E-ISSN: 2710-2572
2021: Vol 3, No. 1, pp 31-40. https://doi.org/10.51986/ijrcs-2021.vol3.01.04
Interdisciplinary Journal of Rural and Community Studies

Trend Analysis in Sugarcane Growth in Mumias Sugar Belt, Western Kenya; for the Period 1985-2015

Protas Fwamba Khaemba[1]
Kenyatta University, Kenya
Philomena W. Muiruri[2]
Lecturer, Kenyatta University, Kenya
Thomas N. Kibutu[3]
Lecturer, Kenyatta University, Kenya

CORRESPONDENCE

Protas Fwamba Khaemba
Department of Geography
Kenyatta University, Kenya
Email: fwamba8@gmail.com

Copyright:
© The Author(s) 2021.
Published by ERRCDF. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives (CC BY-NC-ND 4.0) licence.

DOI: 10.51986/ijrcs-2021.vol3.01.04

Abstract: *The study was carried out to examine trends in the output and acreage in the Mumias Sugar belt from the period 1985-2015. We used secondary data collected from Mumais Sugar Company records for the period 1985-2015 for the study. The trend analysis of sugarcane production in the Mumias Sugar Belt is important, where sugarcane is the major cash crop and absorbs a majority of the agrarian population in the region. The study used the expert modeler, an autoregressive integrated moving average (ARIMA), to predict the output. The forecast period was 2016 through March 2021 and employed two scenarios: I) forecast with +2 harvesting age predictor modification and ii) forecast with +10 hectares predictor modification. The predicted value showed good agreement with the observed values from the series plot, indicating that the model has a good predictive ability. The application of the model revealed that the results in the prediction tables show that, in each of the six forecasted quarters, increasing the harvesting age by two months is expected to generate about 4.52 more tons of yields per hectare than increasing area harvested by 10 hectares that would decrease the yield by 0.01 tons per hectare. The study recommends research and development on sugarcane varieties that mature early, making sugarcane-based Agri- enterprises and sustainable. In addition, Mumias Sugar Company should seek profitable techniques to increase the recovery per cent, and farmers seek good management practices to increase the efficiency of the sugarcane farms in the sugar belt.*

Keywords: Sugarcane production, Sugar belt, Mumais, Trend Analysis, Sugarcane growth.

1. Introduction

The inception of contract sugarcane farming in Kenya increased the output and yields in the period 1980-2000. Since 2000, sugarcane production has been deteriorating over the years (Mulianga *et al*. 2015). Kenya's sugarcane production trends suggest that production increases are correlated with increases in total land planted to cane than with increases in yield (Kenya Suger Board, 2014). Sugarcane output per hectare in the 1990s and 2000s has significantly declined compared to yields obtained in the 1980s. The current production of sugarcane is about 60.52 tonnes per hectare (Kenya Sugar Board, 2014), which is low compared to 90.86 tonnes per hectare in 1996. In addition, sugarcane output fell from 639.7 thousand tonnes in 2016 to 376.1 thousand tonnes in 2017, drop by 41%, just within one year. KSB Report (2010) reveals that the total area under sugarcane cultivation decreased from 220 800 ha. in 2016 to 191,200 ha. in 2018. During the same period, the sugar yield per hectare also reduced from 62.3 to 55.3 tons of cane per hectare. The reduction was attributed to the declining farmers' participation and begging their decisions to grow cereal crops (Khaemba, Muiruri & Kibutu, 2021). As a result, the quantity of sugarcane delivered to the sugar factories in Kenya reduced from 7.2 million tonnes to 4.8 million tonnes (a 33.3%drop in cane supply: KSB, 2018). Several reasons have been cited for reducing productivity, such as low-quality sugarcane varieties, poor agricultural management practices, delayed harvesting of mature sugarcane and poor pricing (KSB, 2010).

