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تقييم المخاطر المحتملة للتغيرات المناخية على الأمن الغذائي في دول حوض النيجر بإستخدام بانل ARDL

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Potential Impact Assessment of Climate Change on Food Security in Niger Basin Countries using Panel ARDL Analysis

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تقييم المخاطر المحتملة للتغيرات المناخية على الأمن الغذائي فى دول حوض النيجر بإستخدام بانل ARDL

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الملخص

هدفت هذه الورقة البحثية إلى دراسة تأثير تغير المناخ على الأمن الغذائي فى ٩ دول أفريقية فى حوض النيجر. قامت بجمع البيانات من مؤشرات التنمية العالمية خلال الفترة ١٩٩٠-٢٠٢١. ونظرت فى كيفية تأثير تغير المناخ على الأبعاد الأربعة للأمن الغذائي (توافر الغذاء، وإمكانية الوصول إلى الغذاء، واستخدام الغذاء، واستقرار الغذاء) فى دول حوض النيجر من خلال أربعة نماذج قياسية. تم تطبيق تقدير المربعات الصغرى العادية لبيانات البانل، واستخدم اختبار جذر وحدة لبيانات البانل بالاعتماد على اختبار Fisher-ADF، ثم تم تقدير متوسط المجموعة (PMG) لنماذج الإبطاء الزمنى الموزع لبيانات البانل panel ARDL فى النماذج الأربعة فى المدى الطويل، والمدى القصير، والتكامل المشترك على مستوى الدول.

أشارت النتائج إلى أن تغير المناخ أثر على الأبعاد الأربعة للأمن الغذائي فى دول حوض النيجر. وفيما يتعلق بتوافر الغذاء، يُعتقد على نطاق واسع أن تغير المناخ يقلل من غلات المحاصيل. فضلاً عن آثار الأحداث المناخية المتطرفة على إمكانية الوصول إلى الغذاء. قد تؤدي التغيرات فى أنظمة الإنتاج الناجمة عن تغير المناخ إلى تغيرات لاحقة فى الأنماط الغذائية واستخدام الغذاء. وسيؤثر تغير المناخ أيضًا على استقرار النظم الغذائية وقدرتها على الصمود.

لم تختبر هذه الورقة تأثير تغير المناخ على دول حوض النيجر كمجموعة فحسب، بل اختبرت أيضًا تأثيره على مستوى الدول. وقد تم التوصل إلى أن التغيرات المناخية لها تأثيرات متفاوتة عبر دول الحوض.

الكلمات المفتاحية: حوض النيجر، تغير المناخ، الأمن الغذائي، اختبارات التكامل المشترك، بانل ARDL

Potential Impact Assessment of Climate Change on Food Security in Niger Basin Countries using Panel ARDL Analysis

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Abstract

This paper aimed at investigating the impact of climate change on food security in 9 African countries in Niger Basin. It collected data from World Development Indicators (WDI), over the period of 1990–2021. It looked at how climate change affected the four dimensions of food security (food availability, food accessibility, food utilization, and food stability) in Niger Basin countries through four econometric models. The paper applied Panel Ordinary least squares estimate, utilized the panel unit root test using Fisher-ADF test, then estimated the pool mean group (PMG) panel autoregressive distributed lag (ARDL) in the four models in the long run, short run and the cointegrating term at a country level.

Results indicated that climate change affected the four dimensions of food security in Niger Basin countries. For food availability, climate change is widely believed to reduce crop yields. as well as the impacts of extreme climate events on food accessibility. The changes in production systems induced by climate change may cause consequent changes in dietary patterns and food utilization. Climate change will also influence the stability and resilience of food systems.

This paper has not only tested the impact of climate change on the Niger Basin countries as a group, but also it tested its effect at the country level. It has been concluded that the climatic variables have varying effects across the countries of the Basin.

Keywords: Niger Basin, climate change, food security, cointegration tests, panel ARDL.

Introduction

The Niger River originates in the Guinea highlands and flows 4,200 km through the humid tropical regions of Mali and Niger to the Niger delta in Nigeria; it is considered the third longest river in Africa (Goulden and Few, 2011).

The Niger River Basin (NRB) is situated in the West and Central Africa and covers 7.5% of the African continent (2.13 million km^2). Benin, Burkina Faso, Cameroon, Chad, Cote d'ivoire, Guinea, Mali, Niger, and Nigeria are the nine countries that make up its basin. Seven out of the nine basin countries were ranked among the world's 20 poorest. Most of them cope with challenging climatic conditions and fast population growth (The Water, Energy & Food Security Resource Platform, 2018).

A variety of livelihood strategies are used by the people in the basin, comprising fishing, crop-livestock systems, pastoral systems, and dry- and wet-season cropping systems. Every country in the Niger Basin undergoes severe poverty; most of poverty indicators, such as the Human Development Index [HDI], life expectancy, child mortality, and Social Vulnerability Index, classify them as "poor" (Namara, et al, 2011).

Its population is rapidly increasing. Nigeria, Mali, and Niger account for nearly 90% of the basin's population. The three countries encompass almost 76% of the basin's total area. Except for Nigeria, most of the basin's population is rural and depends mainly on agriculture, animal husbandry, or fishing for a living; nevertheless, urbanization is increasingly proceeded (World Bank, 2015).

Based on the Intergovernmental Panel on Climate Change (IPCC) Niger Basin has been identified as one of the world's most vulnerable regions to climate change. The main reasons are that seven of the nine countries experience frequent droughts, have a high reliance on natural resources, high population growth and have fragile institutions. (The Water, Energy & Food Security Resource Platform, 2018). The Basin also suffers from a significant adaptation deficit, with national and local governments poorly capable of mitigating the future environmental risk impacts of climate changes (World Bank, 2015).

