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Food Insecurity in ECOWAS Region: The Nexus of Climate Change and Macroeconomic Dynamics

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Abstract: Food insecurity remains a recurrent issue in the Economic Community of West African States (ECOWAS), worsened by the combined constraints of climatic unpredictability and macroeconomic volatility. This study examines the interaction between climate change factors—such as precipitation, temperature, and CO_2 emissions—and macroeconomic elements, including food production, exports, imports, inflation, GDP, population, and consumer prices, to assess their impact on food security in ECOWAS member countries from 2000 to 2023. By employing panel econometric models, including Common Effects, Fixed Effects, and Random Effects, along with thorough diagnostic tests, the research reveals that food production, temperature, and exports significantly enhance food security. However, irregular rainfall and reliance on imports tend to have a detrimental effect. Interestingly, the Consumer Price Index and population growth show varied impacts, highlighting the structural and institutional differences among the member states. The findings underscore the urgent need for integrated regional policies that tackle climate change resilience, stable macroeconomic conditions, and agricultural productivity simultaneously. Strategic actions aimed at curbing inflation, encouraging climate-smart farming, facilitating trade, and improving infrastructure are essential for fostering sustainable food systems across ECOWAS. To effectively combat food insecurity in the region, comprehensive policy frameworks that focus on climate adaptation, economic stabilization, and equitable agricultural development are crucial. Additionally, regional cooperation can play a vital role in addressing food security challenges amid climate change and shifting global economic trends.

Keywords: *Accessibility, Availability, ECOWAS, Consumer price, Exports, GDP, Inflation*

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1. Introduction

Food insecurity stands out as a critical challenge for the Economic Community of West African States (ECOWAS). This region is grappling with rapid population growth, high poverty levels, and a heavy dependence on agriculture (FAO, 2021). Despite having abundant natural resources, millions of people in ECOWAS struggle to access enough nutritious food due to deep-rooted structural issues. The situation is made worse by the combined effects of climate change and economic factors, which threaten agricultural productivity, food prices, and the overall stability of food systems (IPCC, 2022; World Bank, 2020). The Food and Agriculture Organisation (2002) defines food security as a state where everyone has the financial, social, and physical means to access adequate, safe, and nutritious food that meets their dietary needs and preferences, enabling them to lead active and healthy lives. The Global Food Security Index (GFSI), created by Economist Impact, provides a comprehensive assessment of food security across countries. According to Economist Impact (2023), food security is evaluated through both qualitative and quantitative measures, organized into four key dimensions: affordability, availability, quality and safety, and natural resources and resilience. The affordability aspect examines how well consumers can afford food, their sensitivity to price changes, and the presence of policies or initiatives that enhance food access. Key indicators of food affordability include the share of food expenses in total household spending, the percentage of the global population living in poverty, agricultural tariffs on imports, food assistance programs, farmers' access to financial resources, and the volatility of agricultural production. The food availability pillar focuses on how well food supplies meet demand, the logistics involved, and the resilience of our farming systems. When we talk about food availability, we look at metrics like how much food is available per person each day (measured in kcal), government investment in agricultural research and development, and the amount of food wasted during transportation, storage, and delivery. We also consider the infrastructure needed for agriculture, such as roads and irrigation systems, as well as the political stability and corruption levels that can affect food and farming. On the other hand, Food Quality and Safety examines the nutritional value and safety of the food that consumers can access. Key indicators here include the diversity of diets, adherence to national nutritional standards, the availability of essential micronutrients like iron, zinc, calcium, and vitamins, and the effectiveness of food safety policies to prevent contamination. Lastly, the natural resources and resilience pillar looks at how vulnerable a nation is to climate change and environmental threats, along with its ability to adapt and respond to these challenges over time. Important metrics in this area include susceptibility to climate-related risks like droughts and floods, per capita water availability, land degradation and desertification, adaptation strategies such as early warning systems, biodiversity preservation, and urban capacity to manage food resources.

Food security is incredibly important for tackling poverty and is a cornerstone for social and economic development. By ensuring that everyone has access to enough safe and nutritious food, food security boosts health and productivity, helping families lift themselves out of poverty. In many developing countries, a significant number of people depend on farming, and when food security improves, it leads to greater productivity, which in turn increases their income. Keeping food prices stable is another key element of food security, especially for low-income families who spend a large portion of their income on food. This stability helps them manage their budgets better and avoid food crises. Additionally, food security encourages investment in education, which is crucial for empowering future generations to fight against poverty. It also builds resilience against economic challenges and natural disasters, enabling struggling families to withstand tough times. Overall, food security is essential for national resilience and serves as a fundamental building block for economic growth. By promoting safe food production, we can reduce poverty and inequality, while also supporting sectors like agriculture, tourism, and food processing, which are vital for attracting investments and driving economic progress (Naidanova and Polyanskaya, 2017).

Climate change has significantly altered temperature and rainfall patterns across West Africa, leading to increased flooding, droughts, and other extreme weather events that threaten agricultural productivity and the livelihoods of many (Ayanlade et al., 2018). These environmental issues not only reduce food supply but also heighten the vulnerability of smallholder farmers who often lack the means to adapt (Adesina and Ojo, 2020). At the same time, macroeconomic factors like inflation, fluctuating currency rates, and uneven economic growth make it harder for people to access food by driving up prices and limiting purchasing power (Nwosu and Eze, 2019; IMF, 2022). The interplay between climate change and economic dynamics creates a complicated challenge for food security in ECOWAS, as the effects of climate change often lead to economic instability, while economic weaknesses hinder both governments and consumers from effectively responding (United Nations Economic Commission for Africa [UNECA], 2021). Therefore, understanding how these factors interact is essential for crafting integrated strategies that can bolster resilience and ensure long-term food security across the region.

Food security isn't just about how much food we can grow; it's influenced by a variety of macroeconomic factors. Research shows that elements like population size, income per person, poverty levels, and trade—both exports and imports—play a crucial role (Ceballos et al., 2021; Chriest and Niles, 2018; Naidanova and Polyanskaya, 2017; Rice et al., 2023). Interestingly, some studies suggest that while a growing population can negatively affect food security in the short term, its long-term impact is less severe (Bakari et al., 2018; Ceesay and Ndiaye, 2022; Sun and Zhang, 2021). When it comes to GDP per capita, the findings are mixed; some research indicates that an increase in GDP per capita can improve food security, while others argue that economic growth in the agricultural sector is what really matters for food security in Asian and African countries. Additionally, some studies have found that economic growth doesn't significantly affect food security in low-income nations (Gnangnon, 2023; Sassi and Trital, 2023). Although there's been a lot of research on climate change and economic issues separately, very few studies have looked at how these factors intersect to create food insecurity in the ECOWAS region. Most existing research tends to treat climate and economic factors in isolation, overlooking how their interplay can affect food systems. This gap highlights the need for thorough, multidisciplinary research and policies that tackle the complexities of food insecurity in the area. This study aims to explore the intricate relationship between climate change, macroeconomic factors, and food insecurity in the ECOWAS region, to provide evidence-based insights to assist stakeholders and policymakers in developing effective solutions.

2. Relevant Literature

The ECOWAS is a political and economic union made up of 15 countries in West Africa. Its main goal is to promote economic collaboration, political stability, and development among its members. Unfortunately, food insecurity remains a significant issue in the ECOWAS region, with many people struggling to access enough safe and nutritious food. According to the FAO (2021), over seventy million people in West Africa faced food shortages in 2020, with Nigeria, Niger, and Burkina Faso being the hardest hit. The region's challenges are compounded by high poverty levels, rapid population growth, weak institutions, and ongoing sociopolitical unrest (ECOWAS Commission, 2021).

