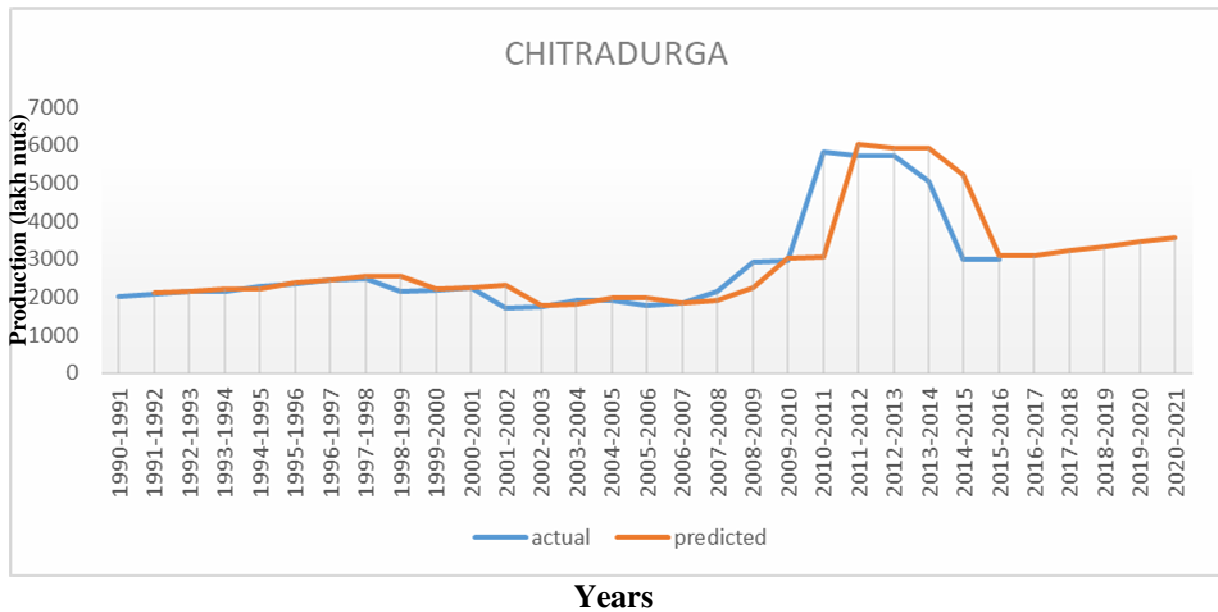


Fig.14: Observed and predicted production of coconut in Chitradurga district

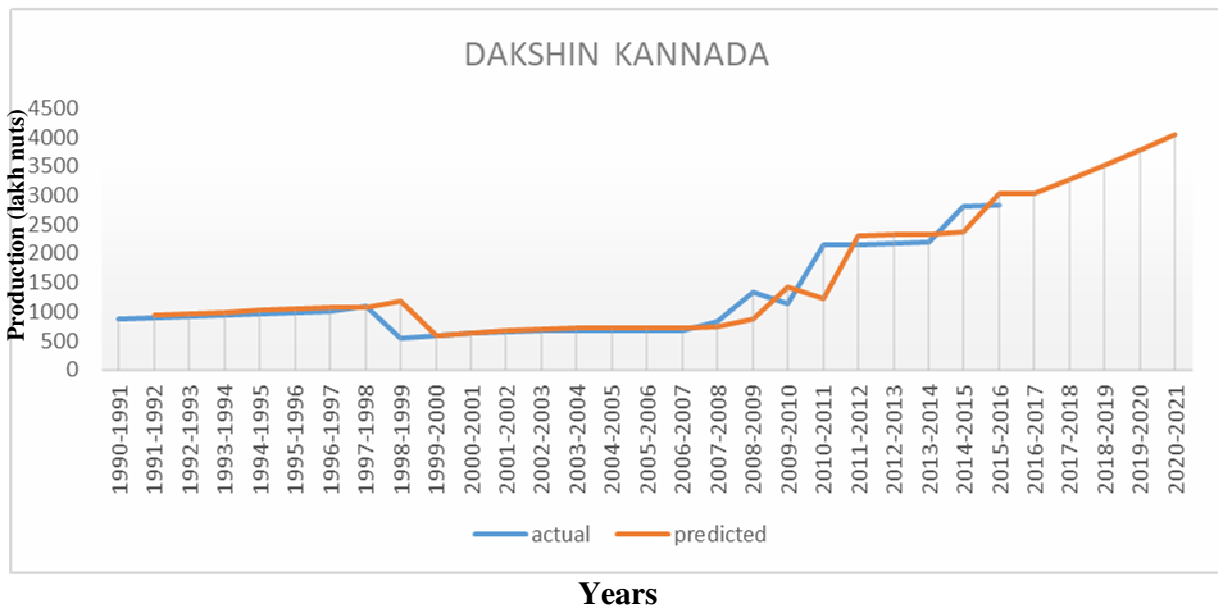


Fig.15: Observed and predicted production of coconut in Dakshin Kannada district

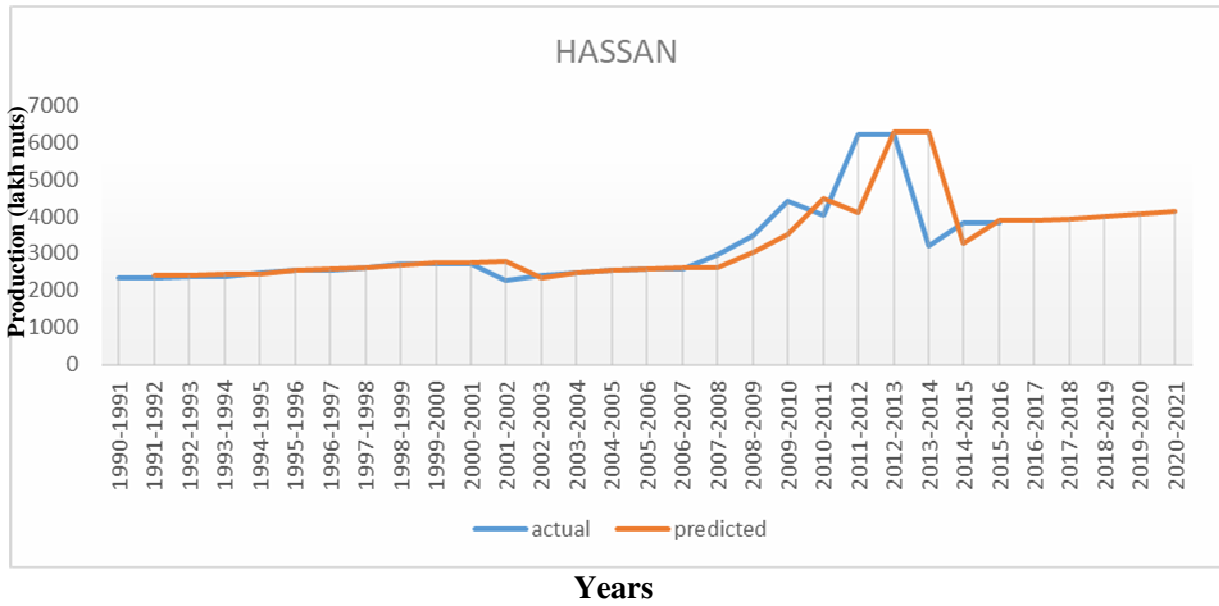


Fig.16: Observed and predicted production of coconut in Hassan district

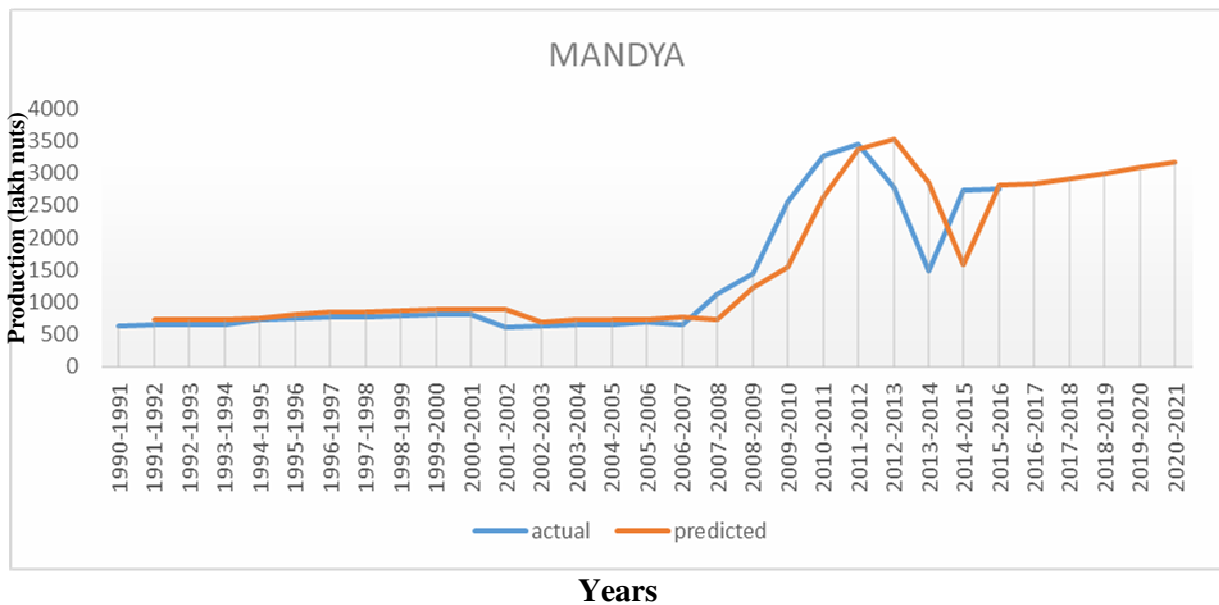


Fig.17: Observed and predicted production of coconut in Mandya district

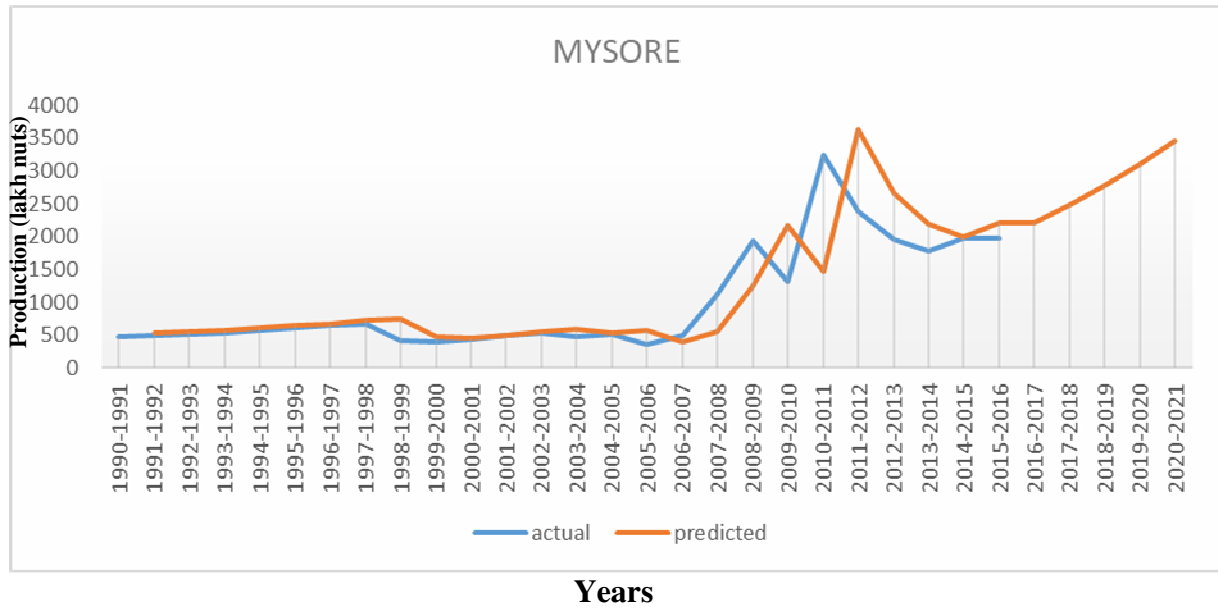


Fig.18: Observed and predicted production of coconut in Mysore district