Studies on Kenya's agriculture show decreased output and increased input usage, while yields per hectare have declined. Some literature has dealt with trends in coffee, tea and maize (Abdullah & Abdul-Rahman, 2017). However, information on Kenya's sugarcane production trend is scanty. Given Kenya's Vision 2030 drive towards food sufficiency, it becomes imperative to forecast food production. Hence, this study analyzed trends in the growth area, output and yields in sugarcane production in Mumias Sugar Belt, Western Kenya, for the period 1985-2015.

Cite this article (APA):
Olabamiji, A. E., & Ajala, O. A. (2021). Khaemba, P. F., Muiruri, P. W., & Kibutu, T.N. (2021). Trend Analysis in Sugarcane Growth in Mumias Sugar Belt, Western Kenya; For the Period 1985-2015. *Interdisciplinary Journal of Rural and Community Studies*, *3*(2), 31-40. https://doi.org/10.51986/ijrcs-2021.vol3.01.04

2. Literature Review

In the middle of the last century, global sugarcane production was estimated at 260 million tons produced on 6.3 million hectares of land, with an average yield of 40 tonnes per hectare (FAO, 2016). By 1980, the global harvest of sugarcane from 13.6 million hectares had reached 770 million tonnes, averaged at 57 tonnes per hectare (FAOSTAT, 2017). Thirty years later, sugarcane production for 2007 had doubled to 1,525 million tonnes from 21.9 million hectares of land at 69.6 tonnes per hectare (FAO, 2016). Sugarcane is now cultivated on about 23.8 million hectares by 45 million sugarcane farmers worldwide. Globally, sugarcane production is nearly 1.72 billion tonnes per year and has decreased, having reached a peak of 1.9 billion tonnes in 2013 (Sari *et al.,* 2015). From 2014 onwards, only the area cultivated continued to grow, whereas yields have declined drastically (FAO, 2016).

The International economic crisis, which led to a fall in commodity prices and lack of liquidity in the financial market, seemed to have initiated the declining global sugarcane production. The critical consequence of this has been sustained yield decrease over the years. For example, global sugar production for 2015 declined by 3 million metric tonnes at 1.72 billion tonnes with the reduction witnessed in the European Union, Ukraine, Brazil and India, (Sari *et al.,* 2015). In addition to this, drought cut the global supply, with production dropping below consumption. For example, sugarcane yields in Brazil indicated 16.9 million tonnes reduction from 2013/2014 crush of 596.9 million tonnes (Jadhav *at al.,* 2015). This reflected a significant drop in yields stemming from an extended period of drought stretching from 2013 (Jadhav *et al.*, 2015).

The study by Akhter *et al.* (2016) on trends in the area, output and yields of major cash crops of Bangladesh from 1969-2009, 40-years period established a positive trend in the area, production, and yield of sugarcane. A similar study by, Greeshma (2014) in Pakistan indicated decreased area under sugarcane over time due to the shifting of the area to other cereal crops. On the other hand, Naidu and Hunsigi (2003) revealed increased sugarcane production in some regions of India due to the area expansion which accounted for 65%. The study by Kumar (2014) analyzed the trends in the area, production and productivity of sugarcane crop in Haryana state at both district and regional levels from 2000-01 to 2009-10. The study indicated a higher rate of change in the area of sugarcane crop than the rate of change in production in most of the Haryana districts.

There is wide crops variability in Africa. For instance, Nmadu *et al.* (2013) found that Nigeria had increased rice production for the period 1983 – 2003 and stagnated in sugarcane output and hectares for the period 1960-2010. Earlier on, Onyenweaku (2004) found Nigerian agricultural production stagnated for the period 1970 – 2000. On the other hand, Maikasuwa *et al.* (2013) study of trend analysis of area and productivity of sorghum in Sokoto state, Nigeria, found an accelerated area planted but decelerated productivity. The survey of sugarcane production in Nigeria for the period 1960-2010 and forecast to the year 2020 show that sugar output would rise to 2.8 million tons from about 88,000 hectares of land by the year 2020. However, this was insufficient in catering for the increasing population (Nmadu *et al*., 2013). Mutanga *et al.* (2013), a study on trend analysis of small-scale sugarcane production in Zimbabwe, shows a declining trend with a few years of improved production over the 11 years under investigation.