Climate Change and Food Security in ECOWAS

Climate change poses a significant threat to food security in the ECOWAS region, which heavily depends on rain-fed agriculture and delicate ecosystems. The Intergovernmental Panel on Climate Change (IPCC, 2022) has highlighted West Africa as a climatic hotspot, facing challenges like rising temperatures, unpredictable rainfall, prolonged droughts, and increased flooding. These climate shifts directly impact crop yields, livestock production, and fisheries, which are vital sources of food and income for millions in ECOWAS. With about 90% of farming in the area relying on rain-fed methods, this sector is particularly vulnerable to changes in rainfall patterns and drought frequency (Ayanlade et al., 2018). For instance, prolonged dry spells can reduce soil moisture and water availability, hampering crop growth and leading to failed harvests (Adesina and Ojo, 2020). Additionally, flooding caused by heavy rains can damage crops and agricultural infrastructure, limiting both production and market access (FAO, 2021). Research indicates that the increasing frequency and intensity of flooding, drought, and deforestation have led to significant crop yield losses, especially in the Sahel region (Niang et al., 2014). Between 2010 and 2012, droughts in the Sahel resulted in severe food supply losses and exacerbated hunger issues (World Bank, 2020).

The consequences of these impacts are quite serious. When agricultural efficiency drops, it leads to a reduced food supply, which in turn drives up costs and puts smallholder farmers—who depend on steady harvests—at risk (Olaniyi and Adegboye, 2019). Additionally, the decline of natural resources like soil and water exacerbates food insecurity by threatening the long-term viability of agriculture (Ayanlade et al., 2018). Climate change also plays a significant role in food security, affecting nutrition and health. Rising temperatures and changing rainfall patterns can increase the spread of vector-borne diseases and diminish the nutritional quality of staple foods, which only worsens malnutrition (FAO, 2021). To tackle these challenges, ECOWAS countries have recognized the need for climate adaptation strategies that promote resilient farming practices, diversify income sources, and enhance early warning systems for climate-related disasters (ECOWAS Commission, 2021). Nevertheless, challenges remain due to a lack of financial resources, inadequate infrastructure, and limitations in institutional capacity (Adekunle and Yusuf, 2020).

Macroeconomic Dynamics and Food Security in ECOWAS

Macroeconomic factors play a crucial role in shaping food security in the ECOWAS region, influencing everything from food availability to access and pricing. Some of the key macroeconomic elements that affect the food system include inflation, fluctuations in exchange rates, GDP growth, and government fiscal policies. For instance, inflation—especially food inflation—can erode consumer purchasing power, making it harder for vulnerable populations to access proper nutrition (World Bank, 2020). In many ECOWAS countries, high and unpredictable inflation rates have led to sudden spikes in food prices, hitting low-income families the hardest, as they often allocate a large portion of their disposable income to food (Nwosu and Eze, 2019). Take Nigeria, for example, which has experienced periods of double-digit inflation that have diminished real incomes and worsened food insecurity (IMF, 2022). Additionally, fluctuations in exchange rates significantly affect food security by altering the costs of imported food and agricultural inputs like fertilizers and machinery (Nwosu and Eze, 2019). When local currencies depreciate, the price of imports rises, which typically results in higher domestic food prices (Adekunle and Yusuf, 2020). This situation is particularly critical in ECOWAS countries that rely heavily on food imports to meet local demand.

Economic growth is often seen as a way to reduce poverty and improve food availability, but it doesn't always lead to equal food security for everyone. Even with overall economic improvements, many families still struggle to get enough food because of uneven development, limited job opportunities, and ongoing income inequality (IMF, 2022). Additionally, economic shocks, like drops in commodity prices, can hinder growth and increase food poverty. The choices made by governments regarding fiscal policy and public investment play a crucial role in how resilient food security is. Investing in farming infrastructure, developing rural areas, and strengthening social security networks can boost production capacity and help protect vulnerable communities from sudden food price increases (ECOWAS Commission, 2021). However, many ECOWAS governments face budget constraints, partly due to economic disruptions caused by climate change, which limits their ability to make these essential investments (Adekunle and Yusuf, 2020). In the end, the interplay of these macroeconomic factors shapes the stability of food systems in ECOWAS, highlighting the need for cohesive social and economic policies to ensure food security.

The Nexus of Climate Change and Macroeconomic Dynamics

The interplay between climate change and macroeconomic factors is a crucial link that significantly affects food security in ECOWAS. Climate change doesn't just cut down agricultural yields; it also has extensive economic repercussions for national economies and the well-being of families. Events like droughts and floods, driven by climate change, can severely reduce crop yields and livestock productivity, which in turn lowers agricultural output—a vital part of GDP for many ECOWAS countries (Adesina and Ojo, 2020). These environmental challenges often lead to slower economic growth, budget deficits, and currency devaluation, all of which jeopardize the macroeconomic stability necessary to support food systems (UNECA, 2021). For instance, losses in agriculture due to climate issues can shrink export revenues and government income, which in turn limits public spending on agriculture and social safety nets that are essential for ensuring food security (Adekunle and Yusuf, 2020).

Macroeconomic instability, which shows up as high inflation, erratic currency rates, and shaky fiscal conditions, can really intensify the impact of climate shocks on food security. When inflation spikes due to climate-related supply issues, food prices soar, making it harder for vulnerable groups to access what they need (Brown et al., 2021). Additionally, when the exchange rate drops, it drives up the cost of imported food and agricultural supplies, further straining food affordability (Nwosu and Eze, 2019). This creates a vicious cycle where economic disruptions caused by climate change limit both governments' and families' ability to cope and invest in resilience strategies. With insufficient financial resources and unstable economies, it becomes tough to implement climate adaptation programs and cushion against food price shocks, worsening food insecurity (ECOWAS Commission, 2021). Addressing this complex issue requires coordinated policy efforts that stabilize macroeconomic conditions while also bolstering climate resilience. Approaches like climate-smart agriculture, economic diversification, welfare programs, and regional collaboration can all play a role in breaking this cycle and ensuring a sustainable food supply in the long run (FAO, 2021; UNECA, 2021).

Theoretical Framework

Taking a closer look at food insecurity in the ECOWAS region through the lens of climate change and macroeconomic factors means there is a need to blend various theoretical perspectives. This helps understand how economic and environmental elements work together to shape food supply, access, and sustainability. One key framework for this analysis is the Sustainable Livelihoods Theory (SLT), which was introduced by Chambers and Conway in 1992. This theory is often used to explore how households and communities acquire and utilize different types of assets—like human, environmental, financial, physical, and social resources—to sustain their livelihoods. Food security plays a crucial role in these livelihood strategies. In the ECOWAS region, climate change affects natural resources, such as soil fertility and water availability, while macroeconomic shocks can diminish financial and physical capital. The SLT sheds light on how these challenges weaken farmers' resilience and adaptability, ultimately leading to increased food insecurity, as noted by Scoones (1998) and Ellis (2000).

One interesting perspective is the Vulnerability Theory. This theory suggests that food insecurity stems from exposure to shocks, like climate events, as well as sensitivity and the ability to adapt (IPCC, 2022). When climate variability strikes—think droughts and floods—it puts agricultural systems in jeopardy. On top of that, macroeconomic instability, such as inflation rates and fluctuating exchange rates, affects sensitivity by influencing food prices and income levels. The ability of ECOWAS nations and their communities to adapt hinges on factors like governance, infrastructure, and social security measures (Adger, 2006). Additionally, the Climate-Macroeconomic Interaction Model plays a crucial role in this discussion. This model illustrates how climate shocks can affect macroeconomic elements like GDP growth, inflation, and fiscal balance, which in turn shape food security outcomes (Dell et al., 2012; UNECA, 2021). When agriculture in ECOWAS suffers due to climate-related losses, it negatively impacts economic growth and government revenue, limiting resources for food systems and social protection. Rising inflation and currency devaluation lead to higher food prices, exacerbating food insecurity, especially for the most vulnerable populations (Brown et al., 2021).