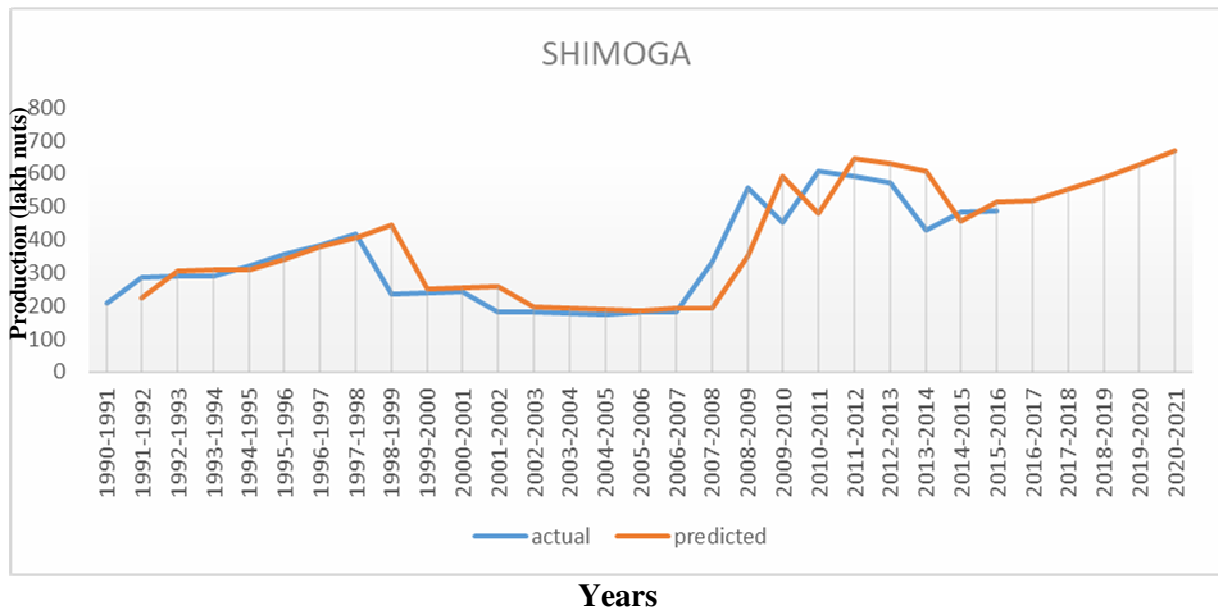


Fig.19: Observed and predicted production of coconut in Shimoga district

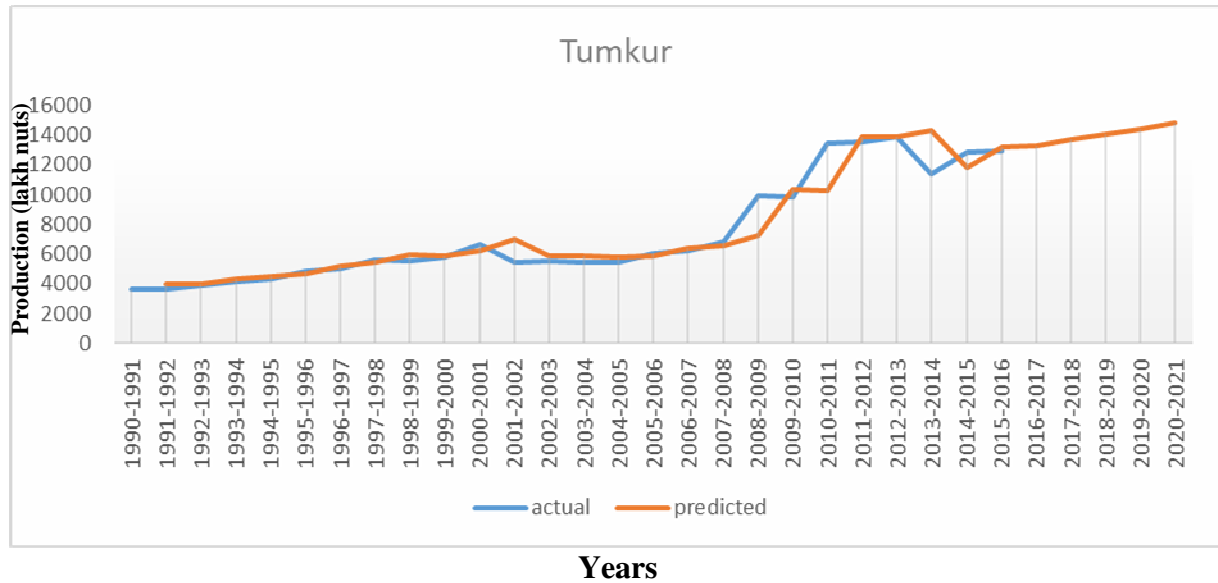


Fig.20: Observed and predicted production of coconut in Tumkur district

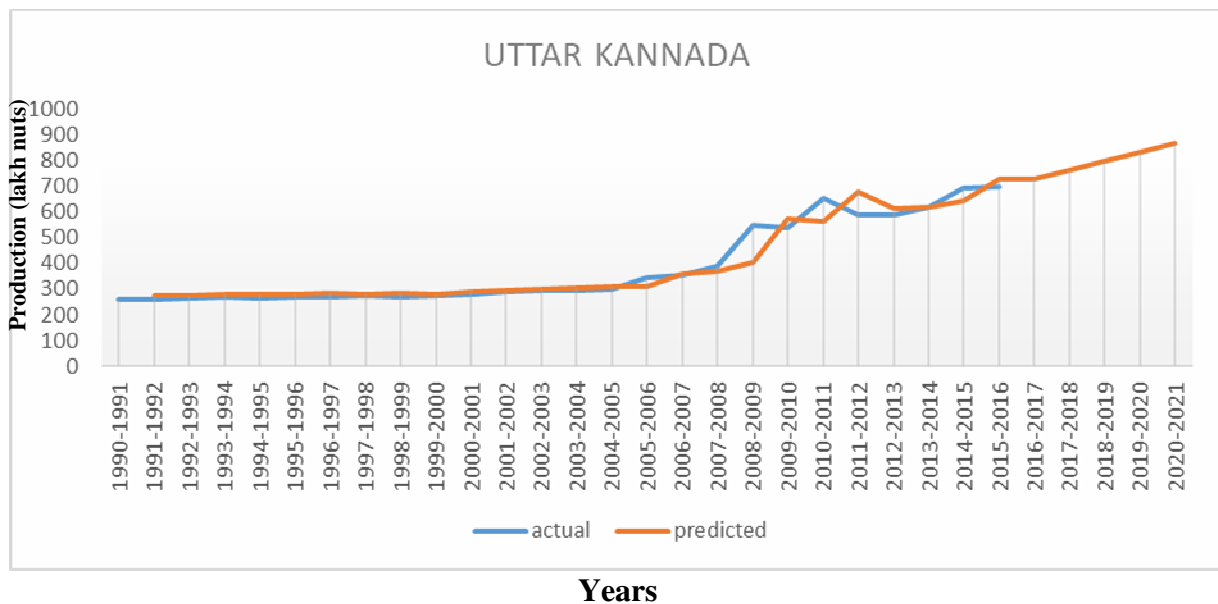


Fig.21: Observed and predicted production of coconut in Uttar Kannada district

Discussion

5. DISCUSSION

The results presented in the previous chapter have been discussed in this chapter. The present investigation is subjected to some of the statistical analysis *viz.*, Stability analysis, Polynomial and non-linear models and ARIMA model. The results of the investigation presented in the previous chapter are discussed in detail in this chapter:

5.1 Stability analysis of coconut productivity in Karnataka.

5.2 Polynomial models on impact of weather parameters on the production of coconut.

5.3 ARIMA model in estimate of coconut production.

5.1 Stability analysis of coconut productivity in Karnataka.

To know the stability of coconut productivity in Karnataka, the different statistical models were applied in the present investigation like compound growth rate and coppock's instability index. To compute these tools the secondary data of productivity of coconut was collected for 26 years that is from 1990-91 to 2015-16.

The results obtained from CGR for the period-I (1990-91 to 2003-04) showed that there was a negative growth in the productivity of coconut for all the ten districts *viz.* Bangalore rural, Chickmagalur, Chitradurga, Dakshin kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar kannada and their values are -1.8088, -1.8070, -1.8094, -0.0880, -1.8112, -1.7735, -1.8450, -1.8094, -1.8082 and -0.0875, respectively. This showed that, the study period-I the productivity of coconut for all the ten districts was decreasing in rate.