The importance of this research paper is clearly evident from the climatic change events associated with deleterious influence on food security in Niger Basin countries. The problem statement is that Niger Basin has been identified as one of the most regions susceptible to climate change; this has been reflected on the food security status.

The research paper aims at assessing the potential risk impact of climate change phenomenon on the inconstancy of food security in Niger Basin countries. The research methodology is provided via inductive method and the application of Panel ARDL Analysis. The hypothesis of the research is that Climate change reveals a potential impact on food security dimensions in Niger Basin countries.

The research paper will be divided into four sections which are: literature review, estimating Panel ARDL with PMG, Empirical Results and Discussion, conclusions and recommendations.

2. Literature Review

2.1 Relationship between climate change and food security pillars

More than one in five Africans experienced hunger in 2020, which is more than twice as many as in any other region. The population of Africa is undernourished to a total of 282 million. Due to a combination of factors including drought, poverty, high food import prices, environmental degradation, displacement, inadequate trade integration, and conflict, almost 17 million people in West Africa alone needed emergency food assistance in 2020 (Verkooijen, 2021).

Climate Change is defined by the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCC) as any change in climate over time, either caused by natural disasters or by human intervention activity, that alters the constituents of the global atmosphere (Antwi, 2013). Also, climate change can be acknowledged as the slow fluctuations in the composition of the global atmosphere induced by diverse human activities and climate alterations over time (ACAPS, 2022).

On the other hand, food security was defined by the World Food Summit in 1996 as "access to sufficient, safe, nutritious food at all times to maintain a healthy and active life." Food security is commonly defined as both physical and economic access to food that meets people's dietary needs as well as their food preferences (El-ladan, 2014). Food security is built on four key components: availability, accessibility, stability, and utilization, all of which are interdependent (Zahid, 2022).

Many reports of the Food and Agricultural Organization (FAO) revealed that the major causative factors of food insecurity in the world are climate change, national economy, and conflict (Ani, et al, 2021). The relationship between climate change and food security has become more distinctive in 2015 after the United Nations endorsed the Sustainable Development Goals (SDGs). These seventeen Sustainable

Development Goals (SDGs) addressed economic, environmental, and social aspects of a sustainable future. Although SDG 2 focused on ending hunger, it also involved issues emphasized on sufficient, safe, and nutritious food for all people at all times by 2030. Hunger results in the deterioration of health, human capital, environmental and socioeconomic issues. As a result, the achievement of SDG 2 was partially dependent upon the accomplishment of other goals (Zahid, 2022).

Through rising temperatures, varying precipitation patterns, and an increase in extreme weather events like droughts and floods, climate change is harming food security. Future climate change is expected to have an increasing impact on food security and agricultural productivity. The four pillars of food security—availability, access, utilization, and stability—are anticipated to suffer from climate change (American University, IOM Chad, and Food Security Cluster, 2021).

The supply side of food security, food availability, refers to the actual presence of food, whether from a household's own production or from markets, including commercial food imports and food aid. (Sisa, 2014) Climate change reduces food availability by decreasing crop yields, livestock productivity, and fish production. In Niger Basin countries, the potential future climate impacts on crop yields are expected to increase due to higher temperature and rainfall fluctuations and their negative role in lowering crop yields (El Bilali, 2021).

Food access refers to a household's ability to obtain food for a nutritious diet through a combination of production, purchase, gifts, and transfers, which is related to food demand. Climate change is expected to have an impact on food economic accessibility by affecting both food prices and livelihoods. Climate change may raise food prices while decreasing how people can obtain food. Food price increases would result from food supply shortages caused by the negative effects of climate change. Such increases in food prices are especially harmful to millions of low-income people in the Niger Basin (World Food Programme, 2022).

Utilization describes how well people make use of the food they have access to, including their capacity to absorb nutrients and consume enough energy and nutrients. Disease and unhygienic conditions can have an impact on a person's ability to absorb nutrients. Climate variability is expected to have an impact on food utilization by affecting the nutrition status and health of the population. Droughts and water scarcity, for example, may have an impact on water quality and hygiene, increasing the disease burden, particularly among poor children (Skah, Lyammouri, 2020).

Climate change influences food availability, access, and utilization implying that it will also have an impact on the stability of food security. Indeed, climate change will have an impact on both the elements (such as water and soil) and activities (such as production, processing, distribution, and consumption) of the food system, affecting both its current functioning and performance as well as its long-term stability and resilience (Schmidt, Muggah, 2021).

2.2 Empirical Studies

The purpose of Oyelami, et al, (2023) study was to investigate the relationship between climate change, institutional quality, and food security (food availability and accessibility) in Sub-Saharan Africa. To achieve the study's goal, data were collected from 26 different

African countries. The data, which included 16 variables, covered the years 1996 to 2020. Cross Sectional - Autoregressive Distributed Lag (CS-ARDL) was used in the study. The obtained results verified the critical role of climate change in regional food sustainability. However, evidence suggests that institutional quality plays a minor role in accomplishing food security.

The paper of Pickson, et al, (2023) investigated the effects of climatic conditions on cereal farming in 18 African countries from 1970Q1 to 2017Q4. using panel econometrics. Results exhibited that rainfall positively affected cereal crops, although average temperatures were typically unfavorable. In the country-specific scenarios, the study observed significant variations in the influence of climatic conditions on cereal production.

The study of Affoh et al, (2022) examined the relationship between temperature, rainfall, and the triple dimension of food security (utilization, accessibility, and availability) in a panel of 25 sub-Saharan African nations between 1985 and 2018. The study estimated the panel autoregressive distributed lag (ARDL) for the pool mean group (PMG) after testing for cointegration, cross-sectional dependence, and unit root. The empirical results showed that, in the long run, rainfall significantly improved food availability, accessibility, and utilization. Temperature, on the other hand, had no effect on food consumption but was detrimental to food accessibility and availability.