The concept of Food Security Theory is crucial in this field. According to the FAO (1996) and Aroyehun (2023), food security consists of four key components: availability, accessibility, utilization, and stability. Climate change significantly affects food availability by altering production and supply systems. Economic factors play a role in food access through income levels and pricing mechanisms. These elements ultimately impact the overall stability and utilization of food among families in ECOWAS (FAO, 2021). By bringing these ideas together, there is a gain in a deeper understanding of food insecurity in ECOWAS as a complex issue influenced by both environmental challenges and economic factors. The Sustainable Livelihoods and Vulnerability Frameworks highlight the need for adaptability and resilience, while economic theories delve into pricing and market dynamics. The Climate-Macroeconomic Interaction Model illustrates how environmental shocks can trigger economic instability, further worsening food scarcity.

3. Materials and methods

This study uses a panel data econometric approach, covering 15 ECOWAS countries from 2000 to 2023. The main focus was a combined food security index that includes factors like availability, accessibility, and consumption, including undernourishment rates and fluctuations in overall food production. It also considers climate factors such as temperature changes, variations in precipitation, and CO_2 emissions. On the macroeconomic side, the study examines GDP growth, food price inflation, imports and exports of food products, and the consumer price index. Additionally, the food production index and population growth rates serve as control variables.

This research dives into the elements of climate change—like precipitation, temperature, and carbon dioxide (CO_2) emissions—alongside key macroeconomic factors such as GDP growth, consumer price inflation, food exports, food imports, the consumer price index, population growth, and the food production index. The goal was to model how these climate and economic variables impact food security in ECOWAS economies that are ranked as having weak or the lowest scores on the global food security index (Economist Impact, 2022). Using a panel data linear regression model, the study looks at the effects of climate change and macroeconomic factors on food security across 11 ECOWAS nations, which are part of a broader list of 113 countries worldwide (Economist Impact, 2022), from 2000 to 2023. The selected countries include Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo. Guinea-Bissau, Cape Verde, Liberia, and The Gambia were intentionally left out to ensure the statistical validity and reliability of comparisons in this research, as they did not meet the minimum baseline information requirements (typically 80 to 90 percent of the necessary indicators) outlined in the Economist Impact (2022) reports. However, their absence does not compromise the regional representation, since the included nations make up a significant portion of the ECOWAS population, agricultural output, and climate sensitivity. It's worth noting that Mali, Burkina Faso, and Niger have announced their intention to withdraw from ECOWAS in 2024-2025 due to political disagreements over sanctions and military governance. Despite the situation, ECOWAS still considers them as members, patiently waiting for the official withdrawal processes to wrap up. This approach is thoughtfully examined, taking into account the changes that occur over time and across different countries. Marwa et al. (2025) outline the following econometric modelling specifications:

$$FS = f(PREC, TEMP, CO2, FPI, EXP, IMP, GDP, POP, CPI) \quad (1)$$

The model equation (1) can be expressed in an explicit and econometric way as follows:

$$FS_{it} = \beta_0 + \beta_1 PREC_{it} + \beta_2 TEMP_{it} + \beta_3 CO2_{it} + \beta_4 FPI_{it} + \beta_5 EXP_{it} + \beta_6 IMP_{it} + \beta_7 INF_{it} + \beta_8 GDP_{it} + \beta_9 POP_{it} + \beta_{10} CPI_{it} + \mu_{it} \quad (2)$$

Where,

FS is the food security index
PREC stand for precipitation or rainfall
TEMP refers to temperature
CO2 indicates carbon dioxide emissions from agriculture
FPI is the food production index
EXP represent food exports
IMP is the food imports
INF is food price inflation
GDP is the growth rate of gross domestic product per capita
POP is the annual population growth rate
CPL is the consumer price index
i refers to the 11 ECOWAS countries
t covers the period from 2000 to 2023
μ is the error term
β_0 is the constant
β_1 - β_{10} are the coefficients of the estimates

The framework of this model was established through three different approaches: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM). CEM operates on the premise that there are no differences between countries, leading to the same intercept point for each nation and time period. On the other hand, FEM allows for fixed differences among countries by giving each one its own baseline. Meanwhile, the REM suggests that the differences between countries are random and not connected to any independent factors. To determine the best model, the Chow test was employed to compare CEM and FEM, the Hausman test was used to see whether FEM or REM was more suitable, and the Lagrange Multiplier (LM) test assessed whether REM was better than CEM. If the test results indicate that the differences between countries are consistent and significant, then FEM is the better choice. However, if the differences are seen as random and unrelated to independent factors, then REM is the more appropriate option (Greene, 2012).

Given the possibility of variables with mixed integration between I(0) and I(1), many models were examined at first, including the Pooled Mean Group (PMG) and Autoregressive Distributed Lag (ARDL) models. However, after assessing stationarity with the Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), and Augmented Dickey-Fuller (ADF) techniques, the findings revealed that variables were stationary at the level [I(0)] and first difference [I(1)]. As a result, this study does not employ the ARDL or PMG models, which are commonly used for variables with heterogeneous levels of integration. Instead, this study employs three primary panel data regression models: the Common Effect Model, the Fixed Effect Model, and the Random Effect Model as used by Marwa et al. (2025). To figure out which of these models was the best fit, Chow, Hausman, and Lagrange multiplier tests were analyzed. These models were selected for their ability to better suit the current data's stationarity, allowing for the examination of linear correlations between variables without taking into account long-term cointegration.

The panel data regression analysis is well-suited for this study since the method allows for deeper investigation through the integration of measurements across time (time-series) and across units (cross-sectional), allowing for heterogeneity between units that classical linear regression cannot detect (Baltagi, 2005; Wooldridge, 2010). The Common Effect Model assumes that there's no variation between units, treating each one the same. In contrast, the Fixed Effect Model accounts for individual differences by adding a unique intercept for each unit, making it useful when distinct changes between units could influence the variable being studied (Hsiao, 2003). The Random Effect Model, on the other hand, assumes that variations among components are random and not related to independent variables, making it more effective if that assumption holds (Baltagi, 2005; Greene, 2012).

To pick the best model, the study relies on statistical methods like the Chow Test to compare the Common Effects Model (CEM) and the Fixed Effects Model (FEM), the Hausman Test to differentiate between FEM and the Random Effects Model (REM), and the Lagrange Multiplier Test to weigh CEM against REM. Selecting the right model is crucial as it ensures an accurate representation of the data's characteristics. The study uses panel data regression because it excels at analyzing differences between units and how variables change over time. While the study did look into the Compound Linear Regression Model (LRM), the nature of the panel data led the study to utilize the CEM, FEM, and REM models, which align with the econometric theories outlined by Hsiao (2003), Baltagi (2005), and Wooldridge (2010). The research draws on panel data from 11 ECOWAS countries, selected based on the Global Food Security Index (GFSI), which gauges a nation's food security score. This index evaluates food security based on availability, accessibility, quality, and sustainability. The countries the study focused on have a food security score of 50 or higher, placing them in the weak to low categories according to GFSI classifications. Specifically, nations with scores between 50 and 59 are labelled as weak, while those below 50 are considered to have the most critical food security issues. The countries included in this study, such as Ghana, Mali, and Senegal, fall into the weak category. Meanwhile, those in the low tier include Benin, Burkina Faso, Côte d'Ivoire, Guinea, Niger, Nigeria, Sierra Leone, and Togo, all of which face significant challenges regarding food access and distribution.

