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ORIGINAL ARTICLE

# Climate change, growth in agriculture value-added, food availability and economic growth nexus in the Gambia: a Granger causality and ARDL modeling approach

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**Abstract**
This paper aims to test empirically, the direction of causality between climate change, agriculture valued added, Food production (the proxy for food availability), and economic growth in the Gambia. This study employed annual data which were collected for the period 1960–2017 and analyzed these data using the ARDL approach and the granger causality framework. The empirical evidence shows that: (1) the short-run and long-run ARDL model confirmed that the growth of fish production and growth of livestock production in the Gambia have significant positive impacts on the growth of GDP; (2) the short-run and long-run ARDL model indicated that growth of food import and growth of agriculture have negative impacts on the growth of GDP; (3) Granger causality analysis between the lagged values of growth of GDP and lagged values of growth of Food availability indicators has unidirectional relationships; (4) lagged values of the growth of GDP Granger cause lagged values of growth of agriculture but lagged values of growth of agriculture do not garger cause lagged values of growth of GDP, which suggested an indirect relationship; (5) the relationship between the lagged values of growth of crop production and lagged values of growth of agriculture indicated a bidirectional relationship. Finally, an important indication is established on the role of fish production, livestock production, climate change, and crop production to control food availability and economic growth in the Gambia.

**Keywords** ARDL · Granger causality · Food production · Agriculture · Climate change · Economic growth

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## Introduction

The Gambian's economy is predominantly reliant on agriculture, tourism, and remittance (IFAD 2019). Farmers are wedged in a ring of low income with high risk related to low rainfall and high temperature. Agriculture is a major economic activity in the Gambia, contributing 25% of the gross domestic product (GDP) and employing about 70% of the labor force with 32% into active primary agricultural production. Agriculture is the main source of income for about 72% of the extremely poor rural households. The sector is characterized by small-scale, subsistence rain-fed crop production (mainly, rice, groundnuts, coarse grains, and cassava), traditional livestock rearing, semi-commercial groundnut, and horticultural production, and a large artisanal fisheries sub-sector. In the last few decades, climate change has become an important topical issue in the world policy agenda. It is evident that climate change affects agricultural productivity through variations in temperature and precipitation. From the mid-1960s, changes in the climate of the Gambia have been characterized by irregular rainfall patterns, storms, the incidence of drought, and cold spells among others (Loum and Fogarassy 2015). This is seen to have a tremendous effect on agricultural production. In addition, it is projected that climate variability will pose both short-term and long-term hindrances to advancing crop production and the livelihood of rural farmers. The cases of deleterious extreme weather events, such as floods, windstorms, rainstorms, drought, and dust storms, are now more frequent and present long-term challenges to agricultural productivity, food security, and malnutrition (Loum and Fogarassy 2015). According to FAO, poverty, food insecurity, and malnutrition have remained unchanged in the Gambia in the last ten years. Food insecurity, in particular, has risen from 5 to 8% over the past five years as a result of drought, floods, and weak food production capacity (FAO 2017). According to FAO (ibid), the Gambia depends heavily on food imports and produces only 50% of the food it needs. There is strong evidence that climate change affects food availability in the Gambia.

## Literature reviews

The Gambia performs relatively badly in terms of human development as the country was ranked 174 out of 189 countries in 2017 in terms of the Human Development Index (HDI) (FAO 2017). Most recent studies indicate that this low level of human development is attributable to low agricultural productivity. In a study conducted by Sillah (2013), it was found that agriculture productivity is the most important variable for economic growth in the Gambia. According to Sillah (ibid), capital per worker is significant and relevant factor input for economic growth in the Gambia. Furthermore, agriculture labor per acre was found to be irrelevant in both short- and long-run analyses (Sillah 2013).

In terms of the relationship between food insecurity and rural development in the Gambia, Patrick (2009) found relatively moderate effects of various interventions, particularly in the Western and North Bank Divisions of the country, where agricultural production of various crops and livestock has improved the livelihood of those particular rural communities. Goshu and Yimer (2017) studied the dynamicsof food security in sub-Saharan Africa. The results revealed that the food stock level of sub-Saharan African countries was improved by agricultural production and industrial value-added.

Bakari et al. (2018) studied the impact of the agricultural trade on a country's GDP and showed that agricultural trade has a positive correlation with gross domestic product. However, agricultural exports and gross domestic product have a weak correlation (ibid). With the help of the static gravity model, Bakari et al. (2018) further show that agricultural exports have a positive effect on economic growth. On the other hand, agricultural imports were found to have a limited effect on economic growth. These results suggest that agricultural exports are the driving force for economic growth in North African countries (Bakari et al. 2018).

To have the ideas of the method used in this study, we now presented different authors' viewpoints. Chabbi (2010) study that investigated the impact of agriculture on economic growth for the Tunisian economy during the period 1961–2007, applied Johansen's multivariate approach and found that agriculture plays a key role in determining economic growth.

Omri and Kahouli (2014) inspected the nexus between domestic investment and economic growth for 13 MENA countries for the period 1990–2010. Using the Generalized Method of Moments (GMM), they found that there is an optimistic bidirectional causality relationship between domestic investment and economic growth.

On the other hand, Keho (2017) used the ARDL model and Granger causality tests and found that there is a positive bi-directional causality relationship between domestic investment and economic growth in both the short and long run in the case of Cote D'Ivoire for the period 1965–2014. Adams et al. (2017) used the ARDL Model and the results of the study revealed that domestic investment has a positive influence on Nigerian economic growth in the long run. Herrerias (2010) observed the Granger causal relationship between industrial investments on economic growth in China for the period 1964–2004. He found out that industrial investment has a positive impact on economic growth in the long run. The results of the study by Herrerias (2010) showed that industrial investment impacted positively China's long-term economic growth between 1964 and 2004. However, in the short term, there was no relationship between the two variables.

Furthermore, Tiba and Omri (2017) studied the relationship between $CO_2$ emissions and economic growth for the case of 24 middle- and high-income countries from 1990 to 2011 by applying the panel simultaneous equations model. The results from this study showed the presence of a bi-directional causality relationship between $CO_2$ emissions and economic growth.

Ceesay et al. (2021) studied the environmental Kuznets curve hypothesis (EKC) using empirical panel data estimation and revealed that growth for $CO_2$, which is used as a proxy for environmental quality or industrialization level revealed that growth for population density, growth of per capita income, growth of per capita income squared, growth of trade openness, growth of exchange rate, and growth of agriculture value-added were statistically significant. The results further indicated that growth of trade openness leads to increases in growth of environmental quality, the study noted.

The study of Ali et al. (2019) explored the causal relationship between agricultural production, economic growth, and carbon dioxide emissions in Pakistan. An autoregressive distributed lag (ARDL) model was applied to examine the relationship between agricultural production, economic growth, and carbon dioxide emissions; result provides evidence of short-run and long-run relationships between agricultural production, gross domestic product (GDP), and carbon dioxide emissions in Pakistan. Another study by Ali et al. (2019) investigated the correlation between carbon emissions, gross domestic product, cereal crop production, and agriculture value-added using time series data from 1961 to 2014. The result of this study shows that there exists both short-run and long-run associations between agricultural production, economic growth, and carbon dioxide emissions in Pakistan.

The aim of the present study is to build on the above studies by demonstrating the nexus between climate changes, growth in agriculture value-added, food production, and economic growth in the Gambia with the help of a Granger causality framework. A further aim of this paper is to determine, using the ARDL model, whether the growth in food import and growth of agriculture have negative impacts on the growth of the Gambian economy. There is no known paper that examines this aspect of the literature in which researchers use time series approaches for this purpose. Therefore, this paper is timely and will help policymakers understand the important linkages between climate change and food production on the one hand, and the ways and manner in which the country's agriculture, climate change, and economic growth are connected. As a result, a key contribution of this paper is that it sheds light on the various policy options at the disposal of policymakers in their quest to address the immense challenges caused by food insecurity in the Gambia.

## Motivation of the study

I was motivated to carry out this research because of complex nature and to try to recommend to policymakers that climate change is a reality in the Gambia and Africa, taking into account the consequence climate change that brings to the livelihoods, economic, income and employment especially the rural poor or the vulnerable population: women, children and elderly that are left behind and are affected by food (in)security at the time of climate crises, such as rising sea levels, drought, water scarcity, increases in temperatures, changes in precipitation patterns, changes in extreme weather events like storms, heat waves, melting glaciers and warming oceans, changes in pests and diseases, changes in atmospheric carbon dioxide and ground-level ozone concentrations and changes in the nutritional quality of some foods, salinization, bushfire, overgrazing, deforestation, land degradation and erosion. All of these variables in one way or the other lead to migration and food (in) security particularly the rural Gambia and Africa as a whole.

## Theoretical model

The paper adopts the theoretical concept of production function by including climate variables into it as used by Apergis and Payne (2011), Lee et al. (2012), Ceesay (2020), Belford et al. (2020), which forms the theoretical basis for the study. Since growth in accounting equation offers guidance for the decomposition of climate change, agriculture value addition, food production, and their impact on economic growth as derived below:

In their framework presented as:

$$Y_{it} = F\left(\mathrm{CO}_{2it}, \mathrm{FP}_{it}, \mathrm{AVA}_{it}, L_{it}, K_{it}, Z_{it}\right), \tag{1}$$

Where:

$$Y_{it} : \text{Economic growth/the rate of change of real GDP/} \\ \text{GDP per capita, current US dollars, at time } t \text{ and observation } i$$

$\mathrm{CO}_{2it}$ : is the $CO_2$ emission per person (proxy for climate change at time $t$ and individual $i$)

$\mathrm{FP}_{it}$ : food production

$$\mathrm{AVA}_{it} : \text{Agriculture valued added}$$

$L_{it}$ : total labor force.

$K_{it}$ : gross capital formation.

$Z_{it}$ : Are others control variables, such as crop production, livestock production, total fish production, food export, food import, and drought.

Aggregate output/economic growth/GDP per capital/real GDP is a function of the real capital stock (proxy variable gross capital formation), labor (labor force proxy), climate change (proxy $CO_2$ emission), food production, and agriculture value-added. From Eq. (1), we get the following as adopted from Dell et al. (2008), Ceesay (2020), Bond et al. (2010) and Belford et al. (2020):

$$Y_{it} = Ab^{\alpha T_{it}} K_{it}^{\rho} L_{it}^{1-\rho-\sigma-\vartheta-\pi} \mathrm{FP}_{it}^{\sigma} \mathrm{AVA}_{it}^{\vartheta} Z_{it}^{\pi} e^{\varepsilon}. \tag{2}$$

Such that: $\rho + \alpha + \sigma + \vartheta + \pi = 1$

$$\frac{\Delta A_{it}}{A_{it}} = g_i + \beta T_{it} \tag{3}$$

where $Y$ is real GDP, $L$ is labor (proxy labor force), $A$ is technology and can also be referred to as labor productivity or total factor productivity, $K$ is gross capital formation, $T$ is the impact of climate change ($CO_2$ emission proxy), $g$ is the growth rate of capital, $t$ is time period and $e$ is exponential and $\varepsilon$ is a constant and it is also the error term in the model. Equation (2) captures the direct effect of climate change, food production, and agriculture value addition on economic growth, e.g. effects on labor productivity and Eq. (3) captures the indirect (dynamic) effect of climate change, e.g. the effect of climate change on other variables that indirectly impact GDP.

