Can Globalisation Improve Food Security under Climate Change? Evidence from Sub-Saharan Africa

Kouakou Martinien KOFFI[1]
Yapo Kambo Paul Rodrigue ALLE[2]

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ABSTRACT

This article analyses the role of globalisation in the relationship between climate change and food security in sub-Saharan Africa. The study uses panel data covering 28 countries from 2001 to 2022 and employs the PCSE estimator, with robustness tests based on the FGLS, Driscoll-Kraay, and System GMM methods to account for potential endogeneity and reverse causality issues. The results show that CO_2 emissions and temperature have a negative effect on food security, while precipitation and globalisation have a positive effect. A disaggregation of globalisation also reveals positive effects from its economic, social, and political dimensions. The interaction terms between climate variables and globalisation are generally positive, indicating that international integration can mitigate the adverse effects of climate change and reinforce the favourable effects of precipitation. However, some interactions with social globalisation remain insignificant. These findings underscore the importance of international integration as a lever for adaptation and argue for the effective implementation of the AfCFTA to strengthen the resilience of food systems in sub-Saharan Africa.

KEYWORDS: *climate change, food security, globalisation, PCSE*

JEL CLASSIFICATION: *C23, F63, Q18, Q54*

1. INTRODUCTION

Globally, food insecurity and hunger are on the rise, affecting more than 30% of the population living in food-insecure households (Sibanda & Mwamakamba, 2021). This trend is particularly alarming in Africa, where hunger continues to rise, unlike in other regions such as Asia and Latin America, where it remains relatively contained. According to FAO et al. (2024), the proportion of hungry people in Africa stands at 20.4%, compared to 8.1% in Asia and 6.2% in Latin America. In addition, Xie et al. (2021) report that in 2020, there were 346.6 million food insecure people in Africa, or 37.3% of the global total, of which 25% were in sub-Saharan Africa. These statistics illustrate the scale of the food challenge facing the region. FAO et al. (2021) further highlight that 21% of Africa's population suffers from hunger on a daily basis, while a significant share of the continent's income depends on the agriculture and food sectors. This high structural dependence on agriculture reinforces the vulnerability of African economies to exogenous shocks, particularly climatic and economic. In addition, recent crises, including the COVID-19 pandemic and the Russia-Ukraine conflict, have exacerbated this situation by causing food prices to rise and reducing people's access to adequate food (Appiah-Otoo et al., 2024).

In the face of this dynamic, the outlook remains worrying. FAO et al. (2024) estimate that sub-Saharan Africa may not achieve Sustainable Development Goal 2 on ending hunger by 2030. The region could even become the region with the highest number of undernourished people in the world. This is largely due to the heavy reliance on rain-fed agriculture, which makes food

[1] Alassane Ouattara University, Bouaké, Côte d'Ivoire, martinienkoffikkm@gmail.com,
[2] Alassane Ouattara University, Bouaké, Côte d'Ivoire, paul01alle@gmail.com,

systems particularly sensitive to climate variations (Kogo et al., 2021). Numerous empirical studies confirm that climate change is a major determinant of food insecurity (Chandio et al., 2023; Rehman et al., 2024; Appiah-Otoo et al., 2024). Sub-Saharan Africa thus appears to be one of the regions most exposed to temperature increases and erratic rainfall (Field & Barros, 2014). Therefore, understanding the mechanisms by which global factors influence the relationship between climate change and food security becomes a research priority.

In this context, globalisation appears to be a potential lever for mitigating or amplifying these vulnerabilities. Several studies highlight its beneficial effects on food security. Cengiz and Demir (2024) show that globalisation contributes to improving access to and availability of food. On the theoretical level, the Heckscher-Ohlin theory (Heckscher, 1919; Ohlin, 1933) suggests that international openness favours specialisation according to comparative advantages, allowing countries to import food goods that they do not produce efficiently. Empirically, trade openness facilitates access to food products (Gnedeka & Wonyra, 2023; Fusco et al., 2020), while economic globalisation can boost growth and increase the resources available for food security (Nugroho et al., 2021). However, these effects are not unequivocal. Shang et al. (2024) show that while globalisation improves food availability, it can in some cases reduce its accessibility. In addition, Khurshid and Abid (2024) point out that political globalisation can expose countries to vulnerabilities related to external dependencies and geopolitical shocks. Thus, globalisation can act as a mechanism for amplifying or mitigating the effects of climate change on food security, depending on the institutional and economic contexts.

In this context, sub-Saharan African countries, which are highly integrated into the dynamics of globalisation while being vulnerable to climate change, are at the heart of these complex interactions. However, while the existing literature has largely focused on the direct effects of climate change and globalisation on food security, few studies have analysed the moderating role of globalisation in the relationship between climate change and food security. This empirical gap limits the understanding of the mechanisms by which globalisation can mitigate or accentuate the effects of climate on food systems. This study aims precisely to fill this gap.

This study makes several contributions to the literature. First, it offers an original analysis of the role of globalisation in the relationship between climate change and food security in sub-Saharan Africa, highlighting not only its direct effect but also its ability to moderate the effects of climate shocks. Second, the study shows that globalisation is a multidimensional factor in resilience: its economic, social, and political dimensions contribute to improving food security and can, to a large extent, mitigate the adverse effects of climate change. It thus highlights the various channels through which international integration can strengthen the resilience of food systems, particularly through access to markets, technologies, resources, and international cooperation. Third, from a methodological standpoint, the study employs an econometric approach combining PCSE, FGLS, Driscoll-Kraay, and System GMM, which allows for addressing key econometric issues and verifying the robustness of the results. Finally, it provides economic policy implications in the context of the AfCFTA, emphasising that regional integration can serve as an important driver of adaptation and food resilience in the face of climate change.

Empirical results show that climate change significantly worsens food security, while globalisation has an overall positive effect. Most importantly, the interaction effect reveals that globalisation mitigates the negative impact of climate change on food security, suggesting that international economic integration can strengthen the capacity of sub-Saharan African countries to cope with climate shocks. These findings thus underscore the importance of policies that promote inclusive and resilient economic integration. From this perspective, the

implementation of the African Continental Free Trade Area (AfCFTA) represents a strategic opportunity to deepen regional trade, strengthen food supply chains, and facilitate small producers' access to African markets.

The rest of the article is structured as follows: the following section presents a review of the literature on the links between climate change, globalisation and food security; the third section offers a descriptive analysis of the context in sub-Saharan Africa; the fourth section details the methodology used; the fifth section exposes and discusses the empirical results; finally, the last section concludes and proposes economic policy recommendations.

2. LITERATURE REVIEW

2.1 Climate change and food security: an overview of the literature

Food is one of the basic needs that are essential for the survival of any living being. Beyond its biological function, it also represents a major economic, social and cultural issue, insofar as it is closely linked to the lifestyles, traditions and organisation of human societies (Feeley-Harnik, 1995; Fieldhouse, 1995; Kittler et al., 2012; Mintz & Du Bois, 2002). Thus, access to sufficient, quality food is now a fundamental right and a central pillar of sustainable human development (Ahmed et al., 2020). In the economic literature, there is a consensus that climate change is a key determinant of food security. Indeed, the study by Ntiamoah et al. (2023) highlights the role of CO2 emissions in intensifying global warming, through the accumulation of heat-trapping greenhouse gases in the atmosphere. This is leading to major climate disruptions, including rising temperatures, rainfall variability, and increased frequency of extreme weather events, which directly affect farming systems. As a result, these changes have significant adverse effects on agricultural production and, by extension, on food security.

In the same perspective, Adesete et al. (2023) analysed the relationship between climate change and food security in 30 sub-Saharan African countries over the period 2000–2019. Their results show that an increase in greenhouse gas emissions worsens malnutrition and undermines food security in the region. They also highlight the differentiated role of economic factors, pointing out that while income and food availability improve food security, the effects of climate change and rising food prices exert significant negative pressure. In addition, the authors show that climate change contributes to chronic food insecurity by generating adverse long-term macroeconomic effects, including increasing poverty and slowing economic growth. In addition, several empirical studies (Thomson et al., 2010; Chapman et al., 2020; Stuch et al., 2021; Merino et al., 2021; Appiah, 2020) confirm the negative relationship between climate change and food security in sub-Saharan Africa. These studies highlight worrying trends such as declining agricultural productivity, land degradation, rising food prices and deteriorating household welfare. These dynamics reflect the structural vulnerability of African food systems to climate shocks, due in particular to the high dependence on rain-fed agriculture and the low level of technological adaptation.

Theoretically, the economic literature suggests that countries facing food supply constraints tend to rely more heavily on imports to meet domestic needs. These constraints can result from several factors, including climate change, technological shocks, and population growth (Egbendewe et al., 2016). In this context, international trade appears to be an essential adjustment mechanism for mitigating imbalances between food supply and demand, although its effectiveness depends on the degree to which countries are integrated into the world economy and the stability of international markets.

In sum, the literature clearly shows that climate change is a determinant of food insecurity, both in terms of its direct effects on agricultural production and its indirect impacts on prices, incomes and macroeconomic conditions.

2.2 The role of globalisation in food security

The link between globalisation and food security can be analysed in the light of the Heckscher-Ohlin (HO) theory of international trade. This theory posits that countries tend to export goods that make intensive use of their abundant factors of production and import those that mobilize their scarce factors. In other words, international specialisation allows for a more efficient allocation of resources on a global scale, thereby improving the overall production and availability of goods, including food. In the context of food security, this approach suggests that countries need to identify their comparative advantages in the agricultural sector and orient their policies accordingly. Thus, globalisation, by promoting trade integration, can help improve access to food, while allowing for better diversification of sources of supply. The development of foreign trade in the agricultural sector therefore appears to be an essential lever for strengthening food security, particularly in sub-Saharan Africa.

However, the recent empirical literature on the relationship between globalisation and food security remains relatively limited (Huda, 2024; Fusco et al., 2020). Despite this relative rarity, existing research converges on the idea that globalisation is a structuring factor in modern food systems. Indeed, economic globalisation has profoundly transformed international relations by reducing geopolitical barriers and intensifying the exchange of goods, services and capital. This increased integration of national economies reinforces food interdependencies between countries, which changes the traditional determinants of food security. The expected benefits of globalisation come largely from international trade, which facilitates the movement of food products and improves their accessibility (Huda, 2024). In this regard, Fusco et al. (2020) show that trade openness has a positive and statistically significant effect on food security in European countries. These results suggest that economic integration helps stabilize food supply by diversifying import sources.

In a context of food insecurity, trade openness allows deficit countries to import food from surplus countries, thus helping to improve food availability at the national level (Gnedeka & Wonyra, 2023). This adjustment mechanism plays a crucial role in reducing imbalances between food supply and demand, especially in economies vulnerable to climate or productive shocks. Dithmer and Abdulai (2017) analysed the impact of trade openness on food security in low- and middle-income countries using a dynamic panel model estimated by the Generalized Method of Moments (GMM) method, on a sample of 151 countries covering the period 1980–2007. Their results indicate that a 10% increase in trade openness reduces the prevalence of undernourishment by about 1%. They also highlight a more pronounced effect of trade openness in countries with low agricultural productivity and low income levels, thus highlighting the role of globalisation as a lever for reducing food vulnerabilities.

Nevertheless, it should be noted that the effects of globalisation on food security are not unequivocal. While improving the availability of and access to food, it can also increase countries' dependence on international markets and increase their exposure to external shocks, such as price fluctuations or trade crises.

3. ANALYSIS OF FOOD SECURITY, CLIMATE CHANGE AND GLOBALISATION

Figure 1 highlights the relationships between two key indicators of food security, namely average protein intake (AV_PR) and average energy adequacy (AV_DI), as well as two major explanatory variables: CO2 emissions, used as a proxy for climate change, and the globalisation index. Trend lines are accompanied by a 95% confidence interval (shaded area), allowing the accuracy of the estimates to be assessed, in addition to adjusted values (fine line) and individual observations (black dots). For the AV_PR, the graphical results indicate that the relationship with CO2 emissions remains weak and imprecise. The slope of the adjusted line is almost flat,

while the confidence interval widens considerably for high levels of CO2, reflecting high uncertainty and a large dispersion of observations. This suggests that the direct impact of climate change on protein intake is difficult to capture in a linear fashion, probably due to indirect and delayed mechanisms affecting agricultural systems. On the other hand, the relationship between the AV_PR and the globalisation index appears clearer and more positive. The slightly steeper slope, coupled with a narrower confidence interval around the core values, indicates that countries that are more integrated into the global economy tend to have higher levels of average protein intake. This result highlights the role of globalisation as a factor in improving access to and availability of food, particularly through trade and the diffusion of agricultural technologies.

Regarding AV_DI, the average adequacy of energy intake shows a similar dynamic. The relationship with CO2 emissions remains weak and characterised by a high dispersion of data, confirming the difficulty of establishing a direct and robust link between climate change and food security at this descriptive stage. This can be explained by the intervention of intermediate variables such as public policies, adaptive capacities or national economic structures. Conversely, the relationship between AV_DI and the globalisation index is positive, albeit moderate, suggesting that a higher degree of globalisation is associated with better energy adequacy. This relationship reflects the potential role of globalisation in stabilizing food supply and reducing nutritional deficits. Overall, these graphical results indicate that globalisation has a more readable and stable effect on food security indicators than climate change. They also suggest that globalisation could play a moderating role in the relationship between climate change and food security in sub-Saharan Africa, mitigating the negative effects of climate disruptions. However, the lack of a clear relationship between CO2 emissions and dietary indicators underlines the need for a thorough econometric analysis integrating fixed effects, relevant control variables and interactions, in order to better identify the underlying causal mechanisms.

Thus, this descriptive analysis is a first step that supports the relevance of empirically examining the role of globalisation as a channel for adjustment to climate shocks in sub-Saharan African countries.