The World Bank offers valuable data on climate change, which includes metrics like temperature, precipitation, and CO2 emissions from agricultural activities. On the other hand, it also provides insights into macroeconomic factors, such as the food production index, the percentage of food exports relative to merchandise imports, the percentage of food imports compared to merchandise imports, inflation rates for food prices, GDP growth per capita based on the national currency, annual population growth rates, and changes in the consumer price index. Additionally, the World Food Security Index evaluates food security through four key pillars: availability, accessibility, utilization, and the stability of food systems (Economist Impact, 2022). To give a clearer picture, Table 1 outlines the descriptions and measurements of these variables.

Table 1: Description and measurement of variables

Symbol	Variables	Description and measurement	Source
FS	Food security	Food Security Index is measured based on the GFSI 4 pillars: affordability, availability, quality and safety, and natural resources and resilience, which is the prevalence of malnutrition (in percentage).	Food and Agriculture Organization
PREC	Precipitation	Annual mean precipitation in mm	World Bank
TEMP	Temperature	Annual mean temperature in oC	World Bank
CO2	Carbon dioxide emissions	Carbon dioxide emissions are the fraction of carbon emissions caused by production from agriculture.	World Bank
FPI	Food production index	The food production index includes food crops that are deemed edible and provide nutrients. Coffee and tea are eliminated because, while edible, they have little nutritional benefit.	World Bank
EXP	Export (% of merchandise exports)	Agriculture-related exports are the aggregate amount of products and services sold abroad, computed using the ratio approach to demonstrate the quantitative contribution of exports to the economy as a proportion of merchandise exported.	World Bank
IMP	Import (% of merchandise imports)	Agriculture-related imports are the entire value of products and services acquired from other countries, correctly quantified by utilising a ratio scale to indicate the agriculture sector's economic impact as a percentage of imports of merchandise.	World Bank
INF	Inflation	Inflation is assessed by consumer prices, which indicate the annual percentage increase in the cost to the typical consumer of obtaining a variety of goods and services that could be set or modified at regular intervals, such as annually.	World Bank
GDP	Gross domestic product	Gross domestic product (GDP) is the total value of merchandise contributed by every producer that lives in the country's economy.	World Bank

		It is estimated without accounting for depreciation of manufactured assets or depletion and deterioration of natural resources. The data are in the prevailing currency of the nation.	
POP	Population growth	The population is calculated using the actual description of population, which includes every resident, irrespective of their legal nationality or citizenship. The annual growth rate is measured in percentage terms.	World Bank
CPI	Consumer price index	The consumer price index is the variation in the price charged to the typical consumer for obtaining a variety of goods and services that can be set or updated at regular periods, such as annually.	World Bank

Source: Field Survey, 2025

4. Results and discussion

The status of food security in ECOWAS countries

Food security ratings in ECOWAS nations reflect the problems and accomplishments that differ in each country and vary according to their situations. Food security was assessed using several essential elements, including the food security environment, food affordability, food availability, food quantity and safety, food utilization, and food sustainability and adaptability.

Table 2: Food security scores in ECOWAS countries

	Food security environment		**Affordability**		**Availability**		**Quantity and safety**		**Sustainability and adaptation**	
	Score	**Δ**	**Score**	**Δ**	**Score**	**Δ**	**Score**	**Δ**	**Score**	**Δ**
Ghana	52.6	-1.6	59.9	-0.5	52.4	-0.9	50.5	-6.2	45.1	+0.8
Mali	51.9	-0.1	53.4	-1.5	48.7	-5.8	56.8	+0.3	48.8	+8.0
Senegal	51.2	+0.4	57.9	+1.3	47.8	-0.2	53.9	+0.6	43.5	0
Burkina-Faso	49.6	-2.2	49.5	-0.6	49.8	-5.7	52.8	-2.6	46.4	+0.1
Benin	48.1	+1.5	50.5	-2.1	53.6	+8.2	48.1	-0.1	38.9	+0.8
Côte d'Ivoire	46.5	-1.9	54.2	-3.0	42.1	-4.7	44.1	-0.9	43.2	+1.2
Niger	46.3	-3.4	42.8	-1.4	41.7	-12.7	47.0	+0.1	55.5	+0.9
Togo	46.2	-2.3	45.7	-6.0	51.0	+1.3	42.3	-0.1	45.4	-3.5
Guinea	45.1	-1.3	37.0	-3.7	49.0	-0.9	39.8	-0.1	56.9	+0.1
Nigeria	42.0	-4.8	25.0	-10.3	39.5	-6.3	55.6	-0.4	53.7	-0.1
Sierra Leone	40.5	-2.4	36.6	-4.0	35.5	-3.8	41.8	-3.2	49.8	+1.9

Δ means the score change; Scores are normalized 0–100
Source: Field Survey, 2025

Table 2 displays food security scores across ECOWAS nations, as represented by the information available. The analysis reveals varying levels of achievement across five key areas: food security environment, affordability, availability, quantity and safety, and sustainability and adaptation, along with their respective score changes [Δ]. These indicators shed light on both the weaknesses and strengths within the region's food systems. Notably, no country has reached an ideal food security score, indicating that there’s room for improvement across the board. Several nations experienced a decline in their food security rankings, particularly concerning pricing and accessibility. On a brighter note, a handful of countries have made strides in sustainability and adaptation, reflecting a growing awareness and response to climate change and environmental challenges. The most significant issue appears to be affordability, suggesting that inflation, poverty, and economic instability are major hurdles for food security in ECOWAS. Decreases in availability point to potential problems with agricultural production, infrastructure, or disruptions in the supply chain. While many countries are seeing slight advancements in sustainability and adaptation, this progress may stem from an increased emphasis on climate resilience strategies. Overall, the findings paint a picture of a generally weak food security landscape in the ECOWAS region. For example, despite being Africa's largest economy, Nigeria scored the lowest in affordability (25.0) and experienced the steepest decline (-10.3), a finding that is consistent with FAO (2023), which points out that high inflation and devaluation of the currency have undermined purchasing capacity and access to food in West Africa's largest country.

Food security environment

Ghana (52.6), Mali (51.9), and Senegal (51.2) are leading the pack with the highest food security environment scores in the region. This indicates that these countries have significantly stronger institutional and policy frameworks to bolster their national food systems. The results highlight the robustness of their governance, the consistency of their policies, and their capability to effectively implement and monitor food security initiatives. Ghana's impressive score of 52.6 showcases the effectiveness of its comprehensive agricultural policies, investments in rural infrastructure, support for agribusiness, and a vibrant research-extension system, all of which align with the FAO's assessments of Ghana's food governance (2021b). The government has made food self-sufficiency a priority through initiatives like the Planting for Food and Jobs (PFJ) project, which has enhanced access to inputs, extension services, and marketing opportunities (MoFA, 2019). These efforts are in line with Ghana's National Agriculture Investment Plan (NAIP II), which focuses on resilience, modernizing food systems, and engaging the private sector (FAO, 2021b). Aidoo et al. (2019) noted that Ghana's relatively stable political environment and well-organized food policy execution have positively influenced food supply and accessibility.