Due to recurring droughts for consecutive three years 2001-02, 2002-03 and 2004-05, the drought of 2003 was considered of severe in nature, the agriculture and horticulture crops were adversely affected in almost all parts of Karnataka during the three consecutive year. The severity of drought was more in the dry zones, due to this reason there is a decrease in agriculture and coconut production. The state received annual rainfall of 876 mm in 2003 as against the normal rainfall of 1139 mm. This is one of the reason for the decreasing in the productivity of coconut in the period-I. The results of productivity of coconut for all ten districts are shown graphically in the Fig.2 to 11. In the Fig.2 to Fig.11 year (time) was considered as x - axis and productivity (lakh nuts) was considered as y – axis.

The results obtained from CGR for the period-II (2004-05 to 2015-16) showed that there was a positive growth in the productivity of coconut for all the ten districts *viz.*, Bangalore rural, Chickmagalur, Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar Kannada and their values are 10.3554, 12.1255, 9.5269, 14.4223, 5.4548, 11.5715, 13.2824, 13.6668, 6.3446 and 6.4311 respectively. This showed that, the study period-II the productivity of coconut was increased growth rate observed.

After the period-I there is an expansion in the area, growth in productivity is a combined phenomenon involving both the area growth and production growth. Particularly after 2007, as a result of drastic increase in productivity 2007 onwards which may be attributed to the bumper production in 2006 on account of good rainfall. Also, the National horticulture mission, which was introduced in 2006 started undertaking many developmental and crop improvement activities like improved management practices, pest and disease control measures, which resulted in increased productivity. The results of productivity of coconut for all ten districts were showed graphically in the Fig 2 to 11.

The results obtained from CGR for the whole period (1990-91 to 2015-16) showed that there was a positive growth in the productivity of coconut for all the ten districts *viz.*, Bangalore rural, Chickmagalur, Chitradurga, Dakshin Kannada, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttar Kannada and their values are 2.8465, 3.1965, 2.4467, 5.5481, 0.8678, 3.6365, 4.4567, 4.5532, 1.0593 and 2.6409, respectively. Dakshin Kannada district has highest growth rate (5.5481) and the least is 0.8678 Hassan district.

Overall, the coconut scenario in Karnataka has been improving, particularly after the year 2007, as a result of drastic increase in productivity 2007 onwards which may be attributed to the bumper production in the year 2006 and national horticulture mission initiatives in the subsequent years. The scenario of productivity of coconut looks positive and good in the state. Also release of new varieties and hybrids contributed to the productivity of coconut. Also, the National horticulture mission, which was introduced in the year 2006 started undertaking many developmental and crop improvement activities like improved management practices, pest and disease control measures, resulted in increased productivity of coconuts.

For coppock's instability analysis, whole data was sub-divided into two periods *i.e.* period I (1990-91 to 2003-04) and period II (2004-05 to 2015-16) and the overall instability

has also been analysed. The results observed, interpreted and discussed here. In case of coconut productivity, result showed that the instability during period II (1990-91 to 2003-04) for ten districts was higher compared to period I (2005-06 to 2015-16). Overall (26 years) contribution of productivity for instability was lower than period II but higher than period I. The coconut productivity was stable over the period of 1990-91 to 2015-16. The variation in sub periods especially in second period is due to the drastic increase in production and productivity especially after 2006-07 and facilities provided by national horticulture mission.

The result presented in the table 4.1.3 depicts that regarding the productivity of coconut crop for the period 1990-91 to 2015-16, the lower instability index was found in Uttar kannada district (3.53%), followed by Tumkur district (5.02%) and Bangalore rural district (5.86%) which showed stable productivity in coconut.

Further, for the period-I (1990-91 to 2003-04), the Uttar Kannada district (0.21%) possess least instability index followed by Dakshin Kannada district (0.21%). The result was presented in the table 4.1.1.

However for the period-II (2004-05 to 2015-16), the least instability index was found in Uttar Kannada district (4.84%), followed by Tumkur district (5.94%) and Bangalore rural district (7.02%) in the productivity of coconut crop among the districts of Karnataka. The result is presented in the table 4.1.2.

It was evident from the analysis that, the instability index was least in Uttar Kannada district followed by Tumkur and Bangalore rural district revealed that the instability in productivity of coconut during the period 1990-91 to 2003-04 and 2004-05 to 2015-16 under study with a reason being higher production of coconut. Low farming productivity due to mono cropping practices, poor genetic makeup and nutrient deficiency of the soil.

The instability analysis was supported by Vasudev *et al.* (2012) studied on growth in food grain production in India is technology led or policy led: special reference to Andhra Pradesh with district wise economic analysis. They used time series data for the period of twenty years from 1990-91 to 2009-10. Their result revealed that country as a whole, during the period -I, productivity variability had more influence on production fluctuations than by instability in area. During the period -II also instability in productivity has more influence on production variability than by instability in area. State as a whole, during both periods,

productivity variability had more influence on production fluctuations than by instability in area. Inter period comparison revealed that instability in production and productivity during the period-II was less than period-I. Among the regions, during the period -I, the lowest instability in area, production and productivity were recorded in coastal Andhra. Highest instability in area and productivity were recorded in Rayalaseema. In 19 districts, out of 22, production fluctuation was more influenced by instability in productivity than variability in area.