Some literature in Kenya has dealt with trends of coffee tea, maize and sugarcane at the national level (Kibaara *et al.*2008) and Abdullahi *et al.* (2000). However, none of the literature researched has examined the trends in sugarcane production in major sugar belts like Mumias Sugar Belt. Despite the fact that the Mumias Sugar Belt is the largest producer of sugar in Kenya, the pattern of growth in the area, output and sugarcane yields has not been established and documented. For instance, Mwanga *et al.* (2017) only modelled sugarcane yields in the Kenya Sugar Industry using a SARIMA Model Forecasting.

3. Materials and Methods

The study was carried out in the Mumias Sugar Belt of Western Kenya. The belt covers Kakamega, Bungoma, Busia, Vihiga and Siaya Counties. Mumias Sugar Belt lies between latitude 0° 22′ 14′′ N and longitude 34° 32′ 6′′ E (Fig. 1). The Belt enjoys a well-distributed annual rainfall with two rain maxima (March/May- long rains and August/ October- short rains). It has a 1250mm/year precipitation range to 1800 mm/ year (Mkomwa *et al*., 2011). Most farming activities take place during the long rains. The area has a temperature range of 21 °C to 25°C all year round (Mkomwa *et al.,* 2011). Sugarcane farming covers more than half of the arable land area. Sugarcane agriculture is the main cash crop, though with decreasing performance since 2000.

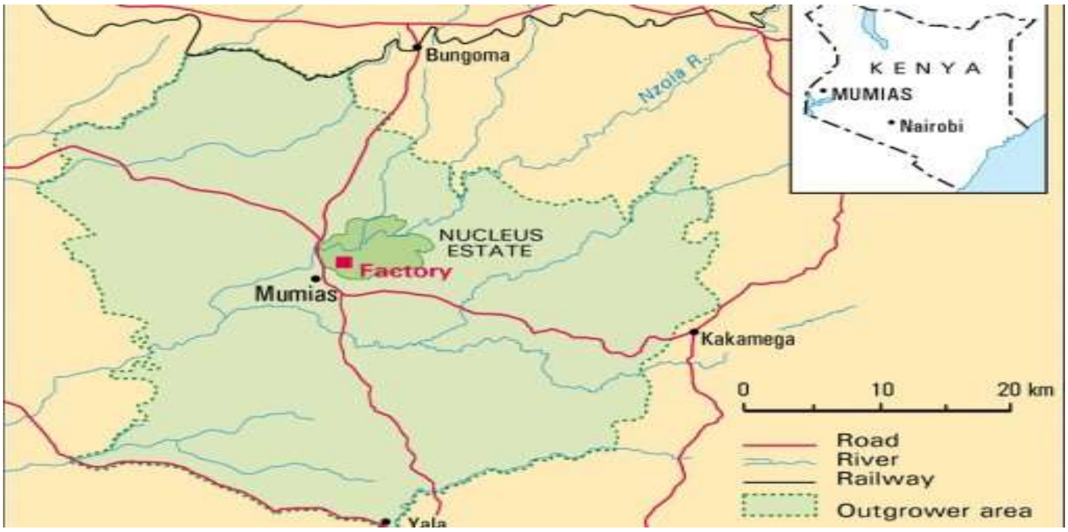

Figure 1: *Geographical Location of Mumias Sugar Belt in Western Kenya*

The study used time series analysis. This statistical analysis was employed to analyze trends in the growth of the area, output and yields in sugarcane production inMumias Sugar Belt for 1985-2015. The data on sugarcane output, hectares, yields, and harvesting age in months between the years 1985-2015 were obtained from Mumias Sugar Company(MSC) records. Expert modeler of SPSS ver. 18 software was used to fit the best suitable model for the time series data. The analysis was performed by *PROC ARIMA* divided into three stages. The *Identify, Estimate,* and *Forecast* were performed as stated below.