Despite facing some political ups and downs, Mali's impressive score of 51.9 shows that it has a strong and decentralized approach to food security. The country has built fantastic community-based food systems, thanks to government investments in irrigation, livestock, and early warning systems (IFPRI, 2020). Baquedano et al. (2022) highlight how Mali manages to keep local agricultural production steady through farmer cooperatives and climate-resilient practices. This really underscores the importance of community engagement and local governance in maintaining food security, especially in challenging environments. On the other hand, Senegal's score of 51.2, with a positive bump of +0.4, reflects significant strides in improving food security governance. This progress can likely be linked to its Plan Sénégal Émergent (PSE) and the Programme d'Accélération de la Cadence de l'Agriculture Sénégalaise (PRACAS), which focus on transforming agriculture and enhancing institutions. Tadesse et al. (2016) found that Senegal's targeted investments in self-sufficient rice production and climate adaptation strategies have yielded meaningful results. Additionally, the WFP (2022) reports that Senegal has improved its institutional capacity for food security monitoring and emergency planning, which has played a role in this positive trend. The relatively high scores and advancements seen in Ghana, Mali, and Senegal suggest that strong institutions, consistent policies, and long-term investments in food systems are key factors driving food security. In contrast, Nigeria (42.0), Sierra Leone (40.5), and Guinea (45.1) are falling behind, indicating a lack of institutional support, ongoing insecurity, and weak governance frameworks.

Food affordability

Affordability ratings present a significant challenge across various countries. Nigeria (25.0), Sierra Leone (36.6), and Guinea (37.0) are struggling the most, with Nigeria seeing the steepest drop (-10.3). This situation is largely due to soaring food prices, inflation, dwindling purchasing power, and issues in the supply chain. Reports from FAO (2023b) and IFPRI (2022) indicate that these declines stem from macroeconomic instability, ineffective fiscal reforms, the removal of fuel subsidies, and ongoing violence, especially in northern Nigeria. Additionally, Idrisa et al. (2020) highlight that market disruptions and climate-related shocks worsen affordability challenges, particularly in vulnerable economies like Niger and Guinea. On the brighter side, countries like Ghana (59.9) and Senegal (57.9) are faring better, likely thanks to targeted food subsidy initiatives and enhanced market integration. Headey and Ecker (2013) argued that the affordability of food prices is primarily influenced by economic mobility and fiscal policies, especially in nations facing unstable macroeconomic conditions.

Food availability

In many countries, the availability of resources has taken a noticeable hit, with some areas experiencing severe declines. Nations like Niger (-12.7), Mali (-5.8), and Nigeria (-6.3) have faced the steepest drops in availability ratings. These declines can be attributed to ongoing climate shocks, migration driven by conflict, inadequate rural infrastructure, and the challenges of getting food to market. This trend aligns with findings from the OECD and SWAC (2021), which pointed to climate variability and warfare as significant factors disrupting food availability in the Sahel region. On a brighter note, Benin (+8.2) and Togo (+1.3) saw improvements in availability, likely thanks to better storage solutions, investments in irrigation, and generally stable conditions.

Food quantity and safety

It's interesting to see that the quantity and safety rankings have remained fairly stable in some countries. Nigeria (55.6), Mali (56.8), and Senegal (53.9) are showing promising quantity and safety scores, indicating progress in areas like post-harvest processing, food quality, and internal food production systems. This suggests that, even with limited access, these nations can still meet basic caloric needs. Nigeria, in particular, has managed to maintain its relative strength thanks to innovations in post-harvest practices and initiatives from the private sector focused on food safety (World Bank, 2021). On the flip side, Ghana (-6.2) and Sierra Leone (-3.2) have seen declines, pointing to a lack of effective food safety standards and monitoring systems. This aligns with the IFPRI (2022) perspective that post-harvest losses and weak food safety regulations continue to be persistent issues in fragile economies.

Food sustainability and adaptation

This pillar examines how food systems responded to environmental and climatic stress. Guinea (56.9), Niger (55.5), and Nigeria (53.7) had the highest scores in this area, indicating effective national adaptation strategies and resilience-building activities. These nations have participated in climate-smart agriculture (CSA) projects and regional adaptation efforts funded by IFAD (2022) and WFP (2022). Mali had the most positive movement (+8.0) in sustainability, highlighting its efforts in climate adaptation, forest regeneration, and soil management. Togo (-3.5) and Nigeria (-0.1) are either stagnant or on the decline, which could be due to a lack of effective policies or poor program execution. Vermeulen et al. (2012) suggest that adapting to these challenges requires coordinated efforts across multiple sectors. The struggles in Nigeria might indicate that there are fragmented institutional responses to climate issues.

On a brighter note, Senegal stands out with a well-rounded performance across various areas, especially in food affordability (57.9) and food quantity and safety (53.9). This success is likely linked to the country's strong agricultural investment strategies and its approach to diversifying food imports. Even with security challenges, Mali has managed to boost its food supply, safety, and sustainability, probably thanks to donor-supported agricultural resilience initiatives. Table 2 illustrates a varied landscape of food security resilience among ECOWAS countries. While many member states are seeing declines in affordability and availability, a few, like Mali and Senegal, are making strides, particularly in climate adaptation and safety standards. These observations align with broader scientific and institutional assessments (OECD (2021), IFRI (2022), and FAO (2023b)), highlighting the urgent need for inclusive policy reforms, climate-conscious investments, and regional collaboration to safeguard agricultural systems against future shocks.

Stationarity (panel unit root test)

Stationarity plays a crucial role in analyzing time-series and panel data, as it allows for reliable econometric conclusions. A variable is considered stable when its statistical characteristics—like mean, variance, and autocorrelation—stay consistent over time. On the other hand, non-stationary variables can lead to unreliable results in regression analysis. Levin, Lin, and Chu (LLC) (2002) assume a shared unit root process across cross-sections. Im, Pesaran, and Shin (IPS) (2003) provide for individual unit root processes spanning cross-sections. ADF-Fisher Augmented Dickey-Fuller test mixed with Fisher's technique (Maddala and Wu, 1999). PP-Fisher Phillips-Perron test mixed with Fisher's technique (Choi, 2001). The null hypothesis for each test is that the series has a unit root (i.e., is not stationary). If the test result is significant (p-value < 0.10), then reject the null hypothesis and conclude the variable is stationary.

Table 3: Panel unit root test

Variables	Levin, Lin, & Chu		Im, Pesaran, & Shin		ADF - Fisher		PP - Fisher		Order of Integration
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff	
FS	-4.609*** (0.000)	-1.399* (0.081)	-1.593* (0.056)	-3.156*** (0.000)	32.814* (0.065)	60.116*** (0.000)	57.019*** (0.000)	99.294*** (0.000)	I(0)
PREC	0.703 (0.759)	0.633 (0.737)	-0.638 (0.262)	-15.125*** (0.000)	22.748 (0.416)	233.21*** (0.000)	53.827*** (0.000)	2083.02*** (0.000)	I(1)
TEMP	-5.408*** (0.000)	-16.337*** (0.000)	-2.780*** (0.003)	-18.059*** (0.000)	45.392*** (0.002)	280.49*** (0.000)	85.767*** (0.000)	1089.68*** (0.000)	I(0)
CO2	6.583 (1.000)	-5.1551*** (0.000)	5.285 (1.000)	-6.693*** (0.000)	8.808 (0.994)	107.54*** (0.000)	10.929 (0.976)	218.69*** (0.000)	I(1)
FPI	1.118 (0.868)	14.250 (1.000)	2.616 (0.996)	-2.859*** (0.000)	13.837 (0.907)	56.190*** (0.000)	10.471 (0.982)	156.12*** (0.000)	I(1)
EXP	-4.803*** (0.000)	-11.487*** (0.000)	-1.973** (0.024)	-14.125*** (0.000)	40.658*** (0.009)	219.51*** (0.000)	37.169** (0.023)	917.26*** (0.000)	I(0)
IMP	-3.471*** (0.000)	-11.773*** (0.000)	-1.632** (0.051)	-13.336*** (0.000)	34.625** (0.042)	205.11*** (0.000)	39.209*** (0.013)	881.32*** (0.000)	I(0)
INF	4.930 (1.000)	-12.111*** (0.000)	2.827 (0.998)	-14.798*** (0.000)	13.720 (0.911)	235.20*** (0.000)	24.880 (0.303)	678.94*** (0.000)	I(1)
GDP	8.923 (1.000)	-9.449*** (0.000)	8.775 (1.000)	-15.093*** (0.000)	0.219 (1.000)	234.07*** (0.000)	0.060 (1.000)	1289.01*** (0.000)	I(1)
POP	-7.738*** (0.000)	-5.782*** (0.000)	2.298 (0.989)	-8.425*** (0.000)	23.979 (0.348)	133.99*** (0.000)	26.649 (0.225)	123.74*** (0.000)	I(1)
CPI	11.316 (1.000)	6.240 (1.000)	9.087 (1.000)	-2.277 (0.391)	0.195 (1.000)	56.890*** (0.000)	0.023 (1.000)	98.117*** (0.000)	I(1)