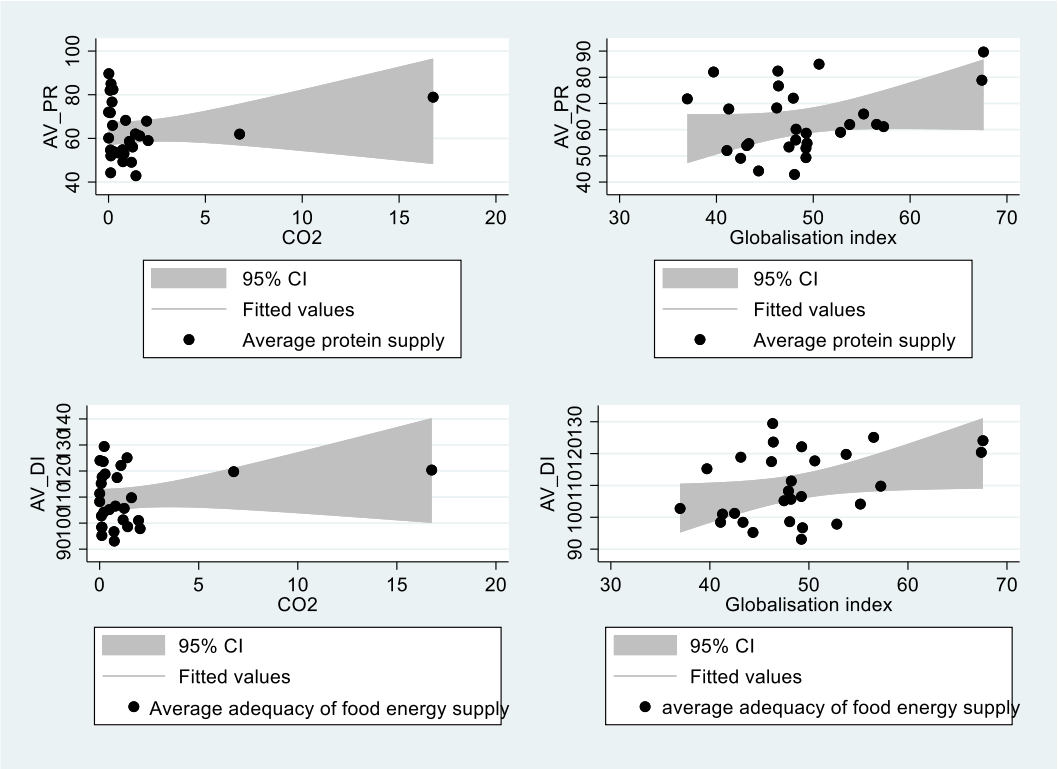


Figure 1. Correlations between CO_2 emissions, the globalisation index and food security indicators

Source: Authors

4. METHODOLOGY

4.1 Model specification

This study aims to analyse the role of globalisation in the relationship between climate change and food security in sub-Saharan Africa. The general form of the relationship between the dependent and explanatory variables can be represented as follows:

$$Y_{it} = \beta' X_{it} + \varepsilon_{it} \tag{1}$$

where represents the dependent variable, is a dimension vector explanatory variables, is a dimension vector the coefficients associated with the explanatory variables, corresponds to the error term with its usual properties. Building on the previous work of Appiah-Otoo et al. (2024), Hamadjoda Lefe et al. (2024), and Gnedeka and Wonyra (2023), and in line with the objective of this study as well as the variables considered, the empirical model is defined by Equation 2 as follows:

$$FS_{it} = \beta_0 + \beta_1 C\lim a_{it} + \beta_2 Global_{it} + \vartheta CV + \varepsilon_{it} \tag{2}$$

Where is the natural logarithm, is the food security measured by the average adequacy of the food energy supply and the average protein supply; measures climate change (CO2, temperature, and precipitation); corresponds to globalisation, refers to control variables and is the error term

In order to determine the influence of globalisation on the relationship between climate change and food security, we estimate the following Equation 3:

$$FS_{it} = \beta_0 + \beta_1 C\lim a_{it} + \beta_2 Global_{it} + \beta_3 (C\lim a_{it} \times Global_{it}) + \vartheta CV + \varepsilon_{it} \tag{3}$$

Where represents the interaction between climate change and globalisation.

4.2 Data

The data in this study are panel data covering the period 2001–2022. For the purposes of this study, 28 countries were selected. Countries were selected based on the availability of data (see Table A7 in the Appendix for the list of countries used in this study). In this study, the dependent variable is food security. The dimensions of food security as well as its indicators were used. The main independent variables are climate change, measured by CO2 emissions, temperature and precipitation, and globalisation, measured by the KOF index and its three dimensions (Gygli et al., 2019). Table 1 presents the description of the variables and the data sources.

Table 1. Description of variables and sources

Variables	Definition of variables	Unit	Sources
AV_DI	Average dietary energy supply adequacy (percent) (3-year average)	%	FAOSTAT
AV_PR	Average protein supply (g/capita/day) (3-year average)	g/cap/day	FAOSTAT
CO2	Emissions from industrial processes	Megatons	WDI
Precipitation (Precipita)	Average precipitation	Millimeters	UN Climate Change (CCNUCC)
Temperature (Temp)	Average annual temperature	degrees Celsius (°C).	UN Climate Change (CCNUCC)
Globalisation	KOF Globalisation Index (0–100); a composite index measuring three dimensions (economic, social, political).	No.	KOF Swiss Economic Institute
KOFEcGI	KOF Economic Globalisation Index (0–100); measures the degree of economic globalisation	No.	KOF Swiss Economic Institute
KOFSoGI	KOF Social Globalisation Index (0–100); measures the degree of social globalisation	No.	KOF Swiss Economic Institute
KOFPoGI	KOF Political Globalisation Index (0–100); measures the degree of political globalisation	No.	KOF Swiss Economic Institute
GDP per Capita	Gross domestic product per capita	International $	WDI
Corruption	Corruption Control Score	No.	WGI
Infrastructure (Infra)	Transportation Infrastructure Index.	No.	AFDB
Trade openness (Trade)	Measures the level of integration of countries into the global economy	No.	WDI
Inflation	Consumer Price Index (2010=100)	No.	WDI
Population	Population growth	No.	WDI
GVC	Value Chain Participation Index	International $	UNCTAD-EORA

Source: Authors.

4.3 Estimation technique

This article examines the effect of globalisation on the relationship between climate change and food security in sub-Saharan Africa. To achieve this objective, the study used the PCSE (Panel corrected standard errors) method developed by Beck and Katz (1995). The advantage of using PCSE over the Generalized Moment Dynamics (GMM) method lies in its ability to resolve the cross-sectional dependence, or better yet the correlation between panels and autocorrelation,

while controlling for heteroscedasticity (Reed & Webb, 2010). The PCSE technique is robust to the possibility of non-spherical errors and is applicable to long panels. To better take into account this estimation technique appropriate to our study, several panel tests are performed. First, the Wald test was performed to detect the presence of heteroscedasticity. Then the Wooldridge (2002) test was used to check for the existence of autocorrelation of the errors. The autocorrelation of errors in a panel model violates the basic assumption of error independence (uncorrelated errors) in classical econometric models. Finally, the Pesaran (2021) CD test was used to check for cross-sectional dependence (see Tables A1, A2 and A3 in the Appendix).

5. RESULTS AND DISCUSSION

5.1 Descriptive statistics

The analysis of descriptive statistics makes it possible to better understand the distribution of variables and to highlight the disparities between the countries studied. Table 2 presents the descriptive statistics of our study variables. It shows that the average dietary energy supply adequacy is 109.54% with a standard deviation of 12.16. The mean protein supply is 63.10 g/cap/day, with a standard deviation of 13.26 and a variation ranging from 36.9 to 97.2 g/cap/day. These statistics reveal that some regions of sub-Saharan Africa face food security challenges. In addition, CO2 emissions range from 0.0011 to 18.5762 megatons, illustrating strong heterogeneity in CO2 emissions across the countries of the region. Precipitation averages 1,000.15 mm annually, ranging from 115 to 2,654.5 mm, while the average temperature is 24.86 °C with little variation. These results highlight the diversity of climatic conditions faced by the countries in the sample. With regard to globalisation, the overall KOF index averages 48.91, indicating a relatively moderate level of international integration. An examination of the various dimensions shows that political globalisation has the highest average level (63.06), ahead of economic globalisation (44.10) and social globalisation (39.83), suggesting that sub-Saharan African countries are more politically integrated than they are economically and socially. Finally, the ranges observed between the minimum and maximum values of all variables reflect significant heterogeneity among countries, which justifies the use of panel data analysis to better understand the determinants of food security in the region.

Table 2. Descriptive Statistics

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
AV_DI	589	109.5399	12.15814	74	135
AV_PR	588	63.1034	13.26073	36.9	97.2
CO2	589	1.450192	3.340726	0.0011	18.5762
Precipitation	589	1000.145	593.2851	115	2654.5
Temperature	589	24.86307	2.984204	18.1	29.3
Globalisation	588	48.91279	8.066426	29.29591	71.9321
KOFEcGI	588	44.10072	10.2453	21.36734	85.35331
KOFSoGI	588	39.83215	12.59054	12.45983	78.20269
KOFPoGI	588	63.06379	12.38346	29.13238	88.96986
GDP Per capita	589	1805.143	2187.374	110.461	11643.5
Corruption	589	-0.57923	0.5625566	-1.53419	0.970904
Infrastructure	477	8.34282	8.123726	1.091045	37.64882
Trade	589	59.77943	28.62357	0	129.779
CPI (Inflation)	569	150.0069	524.9647	7.347208	11076.6
Population	589	2.54E+07	3.42E+07	465958	2.13E+08
GVC	589	3004663	9459261	0	6.75E+07

Source: Authors.

To reduce the asymmetry of the distributions and limit the potential influence of outliers, the variables were transformed using the natural logarithm prior to the econometric estimates, in accordance with the literature (Bellemare & Wichman, 2020). The corruption variable is an exception, as it contains negative values for which the natural logarithm is undefined; it is therefore retained in its original form (Mullahy & Norton, 2022).

5.2 Results of econometric estimates

Tables 3, 4, and 5 present the results of the estimates obtained using the PCSE model. Table 3 presents the results regarding the moderating role of globalisation in the relationship between CO_2 emissions and food security. The analysis shows that CO_2 emissions have a systematic negative effect on food security indicators across all models. A 1% increase in CO2 emissions leads to a 0.0169% decrease in the average adequacy of food energy supply and a 0.0521% decrease in the average protein supply, confirming that climate change directly affects food security in sub-Saharan Africa. This relationship is due to disrupted rainfall patterns, accelerated soil degradation, rising temperatures, and the increased proliferation of diseases and pests, which undermine agricultural production. The region's heavy dependence on rain-fed agriculture amplifies these vulnerabilities, leading to higher food prices and reducing access to food for the poorest populations, in line with the findings of Appiah-Otoo et al. (2024). On the other hand, globalisation has a significant positive effect on food security. A 1 percent increase in the Globalisation Index translates into a 0.46 percent increase in average protein supply, reflecting the role of trade openness and international integration in the diffusion of advanced agricultural technologies, such as improved seeds and high-performance fertilizers. Access to international markets also allows food to be imported in times of shortage, thus diversifying supply and stabilizing local prices, which corroborates the findings of Shang et al. (2024).

An analysis of globalisation reveals that its economic, social, and political dimensions are all positively associated with food security. Economic globalisation can promote access to markets, investment, agricultural inputs, and technologies, while the social and political dimensions can facilitate the flow of knowledge and international cooperation, respectively.

This finding is broadly consistent with Ketu and Mbiankeu Nguea (2024), who show that globalisation can help reduce undernutrition and stunting in Africa, while emphasising that its effects may vary depending on its different dimensions.

An analysis of the interaction between CO_2 emissions and globalisation shows that, despite CO_2's negative effect on food security, the terms of interaction are positive, suggesting that international integration can help mitigate the adverse effects of climate shocks in sub-Saharan Africa. This result can be explained by the role of international trade as an adaptation mechanism, which helps offset local production losses and diversify supply sources, as shown by Janssens et al. (2020) and Aurélien (2025). Globalisation can also facilitate the dissemination of climate-adapted agricultural technologies, including drought-resistant seeds, smart irrigation, and precision farming practices, thereby helping to maintain productivity despite adverse climatic conditions, as shown by the findings of Cengiz and Demir (2024). However, the interaction between CO_2 and social globalisation, while positive, remains statistically insignificant, suggesting that adaptive capacity relies more on economic resources, investments, technologies, and institutional arrangements than on social and informational exchanges alone.

Table 4 highlights a positive association between rainfall and food security. This finding is consistent with that of Affoh et al. (2022), who show that rainfall improves various dimensions of food security, particularly food availability and accessibility. In a region where agriculture remains largely dependent on rainfall, improved rainfall conditions boost agricultural yields, increase food supply, and improve households' access to energy and protein. The results also reveal that the interactions between rainfall and the various dimensions of globalisation are positive. In other words, globalisation reinforces the favourable effects of rainfall on food security. This conclusion suggests that countries more deeply integrated into the global economy are better able to translate favourable climatic conditions into gains in production and food availability through improved access to agricultural technologies, international markets, information, and financial resources. This interpretation is consistent with the work of Gouel and Laborde (2021), which shows that international trade is an important adaptation mechanism that enables economies to better capitalize on their agricultural advantages and reduce the risks associated with climate shocks.