Presenting natural logarithm into Eq. (2) and deviating with respect to time period, we derived Eq. (4) below:

$$g_{it} = g_i + (\alpha + \beta)T_{it} - \alpha T_{it-1}, \tag{4}$$

where $g_{\text{it}}$ is the growth rate of output, direct effects of climate change on economic growth are accounted for by $\alpha$, such as change in rainfall and temperature, and indirect effects are accounted for by $\beta$, such as impact of climate change, flooding or drought on other variables, that indirectly influence GDP.

The study will observe both the direct and indirect effects of climate change, on agriculture value addition, and food production on the economic growth of the Gambia for the periods, observe given variations that will occur over time, thus providing an insightful knowledge on which sector(s) is mostly affected under the following conditions, climatic, agriculture, food production and other factors that affect the economic growth in the Gambia.

## Data and methods

The data generated for this study were created from the World Development Indicators database for the period 1960–2017. The variables included are GDP (current \$), agriculture value-added, crop production, livestock production, total fish production, food production (food availability proxy), food export, food import, average precipitation, and $CO_2$ emission per person (a proxy for climate change). Food production is used as a proxy of one of the four dimensions of food security–food availability due to the following reasons; the first approach to food security is "food availability" because it is certainly the oldest one and still the most influential. Although the core ideas of this approach could be traced back to the Venetian thinker Botero (1588), it was Malthus that popularized it and in datum, is also known as the Malthusian theory of population and food. The method is focused on the (dis)equilibrium between population and food and in command to uphold this equilibrium, the rate of growth of food availability should be not lower than the rate of growth of population and they should at least intersect to have food that satisfied the population growth. In a closed economy setting, this depends mainly on food production and stocks, while in an open economy also, food trade can play a relevant role (Alkire 2002). Until the early 1970s, this was the reference approach for the international community, both at a political and academic level. This was the main reason why we selected the first dimension of food security as a proxy for food production, i.e. food availability.

### Economic model

The economic theory proposes models that explained the behavior of one or more variables, say $Y_1, Y_2, Y_3, \ldots, Y_n$ as a function of the some other variables, say $X_1, X_2, X_3, \ldots, X_m$ which are determined outside the model or which are exogenous in nature, in which we consider the following model, GDP (current \$) as a function of the following variables: labor force, gross capital formation, agriculture valued added, crop production, livestock production, total fish production, food production (food availability proxy), food export, food import, drought, and $CO_2$ emission per person.

## Econometric model

To qualify the relationship between economic variables, it is necessary to propose a functional form that depends on some climate change variables or output variables and unknown parameters. The econometric model can be expressed as follows:

$$Y = f(L, K, X_1, X_2, X_3, \dots, X_k; \beta) + \varepsilon,$$

where $\beta$ is a vector of unknown parameters and $\varepsilon$ is the error term. The nature and the interpretation will depend on the assumption of the error term in the model.

## Empirical model

To assess the presence of food production (proxy for the food availability), climate change, agriculture and economic growth, the study adopted the empirical models as follows:

$$\begin{aligned} \text{LnGdp}_{it} = {} & \beta_0 + \beta_1 \text{LnCrop}_{it} + \beta_2 \text{LnFOSEC}_{it} + \beta_3 \text{LnFish}_{it} + \beta_4 \text{LnA}r_{it} + \beta_5 \text{LnCO2}_{it} \\ & + \beta_6 \text{LnFoodEX}_{it} + \beta_7 \text{LnFoodIM}_{it} + \beta_8 LnPop_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

The variables above abbreviated below.

$$\text{LnGdp}_{it} = \text{is the growth rate of Gdp at time } t \text{ and individual } i$$

$$\text{LnCrop}_{it} = \text{is the growth rate of crop production at time } t \text{ and individual } i$$

$$\begin{aligned} \text{LnFOSEC}_{it} = {} & \text{the growth of Food production(proxy food availability)} \\ & \text{at time } t \text{ and individual } i \end{aligned}$$

$$\text{LnPop}_{it} = \text{growth rate of population}$$

$$\text{LnLiveS} = \text{growth rate of livestock}$$

$$\text{LnA}r_{it} = \text{growth rate of Agriculture at time } t \text{ and } i$$

$$\text{LnCO2}_{it} = \text{growth of CO2 emission per capita at time } t \text{ and individual } i$$

$$\text{LnFoodEX}_{it} = \text{growth of food export at time } t \text{ and individual } i$$

$$\text{LnFoodIM}_{it} = \text{growth rate of food import at time } t \text{ and } i$$

$$\text{LnFish}_{it} = \text{growth rate of fish production}$$

$$\varepsilon_{it} = \text{error term at time } t \text{ and individual } i$$

$$v_{it} = \text{the country's unobserved fixed effect}$$

When we added climate change variables, the model of the relationship between climate change, economics growth, food availability and agriculture takes into account the following model:

$$\begin{aligned}\text{LnCLM}_{it} = {} & \beta_0 + \beta_1\text{LnCrop}_{it} + \beta_2\text{LnFOSEC}_{it} + \beta_3\text{LnFish}_{it} \\ & + \beta_4\text{LnA}r_{it} + \beta_5\text{LnFoodEX}_{it}[+\beta_6\text{LnFoodIM}_{it} \\ & + \beta_7\text{LnPop}]_{it}[+\beta_8\text{LnLiveS}]_{it} + [\beta_9\text{Ln}][[\text{Gdp}]_{it}] + \varepsilon_{it}\end{aligned} \tag{6}$$

The relationships between food availability, agriculture, economics growth and climate change look as the following model:

$$\begin{aligned}\text{LnFOSEC}_{it} = {} & \beta_0 + \beta_1 \text{ LnCrop}_{it} + \beta_2\text{LnGdp}_{it} + \beta_3 \text{ LnFish}_{it} + \beta_4 \text{ LnAr}_{it} + \beta_5\text{LnCLM}_{it} \\ & + \beta_6\text{LnFoodEX}_{it} + \beta_7\text{LnFoodIM}_{it} + \beta_8\text{LnPop}_{it} + \beta_9\text{LnLiveS} + \varepsilon_{it}\end{aligned}$$

NB. The variables of this paper are logarithmized to allow the coefficients to be interpreted as elasticity, with all variables at time $t$ and individual $i$.

## Unit root and Stationarity tests

The time series is said to be stationary time series in weakly sense if its statistical properties do not vary with time (expectation, variance, autocorrelation). The white noise is an example of a stationary time series, with for example the case where $Y_t$ follows a normal distribution $N(\mu, \sigma^2)$ independent of $t$. A non-stationary series can, for example, be stationary in first difference or so (also called integrated of order 1, 2, etc.): $Y_t$ is not stationary, but the $Y_t - Y_{t-1}$ as first difference is stationary. Stationarity tests allow verifying whether a series is stationary or not at levels or first differences or second differences called integration of order 2. There are two different approaches about this: (1) stationarity tests such as the KPSS test that consider as null hypothesis $H_0$ that the series is stationary and the alternative the series is not stationary and (2) unit root tests, such as the Dickey–Fuller test and its augmented version, the augmented Dickey–Fuller test (ADF), or the Phillips–Perron test (PP), for which the null hypothesis is on the contrary that the series has a unit root and hence is not stationary (Pesaran 2007). To examine the long-run and short-run relationships of food production with economic growth, we develop the ARDL-bound testing for co-integration following closely on the work of Menegaki (2019a, b) which examined the energy–growth nexus.

The ARDL equations of correlation between food production (food availability), climate change, agriculture and economic growth nexus equations can be formulated as:

### ARDL model

$$\begin{aligned} \mathrm{lnGDP} = \alpha_0 &+ \sum_{i=1}^{p} \alpha_i \mathrm{lnGDP}_{t-1} + \sum_{i=0}^{q} \beta_{1i} \mathrm{lnCrop}_{t-1} + \sum_{i=0}^{p} \beta_{2i} \mathrm{lnFOSEC}_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{3i} \mathrm{lnAgr}_{t-1} + \sum_{i=0}^{p} \beta_{4i} \mathrm{lnCLM}_{t-1} + \sum_{i=0}^{p} \beta_{5i} \mathrm{LnFoodEX}_{t-1} + \sum_{i=0}^{p} \beta_{6i} \mathrm{LnFoodIM}_{itt-1} \\ &+ \sum_{i=0}^{p} \beta_{7i} \mathrm{LnLiveS}_{t-1} + \lambda_1 \mathrm{lnGDP}_{t-1} + \lambda_2 \mathrm{lnCrop}_{t-1} + \lambda_3 \mathrm{lnFOSEC}_{t-1} \\ &+ \lambda_4 \mathrm{lnAgr}_{t-1} + \lambda_5 \mathrm{lnCLM}_{t-1} + \lambda_6 \mathrm{lnFoodEX}_{t-1} + \lambda_7 \mathrm{lnFoodIM}_{t-1} + \lambda_8 \mathrm{lnLiveS}_{t-1} + \varepsilon \end{aligned} \tag{7}$$

$$\begin{aligned} \mathrm{lnFOSEC} = \alpha_0 &+ \sum_{i=1}^{p} \alpha_i \mathrm{lnFOSEC}_{t-1} + \sum_{i=0}^{q} \beta_{1i} \mathrm{lnCrop}_{t-1} + \sum_{i=0}^{p} \beta_{2i} \mathrm{lnGDP}_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{3i} \mathrm{lnAgr}_{t-1} + \sum_{i=0}^{p} \beta_{4i} \mathrm{lnCLM}_{t-1} + \sum_{i=0}^{p} \beta_{5i} \mathrm{LnFoodEX}_{t-1} + \sum_{i=0}^{p} \beta_{6i} \mathrm{LnFoodIM}_{itt-1} \\ &+ \sum_{i=0}^{p} \beta_{7i} \mathrm{Ln\ Pop}_{\ t-1} + \sum_{i=0}^{p} \beta_{8i} \mathrm{LnLiveS}_{t-1} + \sum_{i=0}^{p} \beta_{9i} \mathrm{LFish}_{t-1} + \lambda_1 \mathrm{lnGDP}_{t-1} \\ &+ \lambda_2 \mathrm{lnCrop}_{t-1} + \lambda_3 \mathrm{lnFOSEC}_{t-1} + \lambda_4 \mathrm{lnAgr}_{t-1} + \lambda_5 \mathrm{lnCLM}_{t-1} \\ &+ \lambda_6 \mathrm{lnFoodEX}_{\ t-1} + \lambda_7 \mathrm{lnFoodIM}_{\ t-1} + \lambda_8 \mathrm{lnLiveS}_{\ t-1} + \lambda_9 \mathrm{LFish}_{t-1} + \varepsilon, \end{aligned} \tag{8}$$

where $\beta_1, \beta_2, \beta_3\ \beta_4, \beta_5$and so on are the coefficients that measure the short-run relationship while $\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6$ and so on are the coefficients that measure the long-run relationship. To test for co-integration, we will use the bounded test that was proposed by Pesaran and Shin (1999) and Pesaran et al. (2001).