***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Source: Field Survey, 2025

Table 3 presents the results of the panel unit root testing. A variable was considered stationary when the test rejects the null hypothesis of a unit root (p-value < 0.1, often at 1%, 5%, or 10%). Stationarity at the level indicates that the variable was stationary in its original form (i.e., it is integrated with order I(0)). Stationarity at first difference indicates that the variable becomes stationary after differencing (i.e., it is integrated with order I(1)). All FS (food security) tests reject the null hypothesis at the level and are stationary. TEMP (temperature): All tests reject the null hypothesis at the level and remain stationary at the level. When it comes to exports (EXP), all tests rejected the null hypothesis at the specified level, indicating that the data was stationary. IMP (imports) all tests reject the null hypothesis at the level and are stationary. POP (population) alone LLC demonstrates level stationarity, whereas others reject only at the first difference and primarily at I(1). PREC (precipitation), CO_2 (carbon dioxide emissions), FPI (food production index), INF (inflation), GDP (gross domestic product), and CPI (consumer price index) were not stationary at the level, but stationary at the first difference (I(1)). Econometric models (Common, Fixed, and Random Effects) were used.

Models comparison

The model comparison reveals how distinct econometric models (Common Effects, Fixed Effects, and Random Effects) reflect the impact of various climatic and macroeconomic factors on food insecurity in ECOWAS nations. The Common Effects Model (CEM), also known as pooled OLS, assumes consistent coefficients across countries and time. Ignores individual differences. The Fixed Effects Model (FEM) accounts for unobserved, time-invariant variability across nations by assigning each country its intercept. The Random Effects Model (REM) implies that country-specific effects are independent and uncorrelated with explanatory factors. Efficient when properly specified.

Table 4: Model comparison results

	Common effects model		**Fixed effects model**		**Random effects model**	
Variable	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
Constant	47.5348***	0.0003	47.5348***	0.0003	-75.9164***	0.0067
PREC	-0.0009	0.1821	-0.0025***	0.0016	0.0028	0.3156
TEMP	1.3667***	0.0000	-0.2590	0.5540	3.9423***	0.0001
CO2	0.2270	0.1109	0.1437	0.2904	2.0090***	0.0007
FPI	0.0756***	0.0000	0.0837***	0.0000	0.0635***	0.0000
EXP	0.0657***	0.0052	0.0540**	0.0140	0.0225	0.4429
IMP	-0.1051***	0.0042	-0.1319***	0.0002	-0.0592	0.3449
INF	0.0046	0.9572	-0.0353	0.6652	-0.0863	0.1892
GDP	-2.1E-14*	0.0879	-4.29E-14***	0.0014	-1.05E-14	0.5773
POP	9.7E-09	0.2858	1.50E-08*	0.0860	7.08E-08	0.2643
CPI	0.0142**	0.0463	0.0172**	0.0117	-0.0123**	0.0504
R-squared	0.4268		0.7615		0.4927	
Adjusted R2	0.3804		0.7138		0.4466	
F-statistic	10.6828		15.9665		10.6829	
Prob(F-statistic)	0.0000		0.0000		0.0000	

***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.
Source: Field Survey, 2025

Table 4 shows that the Fixed Effect Model (FEM) was selected as the model to be analysed for the empirical discussion of the impact of climate change and macroeconomics on food security in the ECOWAS Region. The Fixed Effects Model (FEM) has the greatest R^2 (0.7615), Adjusted R^2 (0.7138), and F-statistic (15.9665), which indicates higher explanatory power and model fit. The Random Effects Model (REM) outperforms the Common Effects Model (CEM) but underperforms the FEM. The FEM explains the majority of the variation in the dependent variable (71.4%), implying that controlling for individual-specific variability is critical. This suggests that structural variations between cross-sections (countries) have a major impact on food security results. According to Baltagi (2008), the FEM is more valid than REM or CEM due to its much higher R^2 and significant variable-specific Hausman test findings.

Selecting between the FEM and the REM in statistical analysis of panel data is a critical option that depends on the structure of the data and the reasonable assumptions we may make regarding unobserved heterogeneity (Baltagi, 2021; Gujarati and Porter, 2009). While REM is frequently selected for its efficiency, there are compelling methodological and theoretical arguments for using FEM in specific situations. The following is an in-depth explanation of why the FEM was chosen over the REM in this research:

FEM enables the relationship between the individual-specific effects (unobserved heterogeneity) and independent variables. REM assumes that the individual effects have no relationship with the variables that explain them. In many real-world circumstances, notably in economic, social, or policy-based investigations, the assumption of no association is sometimes overly strong and unrealistic. For example, in this study on food security in ECOWAS countries, unobserved country-specific characteristics (such as governance effectiveness, capacity of institutions, or social norms) are likely to correlate with observed variables (such as agricultural food production, exports, or imports). REM is more efficient (i.e., reduced variance of estimates) if the premise of no correlation is true. However, if this assumption is broken, REM gives inaccurate and inconsistent results (Wooldridge, 2010). FEM, while possibly less efficient, provides impartial and reliable estimates when a correlation exists. Thus, bias is averted at the price of some efficiency, an acceptable trade-off for more trustworthy inference; as a result, this study chose FEM.

The Hausman specification test, which statistically compares FEM with REM, is commonly used to guide this decision. If the test finds substantial discrepancies between FEM and REM coefficients, it demonstrates that the REM assumption of no correlation has been broken. In this study, the Hausman test rejected the null hypothesis, indicating that FEM is more suitable. FEM focuses on how variables change inside each entity (country) over time, rather than between entities. This is useful when trying to control for time-invariant features (such as location, long-term institutions, and culture) that could otherwise skew the results. Thus, in our study, which focuses on country-specific dynamics throughout time, FEM is suitable. Data from developing country studies (such as ECOWAS) frequently contain significant unobserved heterogeneity by country. REM may mistakenly assign these effects to random fluctuation, whereas FEM accounts for them (Baltagi, 2021). In summary, FEM was chosen over REM not because it is fundamentally superior, but given that the assumption of no correlation between the individual effects and regression coefficients was violated; the Hausman test proved that FEM results in more consistent estimates; and FEM permits greater oversight of unobserved heterogeneity, which is essential for context-sensitive and policy-relevant analysis such as food security in ECOWAS region.

