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Exploring the Future of Cashew Nut Harvests: Strategic Management in Tanzania's Southern Agricultural Zone

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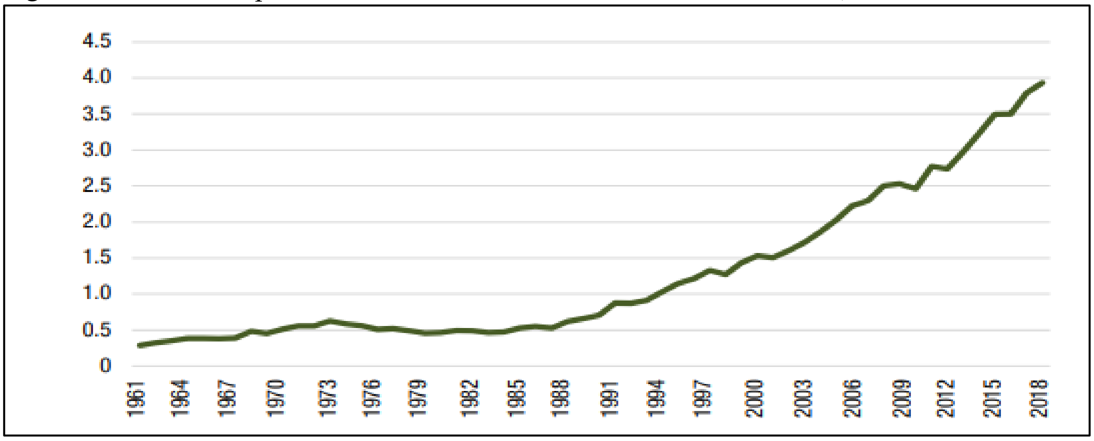
ABSTRACT
This study focused on time series forecasting of the yearly volume of cashew nut production in the Southern Agricultural Zone of Tanzania. This study aimed to predict the trend of cashew nut production in the Southern Agricultural Zone of Tanzania in metric tonnes and to forecast cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026. The study adopted time series analytical methods. Annual secondary data of 32 years from 1989 to 2021 were collected from the Cashew Nut Board of Tanzania, Data given were tested for stationarity before being modeled for forecasting. Time series analytical techniques particularly regression and Box-Jenkins (ARIMA) models were applied for modeling cashew nut production. Akaike's Information Criterion was applied in the ARIMA model selection. The study concluded that there was an increasing trend for cashew nut production if other factors remained constant. Also, the study concluded that ARIMA (0,1,1) was the best forecasting model for cashew nut production in the Southern Agricultural Zone of Tanzania. The value of the best Akaike Information Criterion (AIC) is 358.55. The study recommended that based on the expected increase of cashew nut production in the Southern Agricultural Zone of Tanzania, Tanzania needs to ensure that domestic markets and industries are protected to ensure equilibrium and any excess to be traded in foreign in the long run-in production of cash nut.

Introduction

The One of the goals of the Agenda for 12 Sustainable Development is to ensure sustainable consumption and production patterns, with the goal of assisting developing countries in strengthening their scientific and technological capacities in order to move toward more sustainable consumption and production patterns. Countries must maintain sustainable cashew nuts production in order to meet long term demand for the product. Cashew is among the major edible nuts with increasing demand in the global market. The crop originated from the Northern part of South America. The Portuguese introduced cashew nut to Mozambique where it flourished forming extensive forests, eventually spreading to the

East African region(Muniu et al., 2019). The tree is native to Brazil and first introduced to India and Africa in the 16th century by Portuguese traders with the intention of afforestation and soil conservation, and gradually expanded throughout the world(Faso & Ivoire, 2021). Today, it has been widely grown mainly for its nuts to be used as food, medicine, and source of income in most tropical regions with the largest coverage found in Brazil, India, Vietnam, Indonesia, and several countries in West and East Africa(Cateia et al., 2021).

Figure 1. World production of raw cashew nuts from 1961 to 2018(in million metric tons)



Source: United Nations (2020)

The production of cashew nuts with shell of Africa increased from 379,859 tonnes in 1971 to 2.44 million tonnes in 2020 growing at an average annual rate of 5.17%(World Bank, 2020). Tanzania is now the World's third-largest producer of cashews and maybe the world's most important, with production growing 450%. In Tanzania, cashew nut production is concentrated mainly in eighteen regions namely Dodoma, Tanga, Njombe, Morogoro, Pwani, Dar es Salaam, Lindi, Mtwara, Ruvuma, Iringa, Mbeya, Singida, Tabora, Kigoma, Mwanza, Katavi, Geita and Songwe (URT, 2017). For Tanzania to sustain the supply of cashew nuts, there is a need to formulate strategies for monitoring the production of the crop to gain a competitive advantage. With the aid of mathematical modeling, the production of cashew nuts can be monitored continuously. Forecasting cashew nut production, particularly in the Southern Agricultural Zone of Tanzania, will link the information about past production, present production, and future production to aid in planning and managing the contribution of such crops to the economy in the long run.

Statement of the problem In the Southern Agricultural Zone of Tanzania total cashew nut production reported was produced by 69.5% and the production of cashew nuts was also contributed to other regions which counted 30.5%(URT, 2019). Benta,(2020) investigated the impact of government intervention in the production of cashew nuts in the Southern Zone in Tanzania Mtwara and discovered that the government intervention has, to a smaller extent, contributed to provisions of incentives to the cashew nut farmers. However Benta,(2020) did not estimate the future cashew nut production in Tanzania. This study seeks to forecast the future annual total volume of cashew nut production in the Southern Agricultural Zone in Tanzania to shed light on various implementations of the policy and also to overcome the problems that face cashew nut production.