### Error correction model

**VECM (vector error correlation model) model** Drawing on the work of Granger (1988), the causal link can be tested within the framework of the error-correction model (ECM). ECM is connected with the multiple time series models typically realistic for the data when the primary variables have long-run stochastic trends that often called co-integration. ECMs compute the rate at which the variable of attention moves back towards the equilibrium after a variation in other variables and henceforth, characterize the short-run dynamics. We implement the Granger causality ECM test method in this study since it can treat both large and small sample sizes and therefore having a comparative advantage over the other traditional methods. The Granger causality test based of VECM is thus determined by the following ARDL models:

$$\begin{aligned} \text{lnGDP} = \alpha_0 &+ \sum_{i=1}^{p} \alpha_i \text{lnGDP}_{t-1} + \sum_{i=0}^{q} \beta_{1i} \text{lnCrop}_{t-1} + \sum_{i=0}^{p} \beta_{2i} \text{lnFOSEC}_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{3i} \text{lnAgr}_{t-1} + \sum_{i=0}^{p} \beta_{4i} \text{lnCLM}_{t-1} + \sum_{i=0}^{p} \beta_{5i} \text{LnFoodEX}_{t-1} + \sum_{i=0}^{p} \beta_{6i} \text{LnFoodIM}_{itt-1} \\ &+ \sum_{i=0}^{p} \beta_{7i} \text{Lfish}_{t-1} + \sum_{i=0}^{p} \beta_{8i} \text{LnLiveS}_{t-1} + \text{ECM}_{t-1} + \varepsilon \end{aligned} \tag{9}$$

$$\begin{aligned} \text{lnFOSEC} = \alpha_0 &+ \sum_{i=1}^{p} \alpha_i \text{lnFOSEC}_{t-1} + \sum_{i=0}^{q} \beta_{1i} \text{lnCrop}_{t-1} + \sum_{i=0}^{p} \beta_{2i} \text{lnGDP}_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{3i} \text{lnAgr}_{t-1} + \sum_{i=0}^{p} \beta_{4i} \text{lnCLM}_{t-1} + \sum_{i=0}^{p} \beta_{5i} \text{LnFoodEX}_{t-1} + \sum_{i=0}^{p} \beta_{6i} \text{LnFoodIM}_{itt-1} \\ &+ \sum_{i=0}^{p} \beta_{7i} \text{Lfish}_{t-1} + \sum_{i=0}^{p} \beta_{8i} \text{LnLiveS}_{t-1} + \text{ECM}_{t-1} + \varepsilon. \end{aligned} \tag{10}$$

where $\text{ECM}_{t-1}$ represents lagged error-correction model term which is derived from co-integration equation of ARDL-bound testing of co-integration.

Nida et al. (2018) used the ARDL-bound testing method and found that along with a long-run relationship between natural disasters and economic growth, there is also a unidirectional causality between these two variables. The causality between these variables cannot be determined without assessing the *F*-statistic and the lagged error-correction term. If we understand the Granger causality test very well, it is not difficult to know that if the *F*-statistic of the descriptive or explanatory variable is significant, then the short-run causal effects and long-run causal effects can be determined by the coefficient of the lagged error correlation term in the model. We have included ECMs in both the Eqs. (3) and (4).

**Table 1** Descriptive statistics

| Variables | No. of observation | Mean | Standard deviation |
|---|---|---|---|
| lnGDP | 48 | 19.730 | 0.985 |
| LnFoodImprot | 48 | 3.469 | 0.176 |
| LnFOSEC | 48 | 4.321 | 0.248 |
| LnLifesto | 48 | 4.162 | 0.429 |
| InCO2 | 48 | −0.928 | 0.205 |
| LnCrop | 48 | 4.351 | 0.258 |
| LnAg | 48 | 3.237 | 0.193 |
| LnFoodEX | 48 | 4.402 | 0.256 |
| LFish | 48 | 9.977 | 0.610 |

Source: Authors' computation, 2020

**Table 2** Correlation matrix

| Variables | lnGDP | LnCrop | LnAg | LnLifesto | LFish | LnFOSEC | LnFoo-dEX | LnFood-Improt | InCO2 |
|---|---|---|---|---|---|---|---|---|---|
| lnGDP | 1.000 | 0.170 | −0.700 | 0.900 | 0.920 | 0.490 | −0.560 | 0.720 | 0.600 |
| LnCrop | 0.170 | 1.000 | 0.300 | 0.360 | 0.350 | 0.920 | 0.010 | 0.180 | o.11 |
| LnAg | −0.730 | 0.300 | 1.000 | −0.660 | −0.580 | −0.040 | 0.510 | −0.560 | −0.200 |
| LnLifesto | 0.900 | 0.360 | −0.700 | 1.000 | 0.930 | 0.690 | −0.460 | 0.710 | 0.390 |
| LFish | 0.920 | 0.350 | −0.600 | 0.930 | 1.000 | 0.650 | −0.470 | 0.690 | 0.540 |
| LnFOSEC | 0.490 | 0.920 | 0.000 | 0.690 | 0.650 | 1.000 | −0.190 | 0.440 | 0.220 |
| LnFoodEX | −0.560 | 0.010 | 0.510 | −0.460 | −0.470 | −0.190 | 1.000 | −0.410 | −0.420 |
| LnFood-Imp | 0.720 | 0.180 | −0.600 | 0.710 | 0.690 | 0.440 | −0.420 | 1.000 | 0.210 |
| InCO2 | 0.600 | 0.110 | −0.200 | 0.390 | 0.540 | 0.220 | −0.422 | 0.210 | 1.000 |

Source: Authors' computation, 2020

## Econometric results

The data for this study were generated from World Development Indicators for the periods 1960–2017. Table 1 below shows the descriptive statistics for the variables used in the study. The natural logarithm of GDP has the highest mean and it is also associated with the highest standard deviation.

### Descriptive statistic

The correlation matrix is used to determine the relationship between two variables (see Table 2 below). The Pearson correlation coefficient is used to represent

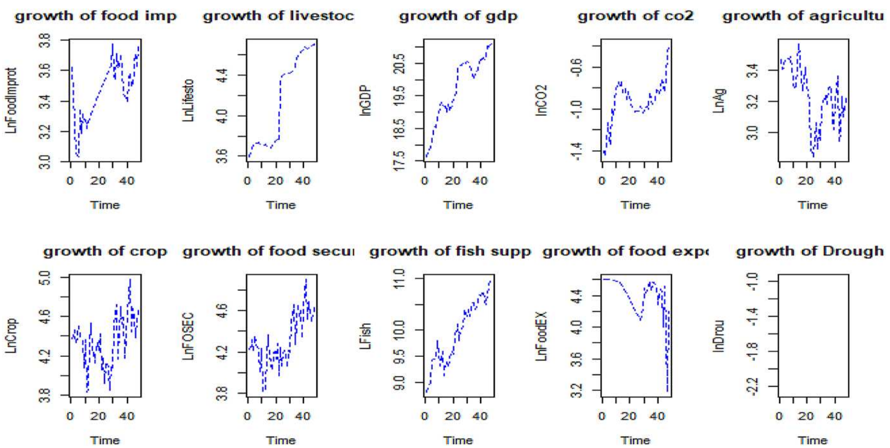



**Fig. 1** The Fluctuation of time series plot for the Gambia. Source: Drawn by the authors using research data, 2020

this relationship which ranges from − 1.00 to + 1.00. The results of the test of correlation show that the relationship between the growth of crop production in the Gambia and GDP growth rate is slightly positive (a correlation coefficient of 0.17). Thus, if the growth of crop production increases by 1%, the growth rate of GDP rises by 0.17%. In the Gambia, due to the lack of mechanization ways in agriculture, the growth of agriculture is negatively related to the growth of GDP (the correlation coefficient of − 0.73). In addition, the growth of C02 emission per person has a negative relationship with the growth of agriculture (Table 2).

The growth rate of GDP and the growth of food production (food availability proxy) are positively correlated with a correlation coefficient of 0.49. Finally, the growth of fish production in the Gambia is positively correlated with the GDP growth rate (with a correlation coefficient of 0.92). Hence, if the growth of fish production increases by 1%, the growth rate of gross domestic product (GDP) increases by 0.92%. With this huge increase, the youth and the government of the Gambia should take advantage of the fish production as a means of not only enhance the livelihood of Gambians but also as a means of boosting the country's economic growth. In Fig. 1, the growth of GDP fluctuated in the Gambia since the country's economy experienced some form of breakpoint 1981 and 1995 when we estimated the breakpoint date.

It can be seen from Fig. 1 that while the growth of food imports rises in the Gambia, the growth of agriculture decreases. This is since the economy of the Gambia is import-based, and since the country's agriculture is not producing enough, the country imports the vast majority of the goods and services it needs.

On the other hand, the growth of export is falling and this can be attributed to the persistent decline in the growth of agricultural output.

The persistent falls in the growth rate of agricultural output have implications for food production because increased food production depends mostly on a growing agricultural sector. However, falling growth rates in agriculture are offset by the growth rates in both fish and livestock production (Fig. 1).

**Table 3** Unit root test

| Variable | ADF level | 1st diff. | PP level | 1st diff. | KPSS level | 1st diff. |
|---|---|---|---|---|---|---|
| lnGDP | 0.055* | 0.075* | 0.055*** | 0.000*** | 0.662*** | 0.357*** |
| LnCrop | 0.001*** | 0.001*** | 0.001*** | 0.000*** | 0.393*** | 0.0.273*** |
| LnAg | 0.018** | 0.019** | 0.019*** | 0.000*** | 0.439*** | 0.261*** |
| LnLifesto | 0.312 | 0.398 | 0.312*** | 0.000*** | 0.387*** | 0.214** |
| LFish | 0.180 | 0.216 | 0.180*** | 0.000*** | 0.159** | 0.103 |
| LnFOSEC | 0.013** | 0.013** | 0.013*** | 0.000*** | 0.456*** | 0.315*** |
| LnFoodEX | 0.001*** | 0.001*** | 0.001*** | 0.000*** | 0.201*** | 0.141* |
| LnFoodImp | 0.068* | 0.069* | 0.068*** | 0.000*** | 0.286*** | 0.185*** |
| InCO2 | 0.302 | 0.174 | 0.302*** | 0.000*** | 0.433*** | 0.247*** |

Source: Authors' computation, 2020

*, ** and *** are statistically significant at 10, 5 and 1%, respectively

Table 3 presents the results of the augmented Dickey–Fuller (ADF) test, Phillips–Perron (PP) test, and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test for all variables in levels and first differences using the time series annual data from 1960 to 2017. The results confirmed that the null hypothesis of unit root at the 5, 1, and 10% critical values for all series can be rejected, except for growth rate of GDP, growth of fish production, growth of $CO_2$, and growth of livestock for ADF test only. Yet, the null hypothesis is rejected at different percentage levels of the critical value for the series in the first difference and the levels. The results in Table 3 show that there is a combination of I (0) and I (1) of the regressions in the models. Hence, it is appropriate to use the ARDL and ECM approaches for the analysis. The lag length is selected using the minimum values of AIC criteria, which shows the smaller the AIC, the better for the model. This finding is consistent with the results from the study done by Shrestha and Chowdhury (2005). The optimal lag for the model is 3. The study also applied the VAR Granger with lag 3 as well, because at some point, the series is not stationary and the study needs to transform the model into stationary time series.