Food security versus climate factors

PREC (precipitation) was only significant in FEM at the 1% level (-0.0025, $p = 0.0016$). Rainfall variability is negative and large under FEM, suggesting that it may affect food security, maybe owing to flooding or unpredictable precipitation. This conclusion is congruent with that of Deressa et al. (2009) and FAO (2016), who discovered that heavy rainfall in Sub-Saharan Africa might harm crops and exacerbate food poverty. Temperature (TEMP) was significant at the 1% level in CEM (1.3667) and REM (3.9423), but not in FEM. This positive coefficient in REM (+3.94) but non-significance in FEM indicates that the impact was not uniform across areas; this might imply that mild warming boosts production in some nations in the region. This conclusion aligns with the findings of Schlenker and Lobell (2010), which indicated that slight temperature increases can actually boost yields in tropical regions at first, but too much heat can be detrimental. As global temperatures continue to rise, we risk damaging agricultural production, changing rainfall patterns, and increasing our susceptibility to natural disasters, all of which can lead to a decrease in food supply (Marwa et al., 2025). CO_2 (carbon emissions) was only significant at 1% of REM (+2.009, $p = 0.0007$). This suggests that the climate change driven by CO_2 could have various implications that aren't captured in FEM, possibly serving as a stand-in for industrialisation or environmental harm. Burney and Ramanathan (2014) found that increased CO_2 levels can negatively impact agricultural productivity due to climate instability. This conclusion aligns well with the assessment by Marwa et al. (2025), which highlighted that increasing CO2 emissions and their impact on climate change could severely threaten food security in Asia.

Food security and food production index

The Food Production Index (FPI) has shown a strong and significant positive relationship at the 1% level across all models—CEM (0.0756), FEM (0.0837), and REM (0.0635). This suggests that as food production increases, so does food security. Essentially, domestic agricultural output plays a crucial role in shaping food security at both national and regional levels. When food production rises, we generally see more food available, lower prices in the market, improved accessibility, and stronger incentives for farmers due to market dynamics. This also leads to reduced dependence on imports, enhancing food sovereignty. This finding aligns with the FAO's 2013 assertion that boosting agricultural productivity and production is fundamental for achieving long-term food security, especially in developing countries. They argue that food availability is the most critical pillar of food security. Supporting this, Smith et al. (2000) provided evidence that expanding agriculture directly alleviates food insecurity and undernutrition, particularly when it focuses on smallholder farmers. Additionally, research by Timmer (2002) and Headey (2011) indicates that increased food production not only enhances availability but also raises rural incomes and improves market efficiency, which in turn enhances both physical and economic access to food. The consistent positive link between FPI and food security across all models reinforces the notion that boosting domestic agricultural output is a practical and essential policy strategy for improving food security in ECOWAS and other developing nations.

Food security versus macroeconomic factors

EXP (exports) was favourably significant in CEM (0.0657) at the 1% level and FEM (0.0540) at the 5% level, but not in REM. Exports benefit food security, partly because foreign exchange gains increase import capacity. This conclusion is consistent with Sassi (2014) observation that trade openness can improve food access in Sub-Saharan Africa, provided export money is reinvested. The analysis shows that imports (IMP) had a notably negative impact at the 1% significance level in both the CEM (-0.1051) and FEM (-0.1319) models. This suggests that relying on food imports or having trade imbalances could put food security at risk. This finding aligns with the work of Rakotoarisoa et al. (2011), who argued that dependency on imports heightens vulnerability to price fluctuations. This idea ties back to vulnerability theory, which posits that macroeconomic instability—like inflation and exchange rate volatility—affects sensitivity by altering food prices and income levels. Additionally, GDP showed a significant negative effect at the 10% level in CEM (-2.1E-14) and at the 1% level in FEM (-4.29E-14). This indicates that GDP has a modest yet noteworthy impact on both CEM and FEM, possibly reflecting an uneven distribution of economic benefits. This conclusion is consistent with Smith et al. (2000), who found that GDP alone may not be sufficient to decrease food insecurity without specific policies.

Food security and population growth

POP (population) was only marginally significant (1.5E-8) in FEM at the 10% level, but not in CEM or REM. This suggests that the impact of population pressure on food security is somewhat limited and can vary depending on the context. The weak positive correlation indicates that larger populations might actually be linked to better food security, but this relationship hinges on how well population growth aligns with agricultural productivity, food distribution systems, and the ability of institutions to expand public services and goods. This finding aligns with Boserup's (1981) hypothesis, which argues that population growth can drive agricultural innovation. As populations grow, countries often have to make more intensive use of land, adopt new technologies, and boost food production, which could ultimately improve food security. Pingali (2012) supports Boserup's view, pointing out that if managed well, population growth can lead to increased investment in agricultural research, infrastructure, and human capital, fostering sustainable agricultural intensification. However, the FAO (2009) warns that rapid population growth in Sub-Saharan Africa has outstripped food availability in many nations, highlighting the urgent need for productive capacity and planning to turn demographic changes into food security outcomes. According to Headey and Ecker (2013), the relationship between population and food security is nonlinear and influenced by factors like economic structure, employment, urbanization, and policy choices. Countries with underdeveloped infrastructure or weak food systems are more vulnerable to food shortages driven by population growth. Therefore, the modest yet positive role of population (POP) in the FEM suggests that population growth can be beneficial for food security, as long as it is paired with improvements in agricultural production, technology adoption, and infrastructure development. The relationship is complex and doesn't follow a straightforward pattern across different regions.

Food security versus consumer price index

The consumer price index (CPI) stood at 5% across all models, though the signals varied (CEM at 0.0142, FEM at 0.0172, and REM at -0.0123). The positive coefficients in both CEM and FEM suggest that a rising CPI, which means increasing consumer prices, is linked to better food security. This could imply a growing economy and improved food supply operations, leading to higher nominal revenues, better food accessibility (assuming actual earnings rise in tandem), and more effective agricultural pricing strategies that encourage production. On the flip side, the negative coefficient in REM might reflect the harmful effects of inflation on food affordability, especially for those in poverty, when price hikes outpace income growth. Additionally, it highlights the changes between entities that REM struggles to capture, unlike FEM. This sign reversal highlights the sensitivity of CPI's influence on model specification, particularly unobserved heterogeneity (as reflected in FEM). CPI hikes can really take a toll on our actual buying power and might even limit access to food (Alem and Söderbom, 2012). The FAO (2008) points out that rising food prices, as shown by CPI spikes, could make food insecurity worse, especially in countries that rely heavily on food imports. The mixed effects of CPI across different models reveal a complex relationship: it appears positive in models that focus on dynamics within a country (FEM), possibly reflecting inflation driven by supply issues or investment growth. On the flip side, it seems negative in REM, which might suggest volatility between countries or broader economic instability. This underscores the need for tailored inflation control strategies and targeted safety nets for vulnerable populations during times of inflation.

The CPI measures the average change in consumer prices for a range of goods and services over a specific time frame (IMF, 2022). It's generally seen as a gauge of inflationary pressure, which can limit food access. Interestingly, under certain circumstances, a higher CPI might actually correlate with improved food security due to factors like structural inequality, policies, or economic conditions. In theory, as CPI rises, food prices go up, making it harder to afford food and ultimately threatening food security (FAO, 2021c). Yet, in some contexts or models, real-world evidence suggests the opposite might be true. The reasons why a higher CPI could be linked to better food security in this study include:

In many developing countries, a bit of inflation can actually signal rising demand, better incomes, or economic growth. This can lead to improved purchasing power and better access to food, especially if wage increases outpace inflation (World Bank, 2020b). Countries that offer subsidized essentials or have specialized safety nets can help protect low-income individuals even when prices go up. Take Nigeria, for example; it has seen mild inflation while rolling out government support programs and subsidies to shield vulnerable populations from food insecurity (NBS, 2022). Additionally, rising food prices, as shown in the Consumer Price Index (CPI), can benefit rural farmers by boosting their income, which in turn enhances their access to food, farming supplies, and essential services (IFPRI 2014). Increases in the prices of staple crops like rice or maize can improve farmers' livelihoods and positively influence national food security metrics in agricultural economies like those in the ECOWAS region.

