© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1720068

Impact Of Climate Change on Household Consumption in Selected Sub-Saharan Africa Countries

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Abstract- This study assesses short- and long-run impacts of climate change on household consumption in selected Sub Saharan African countries (1991–2024) using a panel autoregressive distributed lag (ARDL) framework, with Mean Group and Pooled Mean Group estimators to account for cross country heterogeneity. Cointegration is found for most countries (except Ethiopia), and a negative, significant error correction term indicates adjustment toward the long run equilibrium. Higher CO_2 emissions significantly reduce household consumption, while rising temperatures prompt defensive spending (e.g., subsistence and cooling). Short run effects are pronounced in Niger but weak or insignificant in Kenya, Nigeria, Malawi, South Africa, and Uganda. Policy recommendations include adaptive social protection, climate smart agriculture, rural/peri urban solar mini grids, and strengthened early warning systems to enhance household resilience.

Keywords: Climate Shocks, Consumption, Sub-Saharan Africa

I. INTRODUCTION

Climate change has become one of the defining economic and developmental challenges of the twenty-first century. Beyond its environmental consequences, it increasingly shapes macroeconomic stability, living standards, and human welfare by disrupting production, prices, employment, and household livelihoods. These effects are particularly acute in developing economies, where high dependence on climate-sensitive sectors and limited adaptive capacity amplify vulnerability. Understanding how climate change influences household welfare outcomes has therefore emerged as a critical policy and research priority.

Sub-Saharan Africa (SSA) occupies a distinctive position within this global challenge. Although the region contributes less than 4% of global greenhouse gas emissions, it bears a disproportionately heavy burden of climate-related risks. Rising temperatures, erratic rainfall, droughts, and floods increasingly disrupt agricultural systems, energy generation, transport networks, and supply chains, all of which transmit shocks to households through changes in income, prices, and consumption opportunities. These welfare consequences are especially significant in SSA, where most households remain dependent on climate-sensitive livelihoods and allocate a large share of their expenditure to food and basic necessities.

The manifestation of these vulnerabilities is the observed volatility in consumer prices across the region. Inflationary pressures are frequently amplified by climate-induced supply constraints, particularly in food and energy markets. Existing evidence suggests that consumer prices in many SSA economies respond strongly to climatic variability, generating frequent fluctuations in household purchasing power (IMF, 2022; Banoba, Mwanyumba & Kaninda, 2025). However, price volatility, while informative, captures only part of the welfare component. Household consumption, a more direct measure of material well-being, remains underexplored in climate–welfare analyses, despite being the ultimate channel through which climate shocks affect living standards.

This gap is conceptually significant. The transmission from climate change to household consumption is unlikely to be direct. Rather, CO_2 emission, the standard climate proxy, captures broader processes of environmental stress and industrial activity that influence consumption through multiple intermediary channels: reduced agricultural yields, food shortages, diminished labour productivity, energy deficits, and disrupted market supply. Even modest climate pressures can generate substantial welfare losses in economies with high exposure and low resilience.

Yet the existing literature has overwhelmingly concentrated on agricultural productivity (Maruejols, Jaiswal & Sibhatu, 2024), economic growth (Koledoye et al., 2025), or poverty and inequality (Byrne, 2021; McLaughlin, Bozzola & Nugent, 2023), with limited attention to aggregate consumption outcomes across diverse, urbanising populations. This leaves a critical empirical void, particularly given SSA's rapid demographic and structural transformation, which reshapes both exposure to and coping capacity for climate shocks.
Evidence of climate-induced hardship is not speculative. Recent humanitarian assessments confirm that climatic events are primary drivers of food crises across West, East, and Southern Africa (World Food Programme, 2024; GRFC, 2025; Oxfam, 2025). Households frequently experience overlapping climate, health, and economic shocks, with price and consumption volatility representing pervasive transmission channels (Nikoloski, Christiaensen & Hill, 2018). These developments underscore that climate change is no longer a distant environmental threat but an immediate determinant of welfare.

This study examines the relationship between CO_2 emissions and household consumption expenditure across selected SSA countries, contrasting emission stability with consumption volatility to uncover structural patterns overlooked in prior research. Shifting the analytical lens from production and poverty to consumption, a welfare metric. The paper offers three contributions: (i) linking climate change to household consumption, a dimension rarely explored in SSA cross-country studies; (ii) providing evidence from a region least responsible for emissions yet most vulnerable to their welfare consequences; and (iii) generating actionable policy insights for stabilising expenditure, enhancing adaptive capacity, and embedding climate resilience into development strategies. In doing so, the paper positions climate change as a fundamental determinant of economic welfare and development in Sub-Saharan Africa.

