Agricultural Sciences Journal
Available online at http://asj.mnsuam.edu.pk/index.php
ISSN 2707-9716 Print
ISSN 2707-9724 Online
https://doi.org/10.56520/asj.24.336

Research Article

PREDICTING RICE SELF-SUFFICIENCY IN SIERRA LEONE USING ARIMA MODEL

Andrew B. Sannoh[1], Azhar Abbas*[2], Almazea Fatima[2], Abdulazeez Hudu Wudil[3]

[1]*Department of Agricultural Economics, Njala University, Sierra Leone*
[2]*Institute of Agricultural and Resource Economics, Faculty of Social Sciences, University of Agriculture Faisalabad, Pakistan*
[3]*Department of Agricultural Economics and Agribusiness, Faculty of Agriculture, Federal University Dutse, Jigawa State, Nigeria*
**Corresponding author: azhar.abbas@uaf.edu.pk*

Abstract

Rice is the staple food in Sierra Leone, with the annual consumption increasing faster than the yearly production. As a result, the county is yet to be self-sufficient in rice production, resulting in a very high annual import bill. This paper aims to predict Sierra Leone's self-sufficiency in rice until 2030. The time series modeling approach (Box Jenkins' ARIMA model) was used to forecast rice production, consumption, and finally, rice self-sufficiency in Sierra Leone. The predicted results of the study showed that the self-sufficiency rate of rice will fluctuate between 63% and 65% in the forecasted period of 2021 and 2024 and will then remain stable (constant) at 63% until 2030. Therefore, as shown from the study results, Sierra Leone will continue to import about 37% of rice annually at the current production scenario until 2030. This study's findings showcased that although the country has formulated some viable policies to boost rice production, more effort is needed to ensure self-sufficiency. However, any policy to increase rice production should strive to improve small-scale rice producers in line with their agronomic practices.

Keywords: *ARIMA, Rice Production, Rice Consumption, Self-Sufficiency, Sierra Leone.*
(Received: 29-Oct-2023 Accepted: 05-Apr-2024) Cite as: Sannoh. A. B., Abbas. A., Fatima. A., Wudil. A. H., 2024 Predicting Rice Self-Sufficiency in Sierra Leone Using ARIMA Model. Agric. Sci. J. 10.56520/asj.24.336

1. INTRODUCTION

The agricultural sector of Sierra Leone contributes about 61 percent of its GDP, according to the "CIA World Factbook (2020)". The crop subsector (rice, maize, cassava, and sweet potato) contributed an average of 44.5% to the country's GDP in 2020 (Statistics Sierra Leone, 2021). Although the rice sub-sector accounts for around 62 percent of the Agricultural Gross Domestic Product (AGDP), it imports considerable rice to meet its domestic consumption (Stats. SL, 2021). Statistics have shown that 85 percent of the farmers in Sierra Leone are rice farmers, accounting for 764,491 ha (7644.91 km2) with an average yield of 800,000 metric tons. The average yield per hectare was 1.2 less than the African average of 2.1 and only 35% of the global average of 3.4 t/ha (Fahad et al., 2019). The average annual rice consumption per person was around 100kg in 2013. However, this average rose to 185 kg in 2017 (FAOSTAT (2017). Sierra Leone ranked sixth in the global ranking in terms of per capita rice consumption (FAOSTAT, 2017). "World Data Atlas (2018)" estimated that the country spent around 800 million U.S. dollars on rice imports between 2010 and 2017, nearly 100 million U.S. dollars a year. In 2019 alone, over 360,000 MT were imported, the highest rice import history according to the "World Data Atlas (2019)". Besides reducing available funds for national building, this importation also disincentives local farmers because the imported rice is relatively cheap and better processed (World Bank, 2014).

Agricultural policies in Sierra Leone can be traced back to colonial rule. However, the policies could all be divided into five main phases. The very first phase was known as "the colonial and decolonization era (mostly the period leading up to independence, 1900–1961)," and policies at that time were geared mainly towards tackling specific socio-political problems known as the British colonial agricultural policies. These policies did not take a more comprehensive view of the agricultural sector's problems. Their main concern was exporting raw materials to Britain for their industries. The second policy covers the first three decades of "the post-independence era (1961–1990)." A 10-year strategy (1962–1971) for social and economic growth was developed as a blueprint for the country's development at independence, in which two significant challenges within the agricultural sector were highlighted: (a) low production output and (b) instability of the export market. The third phase was “The Period of New Order/Civil Conflict” (1985–2000). The government faced significant economic challenges such as inflation, foreign debt, rampant unemployment, the fact that the foreign exchange rate dropped to its lowest, etc. A 'new order' was declared when the new government assumed power in 1985. The fourth phase was " post-conflict reconstruction (2001–2007)." In January 2002, when the war was officially declared over, the country was experiencing a speedy recovery in stabilizing the economy. All the policies but one program was directed toward economic recovery, sustainability, and the country's stability. Lastly, the fifth phase was "The time of transition to growth and poverty alleviation/The Food Security Policy (2007-date).": the current policy documents were set to achieve the following objectives: (a) agricultural intensification with emphasis on rice production, (b) crop diversification, (c) natural resource conservation, and (d) food safety nets (Kargb (2009). Despite these policy frameworks, the sector faces significant obstacles, which include inadequate rural financial services, insufficient large-scale irrigation facilities, weak rural infrastructure, limited extension services, considerable reliance on rain-fed agriculture, poor research and statistical capacity, and low-value addition.