Furthermore, Table 5 shows that temperature is negatively associated with food security. This finding confirms that rising temperatures constitute a major constraint on agricultural systems in sub-Saharan Africa. It is consistent with the conclusions of Affoh et al. (2022), who highlight an adverse effect of temperatures on food availability and accessibility. Rising temperatures exacerbate water stress, reduce agricultural yields, and further undermine the resilience of populations already vulnerable to food insecurity. However, the interactions between temperature and the various dimensions of globalisation are positive, with the exception of the interaction with social globalisation, which remains positive but is not statistically significant. This result indicates that economic and political globalisation can mitigate the adverse effects of rising temperatures on food security. This buffering capacity can be explained by improved access to adaptation technologies, investments, international markets, and international cooperation mechanisms. Our findings are consistent with those of Aurélien (2025), who shows that international trade reduces the climate vulnerability of sub-Saharan African countries, as well as those of Janssens et al. (2020), who find that trade integration strengthens the adaptive capacity of food systems in the face of climate change.

With regard to control variables, the quality of institutions appears to be a key determinant of food security in sub-Saharan Africa (Phungwayo et al., 2021). Estimates reveal an ambivalent effect of corruption: positive on average protein supply but negative on average adequacy of dietary energy intake. This result underscores the importance of strengthening anti-corruption

measures to sustainably improve food security, in line with the findings of Ogunniyi et al. (2020). With regard to infrastructure, although the literature highlights its positive role, our results indicate that transportation infrastructure has a negative effect on food security. This contradiction can be explained by the still-insufficient level of development of road networks, which hinders the transport of agricultural products, increases transportation costs, and contributes to rising food prices. Trade liberalisation has a positive impact on food security by improving the availability and variety of food products. In a context of chronic food shortages, this openness allows for the importation of foodstuffs to make up for shortfalls in local supply and offer consumers a wider variety of products at competitive prices, as shown by Gnedeka and Wonyra (2023) and Gadhok (2016). This finding is particularly relevant for sub-Saharan Africa, where international trade can help temporarily offset production shortfalls caused by climate shocks.

Overall, the results confirm that food security in sub-Saharan Africa depends not only on climatic conditions but also on countries' ability to capitalize on the opportunities offered by international integration. Globalisation thus emerges as a factor of resilience that amplifies the beneficial effects of precipitation and mitigates the adverse effects of CO_2 emissions and rising temperatures. These findings are fully consistent with SDG 2 (Zero Hunger) and SDG 13 (Climate Action), highlighting the importance of policies that simultaneously promote climate adaptation, technology transfer, trade liberalisation, and international cooperation.

Table 3. The Moderating Role of Globalisation in the Relationship Between CO_2 Emissions and Food Security (PCSE Estimates)

	AV-DI								AV-PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
CO2	-0.0169 *** (0.0000)	-0.1196 *** (0.0000)	-0.0009* (0.0636)	-0.0375** (0.0156)	-0.0044*** (0.0038)	-0.0007 (0.9025)	-0.0030** (0.0483)	-0.0414 (0.2028)	-0.0521*** (0.0001)	-0.3475 *** (0.0001)	-0.0048** (0.0348)	-0.1213*** (0.0008)	-0.0096*** (0.0000)	-0.0001 (0.9876)	0.0075*** (0.0010)	-0.3342*** (0.0000)
Globalisation	0.3351 *** (0.0000)	0.3891*** (0.0000)							0.4621 *** (0.0004)	0.6175 *** (0.0005)						
KOFEcGI			0.0022*** (0.0000)	0.0024*** (0.0000)							0.0084*** (0.0000)	0.0092*** (0.0000)				
KOFSoGI					0.0040*** (0.0000)	0.0040*** (0.0000)							0.0050*** (0.0002)	0.0050*** (0.0002)		
KOFPoGI							0.0044*** (0.0000)	0.0041*** (0.0000)							0.0065*** (0.0000)	0.0042*** (0.0000)
GDP per capita	0.0403*** (0.0000)	0.0405*** (0.000)	0.0475*** (0.0000)	0.0333*** (0.0001)	0.0312*** (0.0001)	0.0326*** (0.0001)	0.0409*** (0.0000)	0.0413*** (0.0000)	0.1578 *** (0.0003)	0.1586 *** (0.0001)	0.1655*** (0.0000)	0.1169*** (0.0000)	0.1623*** (0.0000)	0.1659*** (0.0000)	0.1713*** (0.0000)	0.1743*** (0.0000)
Corruption	-0.0153 * (0.0402)	-0.0182* (0.0291)	-0.0074 (0.3401)	-0.0070 (0.3852)	-0.0465 (0.2953)	-0.0462 (0.1427)	-0.0365* (0.0840)	-0.0365* (0.0656)	0.0683 *** (0.0008)	0.0600 *** (0.0002)	-0.0030 (0.7620)	-0.0013 (0.9008)	-0.0879* (0.0690)	-0.0872* (0.0560)	-0.0790*** (0.0000)	-0.0790*** (0.0000)
Infra	-0.0457 (0.0000)	-0.0478 *** (0.0000)	0.0003 (0.3729)	0.0018*** (0.0004)	-0.0013*** (0.0005)	-0.0015*** (0.0015)	-0.0008 (0.1171)	-0.0009*** (0.0039)	-0.1309 *** (0.0000)	-0.1368 (0.2274)	0.0055 (0.3296)	0.0105 (0.2730)	0.0011 (0.1272)	0.0006 (0.2840)	0.0017* (0.0532)	0.0008 (0.1812)
Trade	0.0118*** (0.0000)	0.0110*** (0.0012)	-0.0000 (0.8836)	0.0001 (0.6105)	0.0001 (0.5570)	0.0001 (0.6809)	0.0002 (0.3024)	0.0001 (0.6647)	0.0302*** (0.0007)	0.0278 (0.2936)	0.0006*** (0.0056)	0.0011*** (0.0001)	0.0011*** (0.0001)	0.0010*** (0.0013)	0.0012*** (0.0000)	0.0004 (0.1429)
Inflation	-0.0122 (0.2073)	-0.0104 (0.2779)	0.0000 (0.9911)	-0.0000 (0.7968)	-0.0002* (0.0884)	-0.0002 (0.1073)	0.0000 (0.9498)	0.0000 (0.5879)	-0.0330 (0.1305)	-0.0279 (0.1814)	-0.0003 (0.1483)	-0.0004* (0.0584)	-0.0007*** (0.0066)	-0.0007*** (0.0094)	-0.0004** (0.0178)	-0.0001 (0.4056)
Population	0.0164*** (0.0001)	0.0149*** (0.0002)	-0.0021 (0.6899)	-0.0041 (0.4118)	0.0133** (0.0266)	0.0130** (0.0327)	-0.0283*** (0.0000)	-0.0272*** (0.0000)	0.0483 *** (0.0000)	0.0442 *** (0.0031)	0.0133 (0.2308)	0.0064 (0.5144)	0.0485*** (0.0024)	0.0478*** (0.0029)	-0.0103 (0.4404)	-0.0020 (0.8851)
GVC	-0.0013** (0.0286)	-0.0017 *** (0.0042)	0.0006 (0.9208)	0.0025 (0.6526)	-0.0077 (0.1783)	-0.0072 (0.2163)	-0.0063 (0.2042)	-0.0030 (0.5005)	-0.0116 *** (0.0000)	-0.0128 *** (0.0002)	-0.0559 (0.1278)	-0.0493 (0.9548)	-0.0893 (0.1743)	-0.0881* (0.0650)	-0.0872** (0.0385)	-0.0617** (0.0295)
Globalisation*CO2		0.0258 *** (0.0005)								0.0742*** (0.0000)						
KOFEcGI*CO2				0.0008*** (0.0090)								0.0026** (0.0403)				
KOFSoGI*CO2						0.0001 (0.4765)								0.0002 (0.2556)		
KOFPoGI*CO2								0.0005 (0.1810)								0.0039*** (0.0000)
Constant	2.9197*** (0.0000)	2.7278 *** (0.0000)	4.4861*** (0.0000)	4.5890*** (0.0000)	4.1927*** (0.0000)	4.1855*** (0.0000)	4.6473*** (0.0000)	4.6109*** (0.0000)	0.8186 *** (0.0000)	0.2667 *** (0.0000)	3.8431*** (0.0000)	4.1977*** (0.0000)	3.1308*** (0.0000)	3.1126*** (0.0000)	3.7597*** (0.0000)	3.4801*** (0.0000)
R^2	0.20	0.21	0.16	0.17	0.18	0.18	0.24	0.24	0.43	0.44	0.49	0.52	0.43	0.43	0.46	0.50
N	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 4. The moderating role of globalisation in the relationship between precipitation and food security (PCSE estimates)

	AV-DI								AV-PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Precipita	0.0001*** (0.0000)	0.0003*** (00000)	0.0000*** (0.0000)	0.0001*** (0.0001)	0.0000*** (0.0000)	0.0001*** (0.0000)	0.0000*** (0.0000)	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0006*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0001*** (0.0000)	0.0003*** (0.0000)	0.0001*** (0.0000)	0.0004*** (0.0000)
Globalisation	0.0016* (0.0782)	0.0035** (0.0347)							0.0057*** (0.0003)	0.0153*** (0.0000)						
KOFEcGI			0.0040*** (0.0000)	0.0001 (0.9546)							0.0142* (0.0510)	0.0011 (0.5314)				
KOFSoGI					0.0018* (0.0535)	0.0069*** (0.0000)							0.0021 (0.2132)	0.0145*** (0.0000)		
KOFPoGI							0.0040*** (0.0000)	0.0070*** (0.0000)							0.0039*** (0.0000)	0.0134*** (0.0000)
GDP per capita	0.0835*** (0.0000)	0.0639*** (0.0000)	0.0719** (0.0230)	0.0846*** (0.0000)	0.0767*** (0.0000)	0.0756*** (0.0000)	0.0749*** (0.0000)	0.0798*** (0.0000)	0.2377*** (0.0000)	0.2010*** (0.0000)	0.1802*** (0.0000)	0.2275** (0.0390)	0.2400** (0.0160)	0.2364*** (0.0000)	0.2185*** (0.0000)	0.2338*** (0.0000)
Corruption	-0.0102 (0.1196)	-0.0111 (0.1039)	0.0187** (0.0122)	0.0229*** (0.0006)	-0.0118 (0.1360)	0.0012 (0.8840)	-0.0283*** (0.0000)	-0.0109* (0.0843)	-0.0084 (0.3893)	-0.0100 (0.2720)	0.0280** (0.0456)	0.0437*** (0.0000)	-0.0284*** (0.0042)	0.0139 (0.1164)	-0.0683*** (0.0000)	-0.0134 (0.1593)
Infra	-0.0003 (0.4634)	-0.0007* (0.0685)	-0.0001 (0.7015)	-0.0007** (0.0260)	-0.0005** (0.0177)	-0.0020* (0.0590)	-0.0003 (0.1369)	-0.0015*** (0.0000)	-0.0034 (0.3486)	-0.0052 (0.1207)	-0.0036*** (0.0000)	-0.0006 (0.2390)	-0.0032** (0.0470)	-0.0018*** (0.0000)	-0.0026*** (0.0000)	-0.0009** (0.0229)
Trade	0.0010 (0.1175)	-0.0011 (0.1239)	-0.0009* (0.0560)	-0.0010** (0.0148)	-0.0010** (0.0382)	-0.0010** (0.0295)	-0.0005* (0.0638)	-0.0005** (0.0136)	-0.0020** (0.0210)	-0.0022 (0.0000)	-0.0009*** (0.0002)	-0.0016*** (0.0000)	-0.0019*** (0.0000)	-0.0018*** (0.0000)	-0.0012*** (0.0000)	-0.0010*** (0.0000)
Inflation	0.0010 (0.9713)	-0.0030 (0.8152)	0.0001 (0.2487)	0.0001 (0.3883)	-0.0001 (0.6649)	-0.0002 (0.2402)	0.0001 (0.4582)	0.0001 (0.3118)	-0.0004 (0.1505)	-0.0004* (0.0581)	-0.0002 (0.3111)	-0.0003** (0.0185)	-0.0004 (0.1850)	-0.0007*** (0.0019)	-0.0005* (0.0736)	-0.0004* (0.0542)
Population	0.0110 (0.2555)	0.0073 (0.4162)	0.0024 (0.8163)	0.0053 (0.5969)	0.0153 (0.1684)	0.0174 (0.1287)	-0.0047 (0.5987)	-0.0105 (0.3014)	0.0316** (0.0401)	0.0247* (0.0810)	0.0033 (0.8171)	0.0145 (0.2492)	0.0272 (0.1219)	0.0340** (0.0252)	0.0174 (0.1688)	-0.0010 (0.9362)
GVC	-0.0242 (0.1674)	-0.0188 (0.2051)	-0.0085 (0.3224)	-0.0092 (0.3068)	-0.0222*** (0.0074)	-0.0121 (0.1728)	-0.0256** (0.0347)	-0.0162* (0.0999)	-0.0958*** (0.0007)	-0.0858** (0.0100)	-0.0565* (0.0740)	-0.0589*** (0.0000)	-0.1035** (0.0345)	-0.0708** (0.0489)	-0.1073** (0.0294)	-0.0777** (0.0112)
Globalisation* Precipta		0.0001** (0.0156)								0.0007*** (0.0000)						
KOFEcGI*Precipita				0.0851* (0.0501)								0.3187*** (0.0000)				
KOFSoGI*Precipita						0.1326*** (0.0009)								0.4318*** (0.0000)		
KOFPoGI*Precipita								0.1423*** (0.0005)								0.4496*** (0.0000)
Constant	4.2627*** (0.0000)	4.6144*** (0.0000)	4.5166*** (0.0000)	5.0349*** (0.0000)	4.2275*** (0.0000)	5.1244*** (0.0000)	4.3660*** (0.0000)	5.5167*** (0.0000)	3.7707*** (0.0000)	4.4279*** (0.0000)	4.3599*** (0.0000)	6.3002*** (0.0000)	3.7100*** (0.0000)	6.6301*** (0.0000)	3.6779*** (0.0000)	7.3126*** (0.0000)
R^2	0.23	0.25	0.27	0.30	0.23	0.32	0.29	0.38	0.53	0.55	0.69	0.79	0.51	0.78	0.53	0.81
N	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 5. The Moderating Role of Globalisation in the Relationship Between Temperature and Food Security (PCSE Estimates)

