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Enhancing fish production for food security in Nigeria

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ABSTRACT

The continuous increase in fish demand has conditioned Nigerians' inclination and taste for imported fish, developing the fish sub-sector of other economies, while damaging Nigeria's sector. Fish is known to be an important component of the human diet, accounting for over 20% of the average intake of animal proteins and essential fatty acids for around half of the world's population, particularly the poor, and adding significantly to their caloric intake (Food and Agricultural Organization-FAO, 2017). Despite Nigeria's high potential for fish production due to its extensive hydrographic resources, FAO (2017) reported that 60% of fish consumed in Nigeria is imported According to the FAO (2017), fish is an important dietary staple and one of the few sources of animal protein available to many Nigerians, with an estimated annual per capita fish consumption of 13.3 kg in 2013. As a result, the goal of this study is to investigate methods to increase fish productivity in Nigeria in order to promote food security. Nigeria was a net importer of fisheries items in 2013, with $1.2 billion in imports and $284,390 million in exports. One of the most important sources of revenue is fishing. In 2014, there were 713,036 people working in inland fisheries, with women accounting for 21% of the total. About 15% of the total 764,615 people engaged in other fisheries were women in 2014 (FAO, 2017). The study employed the DOLS estimation technique to capture the long run dynamics of each explanatory variable on the dependent variable. Major findings revealed that, a percent increase in the total level of fish production will induce 655.88 percent simultaneous increase in food security, while a percent increase in the number of fishermen induces 28.01 rise in the level of food security. The study recommends the implementation of an aquaculture transformation agenda to increase domestic fish production to bridge demand-supply gap and at the long run increase food supply.

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1. Introduction

Countries around the world agreed to address all types of food and nutrition insecurity through the Sustainable Development Goals (SDG).[1]. Although their efforts to address food insecurity and reduce poverty have been significant, but not adequate. In reality, food insecurity is the most visible indicator of poverty, particularly in Africa, where an estimated 25% of people in Sub-Saharan Africa (SSA) are malnourished [2]. Furthermore, the SSA has the world's largest number of young children with vitamin deficiencies and women with iron deficiency [3,4].

Millions of people are either eating insufficiently or eating the wrong foods, resulting in a double burden of malnutrition that can lead to diseases and health crises. According to a 2020 study, about 690 million people, or 8.9 percent of the global population, are hungry, a rise of approximately 60 million in only five years. Food insecurity can devastate diet quality and increase the risk of various types of malnutrition, including undernutrition and obesity. More than 3 billion people worldwide cannot afford healthy diets [5]. In fact, as at 2013, an estimated 842 million individuals, or almost one in every eight people worldwide, suffered from chronic hunger, meaning they did not acquire enough food to live an active life on a daily basis. The affected individuals confront regular shortages of food, which prohibit them from working, hinder their children's growth, expose them to sickness, and result in early death. However, there is a huge disparity among countries, with

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several nations falling well behind. The great majority of people who are malnourished live in developing economies. Although, Sub-Saharan Africa has made some improvement in recent years, but it still has the greatest rate of malnutrition (about 1 in every 4 persons) [6]. In Nigeria, Food and Agriculture Organization [7] indicated that 43 million Nigerians could face severe food insecurity by 2020, out of a total population of around 201 million. According to the organization, the projected figure for 2021 alone could be as high as 16.9 million people.

Fish, as an important component of the African Agri-food framework, can contribute to the goal of reducing food and nourishment uncertainty in Africa. Fish accounts for 19 percent of Africans' animal protein intake and plays an important role in providing a variety of micronutrients and essential unsaturated fats, particularly long-chain polyunsaturated unsaturated fats, which are difficult to replace with other dietary commodities [6,8]. Aside from food and nutrition security, fish contributes significantly to other African development goals. The fishing subsector contributes through furthering financial development, eliminating poverty, and improving the quality of life for marginalized people. The sector sustains the jobs of 12.3 million people, more than one-fourth of whom are women who are generally seen as among the least fortunate and most minimized people in the continent [9].

Furthermore, the availability of low-cost fish, employment possibilities, and consumption contribute to nutrition and food security, while increasing the quantity and variety of fish and other foods consumed by the poor might assist to combat malnutrition. The key to ensuring that fishery development gives maximum nutritional benefits is to ensure that the poor and undernourished have greater access to increased fish supply while also enhancing fishing folk's source of income [10].