Fusco, (2022) carried out a study using a panel data analysis in order to assess the impact of climate change on the level of food security in the Northern and Eastern African countries from 2000 to 2012. The two different indicators of food security were average protein supply and average dietary energy supply. Food security determinants were expressed as a function of rainfall, temperature, land area under cereal production, population size, and GDP. According to the findings, climate change possessed a negative impact on food security in the Northern and Eastern African countries.

The study of Adesete, et al, (2022) investigated the relationship between climate change and food security in 30 Sub-Saharan African countries. The one-step and two-step system generalized method of moments (GMM) models were used in the study's dynamic panel data analysis. The time ranged from 2000 to 2019. According to the study, an increase in greenhouse gas emissions would result in an increase in the prevalence of malnourishment, causing a decrease in food security in SSA. Furthermore, climate change and food prices had a negatively significant impact on food security in SSA, whereas income and food supply exhibited a positively significant impact.

The paper of El Bilali, (2021) examined the state of research in Burkina Faso on the relationship between climate change and food security. It looked at how climate change affects the four dimensions of food security (food availability, food access, food utilization, and food stability). According to the literature, climate change will have an impact on all four dimensions of food security.

The paper of Charlemagne, Sheïtan, (2021) investigated the effect of climate change on cereal yield in Burkina Faso. From 1991 to 2016, the ordinary least squares (OLS) regression model was used to analyze time series data. The results showed that temperature had a negative effect on yield and cereal production, whereas precipitation indicated a positive effect. Furthermore, carbon dioxide emissions had no effect on yield and cereal production.

The paper of Hanif, et al, (2019) aimed to examine the effects of macroeconomic variables and the environment on food security in developing countries. Panel data ranges from 1993 to 2016 were taken. The Pool Mean Group model (PMG) was then applied after checking stationery with LLC and IPS. The Food Production index serves as a proxy for food security. Gross Domestic Product (GDP) and population clearly revealed a positive impact on the food production index, whereas CO_2 and combustible renewable wastes (CRW) showed a negative impact.

The paper of Belloumi, (2014) investigated the effect of climate variables (precipitation and temperature) on food security indicators from 1961-2011 for ten Eastern and Southern African countries by estimating fixed effects models. Food security was approximated by three indicators: food production index, mortality rate of people under five years of age, and life expectancy at birth. The results pointed out that GDP per capita, inflation, population growth, and land under cereal production were significant in explaining food security indicators. For climate variables, overall rainfall had a positively and significant effect on food security, whereas the effect of temperature was negative.

3. Estimating Panel ARDL with PMG

3.1 Model equation

$$\Delta y_{it} = \sum_{k=1}^{p-1} \lambda_{ik}^{*} \Delta y_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta x_{i,t-k} + \varphi_i \left(y_{i,t-1} + \beta_i' x_{it} \right) + \omega_i + \varepsilon_{it} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

Long run coefficients (β_i') same across groups (i.e., cross- sections)

Short run (δ_{ik}') and cointegrating (φ_i) coefficients vary across groups.

PMG: pooled mean group $\beta_i', \lambda_{ik}^{*}, \delta_{ik}'$ vary across groups.

3.2 Availability panel ARDL model is as follows:

$$\begin{aligned}\Delta cy_{it} = & \sum_{k=1}^{p-1} \lambda_{ik}^{*} \Delta cy_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Tem_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pre_{i,t-k} \\ & + \sum_{k=0}^{q-1} \delta_{ik}' \Delta GDP_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Lc_{i,t-k} + \varphi_i (cy_{i,t-1} + \beta_i' Tem_{it}) \\ & + \varphi_i (cy_{i,t-1} + \beta_i' Pre_{it}) + \varphi_i (cy_{i,t-1} + \beta_i' GDP_{it}) \\ & + \varphi_i (cy_{i,t-1} + \beta_i' Lc_{it}) + \omega_i + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)\end{aligned}$$

Where:

Cy: Cereal yield (kg per hectare)

Tem: Mean Temperature (°C)

Pre: Precipitation (mm)

GDP: GDP per capita (constant 2015 US$)

Lc: Land under cereal production (hectares)

3.3 Accessibility panel ARDL model is as follows:

$$\begin{aligned}\Delta Price_{it} = & \sum_{k=1}^{p-1} \lambda_{ik}^{*} \Delta Price_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Tem_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pre_{i,t-k} \\ & + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Lc_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pop_{i,t-k} + \varphi_i (Price_{i,t-1} + \beta_i' Tem_{it}) \\ & + \varphi_i (Price_{i,t-1} + \beta_i' Pre_{it}) + \varphi_i (Price_{i,t-1} + \beta_i' Lc_{it}) \\ & + \varphi_i (Price_{i,t-1} + \beta_i' Pop_{it}) + \omega_i + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)\end{aligned}$$

Where:

Price: Consumer food Price (2015=100)

Tem: Mean Temperature (°C)

Pre: Precipitation (mm)

Lc: Land under cereal production (hectares)

Pop: Population growth (annual %)

3.4 Utilization panel ARDL model is as follows:

$$\Delta Mor_{it} = \sum_{k=1}^{p-1} \lambda_{ik}^{*} \Delta Mor_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Tem_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pre_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta GDP_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pop_{i,t-k} + \varphi_i\left(Mor_{i,t-1} + \beta_i' Tem_{it}\right) + \varphi_i\left(Mor_{i,t-1} + \beta_i' Pre_{it}\right) + \varphi_i\left(Mor_{i,t-1} + \beta_i' GDP_{it}\right) + \varphi_i\left(Mor_{i,t-1} + \beta_i' Pop_{it}\right) + \omega_i + \varepsilon_{it} \quad \ldots (4)$$

Where:

Mor: Mortality rate, under-5 (per 1,000 live births)

Tem: Mean Temperature (°C)

Pre: Precipitation (mm)