	AV-DI								AV-DI							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Temp	-0.0267** (0.0370)	0.0005 (0.9394)	-0.0222** (0.0480)	-0.0080 (0.3119)	-0.0253** (0.0130)	-0.0023 (0.5444)	-0.0289** (0.0261)	-0.0182** (0.0118)	0.0431** (0.0400)	0.1042*** (0.0000)	-0.0268*** (0.0000)	-0.0450** (0.0408)	-0.0384*** (0.0000)	-0.0521*** (0.0000)	-0.0422*** (0.0000)	-0.0438*** (0.0007)
Globalisation	0.0051** (0.0190)	0.0195 (0.0000)							0.0167** (0.0319)	0.0167*** (0.0001)						
KOFEcGI			0.0025** (0.0311)	0.0110** (0.0213)							0.0132*** (0.0000)	-0.0024 (0.8495)				
KOFSoGI					0.0033*** (0.0022)	0.0205*** (0.0000)							0.0103*** (0.0000)	0.0001 (0.9951)		
KOFPoGI							0.0033*** (0.0000)	0.0239*** (0.0000)							0.0060*** (0.0000)	0.0437*** (0.0000)
GDP per capita	0.1040*** (0.0000)	0.1015** (0.0119)	0.0864** (0.0410)	0.0824** (0.0238)	0.1125** (0.0370)	0.1227** (0.0283)	0.1071** (0.0164)	0.1204** (0.0497)	0.2918*** (0.0000)	0.2975*** (0.0000)	0.2153* (0.0754)	0.2204*** (0.0000)	0.3174*** (0.0000)	0.3113*** (0.0000)	0.2866*** (0.0000)	0.3108*** (0.0000)
Corruption	-0.0696 (0.2175)	-0.0627 (0.1570)	-0.0455** (0.0176)	-0.0470** (0.0338)	-0.0578* (0.0633)	-0.0663*** (0.0000)	-0.0662*** (0.0000)	-0.0915*** (0.0000)	0.1162*** (0.0000)	0.1323*** (0.0000)	0.0596* (0.0532)	0.0577** (0.0230)	0.0746** (0.0645)	0.0695* (0.0770)	0.0605** (0.0230)	0.1068* (0.0659)
Infra	-0.0027 (0.2290)	-0.0042 (0.6810)	-0.0020 (0.4076)	-0.0024 (0.1759)	-0.0027* (0.0987)	-0.0045** (0.0430)	0.0026* (0.0549)	-0.0035 (0.6502)	0.0093 (0.0278)	-0.0059* (0.0682)	-0.0070*** (0.0000)	-0.0065*** (0.0000)	-0.0091*** (0.0000)	-0.0080*** (0.0000)	-0.0081*** (0.0000)	-0.0098*** (0.0000)
Trade	0.0005** (0.0440)	0.0004* (0.0715)	0.0003 (0.2334)	0.0002 (0.3150)	0.0005* (0.0781)	0.0004** (0.0247)	0.0007** (0.0116)	0.0009*** (0.0000)	0.0008** (0.0227)	0.0009** (0.0276)	0.0003 (0.2390)	0.0002 (0.3111)	0.0007*** (0.0001)	0.0008*** (0.0080)	0.0009*** (0.0001)	0.0012*** (0.0000)
Inflation	0.0003 (0.2031)	0.0003 (0.1233)	0.0002 (0.1090)	0.0002 (0.1073)	0.0003** (0.0196)	0.0004* (0.0717)	0.0001 (0.3104)	0.0001 (0.4165)	-0.0001 (0.7469)	-0.0001 (0.4899)	-0.0002 (0.1066)	-0.0002* (0.0783)	0.0001 (0.4568)	0.0001 (0.5513)	-0.0006 (0.2101)	-0.0006 (0.1594)
Population	0.0491 (0.2672)	0.0554 (0.1732)	0.0390 (0.1043)	0.0390 (0.1945)	0.0397** (0.0317)	0.0419 (0.1290)	0.0673* (0.0544)	0.0837** (0.0324)	0.1319* (0.0511)	0.1172** (0.0173)	0.0834** (0.0523)	0.0834* (0.0900)	0.1025* (0.6830)	0.1012 (0.1652)	0.1622 (0.1906)	0.1923 (0.3885)
GVC	-0.0300 (0.1278)	-0.0350 (0.2456)	-0.0267** (0.0138)	-0.0270 (0.1422)	-0.0360 (0.5530)	-0.0429 (0.6930)	-0.0361* (0.0650)	-0.0371* (0.0547)	-0.1315** (0.0340)	-0.1198*** (0.0000)	-0.1013** (0.0156)	-0.1009*** (0.0000)	-0.1510*** (0.0000)	-0.1469** (0.0470)	-0.1520* (0.0759)	-0.1538** (0.0436)
Globalisation*Temp		0.0005 (0.0002)								0.0013** (0.0240)						
KOFEcGI*Temp				0.3334* (0.0849)								0.4274 (0.4346)				
KOFSoGI*Temp						0.6061*** (0.0000)								0.3634 (0.1573)		
KOFPoGI*Temp								1.2157*** (0.0000)								2.2247*** (0.0000)
Constant	3.1688*** (0.0000)	3.8130*** (0.0000)	3.3658*** (0.0000)	1.7931* (0.0556)	3.2388*** (0.0000)	0.3054 (0.5604)	2.8609*** (0.0000)	-3.9174*** (0.0000)	1.4641*** (0.0000)	-0.0384 (0.8994)	2.4930*** (0.0000)	4.5094 (0.1008)	1.6820*** (0.0000)	3.4405*** (0.0091)	0.9011*** (0.0000)	-11.5032*** (0.0000)
R^2	0.57	0.58	0.56	0.56	0.56	0.58	0.56	0.59	0.71	0.72	0.75	0.75	0.65	0.65	0.62	0.65
N	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

5.3 Robustness analysis

To test the robustness of our results, we used the FGLS (Feasible Generalized Least Squares) and Driscoll-Kraay methods, which correct for autocorrelation, heteroscedasticity, and cross-sectional dependence. Tables 6, 7, 8, 9, 10 and 11 present the results obtained using these two methods, respectively. Furthermore, to account for potential endogeneity issues related to reverse causality and omitted variables, we also estimated a dynamic panel model using the System Generalized Method of Moments (System GMM) (Blundell & Bond, 1998). The results of this estimation are presented in the appendix (See Tables A8, A9 and A10). The tests confirm the overall significance of the models, while the signs of the coefficients of our main explanatory variables and control variables remain consistent with the initial estimates, as well as with the System GMM estimates, which reinforces the reliability of our conclusions.

Table 6. The Moderating Role of Globalisation in the Relationship Between CO_2 Emissions and Food Security (FGLS Estimates)

	AV_DI								AV_PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
CO2	-0.0169*** (0.001)	-0.1196** (0.0278)	-0.0009** (0.0356)	-0.0375** (0.0156)	-0.0044*** (0.0038)	-0.0007*** (0.0025)	-0.0030** (0.0483)	-0.0414** (0.0281)	-0.0521*** (0.0000)	-0.3475*** (0.0000)	-0.0048** (0.0348)	-0.1213*** (0.0008)	0.0096*** (0.0000)	-0.0001*** (0.0006)	0.0075*** (0.0010)	-0.3342*** (0.0000)
Globalisation	0.3351*** (0.0000)	0.3891*** (0.0000)							0.4621*** (0.0000)	0.6175*** (0.0000)						
KOFEcGI			0.0022*** (0.0000)	0.0024*** (0.0000)							0.0084*** (0.0000)	0.0092*** (0.0000)				
KOFSoGI					0.0040*** (0.0000)	0.0040*** (0.0000)							0.0050*** (0.0002)	0.0050*** (0.0002)		
KOFPoGI							0.0044*** (0.0000)	0.0041*** (0.0000)							0.0065*** (0.0000)	0.0042*** (0.0000)
GDP per capita	0.0403*** (0.0005)	0.0405*** (0.0000)	0.0475*** (0.0000)	0.0333*** (0.0001)	0.0312*** (0.0001)	0.0326*** (0.0001)	0.0409*** (0.0000)	0.0413*** (0.0000)	0.1578*** (0.0000)	0.1586*** (0.0000)	0.1655*** (0.0000)	0.1169*** (0.0000)	0.1623*** (0.0000)	0.1659*** (0.0000)	0.1713*** (0.0000)	0.1743*** (0.0000)
Corruption	-0.0153 (0.147)	-0.0182* (0.0875)	-0.0074 (0.3401)	-0.0070 (0.3852)	-0.0465** (0.0176)	-0.0462** (0.0000)	-0.0365** (0.0284)	0.0365** (0.0110)	0.0683*** (0.0000)	0.0600*** (0.0010)	0.0030 (0.7620)	0.0013 (0.9008)	0.0879 (0.2916)	0.0872* (0.0762)	0.0790 (0.3320)	0.0790 (0.2341)
Infra	-0.0457*** (0.0000)	-0.0478*** (0.0000)	0.0003 (0.3729)	0.0018*** (0.0004)	-0.0013** (0.0345)	-0.0015** (0.0154)	-0.0008* (0.0714)	-0.0009** (0.0390)	-0.1309*** (0.0000)	-0.1368*** (0.0000)	0.0055*** (0.0050)	0.0105** (0.0493)	0.0011** (0.0272)	0.0006 (0.2840)	0.0017*** (0.0002)	0.0008* (0.0812)
Trade	0.0118*** (0.0050)	0.0110 (0.19502)	0.0000 (0.8836)	0.0001 (0.6105)	0.0001 (0.5570)	0.0001 (0.6809)	0.0002 (0.3024)	0.0001 (0.6647)	0.0302*** (0.0000)	0.0278*** (0.0000)	0.0006*** (0.0056)	0.0011 (0.3201)	0.0011 (0.7201)	0.0010 (0.3213)	0.0012 (0.1064)	0.0004 (0.1429)
Inflation	-0.0122 (0.2503)	-0.0104** (0.0104)	0.0000 (0.9911)	-0.0000 (0.7968)	-0.0002* (0.0884)	-0.0002 (0.1073)	0.0000 (0.9498)	0.0000 (0.5879)	-0.0330* (0.0601)	-0.0279 (0.1089)	-0.0003 (0.1483)	-0.0004* (0.0584)	-0.0007* (0.0661)	-0.0007* (0.0943)	-0.0004** (0.0178)	-0.0001 (0.4056)
Population	0.0164** (0.0375)	0.0149* (0.0570)	-0.0021 (0.6899)	-0.0041 (0.4118)	0.0133** (0.0266)	0.0130** (0.0327)	-0.0283** (0.0408)	-0.0272 (0.4930)	0.0483*** (0.0002)	0.0442*** (0.0019)	0.0133 (0.2308)	0.0064 (0.5144)	0.0485*** (0.0024)	0.0478*** (0.0029)	-0.0103 (0.4404)	-0.0020 (0.8851)
GVC	-0.0013 (0.2670)	-0.00175 (0.1471)	0.0006 (0.9208)	0.0025 (0.6526)	-0.0077 (0.1783)	-0.0072 (0.2163)	-0.0063 (0.2042)	-0.0030 (0.5005)	-0.0116*** (0.0000)	-0.0128*** (0.000)	-0.0559 (0.6529)	-0.0493 (0.1840)	-0.0893 (0.7665)	-0.0881 (0.2087)	-0.0872 (0.1106)	-0.0617 (0.6328)
Globalisation*CO2		0.0258* (0.0579)								0.0742*** (0.0010)						
KOFEcGI*CO2				0.0008*** (0.0090)								0.0026*** (0.0003)				
KOFSoGI*CO2						0.0001 (0.4765)								0.0002 (0.2556)		
KOFPoGI*CO2								0.0005 (0.1810)								0.0039*** (0.0000)
Constant	2.9197*** (0.0000)	2.7278*** (0.0000)	4.4861*** (0.0000)	4.5890*** (0.0000)	4.1927*** (0.0000)	4.1855*** (0.0000)	4.6473*** (0.0000)	4.6109*** (0.0000)	0.8186* (0.0590)	0.2667 (0.5622)	3.8431*** (0.0000)	4.1977*** (0.0000)	3.1308*** (0.0000)	3.1126*** (0.0000)	3.7597*** (0.0000)	3.4801*** (0.0000)
R^2	0.23	0.27	0.16	0.17	0.18	0.18	0.24	0.24	0.26	0.44	0.49	0.52	0.43	0.43	0.46	0.50
N	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 7. The Moderating Role of Globalisation in the Relationship Between Precipitation and Food Security (FGLS Estimates)