Several models in the literature have been used for forecasting. ARIMA is one of those and has been widely used in various research areas in the agricultural domain for making predictions: to predict food production (Dash et al., 2017), to forecast inflation (Tamuke et al., 2018)", to forecast self-sufficiency of rice (Akouegnonhou et al., 2019), to forecast rice production and area (Arun et al., 20), P Paidipati et al. (2020), and Rani et al. (2020)”. The study in hand also used Box-Jenkins' ARIMA to estimate because of its wide range of success in estimation and prediction purposes. Despite the importance of rice to food self-sufficiency, food security, and poverty alleviation, to the best of my knowledge, no study was conducted to forecast the self-sufficiency of rice production and provide recommendations for improvement in Sierra Leone. Owing to that, this study aimed to predict self-sufficiency in rice production in Sierra Leone from 2021 to 2030 and give policy recommendations for improvement.

2. Methodology

2.1. Methods of Data Collection

The study used time-series data from 1961 to 2020 to predict rice self-sufficiency in Sierra Leone till 2030. The data was collected from the official website of the United States Department of Agriculture – Production, Supply, and Distribution “USDA (2021)”.

2.2. Model Specification

The study seeks to examine the relationship between rice production and rice consumption. After carefully considering essential variables, the following models were specified for the study as:

$$\boldsymbol{PRD = \beta_0 + \beta_1 C + \varepsilon_t \ldots\ldots} \quad \textbf{(1)}$$

Where: PRD: Rice Production

C: Rice Consumption

ε_t: Error term with normal distribution. (Zero mean and constant variance)

2.2.1. ADF Unit Root Test

$$\Delta Y_t = pY_{t-1} + \alpha_i \sum_{i=1}^{n} \Delta Y_{t-1} + \varepsilon_t \ldots\ldots (2)$$

Where: ΔY_{t-1} the lagged difference term and the number of lags were taken so that the error term becomes serially un-correlated and ε_t is the white noise error term.

2.2.2. Autoregressive Integrated Moving Average (ARIMA) Model

Autoregressive Integrated Moving Average ARIMA (p,d,q) model was employed according to "Gujarati *et al.* (2012, p.536)". the model can be specified as follows:

$$Y_t = \delta + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + \epsilon_t \ldots (3)$$

Where:

δ is the intercept, Y_{t-1} is the lag value of Y_t, ϕ_{t-1} is the parameter, and ϵ is the error

Moving Average (M.A.) in this model, the dependent variable is predicted by current and past observations.

$$Y_t = \mu + \theta_1\epsilon_{t-1} + \theta_2\epsilon_{t-2} + \cdots + \theta_q\epsilon_{t-q} + \epsilon_t \ldots\ldots (4)$$

Where; μ is the intercept, θ_1 is the error in predicting the last term, and ϵ is the white noise. The order of the M.R. process is called q.

The generalized ARIMA (p, d, q) model is expressed mathematically as:

$$\Delta_d Y_t = \delta + \{\phi_1\Delta_d Y_{t-1} + \phi_2 \Delta d\ Y_{t-2} + \cdots + \phi_p\Delta_d Y_{t-p}\} + \{\theta_1\epsilon_{t-1} + \theta_2\epsilon_{t-2} + \cdots + \theta_q\epsilon_{t-q}\} + \epsilon_t \ldots\ldots (5)$$

Here: Y_t = Observation at time, Y_{t-p} = Observation at time t = p, δ = Constant error, $\phi_1 \ldots\ldots \phi_p$ = MA parameter, ϵ_t = White noise error term, Δ_d = d^{th} order differences "Gujarati *et al.* (2012, p.536)". The model can also be condensed as:

$$Y_t = \delta + \Sigma_i = 1_p\phi_i Y_{t-I} + \Sigma_j = 1_q\theta_j\epsilon_{t-j} + \epsilon_t \ . (6)$$

Box-Jenkins (B. J) Methodology (predictive/forecasting model)

$$Y_t = \delta + (1+\alpha_1)Y_{t-1} - \alpha_1 Y_{t-2} + \cdots + \alpha_k Y_{t-(k+1)} + U_1 - \theta_1\varepsilon_{t-1} + \theta_1\varepsilon_{t-2} - \cdots - \theta_k\varepsilon_{t-k} + \theta_k\varepsilon_{t-(k-1)} \ldots\ldots (7)$$