Currently, little is known about the mathematical model to be used for forecasting cashew nut production in the Mtwara and Lindi regions, forming the Southern Agricultural

Zone of Tanzania, to provide an overview of the supply of cashew nuts in domestic and foreign markets. Tanzania requires macroeconomic strategies that would encourage cashew nut production and consumption in the country due to government intervention over the long and short term to meet the country's entire cashew nut demand(Ministry of Finance, 2021). The objectives of the study are to forecast cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026, to develop a trend and analyze the equation for cashew nut production in the Southern Agricultural Zone of Tanzania as well and to predict cashew nut production in Southern Agricultural Zone of Tanzania. The findings of this study will be critical in formulating macroeconomic strategies that will promote long-term cashew nut production and sustainable agriculture. In addition, the study will provide crucial data for forecasting cashew nut production in the country as well as consumer markets, encouraging consumers to plan their short-term consumption expenditures.

Theory of production: The theory of production, in economics, is an effort to explain the principles by which a business firm decides how much of each commodity that it sells (its "outputs" or "products") it will produce, and how much of each kind of labor, raw material, fixed capital good, etc., that it employs (its "inputs" or "factors of production") it will use. The theory involves some of the most fundamental principles of economics(Ambilikile, 2019). Production is an activity of transformation, which connects factor inputs and outputs. Production is an activity that increases consumer usability of goods and services. The concept of the theory of production input is a good or service that goes into the production process(Gujarati, 2003a). As economists refer to it, an input is simply anything that a firm buys for use in its production process. An output, on the other hand, is any good or service that comes out of a production process(Dillard, 1990). Inputs are considered variable or fixed depending on how readily their usage can be changed. In an economic sense, a fixed input is one whose supply is inelastic in the short run (Negishi, 2014).

The theory of production may be difficult to explain the principles by which the business has to make decisions on how much of each commodity it sells how much it produces and also how much raw material. i.e., fixed capital and labor it employs and how much it will use.

Forecasting methods theory: The theory of forecasting is based on the premise that current and past knowledge can be used to make predictions (Petropoulos et al., 2022). In particular, for time series, there is the belief that it is possible to identify patterns in historical values and successfully implement them in the process of predicting future values. However, the exact prediction of future values is not expected. Forecasting procedures are best when they relate to a problem to be solved in practice. The theory can then be developed by understanding the essential features of the problem. In turn, the theoretical results can lead to improved practice. Due to forecasting theory, it's hard to predict the future. Even if you have a great process in place and forecasting experts on your payroll, your forecasts will never be spot on. Some products and markets simply have a high level of volatility. And in general, there is just an endless number of factors that influence demand. In this study, the theory of forecasting methods will be applied to predict the future production of cashew nut and the trend of the commodity and predict the future trend of cashew nut. The forecasting theory may be inaccurate in the prediction of future production of cashew nuts due to some difficult issues that face the production, which can occur in different situations such as price fluctuation of the commodity in the market, climate and weather change, and other factors which influence change in cashew nut production. The theory of production and forecasting will be used to guide this study because the production theory is based on explaining the relation between the quantity of commodities and the production of cashew nuts and the price of the commodity and production factors. The forecasting theory in this study will be applied on predict the future production of cashew nut and the trend of the commodity and predict the future trend of cashew nut.

Bello Daouda et al.,(2016) conducted a study to analyze the trend analysis of climate change and its impacts on cashew nut production (Anacardium occidentale l.) in Benin. The linear adjustment with the time series analysis was conducted to assess trends of climatic factors and their effect on nut yields. A correlation analysis between the climatic data of the last 10 years and the cashew nut yields obtained was performed to assess the effect of each climatic factor. The results indicate that rainfall and temperature are marked by very remarkable inter-annual fluctuations. The evolution of the average rainfall and temperature between 1970 and 2015 shows an increasing trend with rates ranging from 0.02% to 24%. The rainfall did not influence the annual nuts production in the Southern zone but the mean temperature of August and Potential Evapotranspiration (PET) of April had a negative influence. Sivaraj et al., (2017) conducted a study to assess the growth and performance of cashew nut production in India from 1965-66 to 2014-15. In this study statistics tools like descriptive statistics and percentage analysis were used to interpret data. The results indicate that increasing trend in the production of cashew nuts in India. Cashew nut attracts people of all categories and all over the world. Probable reasons for that are its pleasant taste and nutritive values. From the farmer's perspective, cashew nut was a cash crop even in dry areas.

The present study aims to assess the growth and performance of cashew nut production in India from 1965-66 to 2014-15. The results conclude that cashew nut production in India increased during the selected period from 1965-66 to 2014-15. Small samples have less variation and are more consistent (i.e., less CV value) when compared with large samples. In large samples, Kerala state has the largest cashew nut production during 1965-66 onwards. But the small samples, Maharashtra state has been largest cashew nut production around 1990-91 years. In that year, Kerala had poor qualities of cashews. So only the cashew production would be decreased. But other states (i.e. Andhra Pradesh, Orissa, Karnataka, and Tamil Nadu) do not change the position of the cashew nut production for large and small samples.

Chukwujioke & Okiemute, (2018) conducted a study to examine the trend analysis of area, yield, and production for cashews in Nigeria. Three Models of trend analysis were applied. The models were the Linear Trend Model, Quadratic Trend Model, and cubic trend Model. Results show that the most appropriate Model for trend analysis of the present study was the Cubic Trend Model based on the highest R2 of (95.76 %), (95.76%) and (88.12%) for cashew area harvested, production, and yield respectively, coupled with the lowest residual sum square and mean square error. This implies that the Cubic Trend Model is applied in examining the trend analysis of area, and yield production for Cashew Nut in Nigeria.