In the identification stage, the study used the *Identify* statement to specify the response series and identify candidate ARIMA models for it. The *Identify* statement read the time series used for differencing them, and computed autocorrelations and partial autocorrelations. A Stationarity test was performed to determine if differencing was necessary). It also has options to test for stationarity and tentative ARMA order identification. In the estimation and diagnostic checking stage, the study used the *Estimate* statement to specify the ARIMA model to fit to the variable specified in the identification stage and estimated that model's parameters. The *Estimate* statement produced diagnostic statistics to help the study judge the adequacy of the model. Significance tests for parameter estimates were done to indicate whether some terms in the model were unnecessary. Goodness-of-fit statistics aided in comparing the model obtained to other models

The modeller used Liung-Box test Q statistic to test the residuals' interdependence and make available statistical inferences of the parameters. The autocorrelations were checked in groups of 4, and the number of lags checked depended on the NLAG= 6. This meant that if the sample value exceeded the critical value of $\chi^{2,}$ distribution with **95** degrees of freedom, then at least one value of sugarcane variables (r) was statistically different from zero at significance level (0.05).

In the forecasting stage, the modeller builder used the FORECAST statement to forecast future times series values and generate confidence intervals for these forecasts from the ARIMA model produced by the preceding ESTIMATE statement. Forecasting of sugarcane production was done, including the output and yields predictors using the best fit model. Prediction based on the fitted model was computed up to 2021, and the one-step forecasting and 95% confidence limits displayed. The parameter values, t- ratio, p-values and standard error (SE) for each sugarcane variable were then tabulated.

4. Analysis and Discussion

4.1 Trends Analysis and Forecasting

The study captured data on two independent variables (Area harvested in hectares and Average harvesting age in months) and two dependent variables (output in tonnes and yield in tonnes per hectare). The study started the time series analysis by grouping the yearly data into groups of four to generate periodicity. Further, it computed: sequence plots, models, series plots and application of time series.

4.2 Sequence Plots

A sequence plot is a run chart that displays observed data in a time sequence. The data displayed in this study represent sugarcane output in tons and yields in tons of cane per hectare for 30 years (1985-2015). This is an aspect of the performance of sugarcane production. The study ran sequence plots for output in tonnes (Figure 2) and yields in tonnes of cane per hectare (Figure 3) over time (30 years) to establish the trends.

Figure 2: *Sequence Plot for sugarcane output in tons*

The sequence plot for sugarcane output in tonnes for Mumias Sugar Beltindicates variations across the years (1986-2015). There were fluctuations over the year with a notable increase from 1986 to 2005, a decline that became steeper, a decline from 2010 to 2015. From 2013 there has been a marked decline in output, with the 2014-2017 period recording 1,200,000 tons as shown in Figure 2. The general increase in output seems to coincide with the period the company provided farm input and paid farmers handsomely and promptly. The sharp decline in output from the 2006-2009 quarter confirms the stoppage of supply to farmers of farm inputs and subsidies and withdrawal of extension services from farmers by the company from the data obtained from the company records. The study also ran the sequence plot for the yields in tons of cane per hectare (see figure 3).

Figure 3: *Sequence Plot for sugarcane yields (Tons of cane per hectare)*

The sequence plot for the yields indicates fluctuation in yields in tonnes of cane per hectare. From the inception of sugarcane in the study area, the yields dropped from 107 tonnes of cane per hectare (TCH) in 1986/89 to 73 TCH in 1970/73 before shooting up to 118 TCH in 1994/97. From 1994/97 quarter, the yields declined drastically to 60 TCH in the 1998/2001 quarter. It then improved slightly to 80 TCH in 2002/05 quarter. Since the 2006/09 quarter, yields have remained below 60 TCH. This sharp drop suggests the impact of the withdrawal of farm subsidies (fertilizers), delayed payment, low payment and field mismanagement, cited by key informants. This scenario is similar to a case in Nigeria where Nmadu (2013) found a stagnated growth in Nigeria's sugar cane output and fluctuating hectares for the period 1960-2010.