GDP: GDP per capita (constant 2015 US$)

Pop: Population growth (annual %)

3.5 Stability panel ARDL model is as follows:

$$\Delta Agri_{it} = \sum_{k=1}^{p-1} \lambda_{ik}^{*} \Delta Agri_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Tem_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pre_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta GDP_{i,t-k} + \sum_{k=0}^{q-1} \delta_{ik}' \Delta Pop_{i,t-k} + \varphi_i\left(Agri_{i,t-1} + \beta_i' Tem_{it}\right) + \varphi_i\left(Agri_{i,t-1} + \beta_i' Pre_{it}\right) + \varphi_i\left(Agri_{i,t-1} + \beta_i' GDP_{it}\right) + \varphi_i\left(Agri_{i,t-1} + \beta_i' Pop_{it}\right) + \omega_i + \varepsilon_{it} \quad \ldots (5)$$

Where:

Agri: Agriculture, forestry, and fishing, value added (constant 2015 US$)

Tem: Mean Temperature (°C)

Pre: Precipitation (mm)

GDP: GDP per capita (constant 2015 US$)

Pop: Population growth (annual %)

4 Empirical Results and Discussion

4.1 Stationary of Cross-sectional time-series

In the following, the stationary of the variables in the four models were tested by using Fisher-type test using ADF (Maddala and Wu ,1999). The only deterministic term in a unit-root test based on a Dickey-Fuller regression is a fixed intercept. Assuming that data-generation process includes a broken linear trend. It is demonstrated theoretically and empirically that, depending on the nature and location of the break, the Dickey-Fuller test can exhibit a wide range of different characteristics under the I (1) null and I (0) alternative hypotheses (Kim, et al, 2004).

So, before knowing if the data is stationary and doesn't need to be differenced, there is a need to determine if there is a trend or intercept (Barreira, Rodrigues,2005). EVIEWS allows all these options with the Panel Ordinary least squares estimate.

Table No. 1: Intercept and Trend test using Panel Least Squares

AGRI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.10E+09	2.53E+09	0.828433	0.4081
@TREND	5.09E+08	1.40E+08	3.625638	0.0003
TEM				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	27.10845	0.161611	167.7385	0.0000
@TREND	0.021939	0.008958	2.449171	0.0149
PRE				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	926.0039	64.82169	14.28540	0.0000
@TREND	2.092169	3.592898	0.582307	0.5608
POP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.933032	0.059752	49.08637	0.0000
@TREND	-0.000529	0.003312	-0.159753	0.8732
GDP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	756.2434	65.18008	11.60237	0.0000
@TREND	14.64060	3.612763	4.052468	0.0001
MOR				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	210.6011	3.188072	66.05908	0.0000
@TREND	-4.032843	0.176707	-22.82226	0.0000
LC				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3495975.	591415.7	5.911198	0.0000
@TREND	68668.67	32780.64	2.094794	0.0371
CERIAL				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	922.0138	49.30565	18.69996	0.0000
@TREND	16.67266	2.732884	6.100755	0.0000
PRICE				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	38.26640	2.645172	14.46651	0.0000
@TREND	2.548371	0.146615	17.38138	0.0000

Source: Prepared by the researcher based on EViews 13

The results shown in table No. (1) were obtained by using Panel Ordinary Least Squares estimates on the variables employed in the four models. As for TEM, GDP, MOR, LC, CERIAL and PRICE variables, Constant and trend were significant so, individual intercept and trend were chosen. For AGRI variable trend was significant so, individual intercept and trend are chosen. For PRE and POP variables individual intercept was significant so, individual intercept was chosen.

Table No. 2: Panel unit root test using Fisher-ADF test

AGRI			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	18.0471	0.4526	Not stationary at level
ADF – Choi Z-stat	1.95219	0.9745	
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	85.0025	0.0000***	Stationary at first difference
ADF – Choi Z-stat	-6.44046	0.0000***	
TEM			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	61.9711	0.0000***	Stationary at level
ADF – Choi Z-stat	-5.29499	0.0000***	
PRE			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	87.5650	0.0000***	Stationary at level
ADF – Choi Z-stat	-7.11900	0.0000***	
POP			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	67.1836	0.0000***	Stationary at level
ADF – Choi Z-stat	-4.78523	0.0000***	
GDP			
Method	Statistic	Prob.	Decision

ADF – Fisher Chi square	20.8034	0.2894	Not stationary at level
ADF – Choi Z-stat	1.06247	0.8560	
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	45.8972	0.0003***	Stationary at first difference
ADF – Choi Z-stat	-3.76442	0.0001***	
MOR			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	148.199	0.0000***	Stationary at level
ADF – Choi Z-stat	-8.41154	0.0000***	
LC			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	13.7334	0.7463	Not stationary at level
ADF – Choi Z-stat	0.48836	0.6874	
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	88.6716	0.0000***	Stationary at first difference
ADF – Choi Z-stat	-6.68001	0.0000***	
CERIAL			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	31.9328	0.0224**	Stationary at level
ADF – Choi Z-stat	-1.78279	0.0373**	
PRICE			
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	7.45210	0.9857	Not stationary at level
ADF – Choi Z-stat	5.63484	1.0000	
Method	Statistic	Prob.	Decision
ADF – Fisher Chi	36.5076	0.0061***	Stationary at first difference
ADF – Choi Z-stat	-1.26665	0.0026***	

Source: Prepared by the researcher based on Eviews 13

***** (1%), and ** (5%) significance levels.**

The results obtained in table No. (2) referred to the unit root test based on Fisher-ADF test. Conspicuously, it could be concluded that all the variables of the four models were stationary at level, except for AGRI, GDP, LC, PRICE variables which were not stationary at level and stabilized when the first difference was taken; therefore, all the variables, in the four models, were integrated at degree I (0) or I (1).