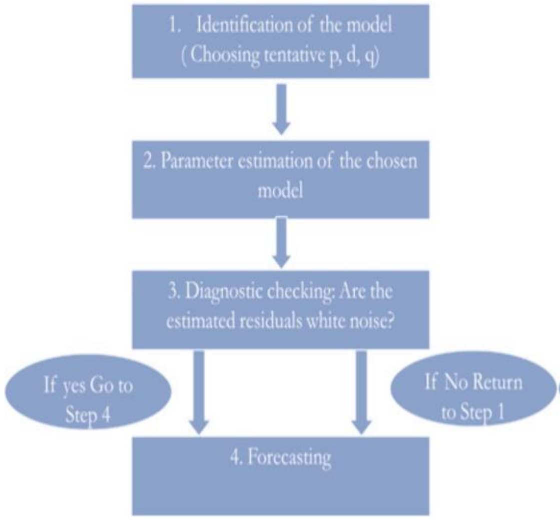


Figure 1: The Box-Jenkins Methodology

Source: "Gujarati et al. (2012, p.536)".

Source: "Gujarati *et al.* (2012, p.536)".

The degree of self-sufficiency = $UP/_{DU}$ X 100 …………………. (8)

Where:

UP = Useable production and DU = domestic use "FAO (2012b); Van Oort *et al.* (2015); Demirbaş *et al.* (2017)".

3. Results and Discussion

3.1. Analysis of Rice Production

3.1.1. Identification of the model

The result showed that data on production were stationary at 2nd difference based on the correlogram. Spikes found lying outside the standard error bounds (95% confidence interval) were used to identify and estimate ARIMA models to get a fitted model for forecasting after meeting the diagnostic criteria. The models identified were ARIMA (1, 2, 1; 2, 2, 1; 3, 2, 1 and 4, 2, 1).

3.1.2. Parametric Estimation of the Model

Table 1: Different ARIMA Model Estimation Summary for Rice Production

	ARIMA(1, 2, 1)	**ARIMA(2, 2, 1)**	**ARIMA(3, 2, 1)**	**ARIMA(4, 2 ,1)**
Sig. Coeff.	0	1	1	**2**
$Sigma^2$ (Volatility)	4587.92	4231.679	4588.108	**4428.484**
Adj. R^2	-0.00	0.00	-0.00	**0.03**
AIC	11.40	11.39	11.40	**11.37**
SIC	11.54	11.53	11.54	**11.51**
F-Statistics	0.92	1.07	0.91	**1.61**

Source: Authors' computation

As presented in Table 1, four models were identified (ARIMA1:2:1, 2:2:1, 3:2:1, and 4:2:1) from the 2nd differenced correlogram. However, ARIMA (4, 2, 1) stood out to be the appropriate model for forecasting in this study, having the: most significant coefficient, lowest volatility, highest adjusted R2, lowest AIC and SIC values, and highest F-statistics "Gujarati et al. (2012, p.536)".

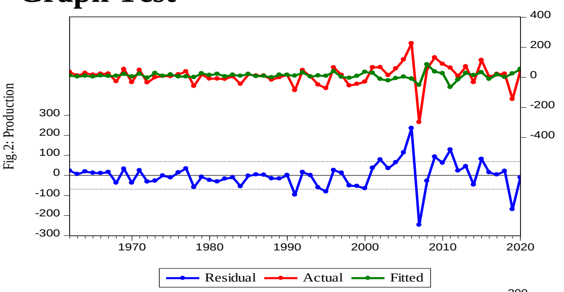
3.1.3. Diagnostic Checking (Validation)

Similarly, validation tests were conducted using three independent methodologies to validate that the identified model was appropriate for forecasting: Residual Diagnostic Test, Actual and Fitted Residual Graph Test, and Covariance and Invertibility.

3.1.3.1. Residual Diagnostic Test

This test showed that the model was white noise, the Ljunge-Box Q statistics Correlogram showed that all the spikes for ACF and PACF are within the standard error bounds (95% Confidence interval line) the p-values are > 0.05. Therefore, we cannot reject the null hypothesis, which means that the model residuals are "white noise."

3.1.3.2. Actual and Fitted Residual Graph Test



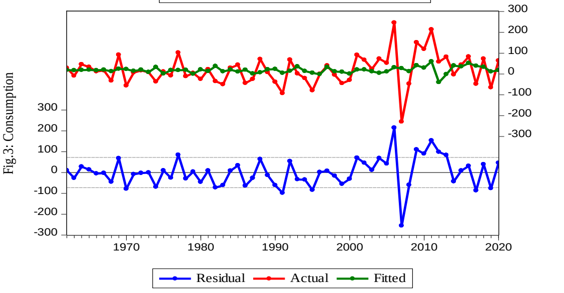
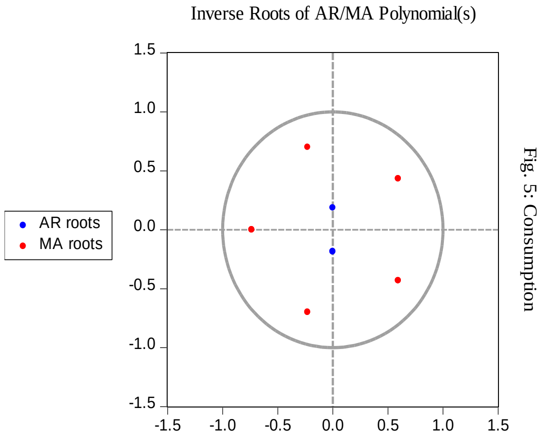