II. LITERATURE REVIEW

2.1 Empirical Review

A significant body of research establishes a direct and detrimental link between climate shocks and household welfare in developing economies, with a particular focus on nutrition and consumption. Foundational work in this area, such as that by McLaughlin et al. (2023), uses detailed panel data from Malawi to demonstrate that long-term weather deviations, particularly reduced rainfall, systematically decrease the daily intake of nearly all key nutrients, including carbohydrates, fat, and protein. Their fixed-effects analysis further reveals that increasing temperatures are correlated with reduced consumption of protein, iron, and several vital vitamins. These findings provide a crucial baseline, suggesting that climate change, through frequent droughts and heat stress, tends to elevate food insecurity and worsen nutrition in vulnerable regions.

Building on this direct nutritional impact, other studies have investigated the role of pre-existing socioeconomic inequalities in mediating these effects. For instance, Shehu and Sadique (2015) employ an OLS framework on rural survey data to show that the impact of weather-induced shocks on consumption expenditure is highly stratified. Their disaggregated analysis reveals that while non-poor households demonstrate resilience to consumption shocks, poor households experience significant and negative responses, highlighting that vulnerability is not uniform. This disparity is further corroborated by Mekonnen, Tessema, Ganewo, and Haile (2021) in Ethiopia, whose logit regression analysis of 185 farmers shows that 60.5% of households experienced food insecurity due to rainfall variability, prompting many to adopt improved crop varieties as a coping mechanism. The prevalence of such insecurity is starkly quantified by Weldearegay and Tedla (2018), who use a Household Food Balance Model in rural Tigray and find that a staggering 84.3% of households live below the recommended calorie intake, underscoring the urgent need for interventions such as irrigation and subsidised farm inputs.

The causal mechanisms driving these declines in consumption and nutrition are further elucidated by

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DOI: https://doi.org/10.64388/IREV10I1-1720068

studies that isolate specific climate shocks. Carpena (2019), using a natural experimental approach with rainfall variation in rural India, finds that a median drought reduces calorie, protein, and fat intake by 1.4%. Critically, this study attributes the decline in nutrient-rich food consumption among low-income earners to reduced household income rather than to higher food prices, pointing to an economic transmission channel. This channel is corroborated by Amondo, Nshakira-Rukundo and Mirzabaev (2023) in Uganda, who employ Instrumental Variable models to show that droughts strongly reduce the availability of macro- and micronutrients essential for children's growth. From a broader consumption perspective, Mudzingiri, Mudiriza, Jana, and Sunge (2024) confirm a positive relationship between precipitation and household per capita consumption in South Africa, emphasising the need for inclusive growth policies that specifically target poor farmers in low-precipitation regions.

Further complicating the relationship, the transmission from climate shock to consumption is not solely about income but is also mediated by agricultural production and market dynamics. Maruejols et al. (2024) demonstrate in India that home-produced food is both critical for consumption and a primary source of vulnerability to climate anomalies, suggesting that policies must support both agricultural practices and market functions. This duality is explicitly modelled by Etwire (2023) in Ghana, who uses a large household dataset to show that a 1°C temperature increase reduces real food consumption per adult by 4.00%, a decline that operates through reduced land and labour productivity. His findings reveal that this effect is more pronounced for farm households, with both farm and non-farm income determining real food consumption by 0.44% and 0.33%, respectively, thereby linking climatic stress directly to the income-generating capacity of different economic sectors.

The disparate effects of climate shocks across different economic groups inevitably translate into broader societal inequality. Aggarwal (2021) evaluates this directly in India, using quantile regression to show that rising temperatures have heterogeneous effects on consumption, with agricultural and industrial households experiencing declines. This finding provides compelling evidence that climate change is not only a welfare issue but also a driver of inequality, disproportionately harming households dependent on climate-sensitive sectors. In response to these pervasive shocks, understanding household-level coping mechanisms becomes paramount. Khalili, Arshad, Kachele, Farajzadeh and Müller (2021) provide critical insights on this front, finding that Iranian farmers hit by severe drought protect their food expenditure by cutting non-food costs. However, their analysis also shows that for households with already low consumption levels, even non-food expenditure is significantly affected, underscoring the policy importance of providing off-farm employment opportunities and compensation schemes for the most vulnerable farm holders.