4.3 Time Series Modeler

The study created a time series using the Expert Modeller that automatically finds the best-fitting model for each of the dependent variable series. The Time Series Modeller supports ARIMA models. ARIMA model types use the standard notation of ARIMA (p, d, q) (P, D, Q), where **p** is the order of auto-regression, **d** is the order of differencing (or integration), and **q** is the order of moving-average. And (P, D, Q) are their seasonal counterparts. The Expert Modeller generated the following types of models for the two variables as summarized in Table 1 below.

Table 1: *Model Description for output and yields*

Model Description			
			Model Type
Model ID	output in tones cane per ha	Model_1	ARIMA (1,0,0) (0,0,0)
	yield in tons per hectare	Model_2	ARIMA (0,1,0) (0,0,0)

The predictions of sugarcane output in tonnes and sugarcane yield in tonnes per hectare were done by the autoregressive integrated moving average (ARIMA) model. In the model, the First case after the end of the estimation period through a specified date in the Forecast Period group" was employed in the model. The dates for the forecast entered were 2021 for the year and 4 for the quarter. The data set contains data from 1986 through 2015. With the current settings, the forecast period will be 2016 through March 2021. Table for predicted values for each dependent variable series was generated. The Expert Modeler has determined that sugarcane output in tonnes was best described by an ARIMA model with one order of auto-regression (AR). The single order of auto-regression specifies that the output variable depends linearly on its previous values and in a stochastic term. The sugarcane yield in tonnes per hectare was best described by an ARIMA model with a single order of differencing. The single order of differencing reflects the upward trend that was evident in the data. ARIMA (0, 1, 0) also referred to as a random walk model.

4.4 Model Statistics

The model statistics table provides summary information and goodness-of-fit statistics for each estimated model. The model for sugarcane output in tonnes contains one predictor while out of the five candidate predictors that were originally specified. It appears that the Expert Modeller has identified one independent variable for sugarcane output in tonnes and two independent variables for sugarcane yield in tonnes per hectare that may prove useful for forecasting (Table 2).

Table 2: *Model Statistics for Output and Yield*

Model Statistics						
Model	Number of Predictors	Model Fit Statistics	Lung-Box Q (18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	
Output in tonnes-Model_1	1	.552	19.062	17	.325	0
Yield in tons per hectare-Model_2	2	.559	7.937	18	.980	0

To test goodness-of-fit statistics, the study considered the stationary R-squared value. This statistic estimates the proportion of the total variation in the series explained by the model and is preferable to ordinary R-squared when there is a trend or seasonal pattern, as is the case here. Thus 55.2% and 55.9% of the total variation in the sugarcane output in tonnes series and the sugarcane yield in tonnes per hectare series respectively are explained by the model. The Ljung-Box statistic, also known as the modified Box-Pierce statistic, indicates whether the model is correctly specified. A significance value less than 0.05 implies a structure in the observed series that is not accounted for by the model. The values of 0.325 for sugarcane output in tonnes and 0.980 for sugarcane yield in tonnes per hectare shown here are not significant, so we can be confident that the model is correctly specified.

4.5 Model Parameters for Sugarcane Output and Yields

The model parameters are based on the model types assigned by the expert modeller. In this study, sugarcane output in tonnes and sugarcane yield in tonnes per hectare that was assigned the ARIMA model has the ARIMA parameters. The ARIMA model parameters table displays values for all of the parameters in the model, with an entry for each estimated model labelled by the model identifier. For this study, it has listed all of the variables in each model, including the dependent and independent variables that the Expert Modeller determined were significant (Table 3).