Despite the fact that undernourishment in Nigeria has declined by more than half, from 19.3 percent in 1990 to 8.5 percent from 2010 to 2012, the number of undernourished people has increased from over 10 million in 2010 to about 14 million by 2016 [10]. Notwithstanding the fishery sector potential, Nigeria lags in increasing its share of global fish production, consumption, and commerce [11]. Hence, importation of foods is one of the nation's main policy concerns, owing to their perceived burden on foreign exchange and competitiveness with the national food sector [12]. Over four decades from 1970 to 2000, the percentage of imports in total consumption of fish in Nigeria more than quadrupled, peaking of 39 percent in 2017 [13]. This contrasts to a 13 percent import share in all food in 2017 (according to FAOSTAT) [13].

In reality, the country is presently experiencing a food crisis as a result of rising population, rising unemployment, and rising poverty rates, all of which are exacerbated by limited availability to both quantity and quality food. Theoretically, fish production may improve national food security by contributing to GDP via macroeconomic channels such as exports or license fees paid by foreign fishing vessels. In practice, the amount to which such contributions lead to increased nutrition and food security is determined by a variety of governance and political issues that differ by nation and are difficult to quantify [8]. Hence, more empirical researches are needed to assess the links between fish production and food security via different routes other than direct fish consumption [14]. Thus, this study empirically examined the casual relationship between food security and fish production in Nigeria using graphs and dynamic ordinary least square estimates. This study presented the graphs of Nigeria economic growth rate, fish production growth rate, numbers of fishermen and growth rate of fish net-export from 1987 to 2018.

2. Literature review

2.1. Conceptual review

For the impoverished in developing nations like Nigeria with access to water resources, fish is a vital and often irreplaceable animal diet [15]. There is substantial dependence on fish in this nation as an alternative to other animal meals which are frequently not available to the poor [16]. As a result, increasing per capita intake of fish and shellfish in Nigeria will help the nation's population health and food security in general. On the other hand, food security is a situation related to continuous availability of food. It refers to physical and economic access to adequate food for all household members, without undue risk of losing the access. Food security is an integral part of human existence and it is simply the accessibility and availability of food to all household in respective of size and status [17]. Food security, according to [18], is a national problem that requires immediate attention. Food security, in a larger sense, refers to maintaining an adequate supply of food and food items on hand at all times to satisfy rising demand and minimize output and price fluctuations [19].

2.1.1. Component of food security

- **Food Availability**: the effect and continuous supply of food at national and household level. A food secured country must have food available to her citizens in appropriate quality and sufficient quality which is a functional food production. Food can be supplied through local production of food and importation. However, local production depends on inputs and output market condition and production capacities of the agricultural sector.
- **Food Accessibility**: food accessibility depends on income levels and its distribution. Individuals must possess adequate monetary resources.
- **Food Utilization**: This involves obtaining, consuming, and digesting fish, all of which are influenced by nutritional quality, knowledge, and health. It include the consumption of safe and nutritious food. Food security include both food input and non-food inputs as health care, sanitation and clean water.
- **Stability of Access**: Food security is determined by the ability to preserve and store produced food. This refers to stability of supply over time. Available food can be supplemented through imports. Due to inefficient harvest, processing and storage technique which result in heavy post-harvest losses Nigeria and make food supply to be unstable.

2.2. Theoretical review

Single-species farming theory is filled with "theoretical" equilibrium models that have been used to manage large-scale fish farming [20]. The notion of maximum sustainable yield (MSY) was adopted as the cornerstone of the fisheries management paradigm in these models. The MSY stressed the need of a state-steady and a constant-parameter system. One of the fundamental tenets of this philosophy was the establishment of mesh size restrictions in order to maximize the sustainable use of fisheries [21]. Internal drivers of change (e.g. fishing effort) have traditionally been the key agents of change that need to be managed in order to achieve sustainable fish production, according to the main management philosophical framework. In fact, external forces (e.g. flooding, nutrients, etc.) have traditionally been ignored by the classical management paradigm, largely because they are uncontrollable. "The theories of fisheries were created in relatively static temperate, single-species Sea and freshwater fisheries, but were tropicalized into comparatively dynamic, flood-pulsed multi-species inland fisheries. Based on fisheries theory, many classic overfishing scenarios were also devised" [21]. Overfishing for growth, recruitment, biological overfishing, economic overfishing, and ecosystem overfishing are examples [20]. These ideas contributed to and solidified the classic fisheries management paradigm.