## ARDL analysis

The ARDL analysis is carried out based on the results in Table 4. In the long run, the growth of crop production in the Gambia has a positive effect on the growth of GDP. From Table 4, it can be seen that a 1% increase in growth of crop production, increases the growth of GDP by 0.054%. In our study, it revealed that the growth rate of GDP and the growth of food production are positively correlated with a correlation coefficient of 0.49 in the Gambia. This is since in the dry seasons' crop production by Gambian helps to contribute to the growth of GDP by a very small amount due to the traditional method of gardening.

**Table 4** ARDL model growth of GDP as dependent variable

```
Coefficients:
       (Intercept)        L(lnGDP, 1)        L(lnGDP, 2)
           6.15948            0.68322            0.04436
            LnCrop     L(LnCrop, 1)            LnFOSEC
           0.60489            0.86721           -0.96455
   L(LnFOSEC, 1)          LnFoodEX   L(LnFoodEX, 1)
          -1.02775            0.00416           -0.18617
              LnAg        L(LnAg, 1)       LnFoodImprot
          -0.11069           -0.33833           -0.03870
L(LnFoodImprot, 1)             LFish        L(LFish, 1)
          -0.26347            0.12530            0.14049
         LnLifesto L(LnLifesto, 1)              InCO2
           1.14634           -0.61730            0.02711
       L(InCO2, 1)
           0.06269

 Long-term coefficients:
     LnCrop      LnFOSEC     LnFoodEX         LnAg LnFoodImprot        LFish
  5.4039057   -7.3134727   -0.6681408   -1.6483059   -1.1092028    0.9756745
  LnLifesto        InCO2
  1.9420084    0.3296430

 Short-term coefficients
   (Intercept)     L(d(lnGDP))        d(LnCrop)       d(LnFOSEC)
   6.159483247    -0.044360790      0.604894088     -0.964553183
   d(LnFoodEX)         d(LnAg) d(LnFoodImprot)         d(LFish)
   0.004160399    -0.110689343     -0.038696259      0.125297521
  d(LnLifesto)        d(InCO2)        L(coint)
   1.146336012     0.027113296     -0.272415263
Own evaluation
```

Source: Authors' computation, 2020

Furthermore, the study also confirmed that using the ARDL framework, the growth of food production (food availability proxy) in the Gambia negatively affects the growth of GDP by 0.0731% in the long run. The possible reason underlying such a result is since the coefficients of the growth of agriculture are negative in both the short run and long run. Agriculture being the backbone of the economy of the Gambia, insufficient food production affects the entire economy, including the consumption of agricultural produce. In both the short run and long run, growth in fish production and livestock in the Gambia has positive impacts on the growth of GDP. This finding is supported by anecdotal evidence, which suggests that Gambian youth are increasingly getting involved in livestock and fish production, which in turn helps boost the economy of the Gambia. The world in general and the Gambia in particular, due to the unachievable of certain SDGS, such as poverty (SDG no.1), Hunger (SDG no 2), and climate change (SDG no.13), the world is still facing starvation, conflict, insufficient water supply, and food production, malnutrition, and poor agricultural practices. In their part, according to Manap and Ismail (2019), they wrote on Food Security and Economic Growth nexus confirmed that food security has an impact on economic growth, especially in dry-land developing countries. Their study revealed that an increase in food security results to an increases in economic growth.

In terms of the impact of the growth of average precipitation and $CO_2$ emission (a proxy for climate change) on the growth of GDP, the findings in Table 4 have shown this to have a positive impact on the Gambian economy. This is consistent with the study done by (Cederborg and Snöbohm 2016) confirmed in their study that the empirical result of the cross-sectional study implies that, there is in fact a relationship between per capita GDP and per capita carbon dioxide emissions. It shows a positive correlation which suggests that growing per capita GDP leads to increased carbon dioxide emissions. In contrast to the study done by Ali et al. (2019) in which they wrote a paper on Analysis of the Nexus of $CO_2$ Emissions,

**Table 5** ARDL model growth of food production as dependent variable

```
Coefficients:
        (Intercept)        L(LnFOSEC, 1)        L(LnFOSEC, 2)
          0.2399884            0.1510273           -0.0146739
             LnCrop        L(LnCrop, 1)                lnGDP
          0.7381121           -0.1163428           -0.0134743
        L(lnGDP, 1)            LnFoodEX        L(LnFoodEX, 1)
          0.0111288           -0.0118260           -0.0111311
               LnAg          L(LnAg, 1)          LnFoodImprot
         -0.0109250            0.0322370            0.0003437
L(LnFoodImprot, 1)               LFish          L(LFish, 1)
         -0.0434347           -0.0007265           -0.0025158
          LnLifesto      L(LnLifesto, 1)                InCO2
          0.2634889           -0.0213961            0.0205244
        L(InCO2, 1)
         -0.0613253

Long-term coefficients:
      LnCrop        lnGDP     LnFoodEX          LnAg LnFoodImprot         LFish
 0.719934867 -0.002715779 -0.026581668  0.024676685 -0.049894245 -0.003754158
   LnLifesto        InCO2
 0.280314589 -0.047242559

 Short-term coefficients
   (Intercept)   L(d(LnFOSEC))       d(LnCrop)        d(lnGDP)
  0.2399884403    0.0146738772    0.7381121111   -0.0134742544
   d(LnFoodEX)        d(LnAg) d(LnFoodImprot)        d(LFish)
 -0.0118260471   -0.0109250168    0.0003437137   -0.0007264964
  d(LnLifesto)       d(InCO2)        L(coint)
  0.2634888694    0.0205243998   -0.8636465732
Own Evaluation using Statistical Software-R
```

Source: Authors' computation, 2020

Economic Growth, Land under Cereal Crops and Agriculture Value-Added in Pakistan, using an ARDL approach confirmed in their results of the short-run ARDL analysis which pointed out that there is a negative and statistically insignificant association between carbon dioxide emissions and gross domestic product in Pakistan. In most of the developed world, the higher the countries' emissions into the atmosphere, the higher the GDP growth. On the other hand, the growth of agriculture and the growth of food imports have negative effects on the growth of GDP in both the short run and in the long run. This is why the importation of food products rises in the Gambia, with traditional ways of agriculture increasing.

Table 4 further shows that the growth of food export has a positive effect on the growth of GDP in the short run and a negative effect on the growth of GDP in the long run.

The results in Table 5 are analyzed below. Table 5 shows that in the long run, the following variables have positive effects on the growth of food production in the Gambia: the growth of agriculture, the growth of crop production, and the growth of livestock production. This means that for the economy of the Gambia to grow, the government needs to develop policies that are geared towards the growth in crops, livestock, and agriculture if the country's food production is to be enhanced.

In the short run, however, the following variables have positive effects on the growth of food production in the Gambia: growths in crop production, food imports, and growth of $CO_2$ emission per person.

On the other hand, the following variables have both short- and long-run positive impacts on the growth of food production in the Gambia: growths in both crop and livestock production. It can be observed in Table 5 that the following variables have both short- and long-run negative impacts on the growth of food production in the Gambia: GDP growth, growth of food export, and growth of fish production.

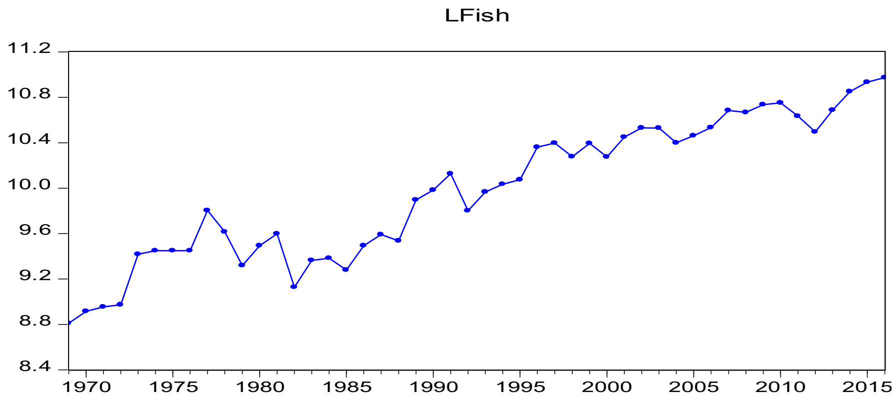



**Fig. 2** The time series graph for the growth of fish production in the Gambia from 1960 to 2017. Source: Drawn by the authors using research data, 2020

**Table 6** Vector autoregressive (VAR) model results

| | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lnGDP | | | | | | |
| lnGDP | | | | | | |
| L1. | .3731046 | .1645772 | 2.27 | 0.023 | .0505392 | .69567 |
| L2. | -.0330973 | .1713371 | -0.19 | 0.847 | -.3689119 | .3027172 |
| L3. | .0488529 | .1252563 | 0.39 | 0.697 | -.1966449 | .2943508 |
| LnCrop | | | | | | |
| L1. | 1.809103 | 1.060869 | 1.71 | 0.088 | -.2701612 | 3.888368 |
| L2. | 3.098078 | 1.299605 | 2.38 | 0.017 | .5508995 | 5.645256 |
| L3. | .7990732 | 1.035377 | 0.77 | 0.440 | -1.230228 | 2.828374 |
| LnAg | | | | | | |
| L1. | .035934 | .2663744 | 0.13 | 0.893 | -.4861502 | .5580181 |
| L2. | -.3081255 | .2233653 | -1.38 | 0.168 | -.7459134 | .1296624 |
| L3. | .0079202 | .2450537 | 0.03 | 0.974 | -.4723762 | .4882166 |
| LnLifesto | | | | | | |
| L1. | .2104039 | .4637054 | 0.45 | 0.650 | -.6984421 | 1.11925 |
| L2. | .931723 | .5377544 | 1.73 | 0.083 | -.1222562 | 1.985702 |
| L3. | .3757485 | .4513716 | 0.83 | 0.405 | -.5089237 | 1.260421 |
| LFish | | | | | | |
| L1. | .0804297 | .1284161 | 0.63 | 0.531 | -.1712612 | .3321206 |
| L2. | .6860993 | .1325978 | 5.17 | 0.000 | .4262124 | .9459862 |
| L3. | .3277848 | .1567165 | 2.09 | 0.036 | .020626 | .6349435 |
| LnFOSEC | | | | | | |
| L1. | -2.763284 | 1.414276 | -1.95 | 0.051 | -5.535213 | .0086458 |
| L2. | -4.084052 | 1.782151 | -2.29 | 0.022 | -7.577005 | -.5910994 |
| L3. | -.9667313 | 1.403347 | -0.69 | 0.491 | -3.717242 | 1.783779 |