4.2 Estimation of the Availability model

Table No. (3): Results of the availability model in the long run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TEM	-147.6665	70.94449	-2.081437	0.0401**
PRE	-1.134498	0.215149	-5.273084	0.0000***
GDP	0.424264	0.067162	6.317058	0.0000***
LC	1.26E-05	1.84E-05	0.684904	0.0051***

Source: Prepared by the researcher based on EViews 13

***** (1%), and ** (5%) significance levels.**

Table No. (3) displayed the long-run availability model results, which indicated that all the variables were significant at 99 % level, except for TEM which was significant at 95 % level. Climate change variables (TEM, PRE) revealed a negative impact on Cereal yield, while the impact of GDP and LC variables was positive on Cereal yield.

Table No. (4): Results of the availability model in the short run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.267180	0.077938	-3.428124	0.0009
D(CERIAL(-1))	-0.300650	0.139198	-2.159870	0.0333
D(CERIAL(-2))	-0.009989	0.160863	-0.062095	0.9506
D(CERIAL(-3))	-0.006001	0.178863	-0.033552	0.9733
D(TEM)	0.834970	36.35952	0.022964	0.9817
D(TEM(-1))	3.406370	68.73160	0.049560	0.9606
D(TEM(-2))	22.16972	30.59417	0.724639	0.4705
D(TEM(-3))	-3.373323	28.17436	-0.119730	0.0049
D(PRE)	0.040290	0.259490	0.155268	0.8769
D(PRE(-1))	-0.523593	0.165571	-3.162355	0.0021
D(PRE(-2))	-0.556946	0.339245	-1.641724	0.1040
D(PRE(-3))	-0.422521	0.221455	-1.907932	0.0594
D(GDP)	0.884725	1.109079	0.797712	0.4270
D(GDP(-1))	1.309346	1.323448	0.989345	0.0250
D(GDP(-2))	-1.330643	1.078532	-1.233754	0.2203
D(GDP(-3))	1.985748	1.456311	1.363546	0.1759
D(LC)	-7.67E-05	9.83E-05	-0.780903	0.4368
D(LC(-1))	6.14E-05	3.98E-05	1.541421	0.0265
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LC(-2))	-2.34E-05	5.86E-05	-0.399489	0.6904
D(LC(-3))	-5.30E-05	8.88E-05	-0.596887	0.5520
C	1033.209	288.4831	3.581525	0.0005

Root MSE	50.51010		
S. D. dependent var	126.8957	Mean dependent var	15.92262
Akaike info criterion	10.23752	S.E. of regression	87.94531
Schwarz criterion	12.69221	Sum squared resid	734765.9
Hannan-Quinn criter.	11.22121	Log likelihood	-1281.203

Source: Prepared by the researcher based on EViews 13

The results presented in table No. (4) showed that in the short term, the cointegrating term (error correction factor) with a value of 0.267 which was negatively significant, exhibiting a convergence Short-term to long-term balance, which measures the imbalance in Cereal yield that can be adjusted from year to year. In other words, when the Cereal yield values deviate through the short term in t-1 from their long-term equilibrium value, the equivalent of 0.267 per cent of this deviation in t period is corrected, and the error correction factor reflects how fast the adjustment is to balance expressing the model's long-term return to equilibrium. Therefore, the cointegrating term reflects how fast the adjustment is to balance. It indicates the statistical incoherence of the parameters of the model and reflects the relative persistence of the long-term error, which designates a dynamic relationship in the short term between the independent variables and dependent variable.

Table No. (5): Results of the cointegrating term at a country level

Benin				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.078887	0.004022	-19.61571	0.0003
Burkina Faso				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.152634	0.043375	-3.518945	0.0389
Cameron				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.492099	0.021524	-22.86327	0.0002
Chad				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.202145	0.019440	-10.39857	0.0019
Côte d'Ivoire				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.146591	0.008678	-16.89274	0.0005
Guinea				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.079482	0.003729	21.31451	0.0002
Mali				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.251756	0.013283	-18.95334	0.0003
Niger				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.620583	0.028547	-21.73930	0.0002
Nigeria				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.539405	0.060922	-8.853982	0.0030

Source: Prepared by the researcher based on EViews 13

The results obtained in table No. (5) referred to the cointegrating terms at a country level. Obviously, it could be concluded that the cointegrating term for all countries were negatively significant except for Guinea.

The source of the Niger River is in the mountains of Guinea in an area with very high rainfall. It then flows northeast through areas with declining rainfall, passing through the Inner Delta in the Sahel (kerres, 2010). Guinea is one of the countries that depends on the Niger River. It is expected that there will be a severe down trend in the rainfall and the water availability because of climate change. So, there would be a decline in water for irrigation purposes, and food availability in Guinea (Seidou, et al, 2020).

4.3 Estimation of the Accessibility model

Table No. (6): Results of the Accessibility model in the long run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TEM	9.683743	2.161439	4.480230	0.0000 ***
PRE	0.125248	0.023726	5.278916	0.0000 ***
POP	3.652808	1.386296	2.634941	0.0098 ***
LC	9.91E-06	4.54E-07	21.85476	0.0000 ***

Source: Prepared by the researcher based on EViews 13
***** (1%), and ** (5%) significance levels.**

Results of the Accessibility model in the long run are shown in table No. (6) and indicated that all variables were significant at 99% level. In addition, there was a positive impact of climate variables (TEM, PRE) on Consumer food Price.