It's important to remember that the Consumer Price Index (CPI) includes both food and non-food elements, like housing, transportation, and energy. So, just because the CPI is on the rise, it does not necessarily mean food prices are skyrocketing. If inflation in non-food areas is the main factor and food prices remain stable, overall food security might not only stay the same but could even improve (FAO, 2021c). In response to inflation spikes, governments often step in with measures like food aid, price controls, or support for agriculture to help ease the burden of rising prices on food access (WFP, 2022b). For example, during a period when Ghana's CPI increased, the country also ramped up food aid and fertilizer incentives, which led to better food security despite the inflation (World Bank, 2021b). In summary, while the CPI is typically associated with inflation that can squeeze consumer budgets and make food less affordable, the current research suggests that a positive link between the CPI and food security might stem from economic growth, increased agricultural income, or effective policy measures. In cases where governments implement supportive policies or farmers benefit from higher prices, the CPI could actually bolster certain aspects of food security rather than undermine them.

Optimal choice model test results

Table 5: Best model selection

Test	Statistic	Prob.
Chow test	11.2732***	0.0000
Hausman test	112.9132***	0.0000
Breusch_Pagan LM	523.2557***	0.0000

*** indicates significance levels of 1%

Source: Field Survey, 2025

Table 5 displays the optimal choice model test results. The Chow test looks for substantial individual effects (i.e., whether intercepts differ across cross-sectional units). The null hypothesis (no individual effects; CEM is acceptable) is rejected at a 1% level. FEM is utilised instead of CEM. Greene (2012) said that the Chow test is appropriate for determining if fixed effects are required, with rejection indicating a preference for the fixed effects estimator over CEM. The Hausman test distinguished between FEM and REM. The null hypothesis (that the difference in coefficients is not systematic; REM is coherent and effective) was rejected. FEM is chosen since REM is unreliable owing to regressor-error term correlation. The Breusch-Pagan Lagrange Multiplier (LM) test assesses whether a REM performs better than a CEM. The null hypothesis (variance of random effects equals zero) was rejected. REM performs better than CEM. This test is used to support the usage of REM over CEM, but not over FEM. Although the LM test favours REM over CEM, the Hausman test favours FEM over REM, which was the stronger criterion. Based on the results from these three experiments, the FEM was the best fit for the panel data.

Cross-section fixed and random effects

Table 6: Cross-section fixed and random effects

Country	Fixed effects	Random effects
Benin	-2.6102	4.26E-12
Burkina Faso	-5.6915	-1.68E-11
Côte d'Ivoire	2.1629	4.46E-11
Ghana	8.5884	1.62E-10
Guinea	-5.5616	1.75E-11
Mali	1.4088	-1.78E-11
Niger	-2.6868	-2.98E-11
Nigeria	10.3265	-1.63E-11
Senegal	0.4867	-4.01E-11
Sierra Leone	-4.2823	-6.30E-11
Togo	-2.1409	-4.41E-11

Source: Field Survey, 2025

Table 6 presents the fixed and random effects alongside the calculated coefficients for food insecurity across various ECOWAS countries, utilizing both the Fixed Effects Model (FEM) and the Random Effects Model (REM). The FEM coefficients show how food insecurity was influenced within each country after considering time-invariant, country-specific factors. Positive values (like those for Ghana, Côte d'Ivoire, and Nigeria) suggest that these nations are experiencing higher levels of food insecurity, while negative values (seen in Benin, Burkina Faso, and Guinea) indicate lower levels, once again accounting for those country-specific factors. The values vary significantly, ranging from -5.69 in Burkina Faso to +10.33 in Nigeria, highlighting the diversity of food insecurity across ECOWAS countries. On the other hand, the REM coefficients for most nations are quite small, hovering around zero, which means that when we factor in random effects—essentially the unique characteristics of each country—the model gives limited weight to the specific features of each nation. These REM values are often significantly lower than those from the FEM, suggesting that the REM may be underestimating the impact of country-specific variables on food insecurity. Therefore, the FEM was the preferred model for grasping the underlying causes of food insecurity in ECOWAS, as it effectively captures the unobserved variations at the country level.

5. Conclusion

This study highlights a significant connection between food insecurity in ECOWAS and various climate change factors, such as temperature, rainfall, and CO_2 emissions, alongside macroeconomic elements like inflation, GDP, and the Consumer Price Index (CPI). The findings indicate that while higher temperatures and food production generally correlate with better food security, erratic rainfall and reliance on imports can increase vulnerability. Additionally, financial instability poses a threat to the region's ability to maintain a steady and adequate food supply. The positive yet limited effects of population growth suggest that while demographic pressure does not directly harm food security, it can become a challenge if not paired with improvements in productivity and infrastructure. Likewise, the mixed results regarding CPI underscore the complex influence of governance and price stability on the resilience of food systems. The robustness of the panel estimation methods used in this study confirms their effectiveness for policy forecasting. These insights underline the urgent need for comprehensive policies that integrate climate adaptation strategies, macroeconomic adjustments, and investments in agricultural productivity and trade efficiency.

In conclusion, tackling food insecurity in ECOWAS requires a multifaceted approach that addresses both climate-related challenges and macroeconomic inequalities. Only by viewing these issues through this dual lens can we achieve food systems that foster sustainability and long-term food security across the region. Based on the study's insights into the interconnectedness of climate change and macroeconomic factors affecting food security in ECOWAS, the following policy recommendations are proposed to build resilience and enhance sustainable food systems throughout the area:

i. Food security in ECOWAS is in a tough spot and not evenly distributed. To tackle this, there is need to focus on making food affordable, improving supply chains, and boosting our ability to adapt. This aligns with the goals of SDG 2 (zero hunger) and the African Union's CAADP (Comprehensive Africa Agriculture Development Programme), which aims to ramp up investment in agriculture and enhance efficiency. There is also a need to transform agrifood systems while ensuring that everyone, especially women, youth, and marginalized groups, has equal opportunities. This can be achieved through better management of water and land, improving market access, alleviating hunger, and investing in agricultural research.

ii. There should also be work on increasing agricultural climate resilience by promoting climate-smart agriculture (CSA). This means encouraging the use of drought-resistant crops, agroforestry, sustainable farming practices, and improved irrigation systems. Additionally, it could boost climate research and technological advancements by fostering regional partnerships focused on adaptable seed varieties and sustainable agricultural management techniques.

iii. To make public investment more effective, there is a need to promote transparency and accountability in food-related spending, including farmer subsidies and social security systems. It's essential to create regional macroeconomic frameworks by aligning fiscal and trade policies across ECOWAS to help cushion against external shocks.

iv. Improving rural infrastructure is crucial, too. There is a need to enhance roads, storage facilities, processing plants, and electricity access to reduce post-harvest losses and lower market costs. Providing affordable fertilizers, better seeds, and mechanization support to smallholder farmers would also help.

v. Finally, there should be work on improving regional trade and integrating food systems by simplifying customs procedures and eliminating non-tariff barriers for intra-regional food trade. It's important to manage emergency grain storage and release strategies among member states and ensure that national food regulations align with the ECOWAS Agricultural Policy framework.

vi. To effectively tackle food insecurity in ECOWAS, there is a need for solid policy frameworks that focus on climate adaptation, economic stability, and fair agricultural growth. Even with the rising environmental and economic hurdles, a coordinated regional effort can help maintain food systems that are resilient, productive, and equitable.

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Data Availability

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

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