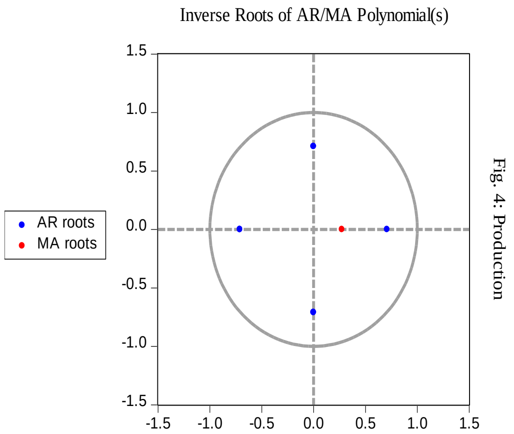
Figure 2 and 3: Actual and Fitted Residual Graph of the Selected Model for Forecasting Production and Consumption, respectively, from 1961 to 2020. (Source: Authors' computation)

Figs 2 and 3 presented the actual and fitted residual line graph for both production and consumption. The former was consistent with model ARIMA 4, 2, 1, while the latter was consistent with ARIMA 2, 2, 5. As shown in Fig. 2 and 3, the actual and fitted residuals showed similar trends in both cases. Hence a good sign for the models to be used for forecasting.

3.1.3.3. Covariance and Invertibility Test

The ARMA process is "covariance" if all the A.R. roots lie inside the unit circle. Similarly, the ARMA process is "invertible" if all the M.A. roots lie inside the unit circle "Gujarati *et al.* (2012, p.536)".



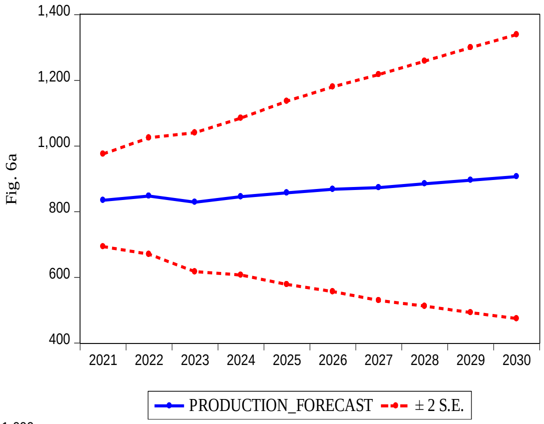


It is seen from the ARMA structures (Fig 4 and 5) that all the A.R. and M.A. roots are laid inside the unit circle. Hence, it can be concluded that the ARMA process was covariance and invertible, which was also a good sign for the models to be used for forecasting. The models were then applied to predict rice production and consumption in Sierra Leone from 2021 to 2030, having satisfied with the diagnostic checking and validation conditions.

3.2. Forecasting

3.2.1. Forecasted Result for Rice Production

Before actual forecasting was conducted, a forecast graph was observed, which according to "Dash et al. (2017)" and "Akouegnonhou et a1. (2019)", should be within ±2 standard error as shown in Figure 6a.