Table No. (7): Results of the Accessibility model in the short run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.180363	0.181244	-0.995140	0.0022
D(PRICE(-1))	0.287961	0.273890	1.051378	0.2958
D(PRICE(-2))	0.445502	0.224847	1.981359	0.0504
D(PRICE(-3))	-0.141967	0.184557	-0.769227	0.4437
D(TEM)	0.262545	2.279212	0.115191	0.9085
D(TEM(-1))	1.988660	2.014860	0.986997	0.3262
D(TEM(-2))	1.900110	1.676443	1.133417	0.2599
D(TEM(-3))	1.227226	2.076174	0.591100	0.5559
D(PRE)	-0.012832	0.014185	-0.904630	0.3680
D(PRE(-1))	-0.006829	0.010538	-0.648047	0.5185
D(PRE(-2))	0.010013	0.007655	1.308015	0.1940
D(PRE(-3))	0.011773	0.006904	1.705316	0.0914
D(POP)	20.17846	12.26917	1.644648	0.1033
D(POP(-1))	-8.307396	6.738360	-1.232851	0.2207
D(POP(-2))	-4.034055	13.41626	-0.300684	0.7643
D(POP(-3))	-0.107074	6.389442	-0.016758	0.9867
D(LC)	4.05E-06	5.95E-06	0.680800	0.4977
D(LC(-1))	-2.48E-06	4.33E-06	-0.572497	0.5683
D(LC(-2))	-2.06E-06	5.69E-06	-0.361443	0.7186
D(LC(-3))	-2.72E-07	2.93E-06	-0.092595	0.9264
C	-37.63318	64.00630	-0.587961	0.5580

Root MSE	1.575313		
S. D. dependent var	6.339447	Mean dependent var	3.087183
Akaike info criterion	4.459735	S.E. of regression	2.742845
Schwarz criterion	6.914428	Sum squared resid	714.7038
Hannan-Quinn criter.	5.443428	Log likelihood	-4991.415

Source: Prepared by the researcher based on EViews 13

Table No. (7) showed the results in the short term, the cointegrating term (error correction factor) with a value of 0.18 was negatively significant, indicating a convergence short-term to long-term balance. This trend meas ures the imbalance in Consumer food Price that can be adjusted from one year to another. In other words, when Consumer Food Price values deviate from their long-term equilibrium value in t-1 over the short term, the equivalent of 0.18 percent of this deviation is corrected in t period, and the error correction factor reflects how fast the adjustment is to balance, expressing the model's long-term return to equilibrium. Consequently, the cointegrating term reflects how quickly the adjustment to balance occurs. It demonstrates the statistical incoherence of the model's parameters and denotes the relative persistence of the long-term error, indicating a dynamic relationship between the independent variables and the dependent variable in the short term.

Table No. (8): Results of the cointegrating term at a country level

Benin				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.069551	0.000941	-73.93483	0.0000
Burkina Faso				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.171275	0.012481	-13.72325	0.0008
Cameron				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.023886	0.000309	77.35187	0.0000
Chad				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.599335	0.006403	-93.60364	0.0000
Côte d'Ivoire				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.192503	0.010342	18.61301	0.0003
Guinea				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.641854	0.007677	83.60307	0.0000
Mali				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.487550	0.007726	-63.10371	0.0000
Niger				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-1.252034	0.068857	-18.18314	0.0004
Nigeria				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.098237	0.001057	-92.91414	0.0000

Source: Prepared by the researcher based on EViews 13

The results obtained in table No. (8) referred to cointegrating term at a country level. Clearly, it could be concluded that the cointegrating term for all countries were negatively significant except for Cameron and Guinea.

Climate predictions in Cameron indicate a temperature increase of 0.7° C by 2025. The other non-cumulative increases expected by 2100 are: 1.2° C in 2035, 2.5° C in 2055, 3.6° C in 2075, and 4.8° C in 2100. These increases are thought to be the most direct result of global warming. A relative increase in precipitation is expected in the Far North, though the magnitude is unknown. Global warming will reduce crop yields, decrease livestock productivity, and cause water shortages in the Far North, which is particularly vulnerable to drought, desertification, and flooding. Extreme weather and climate events, such as droughts and floods, are anticipated to become more common in Cameroon, with negative consequences for human health and life (Lamarche, 2023).

As for Guinea, since it depends mainly on the Niger River, it is expected that negative impacts of climate change through severe down trend in the rainfall, would be more severe on food accessibility in Guinea. (Baptista, et al, 2023).

4.4 Estimation of the Utilization model

Table No. (9): Results of the Utilization model in the long run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TEM	-4.724916	19.39684	-0.243592	0.0081***
PRE	0.167594	0.083303	2.011865	0.0471**
POP	-56.42058	7.538360	-7.484464	0.0000***
GDP	-0.079145	0.016188	-4.889033	0.0000***

Source: Prepared by the researcher based on EViews 13

***** (1%), and ** (5%) significance levels.**

The Utilization model analysis in the long run is shown in table No. (9). Evidently, all variables were significant at 99% level except PRE which was significant at 95% level. Simultaneously, there was a negative impact of variables (TEM, POP, GDP) on Mortality rate, under-5, but PRE revealed a positive impact of on Mortality rate, under-5.

Table No. (10): Results of the Utilization model in the short run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.002254	0.003041	-0.741050	0.0005
D(MOR(-1))	1.237184	0.154673	7.998704	0.0000
D(MOR(-2))	-0.198183	0.253532	-0.781690	0.4363
D(MOR(-3))	-0.142867	0.167538	-0.852747	0.3959
D(TEM)	-0.021973	0.134200	-0.163733	0.8703
D(TEM(-1))	0.127495	0.136156	0.936392	0.3514
D(TEM(-2))	-0.076572	0.173746	-0.440714	0.0104
D(TEM(-3))	0.020496	0.134356	0.152553	0.8791
D(PRE)	-0.001114	0.000524	-2.125671	0.0361
D(PRE(-1))	-0.001488	0.000584	-2.545713	0.0125
D(PRE(-2))	0.000139	0.000387	0.358171	0.7210
D(PRE(-3))	-5.25E-06	0.000575	-0.009144	0.9927
D(POP)	-0.489835	0.501295	-0.977140	0.3310
D(POP(-1))	-0.456777	0.579288	-0.788514	0.0324
D(POP(-2))	0.983827	0.898769	1.094639	0.2764
D(POP(-3))	-1.705047	1.272413	-1.340011	0.1834
D(GDP)	0.002109	0.003873	0.544421	0.5874
D(GDP(-1))	-0.007557	0.005883	-1.284703	-0.0020
D(GDP(-2))	0.005330	0.004861	1.096455	0.2757
D(GDP(-3))	0.002159	0.002652	0.814363	0.4175
C	0.606926	1.206937	0.502865	0.6162
Root MSE	0.110336			
S. D. dependent var	2.327108		Mean dependent var	-3.832540
Akaike info criterion	-0.319349		S.E. of regression	0.192110
Schwarz criterion	2.135343		Sum squared resid	3. 506101
Hannan-Quinn criter.	0.664343		Log likelihood	238.9863