	AV_DI								AV_PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Precipita	0.0078*** (0.0000)	0.0003*** (0.0000)	0.0000** (0.0259)	0.0001** (0.0374)	0.0000*** (0.0055)	0.0001*** (0.0000)	0.0000** (0.0238)	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0006*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0001*** (0.0000)	0.0003*** (0.0000)	0.0001*** (0.0000)	0.0004*** (0.0000)
Globalisation	0.0016* (0.0782)	0.0035*** (0.0000)							0.0057*** (0.0003)	0.0153*** (0.0000)						
KOFEcGI			0.0040*** (0.0000)	0.0001* (0.0707)							0.0142*** (0.0000)	0.0011 (0.4921)				
KOFSoGI					0.0018 (0.1213)	0.0069*** (0.0000)							0.0021 (0.2142)	0.0145*** (0.0000)		
KOFPoGI							0.0040*** (0.0000)	0.0070*** (0.0000)							0.0039*** (0.0009)	0.0134*** (0.0000)
GDP per capita	0.0835** (0.0400)	0.0639** (0.0000)	0.0719*** (0.0000)	0.0846*** (0.0000)	0.0767*** (0.0000)	0.0756*** (0.0000)	0.0749*** (0.0000)	0.0798*** (0.0000)	0.2377*** (0.0000)	0.2010*** (0.0000)	0.1802*** (0.0000)	0.2275*** (0.0000)	0.2400*** (0.0000)	0.2364*** (0.0000)	0.2185*** (0.0000)	0.2338*** (0.0000)
Corruption	-0.0102 (0.1196)	-0.0111 (0.1039)	0.0187 (0.1677)	0.0229* (0.0878)	-0.0118 (0.4282)	0.0012 (0.9342)	-0.0283** (0.0398)	-0.0109 (0.4044)	0.0084 (0.3893)	0.0100 (0.2720)	0.0280* (0.0849)	0.0437*** (0.0012)	-0.0284 (0.1896)	0.0139 (0.3520)	0.0683*** (0.0009)	0.0134 (0.3150)
Infra	-0.0003* (0.0634)	0.0007* (0.0685)	0.0001 (0.8746)	-0.0007 (0.2053)	-0.0005 (0.4099)	-0.0020*** (0.0008)	-0.0003 (0.5121)	-0.0015*** (0.0040)	0.0034*** (0.0000)	0.0052*** (0.0000)	0.0036*** (0.0000)	0.0006 (0.2997)	0.0032*** (0.0001)	-0.0018*** (0.0044)	0.0026*** (0.0005)	-0.0009* (0.0803)
Trade	0.0010 (0.4539)	0.0011 (0.6502)	0.0009 (0.1174)	0.0010*** (0.0014)	0.0010*** (0.0028)	0.0010*** (0.0019)	0.0005 (0.1252)	0.0005 (0.1357)	0.0020 (0.4390)	0.0022 (0.2840)	0.0009** (0.0148)	0.0016*** (0.0000)	0.0019*** (0.0001)	0.0018*** (0.0000)	0.0012** (0.0163)	0.0010*** (0.0010)
Inflation	-0.0000 (0.9713)	-0.0000 (0.8152)	-0.0001 (0.3360)	-0.0001 (0.5051)	-0.0001 (0.6841)	-0.0002 (0.3179)	-0.0001 (0.5989)	-0.0001 (0.5003)	0.0004 (0.1505)	0.0004 (0.0581)*	0.0002 (0.3562)	0.0003** (0.0243)	0.0004 (0.1368)	0.0007*** (0.0001)	0.0005** (0.0292)	0.0004*** (0.0020)
Population	-0.0110 (0.2555)	-0.0073 (0.4162)	-0.0024 (0.8647)	-0.0053 (0.6951)	-0.0153 (0.2874)	-0.0174 (0.2010)	-0.0047 (0.7355)	-0.0105 (0.4177)	-0.0316** (0.0401)	0.0247* (0.0810)	-0.0033 (0.8419)	-0.0145 (0.2906)	-0.0272 (0.1931)	-0.0340** (0.0167)	-0.0174 (0.3988)	-0.0010 (0.9407)
GVC	-0.0242*** (0.0074)	-0.0188** (0.0205)	-0.0085 (0.4740)	-0.0092 (0.4347)	-0.0222* (0.0611)	-0.0121 (0.2837)	-0.0256** (0.0249)	-0.0162 (0.1306)	-0.0958 (0.2718)	-0.0858 (0.1986)	-0.0565 (0.2041)	-0.0589 (0.1206)	-0.1035 (0.4330)	-0.0708 (0.6300)	-0.1073 (0.1023)	-0.0777 (0.4566)
Globalisation*Precipita		0.0071*** (0.0000)								0.0020*** (0.0000)						
KOFEcGI*Precipita				0.0851*** (0.0023)								0.3187*** (0.0000)				
KOFSoGI*Precipita						0.1326*** (0.0000)								0.4318*** (0.0000)		
KOFPoGI*Precipita								0.1423*** (0.0000)								0.4496*** (0.0000)
Constant	4.2627*** (0.0000)	4.6144*** (0.0000)	4.5166*** (0.0000)	5.0349*** (0.0000)	4.2275*** (0.0000)	5.1244*** (0.0000)	4.3660*** (0.0000)	5.5167*** (0.0000)	3.7707*** (0.0000)	4.4279*** (0.0000)	4.3599*** (0.0000)	6.3002*** (0.0000)	3.7100*** (0.0000)	6.6301*** (0.0000)	3.6779*** (0.0000)	7.3126*** (0.0000)
R^2	0.23	0.25	0.28	0.27	0.23	0.22	0.27	0.24	0.53	0.55	0.55	0.52	0.54	0.55	0.54	0.56
N	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 8. The Moderating Role of Globalisation in the Relationship Between Temperature and Food Security (FGLS Estimates)

			AV_DI								AV_PR					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Temp	-0.0267*** (0.0000)	-0.0005*** (0.0034)	-0.0222*** (0.0000)	-0.0080** (0.0327)	-0.0253*** (0.0000)	-0.0023 (0.7226)	-0.0289*** (0.0000)	-0.0182* (0.0894)	-0.0431*** (0.0000)	-0.1042*** (0.0000)	-0.0268*** (0.0000)	-0.0450*** (0.0004)	-0.0384*** (0.0000)	-0.0521*** (0.0000)	-0.0422*** (0.0000)	-0.0438** (0.0155)
Globalisation	0.0051*** (0.0000)	0.0195*** (0.0000)							0.0167 (0.0000)	0.0167 (0.0001)						
KOFEcGI			0.0025*** (0.0007)	0.0110** (0.0440)							0.0132*** (0.0000)	0.0024* (0.O537)				
KOFSoGI					0.0033*** (0.0005)	0.0205*** (0.0000)							0.0103*** (0.0000)	0.0000 (0.9961)		
KOFPoGI							0.0033*** (0.0001)	0.0239*** (0.0000)							0.0060*** (0.0000)	0.0437*** (0.0000)
GDP per capita	0.1040*** (0.0000)	0.1015*** (0.0000)	0.0864*** (0.0000)	0.0824*** (0.0000)	0.1125*** (0.0000)	0.1227*** (0.0000)	0.1071*** (0.0000)	0.1204*** (0.0000)	0.2918*** (0.0000)	0.2975*** (0.0000)	0.2153*** (0.0000)	0.2204*** (0.0000)	0.3174*** (0.0000)	0.3113*** (0.0000)	0.2866*** (0.0000)	0.3108*** (0.0000)
Corruption	0.0696 (0.1276)	0.0627 (0.2700)	0.0455 (0.1360)	0.0470 (0.1000)	0.0578 (0.3850)	0.0663* (0.0646)	0.0662 (0.3020)	0.0915** (0.0400)	0.1162 (0.2210)	0.1323* (0.0970)	0.0596*** (0.0001)	0.0577*** (0.0001)	0.0746*** (0.0002)	0.0695*** (0.0006)	0.0605*** (0.0061)	0.1068*** (0.0000)
Infra	-0.0027* (0.0600)	-0.0042*** (0.0000)	-0.0020*** (0.0000)	-0.0024*** (0.0000)	-0.0027*** (0.0000)	-0.0045*** (0.0000)	-0.0026*** (0.0000)	-0.0035*** (0.0000)	-0.0093 (0.4750)	-0.0059 (0.119)	-0.0070*** (0.0000)	-0.0065*** (0.0000)	-0.0091*** (0.0000)	-0.0080*** (0.0000)	-0.0081*** (0.0000)	-0.0098*** (0.0000)
Trade	0.0005 (0.1140)	0.0004 (0.3171)	0.0003 (0.2971)	0.0002 (0.3936)	0.0005** (0.0422)	0.0004* (0.0678)	0.0007*** (0.0078)	0.0009 (0.1297)	0.0008 (0.2854)	0.0009 (0.6090)	0.0003 (0.4546)	0.0002 (0.5673)	0.0007* (0.0691)	0.0008* (0.0561)	0.0009** (0.0450)	0.0012*** (0.0053)
Inflation	0.0003 (0.3133)	0.0003 (0.2343)	0.0002 (0.1618)	0.0002 (0.1451)	0.0003 (0.4139)	0.0004*** (0.9332)	0.0001 (0.4087)	0.0001 (0.5380)	-0.0001 (0.7469)	-0.0001 (0.4899)	-0.0002 (0.1547)	-0.0002 (0.1398)	0.0001 (0.5077)	0.0001 (0.6170)	-0.0006*** (0.0038)	-0.0006*** (0.0011)
Population	0.0491** (0.0320)	0.0554 (0.2100)	0.0390*** (0.0001)	0.0390*** (0.0001)	0.0397*** (0.0001)	0.0419*** (0.0000)	0.0673*** (0.0000)	0.0837*** (0.0000)	0.1319*** (0.0000)	0.1172*** (0.0000)	0.0834*** (0.0000)	0.0834*** (0.0000)	0.1025*** (0.0000)	0.1012*** (0.0000)	0.1622*** (0.0000)	0.1923*** (0.0000)
GVC	-0.0300 (0.1788)	-0.0350 (0.2912)	-0.0267 (0.1230)	-0.0270 (0.2511)	-0.0360 (0.2290)	-0.0429 (0.1087)	-0.0361 (0.2415)	-0.0371 (0.2001)	-0.1315 (0.7810)	-0.1198 (0.3190)	-0.1013 (0.4291)	-0.1009 (0.5000)	-0.1510 (0.5467)	-0.1469 (0.2165)	-0.1520*** (0.2819)	-0.1538 (0.3110)
Globalisation*Temp		0.0005*** (0.0002)								0.0013*** (0.0000)						
KOFEcGI*Temp				0.3334** (0.0175)								0.4274*** (0.0467)				
KOFSoGI*Temp						0.6061*** (0.0002)								0.3634 (0.1781)		
KOFPoGI*Temp								0.2157*** (0.0000)								0.2247*** (0.0000)
Constant	3.1688*** (0.0000)	3.8130*** (0.0000)	3.3658*** (0.0000)	1.7931* (0.0782)	3.2388*** (0.0000)	0.3054 (0.7036)	2.8609*** (0.0000)	-3.9174** (0.0100)	1.4641*** (0.0000)	-0.0384 (0.8994)	2.4930*** (0.0000)	4.5094*** (0.0014)	1.6820*** (0.0000)	3.4405*** (0.0097)	0.9011*** (0.0023)	1.5032*** (0.0000)
R^2	0.57	0.58	0.53	0.55	0.57	0.56	0.53	0.56	0.71	0.72	0.75	0.72	0.77	0.76	0.75	0.78
N	424		424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 9. The Moderating Role of Globalisation in the Relationship Between CO_2 Emissions and Food Security (Driscoll-Kraay Estimates)

	AV_DI								AV_PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
CO2	-0.0091 (0.1576)	-0.0101 (0.118)	-0.0009** (0.0356)	-0.0375** (0.0156)	-0.0044*** (0.0038)	-0.0007*** (0.0025)	0.0030** (0.0483)	-0.0414*** (0.0028)	-0.0175* (0.0671)	-0.0211** (0.0236)	-0.0048 (0.1348)	-0.1213*** (0.0008)	-0.0096*** (0.0000)	-0.0001* (0.0876)	-0.0075*** (0.0010)	-0.3342*** (0.0000)
Globalisation	0.0049*** (0.0000)	0.0054*** (0.0000)							0.0038** (0.0243)	0.0056*** (0.0005)						
KOFEcGI			-0.0022*** (0.0000)	-0.0024*** (0.0000)							-0.0084*** (0.0000)	-0.0092*** (0.0000)				
KOFSoGI					0.0040*** (0.0000)	0.0040*** (0.0000)							0.0050*** (0.0002)	0.0050*** (0.0002)		
KOFPoGI							0.0044*** (0.0000)	0.0041*** (0.0000)							0.0065*** (0.0000)	0.0042*** (0.0000)
GDP per capita	0.0509*** (0.0001)	0.0511*** (0.0003)	0.0475*** (0.0000)	0.0333*** (0.0001)	0.0312*** (0.0001)	0.0326*** (0.0001)	0.0409*** (0.0000)	0.0413*** (0.0000)	0.2174*** (0.0007)	0.2198*** (0.0008)	0.1655*** (0.0000)	0.1169*** (0.0000)	0.1623*** (0.0000)	0.1659*** (0.0000)	0.1713*** (0.0000)	0.1743*** (0.0000)
Corruption	-0.0455*** (0.000)	-0.0482*** (0.0000)	-0.0074 (0.3401)	-0.0070 (0.3852)	-0.0465 (0.1954)	-0.0462 (0.1100)	-0.0365* (0.0530)	-0.0365* (0.0760)	0.0610*** (0.0002)	0.0712*** (0.0003)	0.0030 (0.7620)	0.0013 (0.9008)	0.0879*** (0.0000)	0.0872*** (0.0000)	0.0790*** (0.0000)	0.0790*** (0.0000)
Infra	-0.0002 (0.6571)	-0.0010** (0.0321)	0.0003 (0.3729)	0.0018*** (0.0004)	-0.0013*** (0.0005)	-0.0015*** (0.0015)	-0.0008*** (0.0071)	-0.0009*** (0.0039)	0.0024*** (0.0000)	0.0003 (0.1400)	0.0055*** (0.0000)	0.0105*** (0.0000)	0.0011** (0.0272)	0.0006 (0.2840)	0.0017*** (0.0002)	0.0008* (0.0812)
Trade	0.0002 (0.5591)	0.0003 (0.3711)	-0.0003 (0.8836)	0.0001 (0.6105)	0.0001 (0.5570)	0.0001 (0.6809)	0.0002 (0.3024)	0.0001 (0.6647)	-0.0001 (0.7413)	0.0003 (0.1401)	0.0006* (0.0576)	0.0011* (0.0631)	0.0011* (0.0951)	0.0010*** (0.0013)	0.0012*** (0.0000)	0.0004 (0.1429)
Inflation	-0.0001 (0.3323)	-0.0001 (0.3182)	0.0000 (0.9911)	-0.0000 (0.7968)	-0.0002* (0.0884)	-0.0002 (0.1073)	0.0000 (0.9498)	0.0000 (0.5879)	-0.0005*** (0.0048)	-0.0005*** (0.0017)	-0.0003 (0.1483)	-0.0004* (0.0584)	-0.0007*** (0.0066)	-0.0007*** (0.0094)	-0.0004** (0.0178)	-0.0001 (0.4056)
Population	0.0181*** (0.0000)	0.0151*** (0.0012)	-0.0021 (0.6899)	-0.0041 (0.4118)	0.0133** (0.0266)	0.0130** (0.0327)	-0.0283*** (0.0000)	-0.0272*** (0.0000)	0.0589*** (0.0003)	0.0472*** (0.0004)	0.0133 (0.2308)	0.0064 (0.5144)	0.0485*** (0.0024)	0.0478*** (0.0029)	-0.0103 (0.4404)	-0.0020 (0.8851)
GVC	-0.0138** (0.0118)	-0.0141*** (0.0026)	0.0006 (0.9208)	0.0025 (0.6526)	-0.0077 (0.1783)	-0.0072 (0.2163)	-0.0063 (0.2042)	-0.0030 (0.5005)	-0.0920*** (0.0001)	-0.0936*** (0.0006)	-0.0559*** (0.0000)	-0.0493*** (0.0000)	-0.0893*** (0.0000)	-0.0881*** (0.0000)	-0.0872*** (0.0000)	-0.0617*** (0.0000)
Globalisation*CO2		0.0002*** (0.0000)								0.0009*** (0.0000)						
KOFEcGI*CO2				0.0008*** (0.0090)								0.0026*** (0.0003)				
KOFSoGI*CO2						0.0001 (0.4765)								0.0002 (0.2556)		
KOFPoGI*CO2								0.0005 (0.1810)								0.0039*** (0.0000)
Constant	3.9611*** (0.0002)	3.9831*** (0.0001)	4.4861*** (0.0000)	4.5890*** (0.0000)	4.1927*** (0.0000)	4.1855*** (0.0000)	4.6473*** (0.0000)	4.6109*** (0.0000)	2.7491*** (0.0000)	2.8332*** (0.0000)	3.8431*** (0.0000)	4.1977*** (0.0000)	3.1308*** (0.0000)	3.1126*** (0.0000)	3.7597*** (0.0000)	3.4801*** (0.0000)
R^2	0.23	0.21	0.16	0.17	0.18	0.18	0.24	0.24	0.51	0.50	0.49	0.52	0.43	0.43	0.46	0.50
N	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 10. The moderating role of globalisation in the relationship between precipitation and food security (Driscoll-Kraay estimates)