***Table 3:** ARIMA Model Parameters*

					Estimate	SE	t	Sig.
Output in tonnes-Model_1	output in tons	No Transformation	Constant		1655230.705	314971.640	5.255	.000
			AR	Lag 1	.817	.172	4.735	.000
	area harvested in hectares	No Transformation	Delay		5			
			Numerator	Lag 0	21.943	8.613	2.548	.020
				Lag 2	22.984	9.698	2.370	.029
Yield in tons per hectare-Model_2	yield in tons per hectare	No Transformation	Difference		1			
	area harvested in hectares	No Transformation	Numerator	Lag 0	-.001	.000	-3.029	.005
			Difference		1			
	harvesting age in months	No Transformation	Numerator	Lag 0	2.261	.517	4.372	.000
			Difference		1			

From the model statistics table 3, the study shows that one for Model_1 (Sugarcane output in tons) and two for Model_2 (Sugarcane yield in tons per hectare) significant predictors. The ARIMA model parameter confirmed that for Model_1 (Sugarcane output in tonnes), the major predictor was "area harvested in hectares" while for Model_2 (yield in tonnes per hectare), they were "harvesting age in the month" and "area harvested in hectares."

4.6 Forecasting

To forecast the trends in sugarcane output and yield, the study plotted the observed and corresponding fit lines to check if abnormal deviations would skew the forecast. It also applied the time series model that the modeler had developed earlier to forecast. The predicted values illustrated by the fit line show good agreement with the observed values because of the small deviations from the observed for all the sugarcane output and yield. Therefore, the series plots for Observed and Fit indicates that the model has the satisfactory predictive ability (Figure 4.3).

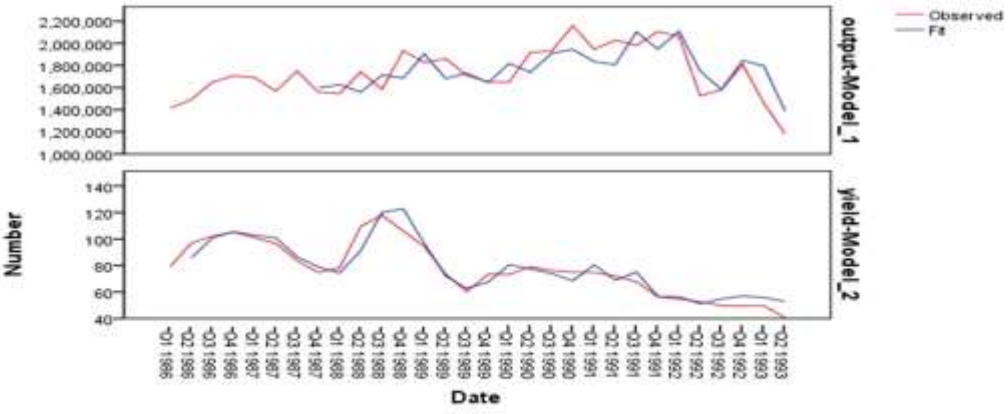

***Figure 4:** Series Plots for Observed and Fit*

5. Presentation of Findings

5.1 Applying Time Series Models in Forecasting to Lead Year 2021

The model was set to generate predicted values for the predictor from 2016 to 2021, which meant six quarters. The predicted values for the time 2016 to 2021 were copied and pasted beneath those of up to 2015 in the SPSS spreadsheet. To incorporate the new values of the time series into forecasts, the Time Series Models procedure of "re-estimating the model parameters and prediction" was deployed to the extent of the time series into the forecast time (2016 - 2021). The results are presented in Table 5.

Table 5: *Output and Yields forecasting model to lead year*

Forecast							
Model		**Q3 2014-2017**	**Q4 2014-2017**	**Q1 2018-2021**	**Q2 2018-2021**	**Q3 2018-2021**	**Q4 2018-2021**
Output in tonnes-Model_1	Forecast	1.17E+006	1.31E+006	1.20E+006	1.22E+006	1.31E+006	1.48E+006
	UCL	1.54E+006	1.78E+006	1.73E+006	1.79E+006	1.90E+006	2.08E+006
	LCL	808346.85	842259.21	675684.70	657869.55	726120.26	874313.13
Yield in tons per hectare-Model_2	Forecast	38.41	35.02	36.64	35.30	35.91	36.13
	UCL	52.81	55.38	61.58	64.10	68.11	71.40
	LCL	24.01	14.65	11.70	6.50	3.71	.85

The forecast table contains the predicted values of the dependent variables (sugarcane output and sugarcane yield), taking into account the values of their predictors in the forecast period. The table also includes the upper confidence limit (UCL) and lower confidence limit (LCL) for the predictions. Thus, the series plot combined the original plot plus the forecast (Figure 5).