Own evaluation

**Authors' computation, 2020**

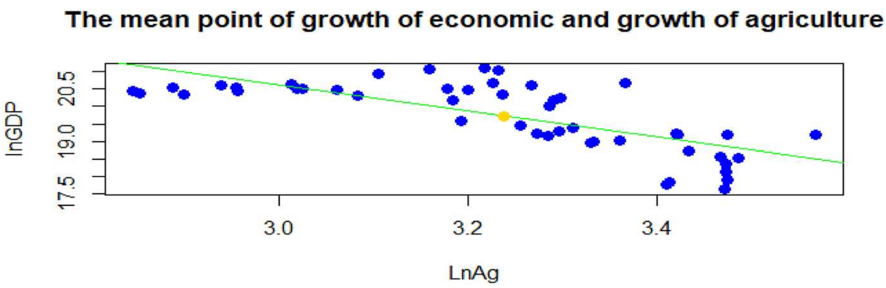



**Fig. 3** The mean point of economic growth and agricultural growth. Source: Drawn by the authors using research data, 2020

The following variables have mixed impacts on the growth of food production in the Gambia: growth of agriculture has a long-run positive impact but in the short run, the impact is negative. In terms of the growth of food import and the growth of $CO_2$, evidence from Table 5 shows that these have positive effects in the short run, but long-run negative impacts.

Figure 3 indicates that there is a negative relationship between agriculture and the growth of GDP in the Gambia as illustrated by the regression line. This means that the sum of the squares of the residual and the sum of squares is explained by the regression has large errors. The outliers from minimum values to maximum values are large and that downward-sloping has an inverse relationship between the growth of agriculture and the growth of GDP. The time series trend for the growth of fish production in the Gambia has an upward trend from 1960 to 2017 as illustrated below (Fig. 2).

## Vector autoregressive VAR results

The vector autoregressive (VAR) results are shown in Table 6 below. Before applying the Granger causality test, the study first applied the VAR model with an optimal lag of 3 based on AIC criteria, which indicates that the lower the lags, the better. As the results generated in Table 6 indicate, the *p* value of growth of crop production is significant at lag 1 and lag 2 and not significant at lag 3. Both lags 1 and 2 have significant positive impacts on the growth of GDP. The growth of agriculture is not statically significant at all in both lags and has a negative coefficient at lag 2. The growth of livestock and growth of fish production have significant impacts on the growth of GDP at lag 2. The third lag for growth of livestock and growth of food production does not have a causality impact on the growth of GDP. The growth of food production in the Gambia has statistically significant negative impacts on the growth of GDP. Growth of food export is highly significant at lag 1 and lag 3 while the growth of food import is significant at lags 1, 2, and 3. The growth of climate change is also significant at lag 1 and lag 3.

As Fig. 3 shows, the mean point—the yellow dot at the center of the distribution confirmed the linearity between the growth of economic and the growth of agriculture value-added in the Gambia has a downward slope. This negative influence of the variables in question confirmed that growth of agriculture value-added does not cause the growth of the economy, the study asserted. In Fig. 4, the growth of climate change and the growth of GDP have a positive relationship, which suggests that in

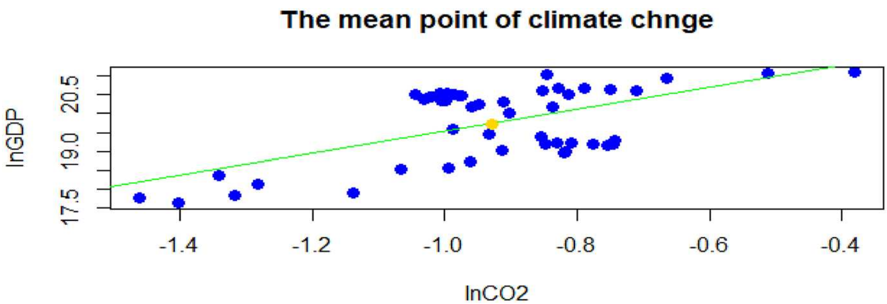



**Fig. 4** The mean point of climate change and economic growth. Source: Drawn by the authors using research data, 2020

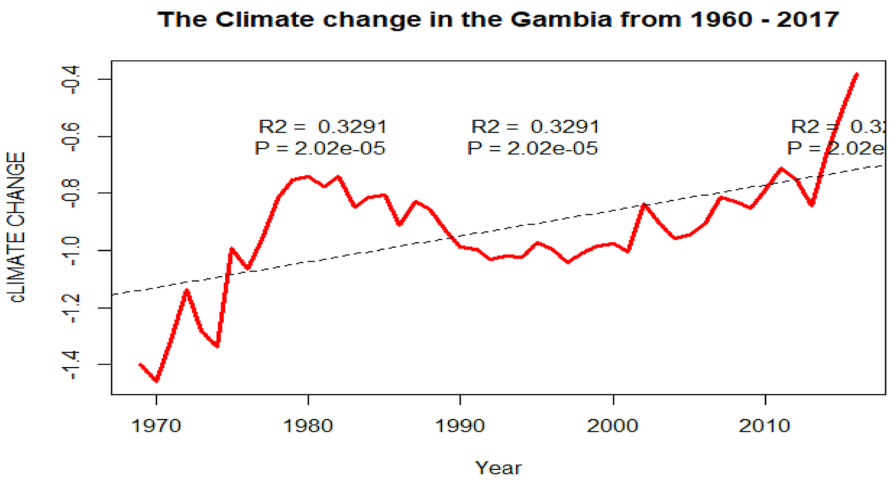



**Fig. 5** Time series plot for climate change in the Gambia. Source: Drawn by the authors using research data, 2020

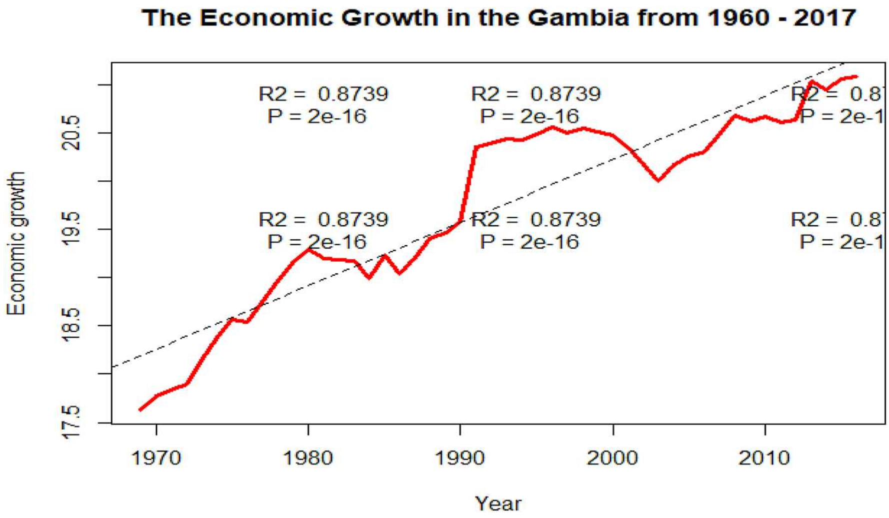



**Fig. 6** The trajectory of economic growth in the Gambia from 1960 to 2017. Source: Drawn by the authors using research data, 2020

the Gambia, as climate change (–$CO_2$ emission) grows, the economy of the Gambia also grows.

In Fig. 5, the fluctuation of climate change in the Gambia over the period from 1960 to 2017 is stationary, because the series fluctuates around its mean. The *p* values are statistically significant for the periods 1981, 1995, and 2017. Climate change also is expected to grow shortly as indicated below (Figs. 6, 7).

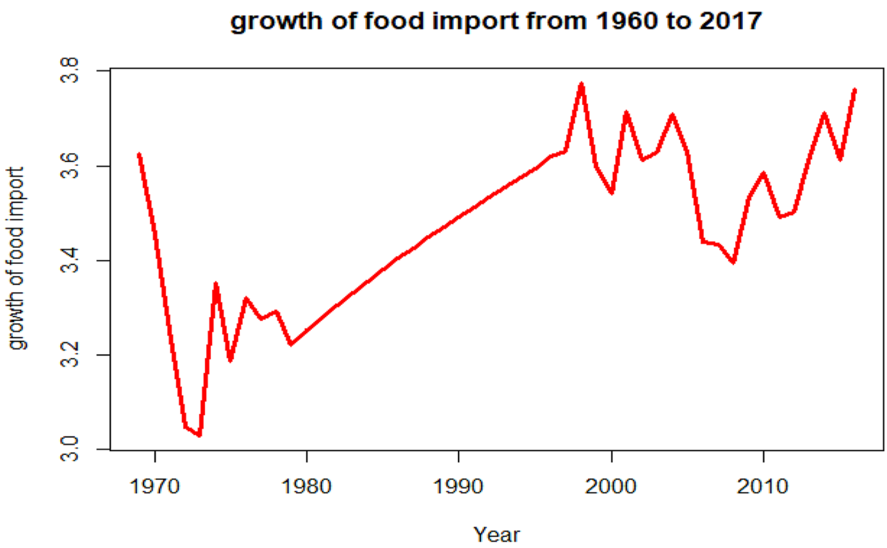



**Fig. 7** The trajectory of growth in food import in the Gambia. Source: Drawn by the authors using research data, 2020

**Table 7** Granger causality test results

| Equation | Excluded | Direction | *p* value | Equation | Excluded | Direction | *p* value |
|---|---|---|---|---|---|---|---|
| lnGDP | LnCrop | DI | 0.006*** | LnFOSEC | LnGDP | INDI | 0.244 |
| lnGDP | LnAg | INDI | 0.576 | LnFOSEC | LnCrop | DI | 0.024** |
| lnGDP | Lnlifestock | INDI | 0.113 | LnFOSEC | LnAg | DI | 0.024** |
| lnGDP | LFish | DI | 0.000*** | LnFOSEC | Lnlifestock | DI | 0.014*** |
| lnGDP | LnFOSEC | DI | 0.008*** | LnFOSEC | LFish | DI | 0.026** |
| lnGDP | LnFoodEX | DI | 0.000*** | LnFOSEC | LnFoodEX | DI | 0.043** |
| lnGDP | LnFoodImport | DI | 0.001*** | LnFOSEC | LnFoodImp | INDI | 0.506 |
| lnGDP | InCO2 | DI | 0.001*** | LnFOSEC | InCO2 | DI | 0.018** |
| lnGDP | Overall | DI | 0.000*** | LnFOSEC | Overall | DI | 0.000*** |

Source: Authors' computation, 2020

*$p$ = 0.10, **$p$ = 0.05, ***$p$ = 0.01. note DI is direct/granger, INDI is indirect/not granger

The growth of food imports in the Gambia from 1980 to 1999 has a constant trend. It means those years' agriculture is good in the Gambia because the government does not spend much on food importation. Import of goods and services costs the economy to grow negatively and the growth of food import shortly has a negative sign and until policy recommendation about agriculture is taken into account, the Gambia may experience food import for some time from now.