Chaithra et al., (2019) was applied ARIMA and the Exponential Smoothing model to study forecasting of the area and production of cashew nuts in Dakshina Kannada. Holt's model was found to have better forecasting ability with the lowest Root Mean Square Error (RMSE) value is 1386.13 tonnes among the different models fitted for forecasting the area under cashew nut. From this model, the area (ha) under cashew nut was forecasted to be 34492.10 tonnes, 34974.81 tonnes, and 35474.87 tonnes for the years 2018, 2019, and 2020, respectively. In the case of cashew nut production, Brown's linear trend model, with a Root Mean Square Error (RMSE) value is 10020.19 tonnes, was observed to have better forecasting ability among the tried models. Production of cashew nuts (in tonnes) was forecasted to be 10230.20 tonnes, 10996.81 tonnes, and 11833.00 tonnes for the years 2018, 2019, and 2020, respectively. Bakshi, B. et al., (2019) conducted a study with the aim of forecasting of area and production of cashew nuts in Dakshina Kannada using ARIMA and exponential smoothing models. In this study, an attempt has been made to forecast the area and production of cashew nuts to help the planners in recommending policies regarding cashew nuts. Production of cashew nuts (in tonnes) was forecasted to be 10230.20, 10996.81, and 11833.00 for the year 2018, 2019, and 2020, respectively. Outcomes emanated from this investigation are expected to help the planners in recommending policies regarding cashew nuts to strengthen the economic backbone of India.

Thusyanthini et al., (2019) conducted a study to preliminary study on factors affecting the production of cashew (Anacardium occidentale L.) in Mullaitivu district, Sri Lanka. This study was conducted to find out the factors affecting cashew production and to identify the major constraints present in cashew cultivation met by farmers in the Maritimepattu Divisional Secretariat Division in Mullaitivu District of Sri Lanka. It examined the social characteristics, economic factors, and farming knowledge of cashew cultivation among farmers in the study area. Data were collected using a structured questionnaire administered to 60 respondents selected through a simple random sampling method. Descriptive statistics and multiple linear regressions were used for the data analysis. The results revealed that age and education level significantly ($P<0.05$) and negatively affected production while farming knowledge and participation in training significantly ($P<0.05$) and positively affected cashew production and it was found that the mean income from cashew production per acre was LKR 121,848.00 per annum and the average yield of the sample of respondents was 312 kg/ha. Finally, the Farmers should be trained and educated well in terms of good agronomic practices, and processing technologies to increase the quality and productivity of cashew nuts. Benta,(2020) we conducted a study to determine the impact of government intervention in the production of cashew nuts in Mtwara Tanzania. The study is about the impact of government intervention on the production of cashew nuts in the Mtwara Region. The study employed both qualitative and quantitative methods of data collection through survey questionnaires, in-depth interviews, and Focus Group Discussions.

The purposive sampling method was used to obtain key informants for interviews while simple random sampling was used to sample respondents to fill the survey questionnaire and focus group discussion participants. Thus, a sample of 119 respondents of which 90 were used for the survey, 9 for interviews, and 20 informants participated through Focus Group Discussion. The result of the analysis revealed that the government intervention has, to a smaller extent, contributed to the provision of incentives to the cashew nut farmers. The government intervention has corrected the cashew nut market to a smaller extent whereby the inequalities and inefficiency were eliminated in that farmers received fair and reasonable prices from the traders. Finally, the government needs to revise its intervention strategies in the cashew sector to enhance further production of cashew nuts.

In the literature review section, the researcher described the Production theory presented by Negishi, (2014) and the forecasting theory described by (Petropoulos et al., 2022). Another part of the review presented several empirical literature based on the cashew nut industry and cashew nut production. The majority of the studies are about cashew nut industry competitiveness, trend analysis of cashew nut production, and factors affecting cashew nut production. Most of them are conducted in other African countries few in Tanzania. Some studies have been conducted about the effect of the exchange rate on cashew nuts export in Tanzania. Also, some of them tried to analyze social-economic factors which affect cashew nut production in Tanzania. Bello Daouda et al.,(2016) conducted to analyze a trend analysis of climate change and its impacts on cashew nut production. However, this study aims to analyze the developing trend equation and forecast cashew nut production for the Southern Agricultural Zone in Tanzania, to see if the total demand in the future will be satisfied with the production.

Method

This chapter presents the methodological issues on the procedures of data analysis for the trend of cashew nut production in the Southern Agricultural Zone of Tanzania. It comprises of study area, research design, and data analysis method which will be used in this study. The study adopted quantitative techniques for data and time series through which the following variables were used namely cashew nut production. Annual secondary data for 35 years from 1989 to 2021 was collected from the Cashew Nut Board of Tanzania. This study will be focused on Tanzania's mainland which is part of the United Republic of Tanzania. The Southern Agricultural Zone of cashew nut production comprises of Lindi and Mtwara regions(Ministry of Agricullture, 2003).

Among these regions contribute about 70 percent to the national cashew nut production. In the cashew crop 2020/2021, Tanzania Produces 206,718 Tons of Raw Cashews nut (RCN). The production hit a four-year low, lowering the income of farmers from Tanzania cashew farmers(CBT, 2021).

The study used secondary and time series data from the year 1989 to 2021 with a focus on cashew nut production in the Southern Agricultural Zone of Tanzania which was collected from the Cashew Nut Board of Tanzania (CBT). The data was received by the researcher via email from the Cashew Nut Board of Tanzania (CBT).

The nature of the dependent and independent variables that will be used in our investigation is described in this section. The following are their description.

Table 1. Description of Variable

Variables	Unit of measurement	Description	Measurement of scale
Cashew nut Production	Tonnes	Dependent variable	Ratio
Time in years	Ratio	Independent variable	Interval

Table 1 presents the data analysis on the procedures of descriptive analysis, regression analysis, and stationarity test by augmented dickey fuller (ADF) for the trend of cashew nut production in the Southern Agricultural Zone of Tanzania. Descriptive analysis presents a measure of central tendency and dispersion of the data. For cashew nut production, descriptive statistics such as mean, maximum, minimum, median, and standard deviation are used in descriptive analysis. In addition, graphs were created to examine the movement of these variables over time.

Linear regression analysis is a statistical tool for the investigation of the relationships between dependent variables and independent variables (Stock & Watson, 2020). Based on historical patterns of data over time, linear regression can be used to estimate trend and project what will happen in the future.