2.2.1 Theoretical framework

2.2.2 Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) provides the macroeconomic point of departure, positing an inverted-U relationship where CO_2 emissions rise with early development but decline after a certain income threshold is reached (Grossman & Krueger, 1995). While this framework effectively links aggregate growth to emission trajectories, its macro focus offers limited insight into how environmental changes translate into household welfare. To capture these micro-level mechanisms, we must turn to theories of consumer behaviour.

Classical consumer theory establishes the normative baseline, assuming rational utility maximisation under stable preferences and complete information (Chiuri, 2000). It would predict smooth adjustments in consumption as incomes rise and pollution falls. In Sub-Saharan Africa, however, these assumptions rarely hold. Climate shocks introduce abrupt income and price volatility, particularly where the EKC threshold remains unattained and structural vulnerabilities, rain-fed agriculture, and poor infrastructure override expected growth-pollution dynamics. This limits classical theory's explanatory power precisely where climate impacts are severest.
Keynesian theory extends the classical view by explicitly incorporating uncertainty and expectations

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into the consumption function (Keynes, 1936). Households respond not only to current income but also to anticipated risks, price volatility, harvest failure, or employment prospects (Drakopoulos, 2021). In climate-sensitive contexts, this behavioural lens explains why consumption adjustments are often more drastic and persistent than standard budget-constraint models predict, as households reduce discretionary spending, increase precautionary savings, or diversify livelihoods in response to unpredictable weather.

Aggregation theory then adds the crucial intra-household dimension. It traditionally assumes income pooling and joint decision-making, but in low-income, shock-prone settings, this assumption often fails. Climate events such as droughts or floods can shift bargaining power and spending priorities, disproportionately affecting women and children. This reveals that consumption responses are not only about total expenditure but also about the distributional layer that both classical and Keynesian perspectives miss.

These frameworks offer complementary insights: classical theory provides the rational baseline, Keynesian captures uncertainty-driven dampening, and aggregation theory highlights distributional dynamics. Applied to Sub-Saharan Africa, where climate-sensitive livelihoods, weak safety nets, and repeated shocks amplify vulnerability, they explain why consumption adjustments often manifest as reduced spending, dietary changes, or altered resource allocation. Yet gaps remain: compounded sequential shocks, informal coping strategies (mutual insurance, migration), and heterogeneous adaptive capacities are still underexplored. Addressing these is essential for moving beyond a static EKC lens toward a dynamic, household-centric understanding of environmental welfare that captures how macroeconomic transitions ultimately shape the consumption choices of the most vulnerable populations.

III. DATA AND METHODOLOGY

3.1 Data and Source

This research utilises two complementary datasets: national household data and geospatial climate indicators from 1991 to 2024. The household consumption variable was obtained from the World Bank. Consumption is preferred over income in this context because it provides a more stable and reliable indicator of living standards in Sub-Saharan Africa, where income levels are difficult to track or are underreported. On the other hand, climate data (precipitation anomalies, temperature, and carbon emissions) are sourced from Our World in Data and the IMF Climate Change Dashboard.

The paper considered seven sub-Saharan African countries: Niger, Kenya, Malawi, Nigeria, South Africa, Uganda and Ethiopia, chosen not only for data availability but also for their shared regional and climatic characteristics. The literature review suggests complex heterogeneity in their climatic and socioeconomic profiles. In the SSA region, agriculture remains largely rain-fed and vulnerable to extreme weather events. Including climate indicators will capture both short- and medium-term shocks that households may face, such as reduced crop yields, food shortages, and income loss.

3.2 Model Specification

The Panel ARDL approach is particularly suited to this analysis because it captures both the immediate and cumulative effects of climate variables on household consumption. While carbon emissions, rainfall, and temperature anomalies exert immediate welfare pressures, their full impact unfolds over the medium- to long-term. The method's flexibility in handling variables with mixed orders of integration I(0) and I(1), combined with its ability to address autocorrelation in a large-T, small-N panel, makes it technically robust. Moreover, the framework accounts for both common regional patterns and country-specific dynamics, an essential feature given the heterogeneity in resilience and economic structures across Sub-Saharan Africa (Ramos-Herrera, 2025). All series, except inflation, were transformed into logarithms to improve interpretability and stabilise variance.