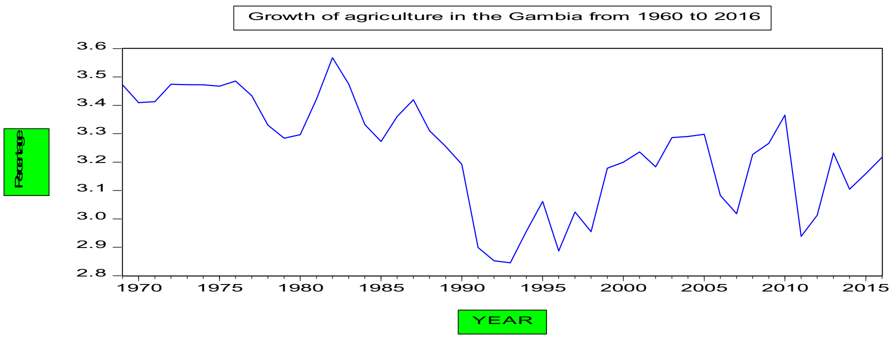



**Fig. 8** The trajectory of agricultural growth in the Gambia. Source: Drawn by the authors using research data, 2020

**Table 8** Granger causality test results

| Equation | Excluded | Direction | *p* value | Equation | Excluded | Direction | *p* value |
|---|---|---|---|---|---|---|---|
| LnCrop | LnGDP | INDI | 0.276 | LnAg | LnGDP | DI | 0.001*** |
| LnCrop | LnAg | DI | 0.050** | LnAg | LnCrop | DI | 0.000*** |
| LnCrop | Lnlifestock | DI | 0.008*** | LnAg | LnFOSEC | DI | 0.000*** |
| LnCrop | LFish | DI | 0.072* | LnAg | Lnlifestock | DI | 0.000*** |
| LnCrop | LnFOSEC | DI | 0.008*** | LnAg | LFish | DI | 0.014*** |
| LnCrop | LnFoodEX | DI | 0.026** | LnAg | LnFoodEX | DI | 0.000*** |
| LnCrop | LnFoodImport | INDI | 0.629 | LnAg | LnFoodImp | INDI | 0.000*** |
| LnCrop | InCO2 | DI | 0.014*** | LnAg | InCO2 | DI | 0.000*** |
| LnCrop | Overall | DI | 0.001*** | LnAg | Overall | DI | 0.000*** |

Source: Authors' computation, 2020

*$p=0.10$, **$p=0.05$, ***$p=0.01$.nte DI is direct/granger, INDI is indirect/not granger

## Granger causality test

The objective of applying the VAR Granger causality test is to verify whether there is a causal relationship between the different variables in our empirical investigation. The causality test indicates that the following variables of Granger cause the growth of GDP in the Gambia: the growth of crop production, growth of fish production, growth of food production, growth of food export, growth of food imports and growth of $CO_2$ (Table 7; Fig. 8).

The results in Table 7 show a surprising picture as the growth of agriculture and the growth of livestock does do not granger cause the growth of GDP. However, the following variables of Granger cause the growth of food production: growth of crop production, growth of agriculture, growth of livestock, growth of fish production, growth of food export, growth of $CO_2$. Nevertheless, the growth of GDP and growth of food import do not garger cause growth of food production in the Gambia. These results are shown in Table 7.

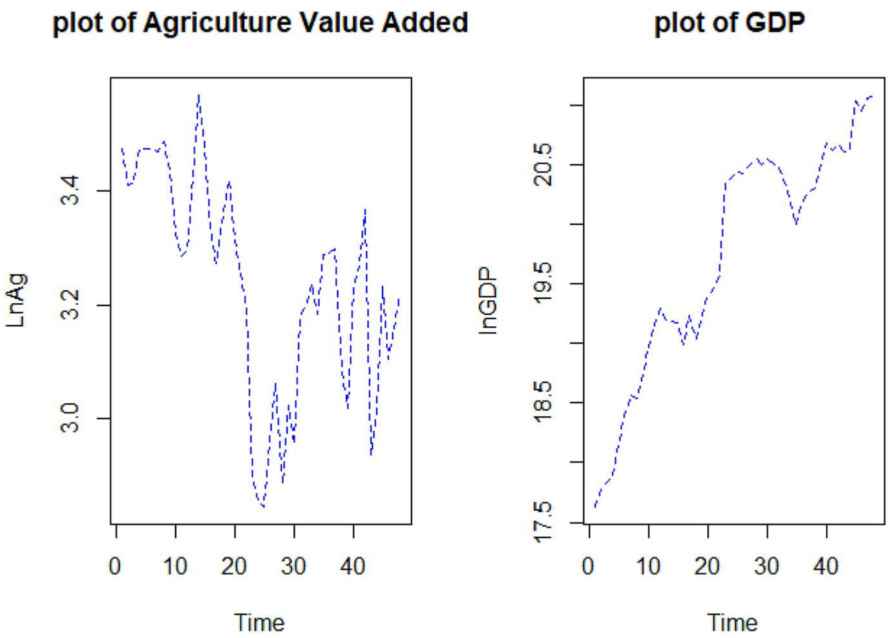



**Fig. 9** Plot of GDP-right and plot of agriculture-left. Source: Drawn by the authors using research data, 2020

**Table 9** Granger causality test results

| Equation | Excluded | Direction | *p* value | Equation | Excluded | Direction | *p* value |
|---|---|---|---|---|---|---|---|
| Lnlifestock | LnCrop | INDI | 0.114 | LFish | LnGDP | INDI | 0.200 |
| Lnlifestock | LnAg | DI | 0.054** | LFish | LnCrop | DI | 0.063* |
| Lnlifestock | LnGDP | INDI | 0.601 | LFish | LnAg | DI | 0.001*** |
| Lnlifestock | LFish | DI | 0.000*** | LFish | Lnlifestock | DI | 0.082* |
| Lnlifestock | LnFOSEC | INDI | 0.134 | LFish | LFOSEC | DI | 0.080* |
| Lnlifestock | LnFoodE | INDI | 0.243 | LFish | LnFoodEX | DI | 0.005*** |
| Lnlifestock | LnFoodIm | DI | 0.020** | LFish | LnFoodImp | DI | 0.020** |
| Lnlifestock | InCO2 | DI | 0.006*** | LFish | InCO2 | DI | 0.039** |
| Lnlifestock | Overall | DI | 0.000*** | LFish | Overall | DI | 0.000*** |

Source: Authors' computation, 2020

*$p=0.10$, **$p=0.05$, ***$p=0.01$.nte DI is direct Granger, INDI is indirect/not Granger

From Table 8 below, it can be seen that the growth of GDP does not cause growth of crop production but the growth of crop production Granger causes growth of GDP, which is a unidirectional relationship. On the other hand, the growth of agriculture Granger causes the growth of crop production, and growth of crop production Granger causes the growth of agriculture in the Gambia, which shows a bidirectional relationship between these variables. In fire8, the growth of economic and the growth agriculture is in opposite direction (Fig. 9).

The following variables of Granger cause the growth of crop production and at the same time Granger causes the growth of agriculture in the Gambia: growth of livestock, growth of fish production, growth of food production, growth of food export and growth of $CO_2$.

The growth of food imports does not cause the growth of crop production (Table 8). The result is not significant statistically. This is true because the country is indebted through importing rather exporting. Furthermore, according to Ceesay et al. (2019), export does not cause growth in the Gambia. Total imports of Granger caused growth and growth of Granger caused import in the Gambia (Ceesay et al. 2019). Growth of food import and growth of GDP do not cause the growth of crop production, because the budget from GDP is used for the importation not the production of crops in the Gambia.

From Table 9, it is clear that the growth of crop production does not influence the growth of livestock. The result is indirect. Growth of GDP does not cause the growth of livestock and growth of livestock does not garger cause the growth of GDP–unidirectional relationship. Growth of agriculture causes livestock and growth of livestock significantly causes growth of the agriculture–bidirectional relationship. Growth of fish granger causes growth of livestock and growth of livestock is also a leading significant positive influence to the growth of fish production–bidirectional. The growth of livestock causes food production but food production does not cause the growth of livestock–unidirectional. Growth of livestock and growth of food export do not influence each other indirectly.

In the Gambia, because of poor agriculture, livestock production only benefits local farmers but is not exported to other countries to drive revenue and boost economic growth. The growth of $CO_2$ is an important variable for the growth of livestock. There is a bidirectional relationship between growth of food import to growth of livestock and growth of livestock to growth of food import–bidirectional relationship. Growth of GDP does not garger cause growth of fish production, but the

**Table 10** Granger causality test results

| Equation | Excluded | Direction | *p* value | Equation | Excluded | Direction | *p* value |
|---|---|---|---|---|---|---|---|
| LnFoodImport | LnCrop | INDI | 0.343 | InCO2 | LnGDP | INDI | 0.000*** |
| LnFoodImport | LnAg | DI | 0.005*** | InCO2 | LnCrop | INDI | 0.178 |
| LnFoodImport | Lnlifestock | DI | 0.030** | InCO2 | LnAg | INDI | 0.893 |
| LnFoodImport | LFish | DI | 0.014*** | InCO2 | Lnlifestoc | INDI | 0.178 |
| LnFoodImport | LnFOSEC | DI | 0.238 | InCO2 | LFish | DI | 0.086* |
| LnFoodImport | LnFoodEX | DI | 0.010*** | InCO2 | LnFoodE | INDI | 0.128 |
| LnFoodImport | LnGDP | DI | 0.001*** | InCO2 | LnFoodI | DI | 0.000*** |
| LnFoodImport | InCO2 | DI | 0.000*** | InCO2 | LnFOSEC | INDI | 0.172 |
| LnFoodImport | Overall | DI | 0.000*** | InCO2 | Overall | DI | 0.000*** |

Source: Authors' computation, 2020

*$p=0.10$, **$p=0.05$, ***$p=0.01$. note DI is direct/Granger, INDI is indirect/not Granger

**Table 11** Granger causality test results

| Equation | Excluded | Direction | *p* value |
|---|---|---|---|
| LnFoodEX | LnGDP | DI | 0.000*** |
| LnFoodEX | LnAg | DI | 0.000*** |
| LnFoodEX | Lnlifestock | INDI | 0.216 |
| LnFoodEX | LFish | DI | 0.000*** |
| LnFoodEX | LnFOSEC | DI | 0.038** |
| LnFoodEX | Lncrop | INDI | 0.152 |
| LnFoodEX | LnFoodImport | DI | 0.000*** |
| LnFoodEX | InCO2 | DI | 0.000*** |
| LnFoodEX | Overall | DI | 0.000*** |

Source: Authors' computation, 2020

*$p = 0.10$, **$p = 0.05$, ***$p = 0.01$. note DI is direct/granger, INDI is indirect/not Granger

growth of fish production causes growth of GDP–unidirectional relationship. The policymaker should look at the production of fish as an important indicator of the growth of GDP in the Gambia. There is a bidirectional relationship between the growth of agriculture and the growth of fish production. This is since fish production is part of an improvement in agricultural activities. The growth of $CO_2$ Granger causes the growth of both fish production and livestock production in the Gambia. Together, growth of food export and growth of food import both Granger cause the growth of fish production. Fish production Granger causes food production and food production also garger causes fish production–bidirectional relationship. These results are shown in Table 9 above.