The regression has five key assumptions which are linear relationship, Multivariate normality, No or little multicollinearity, No auto-correlation and Homoscedasticity.

Linear regression finds the straight line, called the least squares regression line (LSRL) that best represents observations of data set. Suppose Y is a dependent variable, and X is an independent variable. The cashew nut production regression line is

$\text{cashew nut production} = a + b\text{time period in years}$

In this study linear regression applied to develop trend equation for cashew nut production in Southern Agricultural Zone of Tanzania.

The model will be estimated as follows

$y_i = a + bt_i$

$\text{cashew nut production} = a + b\text{time period in years}$

Where

y_i= dependent variable (cashew nut production)

b= slope of the equation

a= The constant of the equation

t_i= period in years

This study focused on the relationship between cashew nut production and time by running a simple linear regression analysis on the two variables.

Stationarity test by augmented dickey-fuller (ADF)

Stationarity refers to a series' mean value remaining constant through time nevertheless, if past effects accumulate and the values climb toward infinity, stationarity is violated. To make a series steady, differencing is utilized. To determine whether or not data series are steady. Because of the stability of important values, the augmented Dickey-Fuller (ADF) test is utilized for the unit root test. The unit root test is used to see if trending data should be differenced or regressed on deterministic functions of time to make the data stable(Trejo, 2012). In this study, the Augmented Dickey-fuller (ADF) was applied to test the stationarity to avoid spurious results in data.

ARIMA

The ARIMA model is a time series prediction method, that was proposed by Box and Jenkins in the 1970s. The model consists of AR, I, and MA. AR represents the Autoregressive model, I represent the Integration indicating the order of single integers, and MA represents the Moving Average model(Ma et al., 2018). ARIMA(p, d, q) is an autoregressive integrated moving average time series, where p denotes the number of autoregressive terms, d the number of times the series has to be differenced before it becomes stationary, and q the number of moving average terms(Castle et al., 2021). The mathematical formulation of the ARIMA (p, d, q) model is generally given by

$\Phi_p(\beta)\Delta^d x_t = \theta_q(\beta)\varepsilon_t$

Where:
β Is the backward shift operator
$\beta_{xy} = x_{y-1}$, Δ = 1- β is the backward difference
Φ_p and θ_q are polynomials of order p0 and q respectively

The methodology of building the ARIMA model according to Box and Jenkins consists of three stages/steps, which are the identification stage or model selection for autocorrelations function (q) and partial Autocorrelation(p), Estimation stage or Parameter Estimation for Estimate the unknown autoregressive and moving average parameters and Checking stage or Model Checking for check estimated results(Gujarati, 2003b).

In this study, the ARIMA model is applied to predict and analyze future cashew nut production in the Southern Agricultural zone of Tanzania.

Model selection criteria

For forecasting, Auto Regressive Integrated Moving Average (ARIMA) models, are used to compare based on RMSE (root mean square error), MAPE (mean absolute percentage error) value, and significance of the parameter estimates(Gujarati, 2003a). For each period, the mean absolute percentage error is expressed as an average absolute. During the estimating and validation periods, the MAPE results are will displayed on each table of ARIMA, Simple Exponential Smoothing, and Simple Moving Average(Castle et al., 2021).

The standard deviation of the residuals is the root mean square error (prediction error). The RSME value of the best statistical fit model should be low. During the estimating and validation periods, the RMSE values are displayed on each table of ARIMA, Simple Exponential Smoothing, and Simple Moving Average(Stock & Watson, 2020). Durbin-Watson test will also be employed to check autocorrelation in the time series data.

Akaike's information criterion (AIC) is often used for model selection, especially in the time series context, it was introduced by Akaike, (1974). This study used AIC for comparing ARIMA models, the one with the lower AIC is generally a better statistical model. The model preferred based on the criteria explained above will be the one with a minimum AIC(Chen, 2019).

This study used the ARIMA model because the model consists of one dependent variable (cashew nut production in metric tonnes) and one independent variable (Time in year).

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Results and Discussion

Overview

This chapter presents and discusses the findings based on forecasts of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026. The chapter presented the results for Descriptive analysis, regression analysis for trends, testing stationarity using the Augmented Dickey-Fuller test on the time series data and ARIMA Box Jenkins techniques for forecasting cashew nut production in the Southern Agricultural Zone of Tanzania were among the analytical methods applied.

Descriptive Statistics

This part presents and discusses the result for descriptive statistics of findings based on forecasts of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026.

Table 2. Descriptive statistics for cashew nut production in general

Statistics	Volume Produced of cashew nut (tonnes)
Mean	**98.49688**
Median	**69.15**
Minimum	**35.6**
Maximum	**398.5**
Standard deviation	**74.14662**

Table 2 of Descriptive statistics shows the results of summary statistics for cashew nut production in general, that is mean of the variable which shows the average value of the variable, standard deviation shows how far the observation is from the sample average for the variable, minimum and maximum value which show the lowest and highest value of the observation of the variable respectively, also variance show how widely observation vary for the variable.

Results presented in Table 4.1 showed that cashew nut production had high data dispersion, confirmed for the highest difference between minimum and maximum values and for the highest standard deviation which is equal to 74.14662. Also, the average production of cashew nuts in the Southern Agricultural Zone of Tanzania is 98.49688 tonnes.