2.3. Empirical review

[22] assessed the economic viability of fish farming in Niger state, Nigeria using questionnaire administered to 90 randomly selected fish farmers in the state. The data collated was assessed using net return, cost-benefit and rate of income analytical techniques. The authors indicated that most of the fish farmers are male aged 31-–45 years. The authors discovered that fish farming is profitable in Niger state due to its considerable positive net returns, cost-benefit analysis, and high rate of return.. Similarly, [19] employed secondary data from World Bank Living Standard Measurement Survey to show the level and pattern of food security in Nigeria. The study utilized descriptive statistics and regression technique. Findings from this study indicated that larger households are more food insecure compared with small households in the country.

[6] looked into the prospects and problems of fish for food security in Africa, as well as the continent's historical patterns in fish availability and consumption. The study utilized four situations comprising of Business-as-usual (BAU) and three alternative situations focusing on three critical outcomes; fish production, per capita income consumption and net trade in Africa. The study found that fisheries and aquaculture make significant role in food security and livelihoods in the continent. Also, the continent will continue to be a net fish-importing continent unless urgent policy measures to promote fish production are adopted.

[23] studied how fish contributes to food and nutrition security in Eastern Africa, with an emphasis on patterns and future prospects. To analyze and monitor aquaculture sector performance, the authors used the WAPI Production Module and WAPI Fish Consumption Module from the World Aquaculture Performance Indicators (WAPI). They found significant deficit in local fish supply in the region occasioned by raising fish imports.

[24] looked into the links between fisheries and agricultural initiatives in various economies for food security. Primary data was collected from 123,730 homes in 6781 clusters across 12 nations for the study (Rwanda, Ghana, Cambodia, Nepal, Haiti, Bangladesh, Mozambique, Ethiopia, Uganda, Malawi, Senegal and Zambia) experiencing high food insecurity. The study indicated that between 10 and 45 percent of the households take fish as an important part of their diet. In fact, households in four countries (Ethiopia, Zambia, Cambodia and Mozambique) that rely on fish for diet are poorer than their counterparts, but five economies (Uganda, Rwanda. Malawi, Senegal and Haiti) shows the contrary.

[25] reviewed literature on aquaculture in Nigeria showing the trends of fish production in the country. The authors also looked into the role of aquaculture in reducing poverty and ensuring food security in Nigeria. They discovered that fisheries and aquaculture, either as a stand-alone activity or in conjunction with other revenue-generating industries, are critical in supplying food and income in the country. Similarly, [26] provided a systematic review of different techniques that can promote increase in food production, poverty alleviation, and food security in Nigeria. The study highlighted the influence of agriculture to food security and the importance of empowering smallholder farmers, especially women and youth.

3. Stylized facts

Trend analysis of the real Gross Domestic Product growth rate, total fish production and number of fishermen in Nigeria from 1987 to 2018 as presented in Fig. 1 shows a minimal increase in fish production in the country which peaked at 30.18% in 1995 and slumped at 19.76% in 1993. The average growth rate of fish production in the country was 5.16% during the period. While the Nigeria economy grew most in 2002 with 14.44% but the most contraction in the economy was experience in 2018 (−25%) with average growth rate of 4.10% covering periods from 1987 to 2018. Fig. 1 revealed that fish production and the economy grew in tandem. However, there were spikes in the number of fishermen in the country during the period. This suggests that there is high occupational mobility in and out of fish farming business among the fish farmers in the country. Fish farming is highly volatile with large numbers of fish farmers' entering and exiting the business. The most increase in the number of fishermen was recorded in 1998 (138.95%) and most decline was recorded in 1992 (-50.59%) with average of 7.24% during the period.

Further examination of the interplay between fish production, fishermen and fish net export in Nigeria revealed that the degree of oscillation in the growth rate of fish net export in the country indicates prevalence of uncertainty in Nigeria fishing sub-sector. In fact, on the average, the net export of fish in the country was negative (-14.47), indicating deficit in domestic production relative to the domestic demand for fish. The trends of fish net exports reaffirm findings from previous studies that the country is experiencing shortage in domestic fish Production [11]. Fig. 2 shows a rescaled version of Fig. 1 including net export. Instability in the number of fish farmers in the country could explain the country's unpredictability in fish demand and supply.