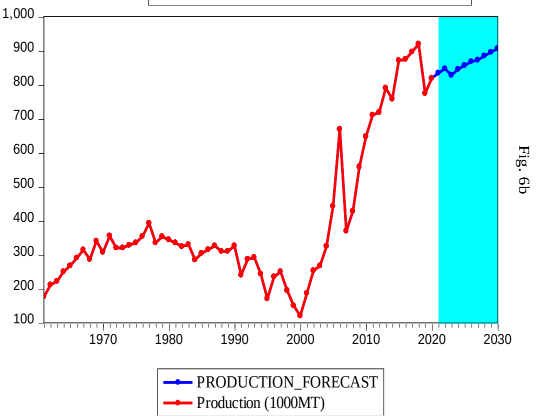


Figure 6 (a and b): Forecast graph of Rice Production in Sierra Leone

Source: Authors' Computation

It is evident from the above (Fig. 6b) that the forecasted rice production clearly showed an upward trend with some fluctuation from 2021 to 2023. From 2024 to 2030, the trend showed a steady increase. This indicated that ceteris paribus, rice production will continue to increase in Sierra Leone till 2030. This is in line with "Oladimeji (2017)" and "Akouegnonhou et a1., (2019", who reported that although there were increasing trends in rice production across sub-Saharan African countries, virtually none of the countries could attain self-sufficiency in rice production shortly. Contrary to that, "Mwaijande (2018)" reported that Tanzania could achieve self-sufficiency in 2027. "Tesfaye et al. (2018)" also noted that Ethiopia could achieve self-sufficiency in 2050. Based on empirical findings, the major bottleneck to self-sufficiency in rice production in the region include; poor agronomic practices (Tsujimoto et al., 2019); inadequate extension and training (Donkoh et al.,2019; Bello et al., 2020), lack of access to credit and input (Ngugi, 2019; Ojo et al., 2020), over-reliance on rainfed agriculture (Klutse et al., 2021; Sarr et al. (2021), weak technology transfer (Soullier et al., 2020), poor macroeconomic policies (Arouna et al., 2020; Sers et al., 2020), policy inconsistency (Oluwatayo et al. (2019; Ikebudu et al., 2021), and political instability (Angelucci et al., 2019; Osabohien et al., 2020).

3.3. Analysis of Rice Consumption

3.3.1. Identification of the models

The result showed that data on consumption were stationary at 2nd difference based on the correlogram. Spikes found lying outside the standard error bounds (95% confidence interval) were used to identify and estimate ARIMA models to get a fitted model for forecasting after meeting the diagnostic criteria. The models identified were ARIMA (1, 2, 1; 1, 2, 5; 2, 2, 1, and 2, 2, 5).

3.3.2. Parametric Estimation of the Model

Table 2.: Different ARIMA Model Estimation Summary for Rice Consumption

	ARIMA(1, 2, 1)	**ARIMA(1, 2, 5)**	**ARIMA(2, 2, 1)**	**ARIMA(2, 2 ,5)**
Sig. Coeff.	0	1	0	**1**
Sigma²(Volatility)	5169.317	4893.656	5167.912	**4891.555**
Adj. R^2	-0.05	0.00	-0.05	**0.00**
AIC	11.52	11.47	11.52	**11.47**
SIC	11.66	11.61	11.66	**11.61**
F-Statistics	0.03	1.06	0.03	**1.07**

Source: Authors' computation

From the above summary (Table 2) after identifying the four models above from the 2nd differenced correlogram, ARIMA (2, 2,

5) stood out to be the appropriate model for forecasting rice consumption. This is so because the model proved to be the most reliable as compared to others by meeting the model selection criteria i.e., having the: most significant coefficient, lowest volatility, highest adjusted R2, lowest AIC and SIC values, and highest F-Statistics.

3.3.3. Forecasting

3.3.3.1. Forecasted Result for Consumption

The forecast graph for rice consumption Fig 7a lies within the ±2 standard error, the 95% confidence interval (C.I), indicating the forecast is suitable.

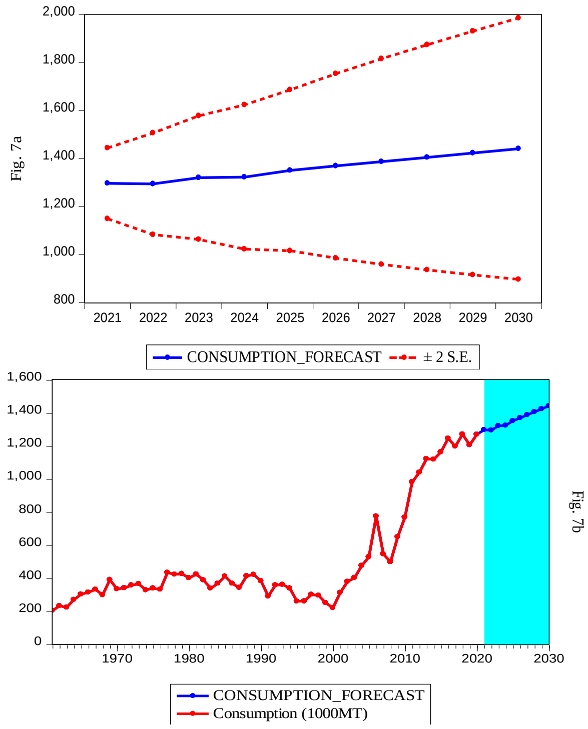


Figure 7 (a and b): Forecast graph of Rice Consumption in Sierra Leone
Source: Authors' computation

It was evident from Fig 7b that the forecasted rice consumption clearly showed an upward trend against the actual consumption. This indicates that, with all other factors remaining equal, rice consumption will continue to increase faster than production from 2023 to 2030. Comparatively, the analysis showed that rice consumption would rise more quickly than its production. This signaled that unless effort is put in place to enhance rice production and productivity in the country, the country will continue to use its proceeds meant for national building for rice importation. This finding is consistent with "Chenoune et al. (2017), Johnny et al. (2019), and Vangahun et al. (2019)", who reported that the per capita consumption of rice in Sierra Leone has been on the increase in the last two decades. Many studies have possible reasons for the rise in the consumption of rice in sub-Saharan Africa "Chenoune et al. (2017); Nigatu et al. (2017); Johnny et al. (2019); Smith et al. (2021)" opined that this rapid increase in consumption was not unconnected with the rapid population growth. Similarly, "Michailof (2016); Mberu et al. (2017); Beson et al. (2018); Adedoyin et al. (2020)" pointed out that rapid increase in consumption in Sub-Saharan Africa was directly correlated with rapid population growth in the region. They, however, suggested that sub-Saharan Africa needs to control its population to avert population explosions. On the contrary, "Johnny et al. (2019); Volz et al. (2020); Smith et al. (2021)" concluded that rice consumption in Sierra Leone mainly resulted from the change in feeding habits due to urbanization.