The trend of cashew nut production over time in the Southern Zone

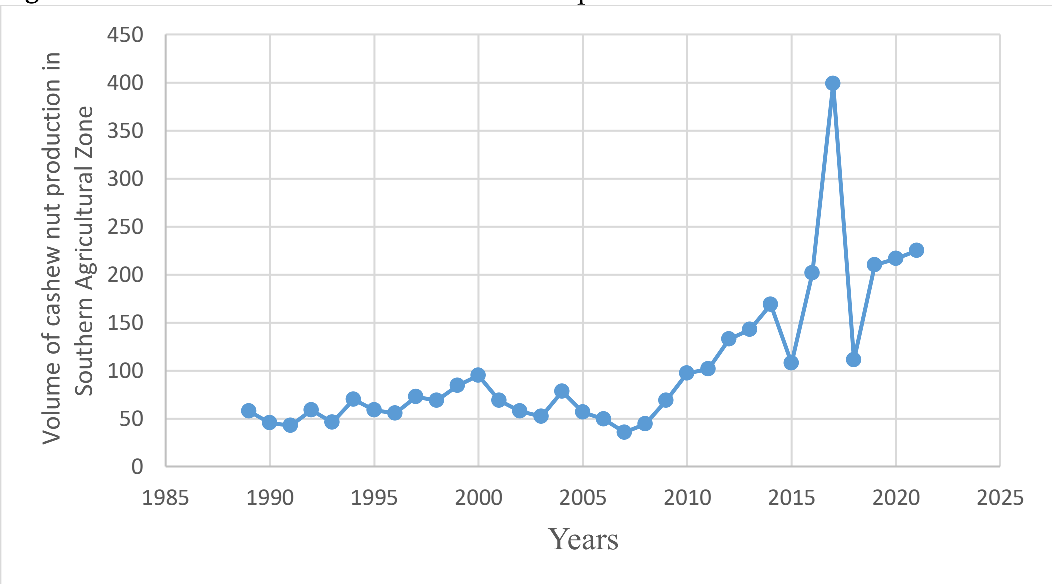
This part presents the result of the trend of cashew nut production over time in the Southern Agricultural Zone.

Table 3. The trend for cashew nut production over time in the Southern Agricultural Zone

Variable	Coefficients	P-value
Intercept	**-10942.74**	**0.000**
Years(time)	**5.508757**	**0.000**
Adjusted R	**0.8671**	
Number of Observation	**33**	

Table 3 and Figure 1 show that the trend of cashew nut production increases over time, p-value less than 0.005. Also, the model $R^2 = 0.8671$ which indicated the strong linear relationship between the variables. Also, the value of the coefficient of the time variable was positive implying that the value of cashew nut production will increase in the long run, if other factors remain constant.

Figure 2. Linear chart for cashew nut production over time



Source: Analyzed Data from Cashew nut Board of Tanzania (2021)

The trend equation corresponds to the equation $\mathbf{Y_t = -10942.74 + 5.508757t}$

Test for stationarity

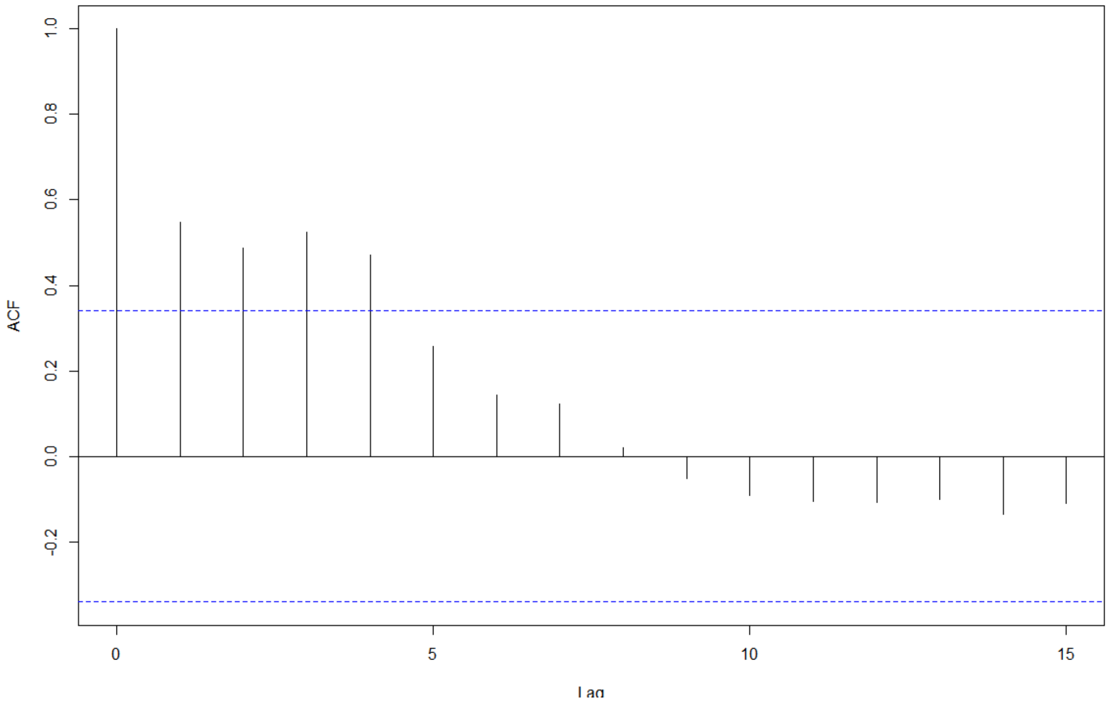
This part presents the result of the test for stationarity by Augmented Dickey-Fuller (ADF) test for unit root at level which is based on forecasts of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026.

Table 4. Augmented Dickey-Fuller test for unit root at the level

Variable	Test statistic ADF at level	5% critical value	P-value at level	ADF result
Volume of cashew nut produced(000'tonnes)	-2.834	-3.580	0.1846	Not stationary

From Table 4. The result revealed that the variable (Cashew nut produced in Southern Agricultural Zone) proved to be not stationary at level I (0) without differencing. This is because the ADF test results show that the test statistic which is -2.834 is greater than the critical value -3.580 which means that we fail to reject the null hypothesis. This is evidenced also by the autocorrelation plots in Figure 4.2 which showed that the data is not stationary since there is a gradual decline of the lags at the level and from lag 1 is out 95% confidence interval.

Figure 3. Autocorrelation plot of cashew nut production in the Southern Agricultural Zone of Tanzania



Hence data need to be differenced. Table 4 present summary of stationarity test for the differenced data.