This empirical strategy is grounded in the theory of household consumption under constraints, where decisions depend on income, prices, and expectations, yet adjust sluggishly to shocks due to imperfect markets. In the Sub-Saharan context, rising temperatures and CO_2 emissions directly shape these choices. Temperature shocks immediately shift spending toward essential coping and subsistence goods, inflating observed consumption without signalling welfare gains. At the same time, higher emissions exacerbate environmental stress and health risks, reducing disposable income and suppressing discretionary expenditure. These forces operate through distinct channels but jointly constrain households' ability to smooth consumption.

Because liquidity constraints, incomplete insurance, and weak social protection are pervasive, households can only partially absorb shocks, leading to a gradual and uneven adjustment toward the long-run equilibrium. The Panel ARDL framework is therefore well-equipped to trace this transitional path, distinguishing short-run responses from long-run coefficients. Critically, the speed and magnitude of adjustment vary with each country's structural vulnerability and adaptive capacity, making the method's heterogeneous specification indispensable for drawing policy-relevant inferences across the region.

Pesaran and Shin (1995) and Zardoub (2020) provide the basis for the panel ARDL (p, q) model, which, for each cross-sectional unit, takes the form:

$$Y_{i,t}= \sum_{j=1}^{P} \varphi_{ij} y_{i,t-j} + \sum_{m=1}^{K} \sum_{j=0}^{qm} \beta_{imj} x_{im,t-j} + \pi_t + \varepsilon_{it} \quad (1)$$

where i = 1…, N and time t = 1,…,T,T, $Y_{i,t}$ is the dependent variable, $x_{im,t}$ are K regressors, μ_i are unit effects, π_t optional time effects, and ε_{it} is the error term.

2) Error-correction representation (ECM form)

$$\Delta Y_{i,t} = \varphi_i (y_{i,t-1} - \theta_i' x_{i,t-1}) + \sum_{j=1}^{P} \gamma_{ij} \Delta y_{i,t-j} + \sum_{m=1}^{K} \sum_{j=0}^{qm} \delta_{imj} x_{im,t-j} + \mu_i + \pi_t + \varepsilon_{it} \quad (2)$$

where, $\varphi_i < 0$ is the speed of adjustment, θ_i' are long-run coefficients (from the cointegrating vector) and γ_{ij} and δ_{imj} capture short-run dynamics.

3) PMG restriction (common long run, heterogeneous short run)

$$\Delta Y_{i,t} = \varphi_i (y_{i,t-1} - \theta_i' x_{i,t-1}) + \sum_{j=1}^{P-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{m=1}^{K} \sum_{j=0}^{qm-1} \delta_{imj} x_{im,t-j} + \mu_i + \pi_t + \varepsilon_{it} \quad (3)$$

where θ is common across i, while φ_i , γ_{ij} and δ_{imj} are unit-specific

The functional model is:

$$HC = f(R, T, CO2)$$

From the functional model, the mathematical model can be derived such that:

$$HC_{it} = R_{it} + T_{it} + CO2_{it} + \varepsilon_{it} \quad (4)$$

Where HC household, Rit precipitation anomaly, T temperature anomaly, and CO2 carbon emissions.

Panel ARDL Level form

$$HC_{it} = \alpha_i + \lambda_t \sum_{j-1}^{p} \beta_{1j} HC_{i,t} + \sum_{j-1}^{q} \beta_{2j} R_{i,t} + \sum_{j-1}^{q} \beta_{3j} T_{i,t} + \sum_{j-1}^{q} \beta_{2j} CO2_{i,t} + \epsilon_{it} \quad (5)$$

Where α_i = country fixed effect; λ_t = time fixed effects.

ECM (error-correction) form

$$HC_{it} = \alpha_i + \sum_{j-1}^{p} \beta_{1j} \Delta HC_{i,t} + \sum_{j-1}^{p} \beta_{2j} \Delta LRA_{i,t} + \sum_{j-1}^{q} \beta_{3j} \Delta CO2_{i,t} + \sum_{j-1}^{q} \beta_{2j} \Delta TE_{i,t} + +\delta_1 HC_{i,t-1} + \delta_2 LRA_{i,t-1} + \delta_3 CO2_{i,t-1} + \delta_4 TE_{i,t-1} + \varphi ECMi_{i,t-1} + \epsilon_{it} \quad (6)$$

Where the $ECMi_{i,t-1}$ is the panel error correction model which captures how household consumption adjusts to changes in CO2, rainfall and temperature in the short-run.

IV. PRESENTATION OF RESULT AND ANALYSIS

4.1.1 Descriptive Statistics

The summary statistics are reported in Table 1.