			AV_DI								AV_PR					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Precipita	0.0001*** (0.0000)	0.0003*** (0.0000)	0.0006*** (0.0062)	0.0001*** (0.0000)	0.0004*** (0.0001)	0.0001*** (0.0000)	0.0002** (0.0134)	0.0001*** (0.0000)	0.0056*** (0.0000)	0.0006*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0001*** (0.0000)	0.0003*** (0.0000)	0.0001*** (0.0000)	0.0004*** (0.0000)
Globalisation	0.0016* (0.0782)	0.0035*** (0.0000)							0.0057*** (0.0003)	0.0153*** (0.0000)						
KOFEcGI			0.0040*** (0.0005)	0.0001 (0.9401)							0.0142*** (0.0000)	0.0011 (0.5372)				
KOFSoGI					0.0018** (0.0138)	0.0069*** (0.0000)							0.0021 (0.1409)	0.0145*** (0.0000)		
KOFPoGI							0.0040*** (0.0000)	0.0070*** (0.0000)							0.0039*** (0.0000)	0.0134*** (0.0000)
GDP per capita	0.0835*** (0.0000)	0.0639*** (0.0000)	0.0719*** (0.0000)	0.0846*** (0.0000)	0.0767*** (0.0000)	0.0756*** (0.0000)	0.0749*** (0.0000)	0.0798*** (0.0000)	0.2377*** (0.0000)	0.2010*** (0.0000)	0.1802*** (0.0000)	0.2275*** (0.0000)	0.2400*** (0.0000)	0.2364*** (0.0000)	0.2185*** (0.0000)	0.2338*** (0.0000)
Corruption	-0.0102 (0.1196)	-0.0111 (0.1039)	0.0187 (0.1661)	0.0229* (0.0769)	-0.0118 (0.3283)	0.0012 (0.9283)	-0.0283*** (0.0040)	-0.0109 (0.2587)	-0.0084 (0.3893)	-0.0100 (0.2720)	0.0280** (0.0314)	0.0437*** (0.0000)	-0.0284*** (0.0034)	0.0139 (0.1325)	-0.0683*** (0.0000)	-0.0134 (0.3033)
Infra	-0.0003* (0.0634)	0.0007* (0.0685)	0.0001 (0.7886)	-0.0007* (0.0873)	-0.0005* (0.0920)	-0.0020*** (0.0001)	-0.0003 (0.3090)	-0.0015*** (0.0047)	0.0034*** (0.0000)	0.0052*** (0.0000)	0.0036*** (0.0000)	0.0006 (0.2999)	0.0032*** (0.0000)	-0.0018*** (0.0001)	0.0026*** (0.0000)	-0.0009*** (0.0048)
Trade	-0.0010*** (0.0000)	-0.0011*** (0.0000)	-0.0009*** (0.0079)	-0.0010*** (0.0005)	-0.0010*** (0.0022)	-0.0010*** (0.0002)	-0.0005** (0.0301)	-0.0005** (0.0216)	-0.0020*** (0.0000)	-0.0022*** (0.0000)	-0.0009*** (0.0026)	-0.0016*** (0.0000)	-0.0019*** (0.0000)	-0.0018*** (0.0000)	-0.0012*** (0.0013)	-0.0010*** (0.0085)
Inflation	0.0004 (0.9713)	-0.0098 (0.8152)	0.0001 (0.1461)	0.0001 (0.2322)	-0.0001 (0.4246)	-0.0002*** (0.0035)	0.0001 (0.4547)	0.0001* (0.0734)	-0.0004 (0.1505)	-0.0004* (0.0581)	-0.0002 (0.2779)	-0.0003*** (0.0002)	-0.0004 (0.1253)	-0.0007*** (0.0000)	-0.0005* (0.0547)	-0.0004*** (0.0000)
Population	0.0110 (0.2555)	0.0073 (0.4162)	0.0024 (0.8504)	0.0053 (0.6930)	0.0153 (0.1790)	0.0174 (0.2438)	-0.0047 (0.6947)	-0.0105 (0.5192)	0.0316** (0.0401)	0.0247 (0.0810)*	0.0033 (0.7937)	0.0145 (0.2883)	0.0272* (0.0522)	0.0340** (0.0327)	0.0174 (0.2063)	-0.0010 (0.9539)
GVC	-0.0242 (0.7114)	-0.0188 (0.2051)	-0.0085 (0.4241)	-0.0092 (0.4320)	-0.0222** (0.0141)	-0.0121 (0.2925)	-0.0256** (0.0496)	-0.0162 (0.3089)	-0.0958** (0.0236)	-0.0858** (0.0153)	-0.0565*** (0.0006)	-0.0589*** (0.0000)	-0.1035*** (0.0000)	-0.0708*** (0.0000)	-0.1073*** (0.0000)	-0.0777*** (0.0000)
Globalisation*Precipita		0.0094*** (0.0000)								0.0078*** (0.0000)						
KOFEcGI*Precipita				0.0851*** (0.0000)								0.3187*** (0.0000)				
KOFSoGI*Precipita						0.1326*** (0.0000)								0.4318*** (0.0000)		
KOFPoGI*Precipita								0.1423*** (0.0000)								0.4496*** (0.0000)
Constant	4.2627*** (0.0000)	4.6144*** (0.0000)	4.5166*** (0.0000)	5.0349*** (0.0000)	4.2275*** (0.0000)	5.1244*** (0.0000)	4.3660*** (0.0000)	5.5167*** (0.0000)	3.7707*** (0.0000)	4.4279*** (0.0000)	4.3599*** (0.0000)	6.3002*** (0.0000)	3.7100*** (0.0000)	6.6301*** (0.0000)	3.6779*** (0.0000)	7.3126*** (0.0000)
R^2	0.23	0.25	0.27	0.30	0.23	0.32	0.29	0.38	0.53	0.55	0.69	0.79	0.51	0.78	0.53	0.81
N	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table 11. The moderating role of globalisation in the relationship between temperature and food security (Driscoll-Kraay estimates)

	AV_DI								AV_PR							
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	(13)	(14)	(15)	(16)
Temp	-0.0267*** (0.0000)	-0.0005 (0.9394)	-0.0222*** (0.0000)	-0.0080 (0.1852)	-0.0253*** (0.0000)	-0.0023 (0.7416)	0.0289*** (0.0000)	-0.0182* (0.0936)	-0.0431*** (0.0000)	-0.1042*** (0.0000)	-0.0268*** (0.0000)	-0.0450*** (0.0071)	-0.0384*** (0.0000)	-0.0521*** (0.0000)	0.0422*** (0.0000)	-0.0438*** (0.0001)
Globalisation	0.0051*** (0.0000)	0.0195*** (0.0000)							0.0167*** (0.0000)	0.0167*** (0.0001)						
KOFEcGI			0.0025*** (0.0002)	0.0110*** (0.0023)							0.0132*** (0.0000)	0.0024 (0.7985)				
KOFSoGI					0.0033** (0.0141)	0.0205*** (0.0023)							0.0103*** (0.0002)	0.0000 (0.9920)		
KOFPoGI							0.0033*** (0.0094)	0.0239*** (0.0000)							0.0060*** (0.0002)	0.0437*** (0.0000)
GDP per capita	0.1040*** (0.0000)	0.1015*** (0.0000)	0.0864*** (0.0000)	0.0824*** (0.0000)	0.1125*** (0.0000)	0.1227*** (0.0000)	0.1071*** (0.0000)	0.1204*** (0.0000)	0.2918*** (0.0000)	0.2975*** (0.0000)	0.2153*** (0.0000)	0.2204*** (0.0000)	0.3174*** (0.0000)	0.3113*** (0.0000)	0.2866*** (0.0000)	0.3108*** (0.0000)
Corruption	0.0696*** (0.0000)	0.0627*** (0.0000)	0.0455* (0.0511)	0.0470*** (0.0007)	0.0578*** (0.0005)	0.0663*** (0.0001)	0.0662*** (0.0000)	0.0915*** (0.0000)	0.1162*** (0.0000)	0.1323*** (0.0000)	0.0596*** (0.0000)	0.0577*** (0.0001)	0.0746*** (0.0003)	0.0695*** (0.0003)	0.0605*** (0.0001)	0.1068*** (0.0000)
Infra	0.0027 (0.2638)	0.0042 (0.1100)	0.0020 (0.4390)	0.0024 (0.1250)	0.0027 (0.2330)	0.0045** (0.0300)	0.0026 (0.6211)	0.0035* (0.0932)	0.0093* (0.0840)	0.0059*** (0.0000)	0.0070* (0.0532)	0.0065** (0.0173)	0.0091** (0.0201)	0.0080** (0.0330)	0.0081** (0.0423)	0.0098** (0.0221)
Trade	-0.0005*** (0.0040)	-0.0004*** (0.0071)	-0.0003 (0.3020)	-0.0002 (0.4089)	-0.0005** (0.0437)	-0.0004* (0.0800)	-0.0007*** (0.0036)	-0.0009*** (0.0009)	-0.0008*** (0.0002)	-0.0009*** (0.0000)	0.0003 (0.1019)	0.0002 (0.3559)	-0.0007*** (0.0022)	-0.0008*** (0.0020)	-0.0009*** (0.0009)	-0.0012*** (0.0000)
Inflation	0.0003** (0.0313)	0.0003** (0.0233)	0.0002*** (0.0012)	0.0002*** (0.0023)	0.0003*** (0.0000)	0.0004*** (0.0001)	0.0001 (0.1747)	0.0001* (0.0660)	-0.0001 (0.7469)	-0.0001 (0.4899)	-0.0002* (0.0593)	-0.0002* (0.0505)	0.0001 (0.3900)	0.0001 (0.4465)	-0.0006*** (0.0082)	-0.0006*** (0.0006)
Population	0.0491 (0.1723)	0.0554 (0.5431)	0.0390 (0.9440)	0.0390 (0.1141)	0.0397 (0.2873)	0.0419** (0.0267)	0.0673 (0.3389)	0.0837** (0.0122)	0.1319 (0.4300)	0.1172 (0.1940)	0.0834** (0.0110)	0.0834* (0.0730)	0.1025* (0.0544)	0.1012** (0.0364)	0.1622* (0.0965)	0.1923** (0.0270)
GVC	-0.0300 (0.1630)	-0.0350 (0.3257)	-0.0267 (0.1015)	-0.0270 (0.4171)	-0.0360 (0.2762)	-0.0429 (0.5341)	-0.0361 (0.6291)	-0.0371 (0.1802)	-0.1315 (0.1300)	-0.1198 (0.5300)	-0.1013 (0.9345)	-0.1009 (0.3945)	-0.1510 (0.1106)	-0.1469 (0.4892)	-0.1520 (0.5381)	-0.1538 (0.2061)
Globalisation*Temp		0.0005*** (0.0002)								0.0013** (0.0000)						
KOFEcGI*Temp				0.3334** (0.0185)								0.4274 (0.3056)				
KOFSoGI*Temp						0.6061*** (0.0042)								0.3634*** (0.0007)		
KOFPoGI*Temp								1.2157*** (0.0001)								2.2247*** (0.0000)
Constant	3.1688*** (0.0000)	3.8130*** (0.0000)	3.3658*** (0.0000)	1.7931** (0.0172)	3.2388*** (0.0000)	0.3054 (0.7367)	2.8609*** (0.0000)	-3.9174** (0.0123)	1.4641*** (0.0000)	-0.0384 (0.8994)	2.4930*** (0.0000)	4.5094* (0.0566)	1.6820*** (0.0000)	3.4405*** (0.0000)	0.9011*** (0.0001)	-1.5032*** (0.0000)
R^2	0.57	0.58	0.56	0.56	0.56	0.58	0.56	0.59	0.71	0.72	0.75	0.75	0.65	0.65	0.62	0.65
N	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

6. CONCLUSIONS

Food security remains a major global concern, particularly in sub-Saharan Africa, where agriculture's heavy dependence on climatic conditions increases people's vulnerability to environmental shocks. In this context, this study analysed the role of globalisation in the relationship between climate change and food security using a panel of 28 sub-Saharan African countries covering the period 2001–2022. The main estimates are based on the panel-corrected standard errors (PCSE) method, while the FGLS, Driscoll-Kraay, and System-GMM methods were used as robustness tests. The results show that CO_2 emissions and rising temperatures significantly reduce food security, while precipitation contributes to its improvement. Furthermore, globalisation has a positive and significant effect on food security, with its economic and political dimensions making particularly important contributions. Most importantly, the interaction terms reveal that globalisation mitigates the negative effects of CO_2 emissions and high temperatures and reinforces the favourable effects of precipitation on food security. These results thus highlight the role of international integration as a mechanism for resilience in the face of climate shocks. They also show that trade liberalisation helps improve food availability by facilitating market access and the diversification of supply sources. Robustness estimates obtained using the FGLS, Driscoll-Kraay, and System-GMM methods generally confirm these main findings.