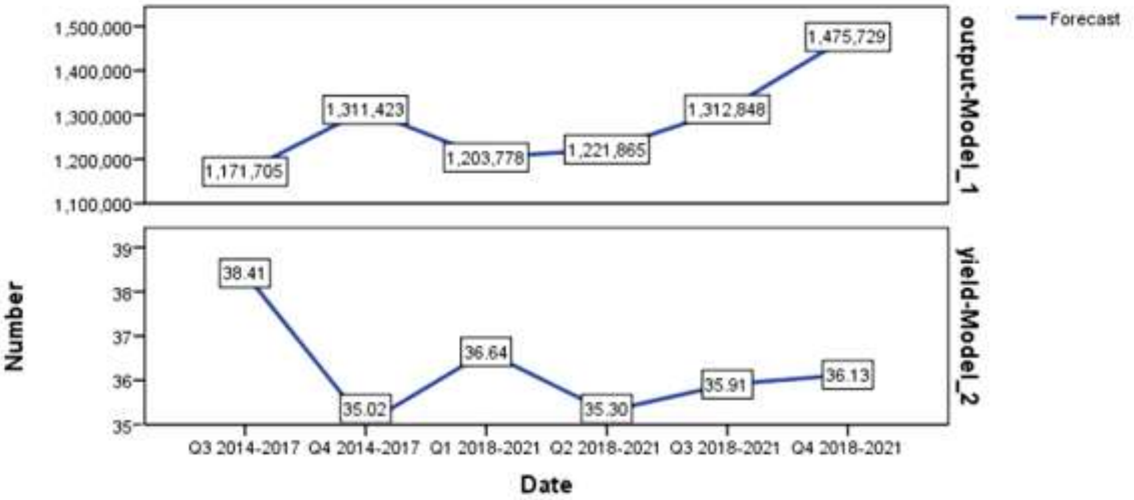

Figure 5: *Series Plots for Original and Forecast*

The forecast for sugarcane output in tons reveals an increase from 1,171,705 in 2016 to 1,475,729 in 2021 (i.e., 304,924 metric tonnes of raw cane for a five-year period). This represents a very insignificant increase that does not match the needs posed by the rate of population growth. Sugarcane yield in tons per hectare depicts a decrease from 38.41 to 36.13 TCH for the period in question. This shows a blinking picture for sugarcane farming in the Mumias Sugar Belt, hence a need for consultative efforts to be made by stakeholders to change this situation to attain Kenya's Vision 2030 of self-sufficiency in food. Lastly, from the forecast, an increase in the harvesting age by two months is expected to generate approximately 4.52 more tonnes of yields than expanding area harvested by 10 hectares that decrease the yield by 0.01 tons per hectare.

6. Conclusion

Based on the figures and tables, this paper shows two major results that can be summarised as follows. The general process of the ARIMA model for sugarcane growth data predicting. The results achieved with best ARIMA model which is ARIMA (1,0,0) (0,0,0) while the other models of the ARIMA have (0,1,0) (0,0,0). The fluctuation of the data set is discussed, and all of the outlier values have been detected. These results guide policymakers in Mumias Sugar Belt to make decisions on best farming practices. These results found that ARIMA model can reasonably well with emerging forecasting techniques in short-term forecasting. The limitation of this model is in using ARIMA model with only short-term forecasting. However, in some cases, the researchers need to make long term forecasting. As future work, this model can be implemented for any other type of data, such as sugar varieties data.

References

Abudallah, A. H., & Abdul-Rahman, A. (2017). Technical efficiency of maize farmers in Ghana: a stochastic frontier approach. *International Journal of Innovation and scientific research*, *29*(2), 110-118.