Table 1: Descriptive statistics

	CO2	HC	TE	RA
Mean	30790.42	11.40	23.57	896.18
Median	22133.50	7.90	23.17	971.67
Std. Dev.	29764.73	12.24	3.15	481.94
Skew.	1.26	2.44	-0.28	-0.17
Kurt.	3.69	11.30	2.64	2.15
Jarque-Bera	67.66	918.51	4.41	8.27
Prob.	0.00	0.00	0.11	0.02
Obs.	238	238	238	238

Source: Authors' Computation, Using E-views 10, (2025) Authors' Computation, Using E-views 10, (2025)

The descriptive statistics reveal substantial cross-panel heterogeneity, underscoring the diversity in climate and spending across Sub-Saharan Africa. Mean CO_2 emissions stand at 3,079.50 metric tonnes, while the harmonised consumer price index (HC) averages 11.40, alongside temperature and rainfall means of 23.57°C and 899.67 mm, respectively. This wide-ranging climate profile directly shapes the region's distinct consumption and inflationary patterns.

The accompanying standard deviations confirm that this heterogeneity is not superficial. With dispersion values of 29.76 for CO_2, 12.24 for HC, 3.15 for temperature, and 48.19 for rainfall, the panel exhibits moderate but meaningful variation. These differences are primarily driven by country-specific factors, such as resource endowments and divergent institutional capacities to absorb climatic shocks, which naturally lead to differentiated household responses. Furthermore, the kurtosis values exceed the normal threshold across all series, ranging from 2.15 for rainfall to 11.30 for HC, indicating leptokurtic, heavy-tailed distributions. Such fat tails are characteristic of environmental and economic data, frequently punctuated by extreme events such as droughts or price spikes. Consequently, the Jarque-Bera statistics firmly reject normality, reinforcing the need for robust estimation techniques in the subsequent panel ARDL regressions to ensure reliable inference despite these distributional irregularities.

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DOI: https://doi.org/10.64388/IREV10I1-1720068

4.1.2 Panel unit root test

This study employs a range of first-generation panel unit root tests, namely the Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), ADF–Fisher, and PP–Fisher tests, to examine the stationarity properties of the variables.

Table 2: Panel Unit Root Tests

	Im, Pesaran & Shin	ADF - Fisher	PP - Fisher	Levin, Lin & Chu
Level				
HC	-6.86549***	74.1386***	57.1623***	-7.33942***
LCO2	0.08706	11.5005	16.2179	-3.10589**
LRA	-7.40888***	79.8835***	148.622***	-5.96528***
LTE	-2.80234*	29.6786*	42.3126***	-5.08199***
First Diff.				
HC	-15.2355***	172.388***	202.133***	-12.4351***
LCO2	-7.31181***	78.138***	151.061***	-4.32331***
LRA	-12.9669***	148.886***	170.34***	-9.48498***
LTE	-13.7293***	158.092***	180.9***	-12.7605***

The LLC test assumes a homogeneous autoregressive parameter across cross-sectional units, whereas the IPS, ADF–Fisher, and PP–Fisher tests allow for heterogeneity in the autoregressive dynamics across panels. The results indicate that most variables are stationary at the conventional level, hence the null hypothesis of no unit root is rejected for most tests (Table 1). However, for LCO_2, the evidence is mixed., as the LLC test rejects the null hypothesis at the 10 per cent significance level, while the IPS, ADF–Fisher, and PP–Fisher tests fail to reject the null. Given that the latter tests permit heterogeneous adjustment processes across cross-sections, the results suggest that LCO_2 is non-stationary at levels for at least some countries. The presence of variables with different or mixed orders of integration motivates the use of cointegration techniques to avoid spurious regression.

Furthermore, the mixed integration properties and potential heterogeneity across countries underscore the appropriateness of estimating an unrestricted and heterogeneous panel model. As argued by Pesaran and Smith (1995), imposing slope homogeneity in dynamic panel settings may lead to inconsistent estimates when long-run relationships differ across cross-sectional units. Consequently, allowing for country-specific short- and long-run coefficients provides a more flexible and robust framework for the empirical analysis.

4.2 Empirical Results

The results from the panel ARDL estimate of the relationship between climate change and household consumption are reported in Tables 3 and 4. Table 3 presents the bound test for the cross-sectional units, while Table 4 reports the PMG and MG coefficients.