4. Methodology

The study employed secondary data in carrying out the analysis, from 1986 to 2018. The method of data analysis employed are Unit Root test by Philip Perron, test for Co-integration by Johansen and Dynamic Least square (DOLS) estimation technique. The logarithms of the variables were obtained to bring the time-series data into the same base and to assess their percentage effects.

4.1. Model specification

In order to analyse the effects of fish production for food security in Nigeria, the model adopts the DOLS linear estimator presented as;

$$Y = X\beta + \varepsilon \tag{1}$$

where y is an n × 1 vector of response variables, X: n × p is design matrix, β: p × 1 is vector consisting of the population parameters, and ε: n × 1 vector of error terms assumed to be independently and identically distributed (IID).

The linear implicit form is further expressed as:

$$FPI_t = f(TFP_t, FISHERMEN_t, FIMPORT_t, FEXPORT_t) \tag{2}$$

where

FPI_t: Fish production index as a proxy for food security at period t.
TFP_t: Total fish production at period t.
$FISHERMEN_t$: Number of fishermen at period t.
$FIMPORT_t$: Fish imports at period t.
$FEXPORT_t$: Fish exports at period t.

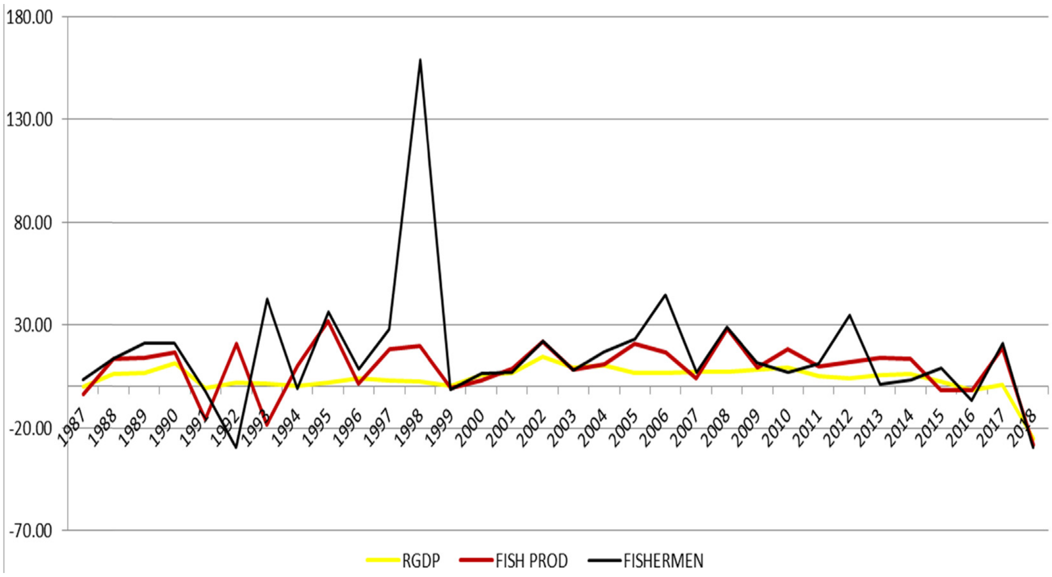

Fig. 1. Growth rate of RGDP, Fish Production and Number of Fishermen from 1987 to 2018.