Akhter, S., Sarker, J. R., & Das, K. R. (2016). Growth and trend in area, production and yield of major crops of Bangladesh. *International Journal of Economics, Finance and Management Science*, *4*(1), 20-25. https://doi.org/10.11648/j.ijefm.20160401.13

Khaemba, P., Muiruri, P., & Kibutu, T. (2021). An Investigation of Coping Strategies Adopted by Small-Scale Sugarcane Growers in Bungoma County, Kenya. East African Journal of Interdisciplinary Studies, 3(1), 89-102. https://doi.org/10.37284/eajis.3.1.310

FAO, (2016). WFP: The State of Food Insecurity in the World 2015. Meeting the 2015 International hunger targets. *Rome,* Food and Agriculture Organization Publications.

FAOSTAT, (2017). Food and Agriculture Organization of the United Nations. http://faostat.fao.org/site/567/default

Greeshma, R. (2014). *Trend analysis of sugarcane area, production and productivity in Andhra Pradesh*. (Unpublished doctoral dissertation, Agricultural University of Hyderabad, India).

Jadhav, M. G., Aher, H. V., Jadhav, A. S., & Gote, G. N. (2015). Crop Planning Based on Moisture Adequacy Index (MAI) of Different Talukas of Aurangabad District of Maharashtra, *India. Journal of Dryland Agricultural Research & Development, 30*(1), 101-103.

Kenya Sugar Board (2014). *Cane Census Report*. Agriculture Department, Nairobi, Kenya.

Kibaara, B., Ariga, J., Olwande, J., & Jayne, T. S. (2008). *Trends in Kenyan agricultural productivity: 1997-2007.* Tegemeo Institute of Agricultural Policy and Development 1093(88047)

Kumar, A. A (2014).*Study of Area, Production and Trade of Sugarcane in Major Sugarcane Producing States of India* (Unpublished Doctoral dissertation, Institute of Agricultural Sciences Banaras Hindu University).

Maikasuwa, A., & Ala, A. L. (2013). Trend analysis of area and productivity of sorghum in Sokoto state, Nigeria, 1993-2012. *European Scientific Journal*, *9*(16), 69-75.

Mkomwa, S., Mzoba, H., & Weldone, M. (2011). *Conservation Agriculture in Kenya; A case of Bungoma District.* Africa Conservation Tillage Network

Mulianga, B., Ogeda, I., & Mwanga, D. (2015). Assessing the Impact of Climate Change on Sugarcane Productivity in Kibos - Miwani, Kenya. *Agricultural and Forest Meteorology, 16*(4), 169-175.

Mumias Sugar Company (MSC). (2016). Mumias Sugar Company Limited Annual Report and Financial Statements. Mumias Sugar Company Limited.

Mutanga, S., Ramoelo, A., & Gonah, T. (2013). Trend Analysis of Small Scale Commercial Sugarcane Production in Post Resettlement Areas of Mkwasine Zimbabwe, Using Hyper-Temporal Satellite Imagery. *Advances in Remote Sensing, 2*(1), 29-34. https://doi.org/10.4236/ars.2013.21004

Mwanga, D., Ong'ala, J., & Orwa, G. (2017). Modeling sugarcane yields in the Kenya sugar industry: A SARIMA model forecasting approach. *International Journal of Statistics and Applications*, *7*(6), 280-288. https://doi.org/10.5923/j.statistics.20170706.02

Nmadu, J. N., Ojo, M. A., & Ibrahim, F. D. (2013). Prospects of sugar production and imports: meeting the sugar demand of Nigeria by year 2020. *Russian Journal of Agricultural and Socio-Economic Sciences*, *14*(2)15-25

Onyenweaku, C. E., & Effiong, E. O. (2005). Technical efficiency in pig production in Akwa Ibom State, Nigeria. *International Journal of Agriculture and Rural Development*, *6*(1), 51-57.

Sari, D., & Wegener, M. (2015). An overview of sugarcane sector in Indonesia, *Sugar Tech.* https://doi.org/10.1007/s12355-06-090-6