Table 3: Bound Tests

Table 3: Bound Tests

Cross-Section	Obs	F-Statistics
Ethiopia	32	2.98
Kenya	32	3.45
Malawi	32	3.12
Niger	32	2.98
Nigeria	32	4.00
South Africa	32	4.26
Uganda	32	6.47

Average		3.89				
	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	2.676	3.586	3.272	4.306	4.614	5.966
35	2.618	3.532	3.164	4.194	4.428	5.816
Asymptotic	2.37	3.2	2.79	3.67	3.65	4.66

* is the cointegration, while I(0) and I(1) are respectively the stationary and non-stationary bounds.

The F-statistics from the bound test suggest 3 cointegrating relationships from the cross-sectional units (Uganda, South Africa, and Nigeria), with the remaining countries exhibiting weak or unstable long-run relationships (Table 3). The average F-statistics confirmed joint cointegration at 10% significance level. By implication, we fail to reject the null hypothesis of no cointegration and state that heterogeneity is observed across individual countries. In other words, a long-run relationship is observed but not common to all panel members.

The Mean Group estimator indicates an average long-run coefficient and a significant coefficient, thereby eliminating the assumption of homogeneity (Table 4). The long-run coefficient indicates that temperature is the main driver of household consumption in the selected SSA countries; a decline in temperature would lead to a significant negative change in household consumption across the region. By implication, a decline in temperature would reduce heat-induced stress, enhance both productivity and crop yields, and the overall heterogeneous effect is economic segregation through increased poverty, with low-income households more exposed to limited adaptation and larger negative consumption effects.

Table 4: Panel ARDL results

	Mean Group		Pooled Mean Group	
	Coef.	Std. Error	Coef.	Std. Error
Long-Run Coef.				
LCO_2	3.041784	3.694679	-2.86342***	0.787521
LRA	-4.18366	9.887515	-1.21158	1.239991
LTE	-331.603***	120.9001	-10.6778*	5.083877
Intercept	1095.856***	396.5551	76.92044***	20.27932
Short-Run Coef.				
ECT-1	-0.7047***	0.084362	-0.53452***	0.093803
ΔHC-1	0.213651***	0.049257	0.177071***	0.055085
ΔLCO_2	-17.3969*	7.936926	-8.7283	6.365995
ΔLRA	1.327226	4.157762	-0.77769	1.785585
ΔLTE	120.8176*	63.8371	15.65858	45.39921
Observation	224	224	224	224
Hausman	52.81547***			

In the short run, increases in CO_2 emissions are negatively associated with household consumption across individual countries, challenging the standard assumption that emissions growth reflects industrial expansion and rising incomes. In Sub-Saharan Africa, CO_2 growth more plausibly captures structural fragilities and welfare constraints rather than consumption-driven economic activity. Weak social protection systems and the predominance of informal and agrarian livelihoods amplify households' exposure to environmental and economic shocks, limiting their ability to smooth consumption.

Elevated CO_2 emissions are associated with poorer air quality and increased incidence of heat- and pollution-related illnesses, which reduce labour productivity and disposable income. At the same time, environmental degradation undermines agricultural productivity, while inefficient and fossil-fuel-dependent energy systems raise energy costs, particularly in energy-poor economies. Together, these channels compress household budgets and suppress consumption. Overall, the findings point to a climate–poverty nexus in which short-run emissions growth serves as a proxy for health, energy, and environmental stresses that directly erode household welfare in vulnerable economies.

Conversely, the positive short-run relationship between temperature and household consumption suggests that immediate increases in temperature stimulate spending. In the heat-prone SSA region, moderately warm conditions can enhance certain crops (e.g., maize and cassava) and trigger seasonal agricultural activities, leading to higher input expenditures on seeds and fertilisers and improved productivity in other sectors. Additionally, households may increase consumption of perishable goods to prevent spoilage and allocate more to cooling and water-related needs. These responses are particularly pronounced in low-income settings with limited adaptive capacity, where temperature fluctuations directly influence daily consumption patterns and economic activity.

The results further indicate that lagged CO_2 emissions negatively affect household consumption, suggesting that past environmental degradation continues to constrain budgets and suppress spending. In contrast, rainfall shows a positive but statistically insignificant effect, implying that short-run changes in precipitation do not necessarily alter consumption patterns in the SSA context.

The results further indicate that lagged CO_2 emissions continue to exert a negative effect on household consumption, while rainfall displays a positive but statistically insignificant association. The error-correction term is negative and statistically significant (at the 0.70 per cent level), with an absolute value below unity, confirming the presence of a stable long-run equilibrium and indicating a moderate speed of adjustment. This suggests that households gradually correct short-run deviations and restore consumption patterns following environmental shocks.