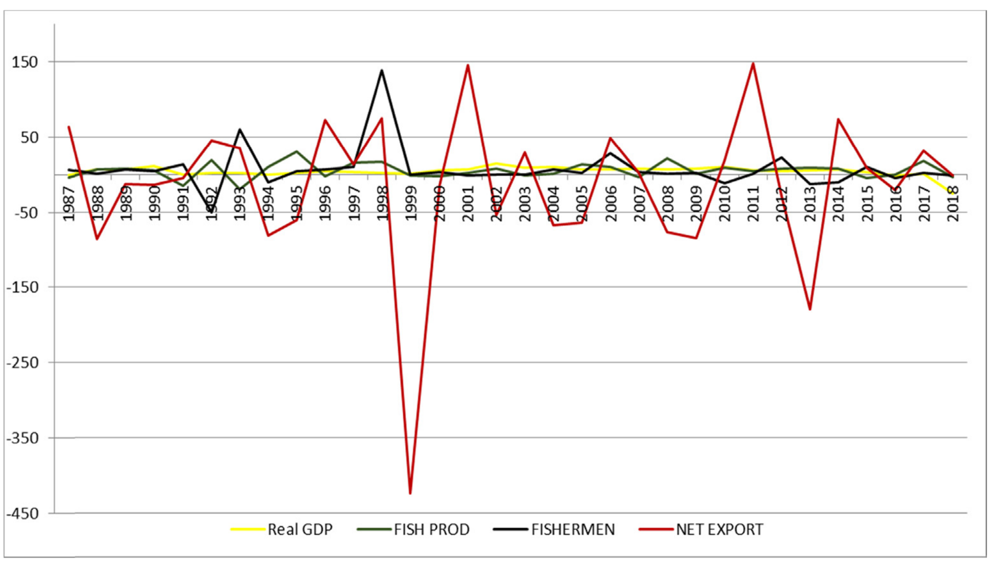

Fig. 2. Growth rate of Real GDP, Fish Production, Number of Fishermen, and Net Export from 1987 to 2018.

The model assumes an empirical form expressed explicitly as:

$$FPI_t = \beta_o + \beta_1 TFP_t + \beta_2 FISHERMEN_t + \beta_3 FIMPORT_t + \beta_4 FEXPORT_t + \varepsilon_t \quad (3)$$

β_o is the constant term while $\beta_1 - \beta_4$ are the estimate parameters and t = 1986 to 2018.

4.2. Data sources and measurement

The secondary data were sourced mainly from the publications of Nigeria's FAO fishery and aquaculture statistical bulletin, statement of accounts and annual reports, World Impact Fish (2018) publications and WDI statistical bulletin. The variables for which data were sourced include; Food production index as a proxy for food security, total fish production, number of fishermen, fish import and export.

5. Interpretation and discussion of results

5.1. Econometrics test

The summary statistics, Philip Perron (PP) unit root test and Dynamic least squares estimation technique (DOLS) are presented in assessing the effect of food production on food security in Nigeria.

5.2. Test for stationarity

A unit root test is used to determine if our estimate coefficients are stationary or non-stationary in their sequence of integration in a time series data collection. The Philip Perron unit root test is used to adjust for serial correlation by estimating a non-augmented version of regression without the lagged difference factors (Phillips and Perron, 1988). Because an ordinary least square (OLS) approach would provide erroneous regression when its series are

Table 1
Philip Perron Unit Root Test and Order of Integration.

Variables	PP Test Statistic Value	5% Akaike Info Criterion	Remark	Order of Integration
FPI	−4.378024	−2.960411	Stationary	I (1)
LTFP	−8.278637	−2.960411	Stationary	I (1)
LFM	−6.335485	−2.967767	Stationary	I (1)
LFIMPORT	−6.233170	−2.960411	Stationary	I (1)
LEXPORT	−8.572341	−2.960411	Stationary	I (1)

Source: Author's Computation from Eviews 9.0.

Table 2
Unrestricted Cointegration Rank Test (TRACE) (TRACE).

Hypothesized		Trace	0.05	
No, of CE(s)	Eigenvalue	Statistics	Critical Value	Prob.**
None*	0.719921	86.11284	69.81889	0.0015
At Most 1*	0.677740	50.47768	47.85613	0.0278
At Most 2*	0.313065	18.77054	29.79707	0.5095
At Most 3	0.210869	8.256098	15.49471	0.4384
At Most 4	0.056386	1.625065	3.841466	0.2024
Trace test indicates 2 cointegrating equation (s) at the 0.05 level				

Source: Authors computation from EViews 9.0.

Table 3
Unrestricted Cointegration Rank Test (Max-Eigenvalue).

Hypothesized		Max-Eigen	0.05	
No, of CE(s)	Eigenvalue	Statistics	Critical Value	Prob.**
None*	0.719921	35.63516	33.87687	0.0305
At Most 1*	0.677740	3,170,714	27.58434	0.0139
At Most 2	0.313065	10.51444	21.13162	0.6954
At Most 3	0.210869	6.631033	14.26464	0.5336
At Most 4	0.056386	1.625065	3.841466	0.2024
Max-eigenvalue test indicates 2 cointegrating equation (s) at the 0.05 level				
**hypothesis rejection at the 0.05 level				

Source: Authors computation from EViews 9.0.

Table 4
Dynamic OLS Estimation Result.