Table 5. Augmented Dickey-Fuller test for unit root after difference

Variable	Test statistic ADF at level	5% critical value	P-value at first level	ADF result
Volume of cashew nut produced(000'tonnes)	-7.409	-3.584	0.000	Stationary

Results presented in Table 5 showed that the data are stationary following the first difference. The ADF test statistic of ADF is smaller than 5% critical value, hence the first differenced data are stationary. This is evidenced also by the autocorrelation plots in Figures 4.3, and 4.4

Figure 4. Autocorrelation plot of first differenced cashew nut production data

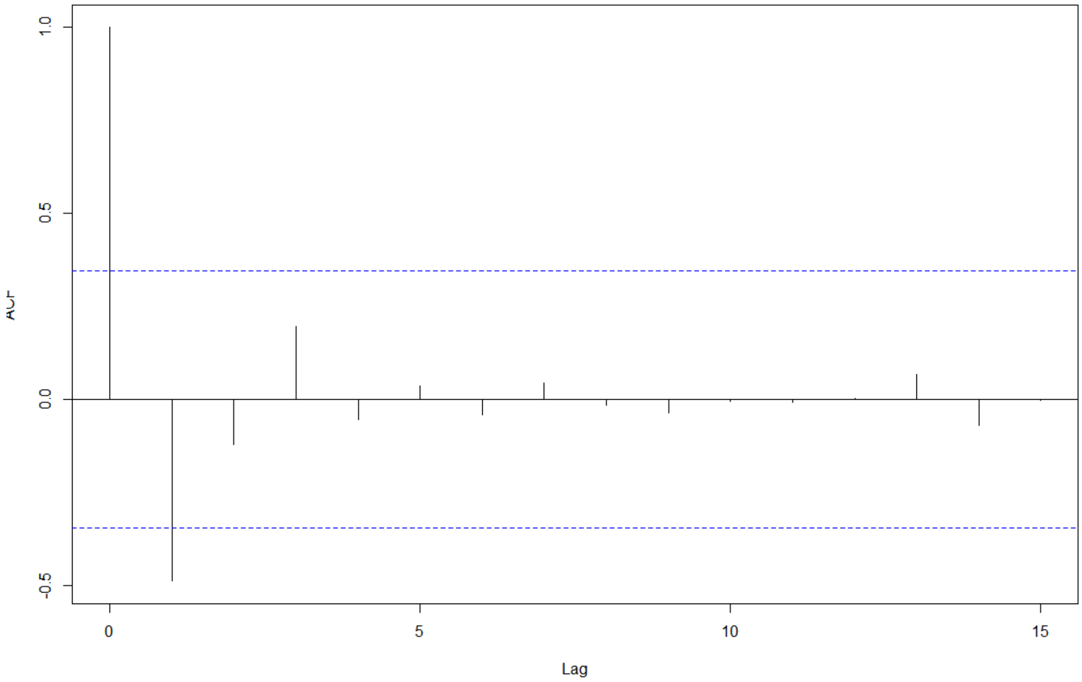


Figure 4 indicated that the data are stationary after the first difference, and the model shows that ACF decays exponentially lag 1, implying that the suggested value for parameter q is 1 in the ARIMA (p, d, q)

Figure 5. Partial autocorrelation function plot of the differenced data to determine the optimal parameters

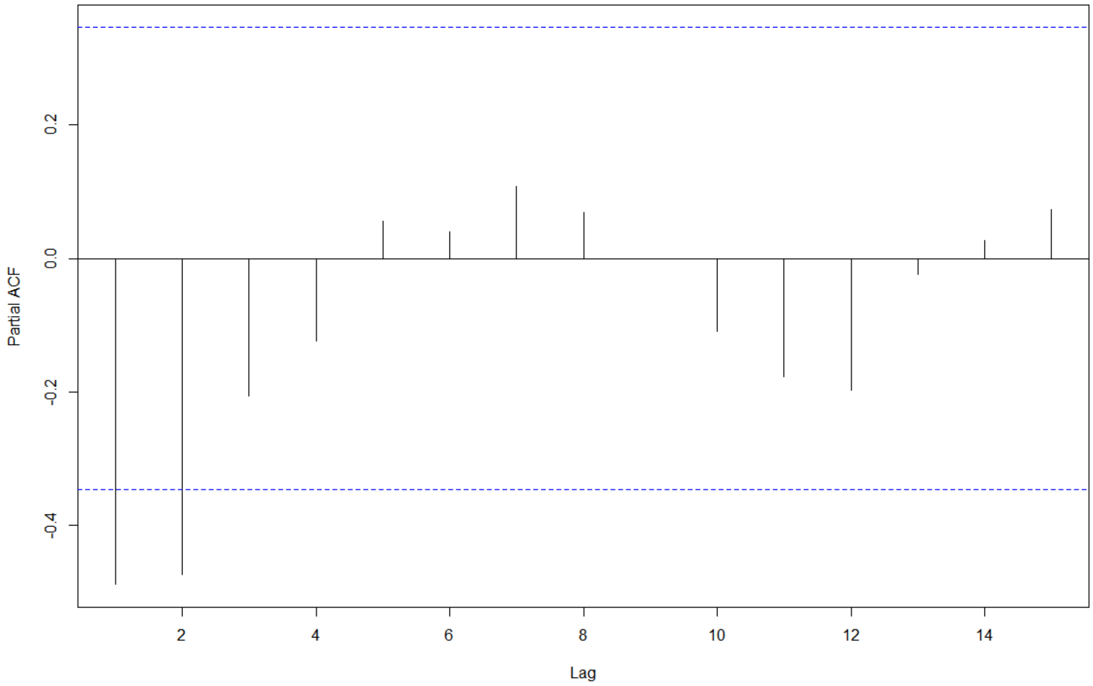


Figure 5 indicated that Partial autocorrelation function has a significant spike after lag 1, implying that the suggested value for parameter p is 0 in the ARIMA (p, d, q).