Table 10 shows the unidirectional relationships between the growths of crop production to the growth of food import, but a bidirectional relationship between growth of agriculture to growth of food import and growth of food import to the growth of agriculture. The growth of livestock and the growth of fish production are a leading indicator for the growth of food imports.

A very important finding is that growth of food production does not cause growth of food import. Growth of food export together with the growth of GDP Granger causes growth in food import. Growth of $CO_2$ Granger causes growth in food import and growth of food import Granger causes growth of $CO_2$. Growth of $CO_2$ Granger causes GDP and growth of GDP Granger causes $CO_2$, which shows a bidirectional relationship. The following variables do not cause $CO_2$: the growth of crop production, growth of agriculture, growth of fish production, and growth of food export.

The results in Table 11 below indicate that the following variables are leading indicators of growth of food export: growth of GDP, growth of agriculture, growth of fish production growth of food production, growth of food import, and growth of $CO_2$ emission.

Both the growth of crop production and the growth in livestock production do not cause growth in food export. This is since agriculture is not a leading indicator for the growth of GDP in the Gambia.

## Econometric tests

### Ramsey reset test for specification

The hypothesis test is as follows:

H0: the model is well specified (the model has no omitted variables).

Ha: the model is poorly specified (the model has omitted variables).

The Ramsey Reset test is a test of omitted variables.

If the null hypothesis is rejected, then there are omitted variables whose integration would improve the estimate. In this case, we can conclude that the model is poorly specified, after having estimated the parameters by the least ordinary squares method.

Ramsey RESET test
Equation: UNTITLED
Specification: LNGDP INCO2 LFISH LNFOODEX LNAG LNCROP
LNFOODIMPROT LNFOSEC LNLIFESTO
Omitted variables: powers of fitted values from 2 to 4

| | Value | *df* | Probability |
|---|---|---|---|
| *F*-statistic | 37.01 | (3, 37) | 0.0000 |
| Likelihood ratio | 66.55 | 3 | 0.0000 |

Source: Authors' computation, 2020

The Ramsey statistics (*F*-statistic) of 37.01 has a *p* value of 0.0000. The model is well specified at the 0.01 level because $p = 0.000 > 0.01$. Note: Why is the choice of 3 for "Number of fitted terms"? The conclusion reached by Thursby and Schmidt (1977) who carried out an extensive Monte Carlo exercise is that the value 3 seems to be generally the best choice.

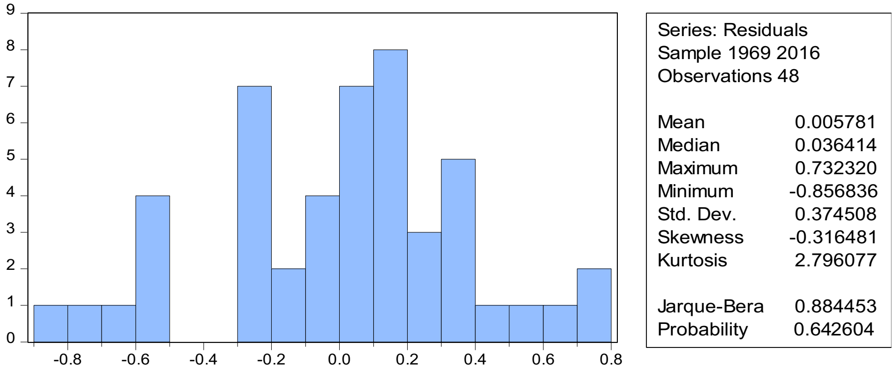
### Jarque–Bera normality test

The hypothesis test is as follows:

H0: the errors of the model follow a normal law of parameters $\mu$ and $\sigma$.

Ha: the errors of the model do not follow a normal law of parameters $\mu$ and $\sigma$.

After having estimated the parameters by the OLS.




**Source:** Authors' computation, 2020

The Jarque–Bera statistics of 0.8845 has a p value of 0.6426. The residuals of the model follow a normal law at the 0.05 level because $p = 0.8845 > 0.05$.

## Heteroskedasticity tests

### White test

The hypothesis test is as follows:

H0: if errors of the model are homoscedastic (the errors have the same variance) and Ha: if errors of the model are heteroskedastic (the errors have different variances). There are 2 options for White test.

**Option 1: No cross terms** After having estimated the parameters by the OLS.

| Heteroscedasticity test: White | | | |
|---|---|---|---|
| *F*-statistic | 0.386897 | Prob. *F*(4,43) | 0.8168 |
| Obs*$R$-squared | 1.667525 | Prob. Chi-Square(4) | 0.7966 |
| Scaled explained SS | 2.908828 | Prob. Chi-Square(4) | 0.5732 |

Source: Authors' computation, 2020

The White statistic (Obs*$R$-squared) of 1.6675 has a $p$ value of 0.7966. The errors of the model are homoscedastic at the 0.05 level because $p = 0.7966 > 0.05$. The White test is a Lagrange multiplier (LM) test. The Lagrange multiplier statistic is $nR^2$ where $n$ is the number of observations or sample size.

### Option 2: Include cross terms

| | | | |
|---|---|---|---|
| Heteroscedasticity test: White | | | |
| *F*-statistic | 0.93952 | Prob. *F*(10,37) | 0.5097 |
| Obs**R*-squared | 9.720179 | Prob. Chi-Square(10) | 0.4654 |
| Scaled explained SS | 16.95587 | Prob. Chi-Square(10) | 0.0753 |

Source: Authors' computation, 2020

The White statistic (Obs*$R$-squared) of 9.7202 has a $p$ value of 0.4654. The errors of the model are homoscedastic at the 0.05 level because $p = 0.4654 > 0.05$. Both the two-option results indicated the model is free from heteroscedasticity.

## Discussion of the results

Results from our finding revealed that the growth of $CO_2$ emission per person (Proxy for climate change in our model) has a positive influence on the growth of GDP in the economy of the Gambia. (Cederborg and Snöbohm 2016) confirmed in their study that the empirical result of the cross-sectional study implies that, there is in fact a relationship between per capita GDP and per capita carbon dioxide emissions. It shows a positive correlation which suggests that growing per capita GDP leads to increased carbon dioxide emissions. In contrast to the study done by Ali et al. (2019) in which they wrote a paper on Analysis of the Nexus of CO2 Emissions, Economic Growth, Land under Cereal Crops and Agriculture Value-Added in Pakistan, using an ARDL approach confirmed in their results of the short-run ARDL analysis which pointed out that there is a negative and statistically insignificant association between carbon dioxide emissions and gross domestic product in Pakistan. In most of the developed world, the higher the countries' $CO_2$ emission into the atmosphere, the higher the GDP growth.

In the Gambia, an agricultural sector which includes production, in fish, livestock, forestry and hunting, crop and so on serves as the backbone of the economy. In our results, it pointed out that economic growth and growth in agriculture value addition in the Gambia show a downward slope. This negative correlation may be attributed to the suggestion that agricultural funds are being diverted and do not reach farmers to adopt new ways in agricultural practices, such as adaptation, mitigation, and resilience, a way of improving agricultural productivity. This is confirmed in the study done by Ceesay (2020), Employment in agriculture, migration, bilateral aids, economic growth, and remittance: evidence from the Gambia found out that, economic growth has a significant negative impact on employment in agriculture with a 10% increase in economic growth and a decrease in employment by 0.05% vice versa. Another study conducted by Belford et al. (2020) confirmed that in Anglophone West African countries, the growth rate of the agricultural sector and temperature is statistically significant and hurts the growth rate of GDP.

In our study, it revealed that the growth rate of GDP and the growth of food production are positively correlated with a correlation coefficient of 0.49 in the Gambia.

Furthermore, the study also confirmed that using the ARDL framework, the growth of food production in the Gambia negatively affects the growth of GDP by 0.0731% in the long run. This is since the coefficients of the growth of agriculture are negative in both the short run and long run. Agriculture being the backbone of the economy of the Gambia, insufficient food production affects the entire economy, including the consumption of agricultural produce. In both the short run and long run, growth in fish production and livestock in the Gambia has positive impacts on the growth of GDP. This finding is supported by anecdotal evidence, which suggests that Gambian youths are increasingly getting involved in livestock and fish production, which in turn helps boost the economy of the Gambia. The world in general and the Gambia in particular, due to the unachievable of certain SDGS, such as poverty (SDG no.1), Hunger (SDG no 2), and climate change (SDG no.13), the world is still facing starvation, conflict, insufficient water supply, and food production, malnutrition, and poor agricultural practices. According to Manap and Ismail (2019), they wrote on Food Security and Economic Growth nexus and confirmed that food security has an impact on economic growth, especially in dry-land developing countries. Their study revealed that an increase in food security results in an increase in economic growth.

## Limitations of the study

This study has limitations that further researchers need to address. The first limitations go to the type of data used in this study which was generally taken from the World Bank. Thus, the results might bring some important outcomes for food security if in the case household's survey is conducted on this topic, such as households characteristics, the demographic status of the households, social and economic status of the households, production of food, and consumption of food by the households. This will have additional policy implications for the policymakers to implement possible solutions to address the issues of climate change, food production, agriculture, and economic growth nexus. The second limitation is that the paper can use cross-sectional variation on food security to study different regions or countries or continents that will yield sound results as well. Basically, even more, interesting results are built in this present study but using panel data model especially fixed effects model will address some issues of specific error term in-country or regions, such as differences in climate and weather, differences in agriculture practice, differences in the political situation, different in institution and governance and so on, all of these will have some outstanding results for the nexus between climate, food security, agriculture, and economic growth. The third limitations are the links between the HDI index and agriculture productivity and food security that the study failed to address. The future researcher could add the specific country's Human Development Index (HDI) to see its relationship with food security through agriculture value-added. Finally, the last limitation can be based on the type of model, as the study addresses the dynamic model (ARDL) to see the trend of the variables in question. The results are actually very impressive, but it could also be nicer if some future research used instrumental variables, to select carefully the instruments so that the number of the equation be endogenous and the number of the equation to be exogenous is to be identical. This will help to select a good proxy for the study.