Results in Table 3 and Fig 8 showed that rice production had positive trends throughout the forecasted period except for 2023. Still, the country could only attain 63.52% self-sufficiency up to 2030 at the current production level. The result (Table 3) also highlighted that while paddy output will only increase by 0.93% for the period under investigation, consumption will increase by 1.18%, much higher than the production by about 26%. If continuous, this mismatch between production and consumption can obliterate all efforts to achieve future efficiency.

Average % change in production = 0.93
Average % change in consumption = 1.18
Average Self-Sufficiency rate =63.52
% difference between Production and consumption = 26

Table 3: Forecasted Percentages Change in Rice Production, Consumption and Self Sufficiency

Year	Forecast Production (1000MT)	% Change in Production	Forecast Consumption (1000MT)	% Change in consumption	Self-Sufficiency (%)
2021	835		1297		64.38
2022	848	1.56	1295	-0.15%	65.48
2023	829	2.24	1321	2.01%	62.76
2024	846	-2.05	1323	0.15%	63.95
2025	857	1.30	1351	2.12%	63.43
2026	868	1.28	1369	1.33%	63.40
2027	873	0.58	1387	1.31%	62.94
2028	885	1.37	1405	1.30%	62.99
2029	896	1.24	1423	1.28%	62.97
2030	907	1.23	1441	1.26%	62.94

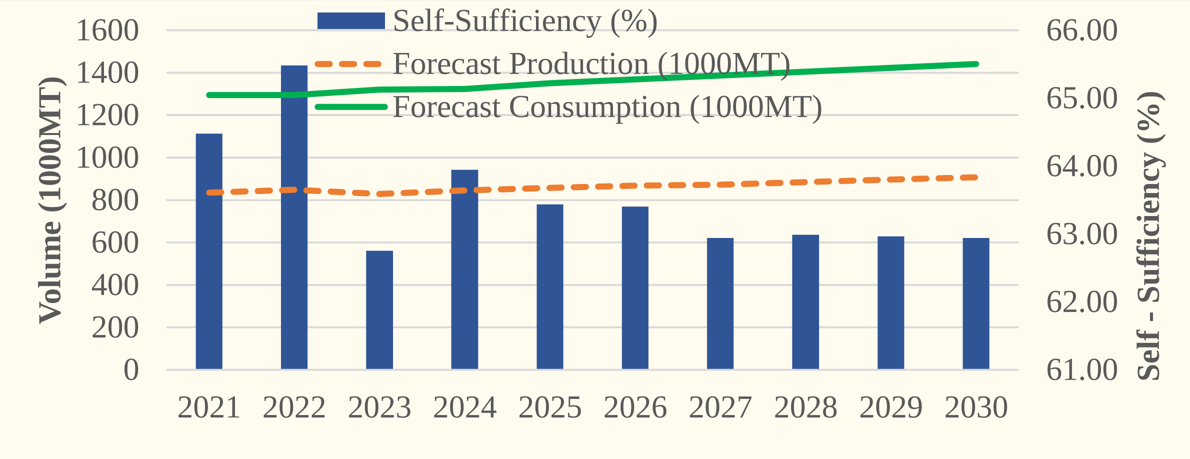


Figure 3 Trends in Rice Production, Consumption and Level of Self-Sufficency

Source: Authors' computation

In addition, Fig 8 showed that the highest rate of change, 2.24, and self-sufficiency, 65.5 percent, could be achieved in 2022 respectively; in contrast, the lowest rate of change, -2.05, and self-sufficiency, 62.76 percent, might be observed in 2023 as and respectively.

4. Conclusion

As per the result, rice self-sufficiency could not be reached at the current production and consumption level during the next ten years. The output of paddy will fluctuate from 63% to 65% between the period of 2021 and 2024 and will then remain the same (constant) at around 63% from 2025 to 2030. However, trends of the annual rice consumption showed an average yearly increase of 1.18 percent faster than annual rice production in Sierra Leone. Therefore, as shown by the research result, Sierra Leone will continue importing about 37% of rice annually to meet its domestic demand until 2030.