Estimating the ARIMA (p, d, q) model

We have d = 1, q = 1 and p = 0. With these values, it consists of 2 models. Since we have all the models then through Akaike Information Criterion the study obtained the best model.

Akaike's information criterion

This part presents the Model and Akaike's information criterion to select the best model with the minimum/lowest AIC.

Table 6. Akaike's information criterion

Model	Akaike's information criterion(AIC)
(0,1,1)	358.55
(0,1,0)	386.89

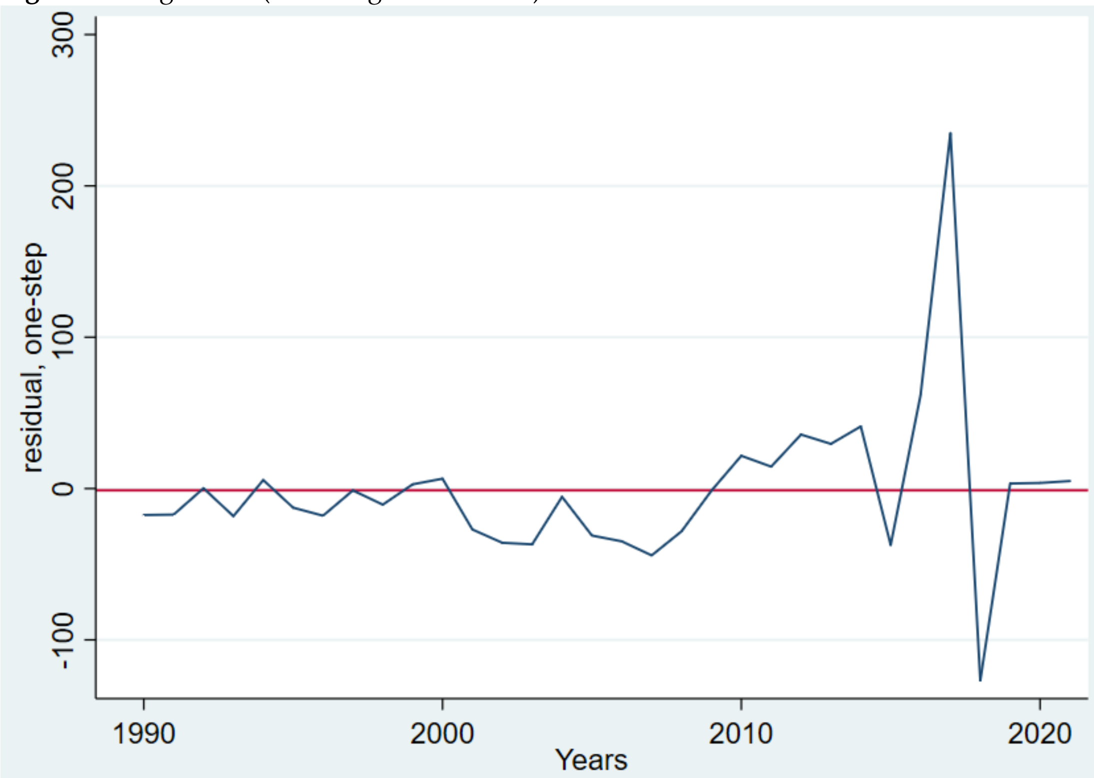
Source: Analyzed Data from the Cashew Nut Board of Tanzania (2022)

The model with a minimum value of Akaike's information criterion (AIC) is model (0, 1, 1) as the best model compared to the other model. So the model was used to forecast cashew nut production in the Southern Agricultural Zone in Tanzania and the linear trend given by $\mathbf{y'_t = 0.7087 - 0.1166y'_{t-1}}$ since it is the best model fit for forecasting where by $\boldsymbol{y't}$ is the volume of cashew nut production differenced at level one.

Model Diagnostics (Checking for Residual).

Since the residuals are useful in checking whether a model has adequately captured the information in the data, after obtaining the best model the Diagnostics process takes place to ensure that the model is appropriate for forecasting. In this process the residual is confirm if they are white noise.

Figure 6: Diagnostics (Checking for Residual)



Since the values of the residual wiggle around the mean (red line), this indicates that the errors are white noise.

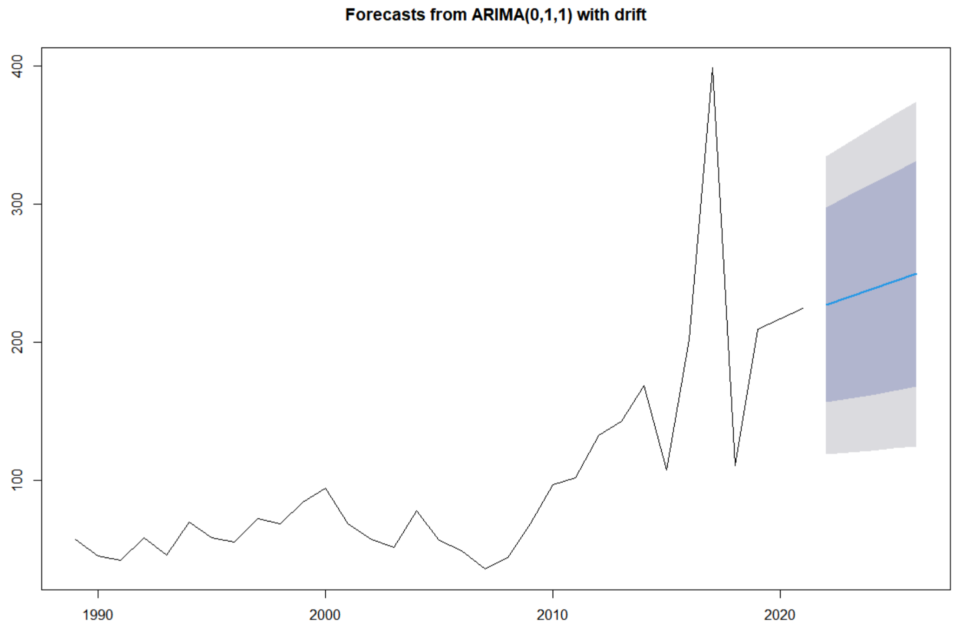
Forecasting of the total cashew nut production in the Southern Agricultural Zone of Tanzania by singing ARIMA (0, 1, 1)

This part presents the points forecast of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026 by using ARIMA (0,1,1).