Based on these findings, several economic policy recommendations can be formulated. First, the negative effects of CO2 emissions and rising temperatures underscore the need to strengthen climate adaptation strategies in the agricultural sector, particularly through the dissemination of climate-resilient agricultural technologies, the improvement of irrigation systems, and the promotion of resilient agricultural practices. Second, given that globalisation, particularly in its economic and political dimensions, improves food security and mitigates the adverse effects of climate change, policymakers should promote policies that foster economic integration, productive investment, and regional cooperation. From this perspective, the effective implementation of the African Continental Free Trade Area (AfCFTA) could strengthen the mechanisms identified in this study by facilitating trade in food products, agricultural inputs, and technologies among African countries. By promoting greater market integration, the AfCFTA could help diversify supply sources, mitigate the effects of production shortfalls caused by climate-related hazards, and facilitate the dissemination of agricultural innovations adapted to climate change. Third, the positive effect of trade liberalisation suggests the need to limit barriers to food trade, particularly during times of crisis, in order to ensure the availability and affordability of food. Finally, the positive role of political globalisation highlights the importance of strengthening regional institutional cooperation to support technology transfer, the coordination of agricultural and trade policies, and the implementation of collective responses to climate challenges. These approaches would help strengthen the resilience of food systems while reconciling the objectives of food security, economic integration, and adaptation to climate change in sub-Saharan Africa.

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APPENDIX

Table A1. Heteroscedasticity Test Result

	Model 1	Model 2	Model 3	Model 4
Statistics	Chi2(27) = 7120.56	Chi2 (27) = 7229.39	Chi2 (27) = 1731.59	Chi2 (27) = 2187.87
P-value	Prob> chi2 = 0.0000	Prob> chi2 = 0.0000	Prob> chi2 = 0.0000	Prob> chi2 = 0.0000

Source: Authors

Table A2. Error Autocorrelation Test Result

	Model 1	Model 2	Model 3	Model 4
Statistics	F(1,26) = 1107.553	F(1,26) = 1093.164	F(1,26) = 1461.416	F(1,26) = 1448.206
P-value	Prob> F = 0.0000	Prob> F = 0.0000	Prob> F = 0.0000	Prob> F = 0.0000

Source: Authors

Table A3. Cross-sectional dependence test

Variables	**CD Statistic**	**p-value**
AV_DI	18.42	0.000
AV_PR	-1.75	0.080
CO2	78.78	0.000
Globalisation	92.47	0.000
GDP	68.41	0.000
Corruption	28.58	0.000
Transport Infrastructure	36.98	0.000
Trade Openness	9.76	0.000
Inflation	76.05	0.000
Population	105.28	0.000
GVC	65.00	0.000

Source: Authors

Table A4. Correlation Matrix (AV_DI)

	AV_DI	CO2	Globalisation	Gdp per capita	Corruption	Infra	Trade	Inflation	Population	GVC
AV_DI	1.0000									
CO2	0.1987*	1.0000								
Globalisation	0.3926*	0.4974*	1.0000							
Gdp per capita	0.3341*	0.3300*	0.6320*	1.0000						
Corruption	0.0654	0.1051*	0.3690*	0.3302*	1.0000					
Infra	0.0752	0.0827	0.6007*	0.5958*	0.6704*	1.0000				
Trade	0.1737*	-0.2424*	0.2049*	0.4359*	0.2130*	0.4804*	1.0000			
Inflation	-0.0891*	0.0109	0.0687	-0.0221	-0.0986*	0.0239	0.0192	1.0000		
Population	0.0715	0.5301*	0.1322*	-0.0724	-0.2139*	-0.2118*	-0.5937*	0.0130	1.0000	
GVC	0.1974*	0.9095*	0.4742*	0.4382*	0.1223*	0.1456*	-0.0963*	-0.0118	0.3297*	1.0000

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table A5. Correlation Matrix (AV_PR)

	AV_PR	CO2	Globalisation	Gdp per capita	corruption	Infra	Trade	Inflation	Population	GVC
AV_PR	1.0000									
CO2	0.1642*	1.0000								
Globalisation	0.3596*	0.4974*	1.0000							
Gdp per capita	0.5766*	0.3300*	0.6320*	1.0000						
Corruption	0.2401*	0.1051*	0.3690*	0.3302*	1.0000					
Infra	0.3145*	0.0827	0.6007*	0.5958*	0.6704*	1.0000				
Trade	0.3232*	-0.2424*	0.2049*	0.4359*	0.2130*	0.4804*	1.0000			
Inflation	-0.0297	0.0109	0.0687	-0.0221	-0.0986*	0.0239	0.0192	1.0000		
Population	-0.0470	0.5301*	0.1322*	-0.0724	-0.2139*	-0.2118*	-0.5937*	0.0130	1.0000	
GVC	0.1911*	0.9095*	0.4742*	0.4382*	0.1223*	0.1456*	-0.0963 *	-0.0118	0.3297*	1.0000

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table A6. Variance Inflation Factor Test

Variables	**VIF**	**1/VIF**
Population	11.88	0.0842
Global Value Chains (GVC)	8.75	0.1143
GDP	8.08	0.1238
Trade	3.14	0.3180
Globalisation	2.99	0.3347
Infrastructure	2.76	0.3625
Corruption	2.46	0.4072
Inflation	1.11	0.9013
Mean VIF	5.14	

Source: Authors

Table A7. List of countries

Angola	Gambia	Mauritius	Sierra Leone
Cape Verde	Ghana	Mozambique	South Africa
Cameroon	Guinea	Namibia	Tanzania
Chad	Kenya	Niger	Togo
Côte d'Ivoire	Madagascar	Nigeria	Uganda
Ethiopia	Mali	Rwanda	Zambia
Gabon	Mauritania	Senegal	Zimbabwe

Source: Authors

Table A8. The Moderating Role of Globalisation in the Relationship Between CO_2 Emissions and Food Security (System-GMM Estimates)

VARIABLES	AV_DI								AV_PR							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**
L.AV_DI (-1)	0.9063*** (0.0000)	0.9174*** (0.0000)	0.9105*** (0.0000)	0.8834*** (0.0000)	0.9135*** (0.0000)	0.7070*** (0.0000)	0.9065*** (0.0000)	0.8890*** (0.0000)								
L.AV_PR (-1)									0.8994*** (0.0000)	0.9311*** (0.0000)	0.9098*** (0.0000)	0.9214*** (0.0000)	0.7838*** (0.0000)	0.7935*** (0.0000)	0.8000*** (0.0000)	0.7977*** (0.0000)
CO2	-0.0036*** (0.0077)	-0.0028** (0.0413)	-0.0038*** (0.0022)	-0.0099* (0.0532)	-0.0046*** (0.0007)	-0.0238*** (0.0097)	-0.0046*** (0.0005)	-0.0172* (0.0762)	-0.0006* (0.0708)	-0.0374*** (0.0011)	-0.0010* (0.0847)	-0.0111* (0.0718)	-0.0010* (0.0566)	-0.0054* (0.0812)	-0.0004* (0.0394)	-0.0051* (0.0501)
Globalisation	0.0028*** (0.0000)	0.0033*** (0.0000)							0.0039*** (0.0000)	0.0063*** (0.0000)						
KOFEcGI			0.0008* (0.0720)	0.0009* (0.0602)							0.0014** (0.0288)	0.0018*** (0.0089)				
KOFSoGI					0.0008** (0.0357)	0.0011* (0.0780)							0.0012** (0.0313)	0.0004 (0.9779)		
KOFPoGI							0.0005* (0.0918)	0.0008** (0.0231)							0.0023*** (0.0000)	0.0023*** (0.0000)
GDP per capita	0.0005*** (0.0092)	0.0002* (0.0615)	0.0038* (0.0864)	0.0070* (0.0573)	0.0004* (0.0976)	0.0023* (0.0525)	0.0062* (0.0964)	0.0063* (0.0935)	0.0336*** (0.0000)	0.0316*** (0.0000)	0.0218*** (0.0001)	0.0210*** (0.0001)	0.0233*** (0.0000)	0.0287*** (0.0000)	0.0270*** (0.0002)	0.0310*** (0.0013)
Corruption	-0.0031 (0.8094)	-0.0012 (0.9202)	-0.0129 (0.4135)	-0.0159 (0.2837)	-0.0019 (0.9043)	-0.0028 (0.8049)	-0.0081 (0.6580)	-0.0158 (0.3864)	0.0196* (0.0682)	0.0446*** (0.0003)	0.0438*** (0.0003)	0.0520*** (0.0002)	0.0617*** (0.0000)	0.0557*** (0.0012)	0.0438*** (0.0010)	0.0441*** (0.0055)
Infra	-0.0011*** (0.0018)	-0.0014*** (0.0011)	-0.0012*** (0.0050)	-0.0013*** (0.0037)	-0.0008** (0.0208)	-0.0061*** (0.0000)	-0.0010** (0.0163)	-0.0016*** (0.0034)	-0.0007** (0.0434)	-0.0008** (0.0230)	-0.0006** (0.0347)	-0.0008** (0.0136)	-0.0003 (0.3560)	-0.0009 (0.2089)	0.0004 (0.3286)	0.0002 (0.5491)
Trade	0.0001* (0.0562)	0.0002* (0.0958)	0.0005* (0.0605)	0.0004* (0.0926)	0.0001** (0.0221)	0.0003** (0.0438)	0.0001* (0.0681)	0.0001** (0.0414)	0.0002* (0.0649)	0.0003** (0.0364)	0.0002* (0.0756)	0.0002* (0.0891)	0.0003** (0.0329)	0.0003* (0.0710)	0.0003*** (0.0099)	0.0003*** (0.0065)
Inflation	-0.0001** (0.0161)	-0.0001** (0.0129)	-0.0001 (0.2376)	-0.0002 (0.3350)	-0.0001** (0.0195)	0.0001* (0.0835)	-0.0007 (0.5348)	-0.0002 (0.4276)	-0.0001** (0.0451)	0.0011 (0.7617)	-0.0006 (0.3344)	0.0009 (0.9848)	-0.0001** (0.0373)	-0.0001 (0.1125)	-0.0001*** (0.0082)	-0.0001** (0.0175)
Population	0.0250* (0.0563)	0.0317** (0.0327)	-0.0274** (0.0388)	-0.0280** (0.0421)	0.0028 (0.8879)	0.0362 (0.2826)	-0.0236* (0.0899)	-0.0199 (0.1743)	0.0645*** (0.0004)	0.0757*** (0.0011)	0.0049 (0.7753)	0.0033 (0.8627)	0.0128 (0.5205)	0.0413 (0.2492)	0.0780*** (0.0001)	0.0848*** (0.0001)
GVC	-0.0017 (0.6702)	-0.0017 (0.6975)	-0.0003 (0.9433)	0.0029 (0.5242)	-0.0048** (0.0373)	0.0026 (0.8159)	-0.0027 (0.4172)	-0.0011 (0.7496)	-0.0100*** (0.0013)	-0.0063** (0.0492)	-0.0051* (0.0564)	-0.0045* (0.0869)	-0.0115*** (0.0000)	-0.0097*** (0.0002)	-0.0137*** (0.0000)	-0.0147*** (0.0001)
Globalisation*CO2		0.0005* (0.0506)								0.0006*** (0.0012)						
KOFEcGI*CO2				0.0001** (0.0364)								0.0002* (0.0828)				
KOFSoGI*CO2						0.0002** (0.0443)								0.0001 (0.5179)		
KOFPoGI*CO2								0.0002* (0.0708)								0.0009* (0.0687)
Observations	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424
Number of PAYS	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
No. of instruments	21	23	21	21	21	21	23	23	21	21	21	23	23	23	21	21
AR1 p-value	0.012	0.082	0.042	0.014	0.069	0.024	0.077	0.090	0.074	0.027	0.044	0.096	0.077	0.001	0.033	0.092
AR2 p-value	0.626	0.773	0.749	0.709	0.531	0.321	0.518	0.364	0.631	0.777	0.422	0.423	0.470	0.443	0.659	0.646
Hansen p-value	0.674	0.794	0.773	0.679	0.782	0.894	0.724	0.799	0.791	0.754	0.722	0.721	0.474	0.854	0.840	0.394
Sargan p-value	0.776	0.729	0.719	0.404	0.965	0.794	0.950	0.790	0.886	0.899	0.871	0.781	0.888	0.984	0.789	0.898