5. Policy Implication and Options

Agricultural policies and initiatives in Sierra Leone should be developed in light of current cultural, political, and economic realities for sustainability. The government should develop policies relevant to rice production focusing on increasing yields, pest management, labor-saving technology, and growing investment in research and extension services. There is a need for the improvement of existing irrigation structures and the development of new irrigation facilities. Investment in anticipatory research has to be prioritized by the government to combat climate change. Technologically advanced information and communication technologies (ICTs) can also reach farmers in remote locations and successfully install the technology. Establishing private-public partnerships and organizing farmers into user groups will improve training, farmer education, and technology adoption for intensive commercial rice cultivation.

Access to credit without rigid collateral, as was successfully done in Bangladesh through Grameen Bank, could also help resource-poor farmers increase their productivity. Improvements in marketing, processing, and value addition will also help farmers increase their returns and the marketability of their output. Above all, governments should establish proper and effective communication tactics with paddy rice farmers, such as radio, television, telephone, and remote learning and teaching, for spreading knowledge and technologies.

6. Declaration of Competing Interest

The authors declare that they have no known financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. Funding:

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

8. REFERENCES

Adedoyin, F. F., Alola, A. A., & Bekun, F. V. (2020). The nexus of environmental sustainability and agro-economic performance of Sub-Saharan African countries. Heliyon. 6, 9

Akouegnonhou, O. & Demirbas, N. (2019). Forecasting of rice self-sufficiency in the Benin Republic using ARIMA model. Selcuk Journal of Agriculture and Food Sciences. 33, 204-214.

Angelucci, F., Asante-Pok, A., & Anaadumba, P. (2019). Analysis of incentives and disincentives for rice in Ghana. Gates Open Res. 3:1325.

Arouna, A., Soullier, G., Del Villar, P. M., & Demont, M. (2020). Policy options for mitigating impacts of COVID-19 on domestic rice value chains and food security in West Africa. Global Food Security. 26.

Arun, G. C. & Jun-Ho, Y. (2020). Rice Production of Nepal in 2030: A Forecast using Autoregressive Integrated Moving Average Model. 25, 31-57.

Bah, A. A. 2013. Strategies for promoting rice self-sufficiency in Sierra Leone. Journal of Northeast Agricultural University (Eng. Ed.), 20, 78-86.

Bello, L. O., Baiyegunhi, L. J., & Danso-Abbeam, G. (2020). Productivity impact of improved rice varieties' adoption: case of smallholder rice farmers in Nigeria. Economics of Innovation and New Technology. 30, 750-766.

Beson, P., Appiah, R., & Adomah-Afari, A. (2018). Modern contraceptive use among reproductive-aged women in Ghana: prevalence, predictors, and policy implications. BMC women's health, 18, 1-8.

Brief, B. C. (2013). Sierra Leone.

Chenoune, R., Allen, T., Komarek, A. M., Paloma, S. G., Flichman, G., Capillon, A., & Belhouchette, H. (2017). Assessing consumption-production-resources nexus decisions for rice-focused agricultural households in Sierra Leone. Land Use Policy, 67, 597-607.

CIA World FactBook. 2020. Sierra Leone Economy 2020. Available online with updates at https://theodora.com/wfbcurrent/sierra_leone/sierra_leone_economy.html. Accessed on 11-05-2021.

Dash, A., Dhakre, D. S. & Bhattacharjee, D. (2017). Forecasting of food grain production in Odisha by fitting ARIMA model. Journal of Pharmacognosy and Phytochemistry. 6, 1126-1132.

Demirbas, N., Niyaz, ÖC, & Daysal, H. (2017). Evaluation of Self-Sufficiency in Lentil Production in

Turkey. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, (JAFAG), 34, 282-291.

Donkoh, S. A., Azumah, S. B., & Awuni, J. A. (2019). Adoption of improved agricultural technologies among rice farmers in Ghana: A multivariate probit approach. Ghana Journal of Development Studies. 16, 46-67.

Fahad, S., Adnan, M., Noor, M., Arif, M., Alam, M., Khan, I. A., ... & Wang, D. (2019). Major constraints for global rice production. In Advances in rice research for abiotic stress tolerance (pp. 1-22). Woodhead Publishing.

FAO. 2012b. FAO Statistical Yearbook 2012, World Food and Agriculture. http://www.fao.org. Accessed on 12-09-2020

FAOSTAT. 2017. Rice Consumption Per Capital in Sierra Leone. Available online with updates at https://www.helgilibrary.com/indicators/rice-consumption-per-capita/sierra-leone/ Accessed on 11-05-2021.

Gujarati, D. N., Porter, D.C., & Gunasekar, S. (2012). Basic econometrics. Tata McGraw- Hill Educatio

Ikebudu, M. (2021). Government Intervention on Agricultural Goods Imports in Developing Countries: A Survival Necessity or An Unnecessary Protectionism? The Case of Nigeria's Policy Intervention on Rice.

Johnny, M., & Mansaray, B. (2019). Socio-cultural factors of food insecurity in Sierra Leone. Developing Country Studies. 9.

Klutse, N. A. B., Owusu, K., Nkrumah, F., & Anang, O. A. (2021). Projected rainfall changes and their implications for rainfed agriculture in northern Ghana. Weather.