Table 7. Forecasting of the total cashew nut production in the Southern Agricultural Zone of Tanzania by using ARIMA (0, 1, 1)

Years	Point forecast(000' tonnes)	Low 95	High 95
2022	**226.8**	**119.0**	**334.7**
2023	**232.5**	**120.2**	**344.9**
2024	**238.2**	**121.5**	**354.8**
2025	**243.8**	**123.0**	**364.6**
2026	**249.5**	**124.7**	**374.3**

Figure 8. Forecasting of the volume of cashew nut production in Southern Agricultural Zone based on forecasted values using model (0, 1, 1) with drift



The figure above shows the trend of cashew nut production for the next five years as it shows that the production and the shade there show the confidence interval of where the production will lie.

Discussion of the findings

In this study different models have been applied in modeling time series data of volume of cashew nut production, the model employed linear trend, Akaike's information criterion as well as ARIMA models. The finding also indicated amongst the models for estimating future cashew nut production value in the Southern Agricultural Zone of Tanzania.

This finding is similar to (Bishvajit et al., 2019) who conducted "Forecasting of Area and Production of Cashew Nut in Dakshina Kannada Using Arima and Exponential Smoothing Models". The finding also indicated that among the models for estimating the future cashew nut production volume of India, ARIMA (1, 1, 0) is considered to be the best model for forecasting the future cashew nut production volume of India. This is because it has the smallest BIC and AIC during the model estimation a validation period the study is similar to (Kolliesuah et al., 2020) who conducted a study on "trend analysis of production, consumption, and export of cashew crop in West Africa from 1980 to 2025" in West Africa employ a time series analysis to identify the best-fit model for the trend of production, consumption, and export of cashew crop in west Africa, using BIC and AIC criteria and it was found that ARIMA (1,1,1) was the suitable model.

Finally, the findings show that the volume of cashew nut production is expected to increase over the coming five years. This finding is similar to the study of (Bishvajit et al., 2019) the study "Forecasting of Area and Production of Cashew Nut in Dakshina Kannada Using Arima and Exponential Smoothing Models" in India using time series data which they find indicated that the future cashew nut commodity will be higher compared to that of the present.

Data given also tested for stationarity and their trend was determined before employing chosen forecasting techniques. It has been observed that the time series of the volume of cashew nut production are non-stationary. At 95% confidence interval level there is statistically significant trending in the series. Under this study, ARIMA (0,1,1) has been selected as the best model for forecasting future the value of cashew nut production in the Southern Agricultural Zone of Tanzania. This is because it has the smallest AIC during the model estimation a validation period. The model has been selected to be supplied to meet the demand for the cashew nut produced in the country.

Conclusion

This chapter presents the summary of what has been done in the study, the conclusion of the study, and recommendations. An area for further studies is also presented in this chapter. Time series analysis comprises methods for analyzing data to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of the model to predict future values based on previously observed values. The study set out to investigate the best time series model that can be used to forecast the annual volume of cashew nut production in the Southern Agricultural Zone of Tanzania.

The study began by assessing the trend of given data. The stationarity test was done by both the graphical method and the Augmented Dickey-Fuller Test. The data were later transformed into a stationary series by differencing. Under this study, Akaike's information criterion linear trend and forecasting technique used include Autoregressive integrated Moving Averaging (ARIMA).

The results of the study indicated that the time series data given varies over time. The application of the selected forecasting model indicated that ARIMA (0,1,1) is the best model for forecasting cashew nut production in the Southern Agricultural Zone of Tanzania. This part presents a conclusion on the trend of cashew nut production and forecast cashew nut production based on forecasts of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026. The study concludes that the volume of cashew nut production Southern Agricultural Zone of Tanzania tends to fluctuate over time. However, ARIMA (0,1,1) is the best model which shows up trending future volume of cashew nut supply to satisfy the total demand. For the case of estimating cashew nut production, linear trend model given by $\mathbf{y'_t = 0.7087 - 0.1166y'_{t-1}}$ has been selected as the best model to predict the total volume of cashew nut supply for future demand and this equation would have been the aggregate supply information if the study had combined with the total import of the country to get the total supply of the country. This part presents the recommendations based on the trend of cashew nut supply and the forecast of cashew nut supply on forecasts of cashew nut production in the Southern Agricultural Zone of Tanzania from 2022 to 2026. It is recommended that models that have been developed may be a useful tool for producing reasonably reliable trends of production in some future years.

This forecast can provide a guideline for understanding whether the ever-growing population of Tanzania will be satisfied expected number of produced cashew nuts. In addition, policies in cashew nut production may also be formulated based on the expected cashew nut production in the Southern Agricultural Zone of Tanzania based on the total demand of the cashew nut in the country to make sure that in the future the production of cashew nut in Southern Agricultural Zone of Tanzania meet the total demand and also importation should be reduced and restriction for protecting internal industries to be formulated.

The main purpose of this study was to forecast cashew nut production in the Southern Agricultural Zone of Tanzania. The study considered a change in the volume of cashew nut production as a function of time. However, the volume of cashew nut production does not depend on time and the Southern Agricultural Zone of Tanzania only. By considering the importance of this subsector for generating employment for smallholder farmers, further studies may include other factors to predict the cashew nut production in Tanzania such as consumption in a year, cashew nut price, and climate factors, and also may include other Agricultural Zone of Tanzania such as Ruvuma and Pwani to predict the cashew nut production in Tanzania.

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