Dependent Variable: FPI				
Method: Dynamic Least Squares (DOLS)				
Cointegrating equation deterministic: C				
Fixed leads and lags specification (lead = 1, lag = 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LTFP	655.7745	175.9737	3.7265	0.0047
LFISHERMEN	28.0297	9.3813	−2.9878	0.01525
LIMPORT	−28.4408	9.3322	3.0475	0.0138
LEXPORT	−6.1838	4.9400	−1.2517	0.2422
C	−1668.3902	312.5869	−5.3373	0.0004
R-squared	0.9809	Mean dependent var		84.1430
Adjusted R-squared	0.9470	S.D. dependent var		24.8098
S.E. of regression	5.7096	Sum squared residual		293.3930
Long-run variance	29.9082			

Source: Author's computation from EViews 9.0.

unit root non-stationary at I (0), the results of unit root tests generally decide the estimation strategies to be used.

Since all the variables were stationary after first difference, thus, they are integrated of order one which fulfils the condition for Johansen Cointegration test and is also a perquisite for adopting the dynamic least square estimation technique (presented in Tables 1–3).

5.3. Johansen cointegration test

The Johansen Cointegration test is used to determine if a linear combination of integrated variables remains stationary over time. If this is true, then there is co-integration between the variables. The number of integrating ranks and vectors is determined using the trace test and the highest Eigenvalue.

Hypotheses for test for Co-integration:

$$\mathrm{Ho}: \ \delta = 0(\mathit{Absent\ \ of}\ \ \mathrm{Co-integration})$$

$$\mathrm{H1}: \delta = 0(\mathrm{Presence\ \ of\ \ Co-integrations})$$

The existence of two co-integration equations is confirmed by the trace and maximum eigen value statistics. As a result, there is a long-term association between fish output and food security, implying that the entire amount of domestic fish production is critical for assuring Nigeria's long-term food security.

5.4. Dynamic Least Squares (DOLS)

Stock and Watson in 1983 established the Dynamic Least Square (DOLS) approach for estimating co-integrated with non-stationary variables in order to identify the influence of some independent variables on the dependent variable [27]. As a result, the DOLS model is used to estimate a single cointegrating vector that characterizes the long-run relationship among other variables in the model by regressing the dependent variable, ''fish supply'', on contemporaneous explanatory variables with the leads and lags of their first differences, and the constant term, using ordinary least squares. In DOLS regression, the aim of Lags and Leads is to minimize bias produced by the endogeneity problem.

The assumptions for estimating a DOLS model are met since there is a long run link between the variables. The table shows results for Dynamic least squares with an adjusted R^2 of 0.95 which indicates that total fish production, the number of fishermen, fish import and exports jointly explains 95 percent variations of food security in Nigeria while as other variables not captured in this model can explain the remaining 5 percent change in the dependent variable. The selection criteria of t-statistic value and standard error for all the individual estimated coefficients are strongly statistically significant at 5 percent as well as the constant term.

The dynamic least square (DOLS) is employed to capture the long run dynamics of each explanatory variable on the dependent variable. Specifically, a percent increase in the total level of fish production will induce 655.88 percent simultaneous increase in food security, while a percent rise fisherman would induce 28.01 percent rise in the level of food security. Also, a percent increase in the both fish import and export will induce 28.44 and 6.18 percent rise in Nigeria's food security.

6. Discussion of findings and conclusion

The economic implications of the summary results presented from Table 4 is further explained based on signs and magnitude. The total quantity of fish produced in Nigeria has a favourable and stronger impact on food security, which may be linked to the fishery sector of the economy. Nigeria is the biggest aquaculture producer in Sub-Saharan Africa, and its importance is gradually growing, with an average annual growth rate of 20,000 million tonnes of fish [23].

Nigeria's population increases in geometric rate but not in tantamount to the total level of fish produced in the country as there is a wide gap which adversely affects food production and ultimately threatens food security, hence the need for fish importation to augment the demand-supply gap. However, fish importation has a negative long run effect on economic growth due to depreciation in currency value from outflow of resources. The study recommends awareness and orientation of large-scale fish farming and fish related activities by the government, to enhance total domestic fish production both in rural and urban areas in order to curtail the demand of fish and supply deficit, as well as eradicate excess fish importation into the country. Also, the government should put in place governance structures and rules that safeguard the long-term productivity of inland and marine capture fisheries at sustainable levels, in order to assure the continuous supply of fresh, dried, and smoked fish from these sources. Furthermore, the government can bring in foreign investors to educate and encourage more youths to pursue careers in fish farming, as well as train fishermen on how to use modern technology and procedures to improve the fish subsector.

Declaration of Competing Interest

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

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