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table A9. The moderating role of globalisation in the relationship between precipitation and food security (System-GMM Estimates)

Variables	AV_DI								AV_PR							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**
L.AV_DI (-1)	0.9550***	0.4011***	0.8027***	0.6995***	0.8738***	0.8300***	0.8923***	0.8986***								
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)								
L.AV_PR (-1)									0.9162***	0.9038***	0.7218***	0.7137***	0.6345***	0.8078***	0.8628***	0.8515***
									(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Precipita	0.0007**	0.0002*	0.0003**	0.0054*	0.0005***	0.0008**	0.0000**	0.0006***	0.0775***	0.0001**	0.0001*	0.0006*	0.0044*	0.0005**	0.0007**	0.0009*
	(0.0441)	(0.0726)	(0.0323)	(0.0794)	(0.0076)	(0.0141)	(0.0270)	(0.0036)	(0.0090)	(0.0401)	(0.0817)	(0.0552)	(0.0732)	(0.0300)	(0.0397)	(0.0954)
Globalisation	0.0022**	0.0089**							0.0034**	0.0006*						
	(0.0410)	(0.0173)							(0.0132)	(0.0247)						
KOFEcGI			0.0014**	0.0014***							0.0004*	0.0005**				
			(0.0433)	(0.0002)							(0.0730)	(0.0207)				
KOFSoGI					0.0011**	0.0010**							0.0001*	0.0005*		
					(0.0487)	(0.0434)							(0.0597)	(0.0902)		
KOFPoGI							0.0009***	0.0004*							0.0025***	0.0019***
							(0.0032)	(0.0622)							(0.0000)	(0.0088)
GDP per capita	0.0117*	0.0079	0.0342**	0.0480***	0.0268***	-0.0167*	0.0106*	0.0086	0.0400***	0.0380***	0.0329***	0.0280***	0.0284***	0.0331***	0.0307***	0.0319***
	(0.0600)	(0.2015)	(0.0464)	(0.0000)	(0.0002)	(0.0688)	(0.0578)	(0.1238)	(0.0000)	(0.0000)	(0.0000)	(0.0036)	(0.0023)	(0.0042)	(0.0000)	(0.0000)
Corruption	-0.0181***	-0.0334***	-0.0140	-0.0491***	-0.0119	-0.0045	-0.0085	-0.0060	0.0012*	0.0232**	0.0289***	0.0167	0.0310**	0.0222***	0.0063*	0.0159**
	(0.0009)	(0.0009)	(0.5668)	(0.0000)	(0.1549)	(0.6173)	(0.1771)	(0.3274)	(0.0542)	(0.0167)	(0.0030)	(0.1970)	(0.0120)	(0.0073)	(0.0738)	(0.0294)
Infra	-0.0005	-0.0007	0.0049*	-0.0007***	-0.0022***	-0.0022**	-0.0004	-0.0003	-0.0019**	-0.0007	-0.0009	-0.0022*	-0.0020***	-0.0023***	-0.0011	-0.0008
	(0.3705)	(0.2495)	(0.0637)	(0.0000)	(0.0000)	(0.0161)	(0.4085)	(0.5078)	(0.0196)	(0.4908)	(0.3671)	(0.0514)	(0.0008)	(0.0053)	(0.1899)	(0.3572)
Trade	0.0002**	0.0033**	0.0004*	0.0003***	0.0003	0.0006**	0.0004**	0.0004**	0.0006***	0.0004	0.0006***	0.0008*	0.0009***	0.0010***	0.0007***	0.0008*
	(0.0358)	(0.0209)	(0.0904)	(0.0013)	(0.1078)	(0.0374)	(0.0243)	(0.0366)	(0.0068)	(0.1684)	(0.0000)	(0.0960)	(0.0001)	(0.0034)	(0.0021)	(0.0782)
Inflation	-0.0000	-0.0001	-0.0004*	0.0005***	0.0003***	0.0004***	-0.0000	0.0000	-0.0001	-0.0002	-0.0001*	-0.0001	-0.0001	-0.0001	-0.0001	-0.0002*
	(0.5052)	(0.1430)	(0.0542)	(0.0000)	(0.0023)	(0.0002)	(0.8637)	(0.8370)	(0.1892)	(0.1979)	(0.0732)	(0.5357)	(0.1598)	(0.5302)	(0.1646)	(0.0591)
Population	0.0061	0.0493	0.0426	-0.1847***	-0.1610***	-0.2230***	-0.0155	-0.0219*	0.0020	-0.0050	-0.0462**	-0.0595	-0.0745**	-0.0531	-0.0016	0.0112
	(0.7741)	(0.1121)	(0.4588)	(0.0000)	(0.0018)	(0.0003)	(0.2386)	(0.0806)	(0.9571)	(0.8824)	(0.0318)	(0.1354)	(0.0430)	(0.2315)	(0.9627)	(0.7345)
GVC	-0.0078**	-0.0021	-0.0244**	-0.0102***	0.0210***	0.0183***	-0.0070*	-0.0064*	0.0006	-0.0022	-0.0015	0.0032	0.0034	0.0029	-0.0016	-0.0007
	(0.0177)	(0.6077)	(0.0360)	(0.0022)	(0.0000)	(0.0000)	(0.0563)	(0.0906)	(0.8728)	(0.6880)	(0.6454)	(0.5052)	(0.3582)	(0.5527)	(0.7087)	(0.9054)
Globalisation*Precipita		0.0008*								0.0002**						
		(0.0524)								(0.0189)						
KOFEcGI*Precipita				0.0298***								0.0436***				
				(0.0008)								(0.0018)				
KOFSoGI*Precipita						0.0196*								0.0444**		
						(0.0847)								(0.0179)		
KOFPoGI*Precipita								0.0188**								0.0233**
								(0.0102)								(0.0412)
Observations	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424
Number of countries	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
No. of instruments	21	21	23	21	21	21	21	21	23	21	21	21	23	23	23	23
AR1 p-value	0.001	0.050	0.010	0.017	0.026	0.033	0.086	0.043	0.017	0.062	0.000	0.069	0.034	0.044	0.056	0.075
AR2 p-value	0.707	0.906	0.230	0.509	0.0615	0.041	0.968	0.930	0.902	0.900	0.849	0.808	0.957	0.740	0.928	0.769
Hansen p-value	0.476	0.396	0.794	0.994	0.854	0.767	0.534	0.677	0.845	0.865	0.632	0.197	0.830	0.309	0.628	0.870
Sargan p-value	0.997	0.995	0.360	0.609	0.998	0.996	0.984	0.977	0.963	0.988	0.907	0.896	0.930	0.936	0.995	0.995

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors

Table A10. The Moderating Role of Globalisation in the Relationship Between Temperature and Food Security (System-GMM Estimates)

Variables	AV_DI								AV_PR							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**
L.av_di (-1)	0.9121*** (0.0000)	0.8954*** (0.0000)	0.8658*** (0.0000)	0.8580*** (0.0000)	0.7030*** (0.0000)	0.5465*** (0.0000)	0.8391*** (0.0000)	0.6509*** (0.0000)								
L.av_pr (-1)									0.9033*** (0.0000)	0.9914*** (0.0000)	0.8773*** (0.0000)	0.8203*** (0.0000)	0.8105*** (0.0000)	0.7301*** (0.0000)	0.8706*** (0.0000)	0.7745*** (0.0000)
Temperature_CB	--0.0037 (0.0580)	-0.0589*** (0.0009)	-0.0035** (0.0335)	-0.0334** (0.0497)	-0.0036* (0.0785)	-0.0389** (0.0123)	-0.0014** (0.0247)	-0.0683* (0.0851)	-0.0092* (0.0503)	-0.0085** (0.0299)	-0.0105*** (0.0052)	-0.0272 (0.1712)	-0.0091** (0.0237)	-0.0090 (0.2966)	-0.0056 (0.2191)	-0.0517* (0.0827)
KOFGI	0.0052*** (0.0025)	0.0207*** (0.0044)							0.0042*** (0.0087)	0.0064* (0.0632)						
KOFEcGI			0.0001** (0.0179)	0.0147** (0.0431)							0.0011* (0.0832)	0.0082** (0.0285)				
KOFSoGI					0.0011** (0.0977)	0.0207* (0.0520)							0.0008* (0.0690)	0.0005*** (0.0083)		
KOFPoGI							0.0014** (0.0147)	0.0309*** (0.0350)							0.0023*** (0.0000)	0.0161** (0.0506)
Lpibh	0.0218** (0.0131)	0.0205** (0.0138)	0.0138** (0.0373)	0.0111 (0.1092)	0.0202* (0.0716)	0.0606*** (0.0001)	0.0175** (0.0184)	0.0186** (0.0317)	0.0415*** (0.0000)	0.0420*** (0.0001)	0.0286*** (0.0001)	0.0328*** (0.0002)	0.0265** (0.0128)	0.0307*** (0.0074)	0.0277*** (0.0009)	0.0229*** (0.0075)
corr	-0.0241* (0.0975)	0.0081 (0.6280)	-0.0032 (0.7573)	-0.0005 (0.9715)	-0.0178* (0.0633)	0.0068 (0.4900)	0.0051 (0.6756)	-0.0440** (0.0335)	0.0025 (0.8346)	0.0195 (0.1725)	0.0128 (0.3939)	0.0180 (0.2630)	0.0001 (0.9955)	0.0032 (0.8394)	0.0037 (0.7908)	0.0239* (0.0963)
Infra_energy	-0.0016** (0.0157)	-0.0004 (0.5631)	-0.0008 (0.3066)	-0.0019** (0.0467)	-0.0011* (0.0619)	-0.0025** (0.0306)	-0.0008 (0.1203)	-0.0021** (0.0402)	-0.0023*** (0.0010)	-0.0027*** (0.0005)	-0.0028*** (0.0056)	-0.0031*** (0.0031)	-0.0014** (0.0457)	-0.0012 (0.2684)	-0.0014* (0.0611)	-0.0003 (0.7959)
ouv	-0.0002 (0.1816)	-0.0043 (0.8161)	-0.0003* (0.0860)	0.0000 (0.8606)	-0.0003 (0.1443)	-0.0007*** (0.0001)	-0.0007*** (0.0024)	-0.0006 (0.1235)	-0.0005** (0.0203)	-0.0004** (0.0498)	-0.0005*** (0.0077)	-0.0006*** (0.0032)	-0.0003 (0.1887)	-0.0003 (0.1921)	-0.0005 (0.1146)	0.0002 (0.7385)
Inflation	0.0006 (0.7031)	-0.0008 (0.7861)	-0.0004 (0.8069)	0.0007 (0.5664)	0.0088 (0.3812)	0.0001* (0.0543)	0.0001* (0.0656)	0.0076 (0.9780)	-0.0001** (0.0325)	-0.0005 (0.8028)	-0.0007 (0.7041)	-0.0001 (0.8219)	-0.0001*** (0.0060)	-0.0001** (0.0254)	-0.0001 (0.3023)	-0.0008 (0.9343)
popula	0.0426 (0.1420)	0.0338 (0.1999)	-0.0200 (0.1651)	-0.0108 (0.4047)	-0.0102 (0.6678)	-0.0749 (0.2230)	-0.0326*** (0.0002)	0.0863 (0.1628)	0.0278 (0.4238)	0.0108 (0.7775)	-0.0552 (0.1323)	-0.0447 (0.2570)	-0.0507 (0.1880)	-0.0516 (0.2247)	-0.0014 (0.9645)	-0.0776 (0.1626)
Cvm	-0.0090** (0.0217)	-0.0058 (0.1417)	-0.0061* (0.0549)	-0.0037 (0.2240)	-0.0057 (0.2528)	0.0018 (0.6698)	-0.0061** (0.0476)	-0.0049 (0.1276)	-0.0007 (0.8788)	0.0036 (0.4752)	0.0056 (0.3472)	0.0061 (0.3134)	-0.0054 (0.1830)	-0.0073 (0.1176)	-0.0037 (0.4906)	-0.0046 (0.4136)
tempglo		0.0010*** (0.0009)								0.0005* (0.0790)						
tempeco				0.7002** (0.0353)								0.4195* (0.0670)				
tempeso						0.8899* (0.0969)								0.0089 (0.9531)		
tempepo								0.6422** (0.0439)								0.9861*** (0.0086)
Observations	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424	424
Number of countries	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
No. of instruments	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
AR1 p-value	0.097	0.044	0.073	0.097	0.020	0.047	0.098	0.005	0.059	0.082	0.060	0.077	0.037	0.079	0.083	0.068
AR2 p-value	0.841	0.962	0.975	0.657	0.861	0.0707	0.808	0.431	0.704	0.977	0.437	0.760	0.406	0.341	0.730	0.437
Hansen p-value	0.678	0.654	0.336	0.520	0.607	0.531	0.732	0.354	0.867	0.492	0.830	0.678	0.853	0.640	0.307	0.754
Sargan p-value	0.896	0.882	0.952	0.799	0.867	0.430	0.764	0.499	0.993	0.996	0.854	0.843	0.744	0.745	0.785	0.398

Notes: Values in parentheses are p-values. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively ($p < 0.01$, $p < 0.05$, and $p < 0.10$).

Source: Authors