Source: Prepared by the researcher based on EViews 13

In the meantime, table No. (10) demonstrated the results in the short term, the cointegrating term (error correction factor) to be approximately 0.002 which was negatively significant, indicating a convergence Short-term to long-term balance, which measures the imbalance in Mortality rate, under-5 that can be adjusted from year to year. Specifically, when Mortality rate, under-5 values deviate from their long-term equilibrium value in t-1 over the short term, the equivalent of 0.002 percent of this deviation is corrected in t period, and the error correction factor reflects the speed of the model's return to equilibrium in the long term. As a result, the cointegrating term reflects how quickly the adjustment to balance is restored. It demonstrates the statistical incoherence of the model's parameters and, the relative persistence of the long-term error, indicating a dynamic relationship between the independent variables and the dependent variable in the short term.

Table No. (11): Results of the cointegrating term at a country level

Benin				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.000812	1.28E-06	636.0722	0.0000
Burkina Faso				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.005526	3.07E-05	180.0861	0.0000
Cameron				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.007961	1.94E-05	409.8274	0.0000
Chad				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.006768	3.96E-06	-1708.768	0.0000
Côte d'Ivoire				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.005800	6.95E-06	-834.1517	0.0000
Guinea				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.002788	4.96E-06	-562.1795	0.0000
Mali				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.018950	1.10E-05	-1727.576	0.0000
Niger				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.009103	1.82E-05	-501.0499	0.0000
Nigeria				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.009380	3.94E-05	-238.2401	0.0000

Source: Prepared by the researcher based on EViews 13

Data attained in table No. (11) exhibited the cointegrating term at a country level. Clearly, it could be deduced that the cointegrating term for all countries were negatively significant except for Benin, Burkina Faso, and Cameron.

A growing body of evidence suggests that climate is changing in West Africa and the Sahel regions. Given the country's reliance on rain-fed agriculture, the economic development of Burkina Faso, a Sahelian and West African countries, is potentially vulnerable to climate change. Burkina Faso is regarded as one of SSA's most vulnerable countries to climate change. Its population is malnourished in all forms. Furthermore, poverty is widespread, with 43.7% of the population living below the poverty line (1.90 USD/day) (Cepero, et al, 2021).

Climate shocks put Benin's agriculture at greater risk and uncertainty because of its strong reliance on weather patterns. Idiosyncratic and covariate shocks are the two types of characteristic shocks. Covariate shocks are universal to all households, so they manifest at the community level, whereas idiosyncratic shocks are unique to each household (e.g., death of the primary wage earner, chronic illness, injury, etc.). Some already impoverished households may become even poorer because of climate shocks. In the absence of policy interventions such as microfinance, insurance, irrigation, etc., they might become extremely risk-overcautious, which would contribute to low production and thus a more destitute (Lokonon, et al, 2015).

4.5 Estimation of the Stability model

Table No. (12): Results of the Stability model in the long run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TEM	-1.63E+09	3.33E+08	-4.883137	0.0000***
PRE	-5800047.	1954636.	-2.967328	0.0038***
POP	39445563	1.23E+08	0.320242	0.0495**
GDP	11446130	965604.4	11.85385	0.0000***

Source: Prepared by the researcher based on EViews 13

***** (1%), and ** (5%) significance levels.**

Results of the Stability model in the long run are shown in table No. (12). They indicated that all the variables were significant at 99% level except POP which was significant at 95% level. Also, there was a negative impact of climate variables (TEM, PRE) on the value added of agriculture, forestry, and fishing, but it was positive with POP and GDP.

Table No. (13): Results of the Stability model in the short run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.035467	0.045926	-0.772266	0.0419
D(AGRI(-1))	-0.163944	0.171071	-0.958341	0.0403
D(AGRI(-2))	0.138791	0.156003	0.889668	0.3759
D(AGRI(-3))	-0.130510	0.254220	-0.513375	0.6089
D(TEM)	21516384	2.56E+08	0.083954	0.9333
D(TEM(-1))	2.91E+08	2.72E+08	1.069234	0.2877
D(TEM(-2))	7.05E+08	5.54E+08	1.273154	0.2061
D(TEM(-3))	-3.24E+08	1.77E+08	-1.824398	0.0112
D(PRE)	2708753.	1880119.	1.440735	0.1529
D(PRE(-1))	-1847203.	1261491.	-1.464301	0.0464
D(PRE(-2))	-3834866.	3686860.	-1.040144	0.3009
D(PRE(-3))	-1448358.	2578559.	-0.561693	0.5756
D(POP)	4.06E+09	3.60E+09	1.126364	0.2628
D(POP(-1))	-2.59E+09	2.84E+09	-0.912592	0.3638
D(POP(-2))	-1.85E+08	9.05E+08	-0.203922	0.8389
D(POP(-3))	1.77E+09	1.79E+09	0.988056	0.0256
D(GDP)	10214328	6044653.	1.689812	0.0243
D(GDP(-1))	-931793.6	4186375.	-0.222578	0.8243
D(GDP(-2))	866001.8	1809602.	0.478559	0.6334
D(GDP(-3))	-1301579.	3172608.	-0.410255	0.6825
C	1.60E+09	2.07E+09	0.772715	0.4416
Root MSE	6.13E+08			
S. D. dependent var	1.58E+09		Mean dependent var	4.89E+08
Akaike info criterion	36.00288		S.E. of regression	1.07E+09
Schwarz criterion	38.45757		Sum squared resid	1. 08E+20
Hannan-Quinn criter.	36.98658		Log likelihood	-4991.415