The results were also in line with the results of Vinayaka *et al.* (2014), who studied on Growth and instability analysis of fruits crops in India-An economic analysis. The study was based on secondary data from 2000-01 to 2010-11. The result showed that in India growth rate of fruits crops productivity was positive (1.05%) and was associated with instability index of 10.16 per cent. In the same period a positive growth rate of area was observed (7.34%) with high instability index of 10.16 per cent, while a positive growth rate of production (8.48 %) with instability index of 0.10 per cent was observed for production. The average of area, production and productivity of fruits crops during this period were 5084.55 ('000 hectares), 55364.64 ('000 million tonnes) and 10.83 (million tonnes/ha) respectively.

5.2 Polynomial models on impact of weather parameters on the production of coconut

Statistical modelling plays a very important role in predicting underlying relationships among crucial variables in an agricultural system. A statistical model can be either 'Linear' or 'Nonlinear'. In a linear model, all the parameters appear linearly, whereas in a nonlinear model, at least one of the parameters appears nonlinearly.

Regression analysis indicated that, there was a significant relationship between production of coconut with average rainfall and production of coconut with average temperature. Models were built in order to predict the productivity of coconut by using time period. Best models were selected based on highest co-efficient of determination (R^2), which explained the variation in dependent variable by the independent variables. Different linear and nonlinear models were fitted for predicting the production of coconut (Table 4.2.1 and Table 4.2.2). Selected districts were found to be significant at 5 per cent level of significance positively contributing to the coconut production.

In the case of production and average rainfall, compound model was found to be best fit for the following districts such as Chitradurga, Dakshin Kannada, Hassan and Uttar Kannada with the highest R^2 value of 0.302, 0.233, 0.205 and 0.291, MSE values were of 0.102, 0.208, 0.068 and 0.102 respectively.

Inverse model was found to be best fit for the districts of Bangalore rural and Tumkur with their highest R^2 values 0.197 and 0.207, MSE values were 37488.209 and 1.013 respectively.

Quadratic model was found to be best fit for the districts Chikamagalur and Shimoga with their highest R^2 values 0.385 and 0.479, MSE values were of 347779.503 and 11690.620 respectively.

Linear model was best fit for Mandya district with the highest R^2 value of 0.181 and MSE value of 773190.455.

Cubic model was best fit for Mysore district with their highest R^2 value of 0.401 and MSE value of 406439.183.

In case of production and average temperature, compound model was found to be best fit for the following districts. Such as Chikamagalur, Chitradurga and Mandya with the highest R^2 value of 0.181, 0.180, 0.204 and MSE values were of 0.271, 0.120 and 0.314 respectively.

Inverse model was found to be best fit for the districts of Shimoga and Tumkur with their highest R^2 values 0.190 and 0.207 and MSE values were 17404.739 and 1.012 respectively.

S-curve model was found to be best fit for the districts of Bangalore rural, Dakshin Kannada and Uttar Kannada with their highest R^2 values 0.219, 0.257 and 0.202, MSE values are 0.233, 0.201 and 0.114 respectively.

Cubic model was found to be best fit for the districts of Hassan and Mysore with their highest R^2 values 0.334 and 0.338, MSE values were 8855462.510 and 449476.861 respectively.

The detailed analysis of fitting the models helped to know the positive significant impact of average rainfall and average temperature on the production of coconut.

5.3 ARIMA model in estimate of coconut production.

The results pertaining to actual and observed production scenario of coconut in each districts, reveals the variation from district to district and in a district there is a variation from year to year.

Forecasting of production was done based on the ARIMA models for ten districts. The predicted values of production of coconut for the next five years (2016, 2017, 2018, 2019 and 2020) were represented in the table 4.3.3.1 to 4.3.3.10. Similar study was done by Srinath Reddy (2013).

In the Table 4.3.3.1 for Bangalore rural district the observed production of coconut increased from 541.72 (1990-91) to 708.81 lakh nuts (2004-05) and decreased from 689.54 (2005-06) to 693.33 lakh nuts (2006-07) and sudden decrease from 201.88 (2007-08) to 158.46 lakh nuts (2008-09) and slight increase in the year (2009-10) 320.24 to 401.58 lakh nuts (2011-12) and sudden decrease from 2012-13 onwards i.e. from 227.65 to 203.46 lakh nuts. The same way predicted production of coconut started increasing trend from 1990-91 to 2004-05 and there was declining trend appeared from 2005-06 to 2007-08 and sudden decreasing trend noticed after 2013-14 onwards.

The result revealed in Table 4.3.3.2 for Chikamagalur district the observed production of coconut increased from 631.97 (1990-91) to 760.22 lakh nuts (2000-01) and decreased from 587.5 (2001-02) to 717.05 lakh nuts (2006-07) and sudden increase in the year (2007-08) 1407.87 to 2396.86 lakh nuts (2015-16). The similar way predicted production of coconut started increasing trend from 1990-91 to 2001-02 and there was declining trend appeared from 2002-03 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards.

The result noticed in Table 4.3.3.3 for Chitradurga district the observed production of coconut increased from 2027.28 (1990-91) to 2233.58 lakh nuts (2000-01) and decreased from 1752.62 (2001-02) to 1838.8 lakh nuts (2006-07) and slight increase from in the year (2007-08) 2164.88 to 2950 lakh nuts (2009-10) and sudden increase in the year 2010-11 (5831.65) to 2013-14 (5711 lakh nuts) and sudden decrease from 2979.15 (2014-15) to 2992.14 lakh nuts (2015-16). The same way predicted production of coconut started increasing trend from 1990-91 to 2001-02 and there was declining trend appeared from 2002-03 to 2007-08 and slight increasing trend noticed in the year 2008-09 to 2010-11 and sudden increase in the year 2011-12 to 2014-15 and sudden decrease in the year 2015-16 onwards.