Based on our established analytical framework, the Mean Group (MG) estimator is the preferred model, confirming the presence of heterogeneity. While most cross-sectional units show evidence of cointegration, with Ethiopia as the only exception, short-run coefficients are generally weak or insignificant for many countries. This underscores that the aggregate regional result masks critical national heterogeneity, with Niger emerging as a distinct outlier in both magnitude and economic interpretation.

Country-Specific Analysis

In Niger, short-run estimates indicate that a unit increase in CO_2 emissions reduces household consumption, while lagged consumption and contemporaneous temperature increase consumption by approximately 0.34 per cent and 197.59 per cent, respectively. These pronounced coefficients do not signify consumption-led economic expansion but instead reflect Niger's extreme structural vulnerability and climatic exposure. With nearly 70% of its territory in the Sahara zone, low and erratic rainfall, and a large population dependent on climate-sensitive livelihoods, household welfare is acutely sensitive to temperature shocks (World Food Programme, 2025).

The negative coefficient on CO_2 emissions aligns with this interpretation. In Niger, emissions growth is largely a proxy for environmental stress, driven by land degradation, biomass energy use, and energy inefficiencies rather than industrial activity. Since 2012, the Nigeriens Nourishing Nigeriens (3N) Initiative has framed climate policy around food security and disaster risk management, employing early warning systems, climate-resilient crops, and emergency food assistance. While such measures help mitigate long-run welfare losses, they may also amplify short-run consumption adjustments during shocks, as households increasingly rely on market purchases and aid-supported consumption to meet immediate needs. Persistent food price inflation and a structural food trade deficit further reinforce this vulnerability-driven consumption pattern (Barois et al., 2024).

In contrast, Kenya, Nigeria, Malawi, South Africa, and Uganda exhibit weak or statistically insignificant short-run coefficients, indicating that short-term environmental shocks do not translate into abrupt consumption adjustments. This pattern suggests greater economic diversification, stronger institutional capacity and climatic buffering mechanisms that enhance short-run resilience. In Nigeria, the National Climate Change Policy (2021–2030) emphasises agricultural diversification and climate resilience. With annual rainfall exceeding 1,000 mm across the guinea savannah, Nigeria's largest agroecological zone is well-suited for arable crop production, hence the country benefits from relatively stable agricultural output. These favourable climatic conditions, combined with diversified production systems, contribute to Nigeria's status as a net food exporter, thereby dampening short-run consumption volatility in response to climate shocks.
In Kenya, the National Climate Change Action Plan (NCCAP) 2018–2022, aligned with the country's long-term climate strategy toward 2030, promotes climate-smart agriculture and crop diversification. Although Kenya experiences high spatial rainfall variability, with less than 500 mm in arid regions and over 1,000 mm in the highlands and Lake Victoria basin, its most productive agroecological zones support maize, tea, coffee, and horticulture, enhancing adaptive capacity despite periodic reliance on food imports during drought years.

Malawi also demonstrates weak short-run effects, reflecting structural and policy-related buffering rather than immunity to climate risk. The country operates under the National Climate Change Management Policy (2016) and complementary agricultural adaptation strategies targeting resilience through 2030. Malawi's subtropical climate, with annual rainfall ranging between 800 and 1,200 mm concentrated in a single rainy season, supports arable agriculture primarily in the central and southern plateau regions. However, agricultural production remains predominantly rain-fed and smallholder-based, making it inherently sensitive to climatic variability. While Malawi attains food self-sufficiency in years of favourable rainfall, its limited export capacity and dependence on seasonal conditions explain the absence of strong short-run consumption responses, as households and institutions rely on coping mechanisms rather than immediate adjustments.

Ethiopia stands apart as the only with no relative convergence, indicating unstable long-run path. The country is characterised by a population of 135 million, a wide range of elevations, persistent drought and famine, and a population that depends on agricultural production as a source of livelihood. This likely results from heavy dependence on rain-fed agriculture, recurrent climate-induced humanitarian crises, and an aid-mediated consumption-smoothing pattern that introduced persistent structural breaks. Additionally, Ethiopia's low and volatile emissions profile, combined with its climate-resilient green economy strategy, Long-Term Low Emission Development Strategy, and the Green Legacy Initiative, may further decouple emissions from consumption dynamics and prevent long-run adjustment. Climate initiatives are supported by the Growth and Transformation Plan II and climate risk management and Disaster Risk Reduction (UNFCCC, 2022). Mogess and Ayen (2023) have reported that mixed adaptation strategies are the most effective means of improving rural household welfare. These findings underscore that the effects of climate variables on consumption in Sub-Saharan Africa hinge on structural vulnerability, climatic exposure, and national policy design.