Mberu, B. U., & Ezeh, A. C. (2017). The population factor and economic growth and development in Sub-Saharan African Countries. African Population Studies. 31.

Michailof, S. (2016). The Potential Consequences of the Rapid Population Growth in Sub-Saharan Africa.

Mwaijande, F. (2018). Stakeholders' engagement at Magozi Rice Irrigation Scheme: Case study of moving from food-aid dependency to food self-sufficiency in Tanzania. J. African Studied Development. 10, 115-123.

Ngugi, M. M. (2019). An Assessment of The Profitability of Rice Production in Mwea Irrigation Scheme, Kenya (Doctoral dissertation, University of Nairobi).

Nigatu, G., Hansen, J., Childs, N., & Seeley, R. (2017). Sub-Saharan Africa is projected to be the leader in global rice imports.

Ojo, T. O., Ogundeji, A. A., Babu, S. C., Alimi, T. (2020). Estimating financing gaps in rice production in Southwestern Nigeria. Journal of Economic Structures 9, 1-18.

Oladimeji, Y. U. (2017). Food production trend in Nigeria and Malthus theory of population: empirical evidence from rice production. Nigerian Journal of Agricultural and Food and Environment. 13,126-132.

Oluwatayo, I. B., Timothy, O., & Ojo, A. O. (2019). Land acquisition and use in Nigeria: Implications for sustainable food and livelihood security. In Land Use-Assessing the Past, Envisioning the Future. IntechOpen.

Osabohien, R., Ufua, C. L., Moses, D., & Osabuohien, E. (2020). Accountability in agricultural governance and food security in Nigeria. Brazilian Journal of Food and Technology. 23,1

Paidipati, K., & Banik, A. (2020). Forecasting of Rice Cultivation in India–A Comparative Analysis with ARIMA and LSTM-NN Models.

EAI Endorsed Trans. Scalable Information Systems. 7, 24.

Rani, S. J., & Babu, N. C. (2020). Forecasting Production of Rice in India–Using ARIMA and Deep Learning Methods.

Sarr, M., Ayele, M. B., Kimani, M. E., Ruhinduka, R. (2021). Who benefits from climate-friendly agriculture? The marginal returns to a rainfed system of rice intensification in Tanzania. World Development. 138,105160.

Sers, C. F., & Mughal, M. (2020). Covid-19 outbreak and the need for rice self-sufficiency in West Africa. World Development. 135,105071.

Smith, C., & Torrente-Murciano, L. (2021). The potential of green ammonia for agricultural and economic development in Sierra Leone. One Earth, 4, 104-113.

Soullier, G., Demont, M., Arouna, A., Lançon, F., & Del Villar, P. M. (2020). The state of rice value chain upgrading in West Africa. Global Food Security 25,100365.

Tamuke, E., Jackson, E. A. & Sillah, A. (2018). Forecasting Inflation in Sierra Leone using ARIMA and ARIMAX: A Comparative Evaluation. Model Building and Analysis Team 4. Theoretical and Practical Research in Economics Fields. 9, 63-74.

Tesfaye, K., Ittersum, M. K. V., Wiebe, K., Boogaard, H. L., Radeny, M. A., & Solomon, D. (2018). Can Ethiopia feed itself by 2050? Estimating cereal self-sufficiency to 2050.

Tsujimoto, Y., Rakotoson, T., Tanaka, A., & Saito, K. (2019). Challenges and opportunities for improving N use efficiency for rice production in sub-Saharan Africa. Plant Production Sciences. 22, 413-427.

Van Oort, P. A. J., Saito, K., Tanaka, A., Amovin-Assagba, E., Van Bussel, L. G. J., Van Wart, J., & Wopereis, M. C. S. (2015). Assessment of rice self-sufficiency in 2025 in eight African countries. Global Food Security. 5, 39-49.

Vangahun, J. M. (2019). Genetic Studies of Salinity Tolerance of Mangrove Rice Varieties in Sierra Leone (Doctoral dissertation, University of Ghana).

Volz, J., Canagarajah, P., & Mehta, K. (2020). The Dimensions of Food Insecurity in Sierra Leone: Cues for Technology Innovation. In 2020 IEEE Global Humanitarian Technology Conference (GHTC) (pp. 1-8). IEEE.

World Bank. 2014. Rice Prices in Sierra Leone. Available online with updates at https://www.statistics.sl/images/StatisticsSL/Documents/rice_prices_in_sierra_leone.pdf. Accessed on 11-05-2021.

World Data Atlas 2019. Top 10 Rice Consuming Countries. Available online with updates at https://www.worldatlas.com/articles/top-10-rice-consuming-counties.html Accessed on 11-05-2021.

World Data Atlas. 2018. Sierra Leone - Rice imports [Dataset]. Available online with updates at https://knoema.com/atlas/Sierra-Leone/topics/Agriculture/Trade-Import-Value/Rice-imports Accessed on 11-05-2021.