Table 4.3.3.4 represents the observed production of coconut increased in Dakshin Kannada district from 881.55 (1990-91) to 1097.3 lakh nuts (1997-98) and decreased from 547.57 (1998-99) to 820.86 lakh nuts (2007-08) and sudden increase in the year 2008-09 onwards i.e. 1334.27 to 2831.26 lakh nuts. The same way predicted production of coconut started increasing trend from 1990-91 to 1998-99 and there was declining trend appeared from 1990-2000 to 2008-09 and increase in the year 2009-10 onwards.

Table 4.3.3.5 describes observed production of coconut in Hassan district increased from 2344.56 (1990-91) to 2717.05 lakh nuts (2000-01) and slight decrease from 2285.96 (2001-02) to 2565.47 lakh nuts (2006-07) and sudden increase in the year 2007-08 (2968.79) to 2012-13 (6208.83 lakh nuts) and sudden decrease from 3198.23 (2013-14) to 3829.3 lakh nuts (2015-16). The same way predicted production of coconut started increasing trend from 1990-91 to 2001-02 and there was slight declining trend appeared from 2002-03 to 2007-08 and increase in the year 2008-09 to 2013-14 and sudden decrease in the year 2014-15 to 2017-18 and increase in the year 2018-19 onwards.

The result noticed in Table 4.3.3.6 for Mandya district the observed production of coconut increased from 642.11 (1990-91) to 814.29 lakh nuts (2000-01) and slight decrease from 610.76 (2001-02) to 655.55 lakh nuts (2006-07) and sudden increase in the year (2007-08) 1134.46 to (2015-16) 2746.59 lakh nuts. The same way predicted production of coconut started increasing trend from 1990-91 to 2001-02 and there was slight declining trend appeared from 2002-03 to 2007-08 and increasing trend noticed after 2010-11 onwards.

In the Table 4.3.3.7 for Mysore district the observed production of coconut increased from 472.00 (1990-91) to 673.00 lakh nuts (1997-98) and decrease trend appeared from 420.95 (1998-99) to 493.12 lakh nuts (2006-07) and sudden increasing trend noticed after 2007-08 onwards i.e. 1126.36 to 1986.74 lakh nuts. The same way predicted production of coconut started increasing trend from 1990-91 to 1998-99 and there was declining trend appeared from 1999-20 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards.

Table 4.3.3.8 depicts that for Shimoga district the observed production of coconut increased from 209.54 (1990-91) to 419.02 lakh nuts (1997-98) and decrease trend appeared from 234.34 (998-99) to 181.78 lakh nuts (2006-07) and sudden increasing trend noticed after 2007-08 onwards i.e. 331.67 to 488.21 lakh nuts. The same way predicted production of coconut started increasing trend from 1990-91 to 1998-99 and there was declining trend

appeared from 1999-20 to 2007-08 and sudden increasing trend noticed after 2008-09 onwards.

Table 4.3.3.9 revealed that for Tumkur district the observed production of coconut was increasing trend from 3610.77 (1990-91) to 12924.64 lakh nuts (2015-16). The same way predicted production of coconut started increasing trend from 1990-91 to 2020-21.

In the Table 4.3.3.10 for Uttar Kannada district the observed production of coconut was increasing trend from 261.67 (1990-91) to 699.27 lakh nuts (2015-16). Predicted production of coconut started increasing trend from 1990-91 to 2020-21.

Main reason for declining in coconut production was due to recurring droughts for consecutive three years 2001-02, 2002-03 and 2004-05, the drought of 2003 was considered of severe in nature, the agriculture and horticulture crops production were adversely affected in almost all parts of Karnataka, some of the major coconut producing districts affected were Chikamagalur, Chitradurga, Hassan, Mandya. The severity of drought was more in the dry zones, due to this decrease in coconut production was observed. The state received annual rainfall of 876 mm in the year 2003 as against the normal rainfall of 1139 mm.

Decline in coconut acreage due to land conversion for commercial and industrial purposes. The decline in production in Karnataka in the year 2011-12, as per the study was primarily because of the severe drought coupled with pest and diseases. Production in Mandya and Mysore districts is not affected to a great extend since better irrigation facilities are available in those two districts.

Production in Karnataka state declined in the year 2013-14 i.e. from 4337 million nuts to 4126 million nuts, showing a marginal decrease of 4.87 per cent, because of the reason insufficient rains and pest and disease attack. Problems faced in the districts was Hassan and Mandya.

Decline in the production may also be due to replacement of the crop by arecanut as it is catching up in the state because of high rate to the arecanut produce. Farmers have neglected coconut crop, as they are getting very low rate for their produce because of involvement of the middlemen. Rodent or squirrel problem also causes reduction in production.

*Summary and
Conclusions*

6. SUMMARY AND CONCLUSIONS

Botanically, the Coconut tree (*Cocos nucifera*) is a member of the family Arecaceae (palm family).

In view of importance of coconut the present investigation on “A statistical investigation of coconut yield in Karnataka state” gives a clear scenario about the instability of the coconut productivity, impact of weather parameters on coconut production and estimation of production. The results obtained from statistical estimation help in learning the future line of work.