V. CONCLUSION AND POLICY RECOMMENDATIONS

This paper investigates the impact of climate change on household consumption in Sub-Saharan Africa (SSA) using a panel ARDL framework on annual data spanning 1991–2024. One key contribution of the paper is the reliance on national-level data to capture both the rural and urban household vulnerability to climate exposure. The paper explicitly accounts for cross-country heterogeneity to provide nuanced evidence that climate-related shocks materially affect household welfare, with structural vulnerability shaping consumption responses across the region.

The Mean Group (MG) estimator emerges as the most appropriate specification, highlighting heterogeneity in both short- and long-run dynamics across countries. Cointegration is observed for most cross-sectional units, with Ethiopia appearing as an exception, indicating that while a stable long-run relationship exists for most of the region, its strength and persistence vary across the region. The negative and statistically significant error-correction term confirms convergence toward the long-run equilibrium at a moderate pace, following short-run environmental disturbances.

The short-run results show that increases in CO_2 emissions are consistently associated with reductions in household consumption, contradicting the conventional view that emissions growth reflects industrial expansion and rising incomes. In the SSA context, CO_2 emissions predominantly capture environmental stress, energy inefficiencies, and health-related burdens rather than consumption-driven factors. Weak social protection mechanisms, widespread energy poverty, and heavy reliance on informal and agrarian livelihoods amplify households' exposure to pollution-induced health costs, productivity losses, and rising energy prices, thereby crowding out discretionary spending. These findings highlight a climate–poverty nexus in which emissions growth directly and immediately undermines household welfare in the region.

In contrast, temperature increases are positively associated with household consumption in the short run, reflecting coping and adaptation responses rather than welfare improvements. In heat-prone SSA countries, moderate temperature increases may stimulate seasonal agricultural activity, while extreme heat episodes increase subsistence expenditures on cooling, water, and perishable goods. These defensive consumption responses can only inflate consumption expenditure without necessarily improving well-being, underscoring the need to distinguish between necessity-induced expenditures and income-driven consumption growth.

Country-level heterogeneity further reinforces these conclusions. Niger emerges as an extreme case in which temperature shocks generate exceptionally large, short-run consumption responses, reflecting acute climatic exposure, structural fragility, and reliance on subsistence aid to smooth consumption. By contrast, Kenya, Nigeria, Malawi, South Africa, and Uganda exhibit weak or insignificant short-run coefficients, consistent with greater economic diversification, institutional capacity, agroecological buffering, and the presence of climate-policy frameworks that help absorb environmental shocks without abrupt consumption adjustments. Ethiopia's lack of cointegration reflects persistent structural breaks arising from dependence on rain-fed agriculture, recurrent climate-induced humanitarian crises, and aid-mediated consumption smoothing, which weaken long-run adjustment mechanisms.

Overall, these findings indicate that climate shocks in SSA operate primarily through short-run welfare constraints rather than growth-enhancing channels. Current adaptation strategies and climate policies may reduce long-run vulnerability, but they do not fully shield households from immediate consumption disruptions.

Recommendations

The heterogeneity in country responses highlights that there is no one-size-fits-all approach, underscoring the need for integrated climate and social protection policies that combine emissions mitigation, affordable and reliable energy access, and targeted consumption-smoothing mechanisms. Specifically:

To mitigate climate-induced welfare losses, this study recommends a multi-pronged strategy. Governments should first scale up adaptive social protection, climate-responsive cash transfers, and food assistance to buffer households during acute shocks. Complementing this, investments in climate-smart agriculture, particularly drought-resistant crops and dry-season farming, are essential for stabilising long-term food security.

To further shield households from income volatility, microinsurance schemes tailored to agricultural risks should be promoted to enable smoother consumption post-shock. Expanding decentralised renewable energy, such as solar mini-grids, would reduce fossil-fuel dependence and support off-farm livelihoods. Finally, strengthening early warning systems and ensuring the timely dissemination of weather information to farmers and local authorities can empower proactive decisions, reducing uncertainty. Without these targeted interventions, climate change will continue reinforcing poverty traps and eroding household welfare across Sub-Saharan Africa.

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