## Conclusion and policy implications and areas for future research

This paper tests the ARDL model and Granger causality linkage between climate change, growth in value-added agriculture, food production (food availability proxy), and economic growth, utilizing annual data from the period 1960–2017. The results empirically demonstrate the nexus that exists between food production, agriculture, climate change, and economic growth (1) in both short run and long run, the ARDL model established that the growth of fish production and growth of livestock production in the Gambia have significant positive impacts on the growth of GDP, thus illustrating the importance of an increase in the production livestock and fishery on the economic growth of the Gambia. The possible policy implication is that it will affect the social–economic interaction in the Gambia, such as employment of youth in these sectors, education for children from their guidance working on these sectors, the research for fishing and livestock, monitoring and control, and so on (2) in both short run and long run, ARDL model manifested that growth of food import and growth of agriculture have negative impacts on the growth of GDP. The possible policy implication is that the growth in food importation will increase government spending and budget deficit, thus negatively impacting on government's ability to provide essential productive infrastructure and development. (3) The Granger causality analysis between the growth of GDP and growth of food production indicates a unidirectional relationship, the direction of Granger causality may change according to the level of development. This illustrates that growth in GDP causes growth in food production or vice versa. (4) Growth of GDP Granger causes the growth of agriculture but the growth of agriculture does not Granger cause growth of GDP, hence there exists an indirect relationship between growth in GDP and agriculture using Granger causality. (5) There exists a bidirectional relationship between the growth of crop production and growth of agriculture, thus manifesting that growth in crop production and growth in agriculture Granger cause each other. (6) It is worth noting that food production indicators (crop production, livestock production, and fish production), economic growth indicators (food import and food export) and climate change indicator $CO_2$) for this study Granger cause agriculture. Finally, ARDL approaches and Granger causality tests manifested that all the associated indicators have a degree of significance as captured in the methodology of the study. It is vital to note that there may exists a non-linear relationship that cannot be taken into account by the ARDL approaches and Granger causality methodology even though that might be important to consider when analyzing the food production, climate change, and economic growth nexus. These nuances thus create avenues to possible future research. We hereby proffer the below-stated policy recommendations.

1. Gambian policymakers should devise a mechanism to increase the production of food and livestock to stimulate economic growth and development.

2. The Gambia needs to reduce its reliance on food importation by investing in food production to feed the rapidly growing population since food imports hurt GDP growth.
3. Provide the necessary infrastructure to expand agriculture (food, livestock, etc.) production to spur economic growth.
4. Streamline and simplify regulations in the agriculture sector to harness energy towards increasing productivity and growth.

Finally, the new directions of future research can add all the components of food security, such as food availability, food accessibility, food stability, and food utilization, to understand the effect of food production on economic growth in the Gambia in particular and the World in general. In addition, future researchers should also look at some of the variables closely, such as $CO_2$ emission per person, average precipitation, temperature, pollution or environmental quality, or industrialization level as a possible proxy of climate change. In a similar vein, future researchers can also do a comparative study on climate change, food production, agriculture, and economic growth nexus by looking at specific regions, countries, continents, West Africa, Sub-Saharan Africa, and so on, to see the nexus between food security and economic growth. Furthermore, further research can address the issues using primary data by doing the household survey to ask not only one parameter of food security, such as food availability but different parameters, such as food accessibility, stability of the food, and as well as utilization. In that, it will help us to understand as climate change worsen or GDP is down or agriculture is affected, what is the likely consequence of food supply and food demand that are needed to solve the problems of food security to achieve the demand of the growing population. Another important issue the future researchers can address is this issue to use randomizing control trials by looking at the population that is eligible or ineligible to participate in the trial. Future researches on this topic in the Gambia cases can compare which region is more food-secure by looking at the vulnerability part of it.

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**Declarations**

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## References


Adams HD, Zeppel MJB, Anderegg WRL, Hartmann H, Landhäusser SM, Tissue DT, Huxman TE, Hudson PJ, Franz TE, Allen CD, Anderegg LDL, Barron-Gafford GA, Beerling DJ, Breshears DD, Brodribb TJ, Bugmann H, Cobb RC, Collins AD, Dickman LT, Duan H, Ewers BE, Galiano L, Galvez DA, Garcia-Forner N, Gaylord ML, Germino MJ, Gessler A, Hacke UG, Hakamada R, Hector A, Jenkins MW, Kane JM, Kolb TE, Law DJ, Lewis JD, Limousin JM, Love DM, Macalady AK, Martínez-Vilalta J, Mencuccini M, Mitchell PJ, Muss JD, O′Brien MJ, O'Grady AP, Pangle RE, Pinkard EA, Piper FI, Plaut JA, Pockman WT, Quirk J, Reinhardt K, Ripullone F, Ryan MG, Sala A, Sevanto S, Sperry JS, Vargas R, Vennetier M, Way DA, Xu C, Yepez EA, McDowell NG (2017) A multi-species synthesis of physiological mechanisms in drought-induced tree mortality. Nat Ecol Evol 1:1285–1291.https://doi.org/10.1038/s41559-017-0248-x

Ali S, Ying L, Shah T, Tariq A, Chandio AA, Ali I (2019) Analysis of the nexus of $CO_2$ emissions, economic growth, land under cereal crops and agriculture value-added in Pakistan using an ARDL approach. Energies. https://doi.org/10.3390/en12234590

Alkire S (2002) Dimensions of human development. World Dev. https://doi.org/10.1016/S0305-750X(01)00109-7

Apergis N, Payne JE (2011) A dynamic panel study of economic development and the electricity consumption-growth nexus. Energy Econ. https://doi.org/10.1016/j.eneco.2010.12.018

Bakari S, Mabrouki M, Elmakki A (2018) The impact of domestic investment in the industrial sector on economic growth with partial openness: evidence from Tunisia. Econ Bull 38(1):111–128

Belford C, Huang D, Ceesay E, Ahmed YN, Jonga RH (2020) Climate change effects on economic growth: mixed empirical evidence. Int J Hum Cap Urban Manag 5(2):99–110. https://doi.org/10.22034/IJHCUM.2020.02.02

Bond S, Leblebicio-Lu A, Schiantarelli F (2010) Capital accumulation and growth: a new look at the empirical evidence. J Appl Econom 25(7):1073–1099

Reinert ES (2016) Giovanni Botero (1588) and Antonio Serra (1613): Italy and the birth of development economics. In: Reinert ES, Ghosh J, Kattel R (eds) Handbook of alternative theories of economic development, Edward Elgar Publishing, pp 3–41

Cederborg J, Snöbohm S (2016) Is there a relationship between economic growth and carbon dioxide emissions? Economic

Ceesay E (2020) Employment in agriculture, migration, bilateral aids, economic growth and remittance: evidence from the Gambia. Econ Manag Sustain. https://doi.org/10.14254/jems.2020.5-1.5

Ceesay EK, Belford C, Fanneh MM, Drammeh H (2019) Relationship between export, imports and economic growth: an export-led growth strategy for the Gambia using the Granger causality test. Int J Soc Sci Perspect. https://doi.org/10.33094/7.2017.2019.42.38.47

Ceesay EK, Belford C, Fanneh MM, Kargbo A, Yaffa S (2021) Testing the environmental Kuznets curve in selected West African countries: empirical evidence estimation. Afr J Econ Sustain Dev 8(1):35–50

Chabbi HE (2010) Agriculture and economic growth in Tunisia. China Agric Econ Rev 2:63–78

Dell M, Jones BF, Olken BA (2008) Climate change and economic growth: evidence from the last half century. Working Paper 14132, NBER Working Paper Series. http://www.nber.org/papers/w14132

FAO (2017) FAO Publications Catalogue 2017. Food and Agriculture Organization of the United Nations

FAO, IFAD, UNICEF, WFP, WHO (2019) The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns. In: the state of the world. https://doi.org/10.26596/wn.201910395-97

Goshu D, Yimer M (2017) The dynamics of food security in sub-Saharan Africa. Int J Sci Technol Res 6(9)

Granger CWJ (1988) Causality, cointegration, and control. J Econ Dyn Control. https://doi.org/10.1016/0165-1889(88)90055-3

Herrerias M (2010) The causal relationship between equipment investment and infrastructures on economic growth in China. Front Econ China (sprInger; Higher Education Press) 5(4):509–526

Keho Y (2017) The exports and economic growth nexus in Cote D'ivoire: evidence from a multivariate time series analysis. Asian J Econ Model 5(2):135–146

Lee YK, Kim YS, Lee KH, Li D-X (2012) The impact of CSR on relationship quality and relationship outcomes: A perspective of service employees. Int J Hosp Manag 31(3):745–756. https://doi.org/10.1016/j.ijhm.2011.09.011

Loum A, Fogarassy C (2015) The effects of climate change on cereals yield of production and food security in Gambia. Appl Stud Agribus Commer 9(4):1–10. https://doi.org/10.22004/ag.econ.226130
Manap NMA, Ismail NW (2019) Food security and economic growth. Int J Mod Trends Soc Sci 2(8):108–118. https://doi.org/10.35631/IJMTSS.280011
Menegaki AN (2019a) The ARDL method in the energy-growth nexus field; best implementation strategies. Econ MDPIpp Open Access J 7(4):1–16
Menegaki AN (2019b) The ARDL method in the energy-growth nexus field; best implementation strategies. Economies. https://doi.org/10.3390/economies7040105
Nida F, Roshan R, Sandesh S (2018) Density based traffic system with emergency. Int Res J Eng Technol 5:2395–0072
Omri A, Kahouli B (2014) The nexus between foreign investment, domestic capital and economic growth: empirical evidence from the MENA region. Res Econ 68:257–263
Patrick SS (2009) A study of food insecurity and rural development in the Gambia: the impact of rural weekly markets (Lumos). In: proQuest dissertations and theses
Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Econom. https://doi.org/10.1002/jae.951
Pesaran MH, Shin Y (1999) An autoregressive distributed lag modelling approach to cointegration analysis. In: Econometrics and economic theory in the 20th century, The Ragnar Frisch Centennial Symposium
Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. J Appl Econom. https://doi.org/10.1002/jae.616
Shrestha M, Chowdhury K (2005) ARDL modelling approach to testing the financial liberalisation hypothesis. Econ Work Pap
Sillah B (2013) Agriculture and growth nexus in Gambia. J Econ Financ Stud. https://doi.org/10.18533/jefs.v1i01.33
Thursby JG, Schmidt P (1977) Some properties of tests for specification error in a linear regression model. J Am Stat Assoc. https://doi.org/10.1080/01621459.1977.10480627
Tiba S, Omri A (2017) Literature survey on the relationships between energy, environment and economic growth. Renew Sustain Energy Rev 69:1129–1146

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