Source: Prepared by the researcher based on EViews 13

Table No. (13) illustrated the short-term results of the stability model, the cointegrating term (error correction factor), with a value of 0.035 was negatively significant, demonstrated a convergence from the short-term to the long-term balance. This measure of the value-added imbalance in agriculture, forestry, and fishing is modifiable year-to-year. To express it in another way, the error correction factor indicates how quickly the adjustment is made to balance, assuring the model's long-term return to equilibrium. When the value added of agriculture, forestry, and fishing values deviate through the short term in t-1 from their long-term equilibrium value, the equivalent of 0.035 percent of this deviation is corrected in t period. As a consequent, the cointegrating term indicates how quickly the adjustment to balance occurs. It displays the statistical incoherence of the model's parameters and shows the relative persistence of the long-term error, both of which indicate a short-term dynamic relationship between the independent and dependent variables.

Table No. (14): Results of the cointegrating term at a country level

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Benin				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.173934	0.003519	-49.43333	0.0000
Burkina Faso				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.063269	0.001737	-36.42532	0.0000
Cameron				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.008170	0.000467	17.51128	0.0004
Chad				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.012387	0.001430	-8.660418	0.0032
Côte d'Ivoire				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.067482	0.018991	-3.553335	0.0380
Guinea				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.196477	0.007297	26.92404	0.0001
Mali				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	0.011566	0.001945	5.946746	0.0095
Niger				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.284645	0.006415	-44.37208	0.0000
Nigeria				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ01	-0.066297	0.000985	-67.31576	0.0000

Source: Prepared by the researcher based on EViews 13

As for the results of cointegrating term at a country level, the cointegrating term for all countries were negatively significant except for Cameron, Guinea, and Mali.

Since Cameron, Guinea, and Mali are considered among the most countries anticipated to undergo the climate change impact on food stability as, in turn, it affects one or more aspect of food security (World Bank, 2018).

Conclusion and Recommendation

It is conspicuous that Climate change possesses a current and future impacts on the Niger basin countries. however, they are essentially associated with social and political factors that must be emphasized when addressing climate related challenges in the Basin. Climate change will likely have significant impacts on the region, including more rainfall variability, more extreme events like droughts and floods, and higher temperatures over time that will rise faster than the global average. Some parts of the Basin will encounter more precipitation, while other parts will receive less.

This paper investigated the impact of climate change on food security in 9 African countries in Niger Basin from 1990 to 2021. It looked at how climate change affected the four dimensions of food security (food availability, food accessibility, food utilization, and food stability) in Niger Basin countries through four econometric models. The paper included temperature and Precipitation as climatic variables and GDP per capita, land under cereal production, and population growth as control variables in the four models to assess their effects on the dimensions of food security food availability (cereal yield), food accessibility (consumer price index), food utilization (mortality rate under 5), and food stability (value added in agriculture, forestry, and fishing). Before knowing if the data is stationary and doesn't need to be differenced, there has been a need to determine if there is a trend or intercept by applying Panel Ordinary least squares estimate. After utilizing the panel unit root test using Fisher-ADF test, the study estimated the pool mean group (PMG) panel autoregressive distributed lag (ARDL). The results of the food availability model indicated a long-run relationship between cereal yield and its determinants. There was a negative impact of climate change variables (TEM, PRE) on Cereal yield. The cointegrating term in the short run was negatively significant and to be about 0.267. The country-specific empirical findings revealed that the climatic variables have varying effects on cereal yield across countries. The results of the food accessibility model exhibited a long-run relationship between consumer price index and its determinants. Meanwhile, there was a positive impact of climate change variables (TEM, PRE) on the consumer price index. The cointegrating term in the short run with a value of 0.18 was negatively significant. The country-specific empirical findings indicated that the climatic variables have varying effects on consumer price index across countries. The results of the food utilization model designated a long-run relationship between mortality rate under 5 and its determinants. There was a negative impact of TEM on mortality rate under 5, and a positive impact of PRE on mortality rate under 5. The cointegrating term in the short run with a value of 0.002 was negatively significant. The country-specific empirical findings indicated that the climatic variables possessed varying effects on mortality rate under 5 across countries. The results of the food stability model revealed a long-run relationship between value added in agriculture, forestry, and fishing and its determinants. There was a negative impact of climate change variables (TEM, PRE) on value added in agriculture, forestry, and fishing. The cointegrating term in the short run was negatively significant with a value of 0.035. The country-specific empirical findings assured that the climatic variables have different effects on value added in agriculture, forestry, and fishing across countries.

In conclusion, this study verified that for food availability, climate change is widely believed to reduce crop yields. as well as the impacts of extreme climate events on food accessibility. The changes in production systems induced by climate change may induce changes in dietary patterns and food utilization. Climate change will also affect the stability and resilience of food systems with consequences in terms of long-term food security. The findings have policy implications. As expected, the Niger Basin countries will experience unstable rainfall and temperature increases, which could have a negative impact on food production, malnutrition, and mortality rates. To mitigate and adapt to climate change, policymakers will need to base policy decisions on the adoption of modern agricultural techniques such as access to improved seed, smart agriculture practice, and irrigation infrastructure to reduce vulnerability to climate shocks.

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