The present study was under taken with the below mentioned objectives.

1. To study the stability of productivity of coconut in Karnataka.
2. To study the impact of weather parameters on the production of coconut.
3. To estimate the production of coconut.

6.1 Methodology

The present study was undertaken in the selected districts of Karnataka state. Study used the secondary data. The secondary data were collected for analysis from different sources were Coconut Development Board, www.indiastat.com and www.karnatakastat.com.

Secondary data regarding area, production and productivity of coconut were collected from 1990-91 to 2015-16. The twenty six years data was used for modelling of production and productivity of coconut in selected districts of Karnataka.

The technique of Compound growth rate, Coppock’s instability index, Polynomial models and ARIMA model technique were adopted with respect to study the objectives *i.e.*, to study the stability of productivity of coconut in Karnataka, to study the impact of weather parameters on the production of coconut and to estimate the production of coconut.

6.2 Major findings of the study

A brief summary of the findings are presented below:

- ✓ Among the statistical tools studied, compound growth rate and coppock’s instability index, the results revealed that the coconut productivity showed the high instability

index in the period-II (2004-05 to 2015-16) compared to the period-I (1990-91 to 2003-04).

- ✓ The growth rate was found to be negative in the period-I for all the ten district than the period-II (2004-05 to 2015-16) which was positive growth rate.
- ✓ In case of production and average rainfall, compound model was found to be best fit for the following districts such as Chitradurga, Dakshin Kannada, Hassan and Uttar Kannada with the highest R^2 value of 0.302, 0.233, 0.205 and 0.291, MSE values were of 0.102, 0.208, 0.068 and 0.102 respectively.
- ✓ Inverse model was found to be best fit for the districts of Bangalore rural and Tumkur with their highest R^2 values 0.197 and 0.207, MSE values were 37488.209 and 1.013 respectively. Quadratic model was found to be best fit for the districts Chikamagalur and Shimoga with their highest R^2 values 0.385 and 0.479, MSE values were of 347779.503 and 11690.620 respectively. Linear model was best fit for Mandya district with the highest R^2 value of 0.181 and MSE value of 773190.455. Cubic model was best fit for Mysore district with their highest R^2 value of 0.401 and MSE value of 406439.183.
- ✓ In case of production and average temperature, compound model was found to be best fit for the following districts. Such as Chikamagalur, Chitradurga and Mandya with the highest R^2 value of 0.181, 0.180, 0.204 and MSE values were of 0.271, 0.120 and 0.314 respectively.
- ✓ Inverse model was found to be best fit for the districts of Shimoga and Tumkur with their highest R^2 values 0.190 and 0.207 and MSE values were 17404.739 and 1.012 respectively. S-curve model was found to be best fit for the districts of Bangalore rural, Dakshin Kannada and Uttar Kannada with their highest R^2 values 0.219, 0.257 and 0.202, MSE values are 0.233, 0.201 and 0.114 respectively. Cubic model was found to be best fit for the districts of Hassan and Mysore with their highest R^2 values 0.334 and 0.338, MSE values were 8855462.510 and 449476.861 respectively.
- ✓ Forecasting of coconut production for the next five years was employed based on ARIMA model for the ten districts. The predicted production results shown that there will be increase in the production of coconut.

6.3 Future line of work

Based on the results and findings generated from the study, the following future line of work is suggested.

- Comparison can be made on different statistical methods used for stability analysis.
- Including other weather parameters like relative humidity, sunshine hours to know the impact on production.
- Use of advanced statistical tools for the prediction or forecast.

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A STATISTICAL INVESTIGATION OF COCONUT YIELD IN KARNATAKA STATE

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2018

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ABSTRACT

This study was conducted during 2016-2018 at the department of agricultural statistics, University of Agricultural College, Dharwad. This study helps to know the stability of productivity of coconut, impact of weather parameters on the production of coconut and estimation of coconut production. Secondary data for the period of 1990-91 to 2015-16 was used. Compound growth rate, Coppock's instability index, polynomial and non-linear models and ARIMA model were used in the study. Compound growth rate and Coppock's instability index was calculated for two sub periods separately *viz.*, 1990-91 to 2003-04 and 2004-05 to 2015-16 and results revealed that the growth rate of productivity of coconut was found to be negative in the period-I for all the ten district than the period-II (2004-05 to 2015-16) which was positive growth rate and Coppock's instability index revealed that coconut productivity showed the high instability index in the period-II (2004-05 to 2015-16) compared to the period-I (1990-91 to 2003-04). The impact of weather parameters on coconut production was measured using polynomial and non-linear models. In case of production and average rainfall, compound model was found to be best fit for the following districts such as Chitradurga, Dakshin Kannada, Hassan and Uttar Kannada with the highest R^2 value of 0.302, 0.233, 0.205 and 0.291, MSE values were of 0.102, 0.208, 0.068 and 0.102 respectively and for production and average temperature, compound model was found to be best fit for the following districts. Such as Chikamagalur, Chitradurga and Mandya with the highest R^2 value of 0.181, 0.180, 0.204 and MSE values were of 0.271, 0.120 and 0.314 respectively. Forecasting of coconut production for the next five years was employed based on ARIMA model for the ten districts. The predicted production results shown that there will be increase in the production of coconut.