



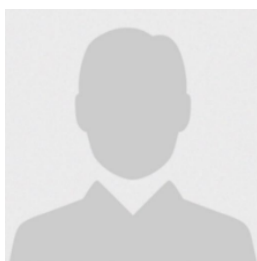
Climate-Induced Health Shocks, Financial Inclusion, and Poverty Dynamics in Selected Sub-Saharan African Countries



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*Climate-Induced Health Shocks;
Financial Inclusion;
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Abstract

This study examines the dynamic relationships among climate-induced health shocks, financial inclusion, and poverty dynamics in five Sub-Saharan African (SSA) countries, using annual panel data from 2000 to 2023 sourced from the World Development Indicators. The study adopts the Pooled Mean Group (PMG) estimator within an Autoregressive Distributed Lag (ARDL) panel framework. The results show that financial inclusion significantly increases per capita consumption expenditure in the long run, confirming its role as a poverty-reducing mechanism. Thus, malaria incidence exerts a strong and statistically significant negative effect on per capita consumption, accentuating the persistent economic burden of climate-sensitive infectious disease. Particularly, cholera incidence yields no significant effect, consistent with its localised and episodic epidemiological pattern. Domestic health expenditure is positively associated with consumption over the long run, though country-level heterogeneity is pronounced. Ditto for Granger causality results, which confirm unidirectional causation from malaria burden and health expenditure to poverty levels. The study concludes with the following policy recommendations: as such, effective poverty alleviation in SSA requires simultaneous investment in climate-resilient health systems and inclusive financial services, with particular attention to institutional efficiency and equitable access.

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1 Introduction

Despite contributing fewer than 3% of global greenhouse gas emissions, Sub-Saharan Africa (SSA) bears a disproportionate share of the consequences of climate change, ranging from macroeconomic disruptions to welfare deterioration (Sinore & Wang, 2025; Serdeczny et al., 2017). Climate-sensitive diseases such as malaria and cholera, compounded by malnutrition and reduced agricultural productivity, are key channels through which environmental shocks translate into deepening poverty (Thomson et al., 2018; Caminade et al., 2014). The consequences for household welfare are severe: falling incomes, rising out-of-pocket health expenditures, and chronic impoverishment, especially among communities whose livelihoods depend on rain-fed agriculture (Traoré & Tetka, 2025; Castaneda Aguilar et al., 2020).

Financial inclusion has emerged as a promising structural response to poverty and economic vulnerability. Defined as equitable and affordable access to formal financial services including savings, credit, insurance, and digital payments, financial inclusion has the potential to buffer households against income shocks and health-related expenditure burdens (World Bank, 2025). In SSA, mobile money adoption has surged, with penetration reaching 12% of adults, compared to a global average of approximately 2% (Demirguc-Kunt et al., 2018). Evidence from Tanzania and other SSA countries suggests that access to mobile financial services has improved household food security, enabled health spending, and supported consumption smoothing (Riley, 2018). Yet significant gaps persist: women, rural populations, and the economically marginalised continue to face barriers of financial illiteracy, high transaction costs, and inadequate infrastructure (Demirguc-Kunt et al., 2018).

The intersection of climate-induced health shocks, financial inclusion, and poverty dynamics represents a critical but underexplored research frontier in SSA. Most existing studies treat these phenomena in isolation, examining either health shock exposure or financial access without modelling their simultaneous effects on poverty outcomes within a unified panel framework. Moreover, few studies employ per capita consumption expenditure as a poverty proxy in conjunction with dynamic panel techniques capable of separating short-run adjustment from long-run equilibrium relationships across heterogeneous SSA economies.

To address these gaps, this study investigates the dynamic effects of climate-induced health shocks (proxied by malaria and cholera incidence) and financial inclusion on per capita consumption expenditure across five SSA countries: Ethiopia, Ghana, Kenya, Nigeria, and South Africa over the period 2000 to 2023. These countries are selected for their geographic and institutional diversity, their varying levels of financial sector development, and their differential exposure to climate-sensitive disease burdens. The analysis employs the PMG estimator of Pesaran et al. (1999), within an ARDL panel framework, which accommodates mixed integration orders, cross-sectional heterogeneity in short-run dynamics, and long-run coefficient homogeneity. The remaining sections of the scholarly article are organised as follows. Section 2 reviews the relevant theoretical and empirical literature and identifies key research gaps. Section 3 details the methodological framework, variable definitions, and data sources. Section 4 presents and discusses the empirical results. Section 5 concludes with policy recommendations.

Literature Review

Conceptual Clarifications

Climate-induced health shocks refer to sudden or systematic health crises precipitated by environmental changes linked to climate variability, including heatwaves, flooding, and drought (Watts et al., 2015). McMichael (2013) frames these as reflecting a deep coupling between ecosystem disruption and human biological vulnerability, while Costello et al. (2009), emphasise that resilience to such shocks requires institutional preparation and health system adaptation. In the same vein, financial inclusion, as conceptualised by Demirguc-Kunt et al. (2018), encompasses affordable, timely, and adequate access to credit, savings, and payment services for individuals and households. Allen et al. (2016) highlight its macroeconomic function as a shock absorber: by extending social safety nets, financial inclusion reduces exposure to catastrophic expenditure and poverty traps. Beyond access, Sarma (2012), stresses that inclusion is fundamentally oriented toward broad development goals, reducing inequality and sustaining economic growth.

Poverty dynamics, distinct from static poverty rates, capture the transitions into, out of, and within states of poverty (Hulme & Shepherd, 2003). While transient poverty is driven by short-run shocks such as disease or climate events, chronic poverty is rooted in structural factors including limited education and labour market exclusion (Krishna, 2020). Understanding this distinction is essential for designing policies that address both the immediate consequences of health shocks and their long-run scarring effects.

Theoretical Foundations

Three theoretical frameworks guide this study. The Socio-Ecological Systems (SES) Theory, developed by Ostrom (2009), models the feedback loops between social and ecological subsystems, emphasising resilience and adaptive governance. Berkes (2017) applied SES theory to show how climate stressors interact with institutional structures, while Folke (2016) demonstrated its relevance to adaptive management under environmental uncertainty. McGinnis & Ostrom (2014) further extended the framework for policy analysis, affirming its interdisciplinary utility.

The Sustainable Livelihoods Framework (SLF), originated by DFID (1999) and grounded in Chambers & Conway (1992), analyses how households mobilise assets to sustain livelihoods under conditions of vulnerability. Scoones (2015) expanded its climate application, emphasising asset-based resilience, while Ashley & Carney (1999) and Rakodi (2014) affirmed its relevance for pro-poor policy in urban and rural contexts. The SLF is particularly suited to this study because it explicitly links vulnerability contexts (climate shocks, disease burdens) to transformative structures (financial inclusion, health policy) in determining poverty outcomes.

Vulnerability Theory, developed by Blaikie et al. (2014), and rooted in the risk-hazard model, identifies how social, economic, and environmental factors shape exposure and adaptive capacity to climate shocks. Adger (2006) and Füssel (2007) extended the framework to capture the social and ecological dimensions of climate vulnerability, while Cutter (2003), underscored the role of structural inequalities in determining hazard outcomes. This study draws on vulnerability theory to contextualise how financial exclusion amplifies poverty risk under climate stress.

Empirical Review

Empirical evidence on the poverty consequences of climate-induced health shocks is substantial. Mathew & Omodele (2024), demonstrated that climate variability significantly worsens under-five and maternal mortality in SSA, compounded by fiscal fragility and poverty. Watts et al. (2019) and Dickerson et al. (2022), documented that malaria and dengue fever disproportionately burden poor households through elevated out-of-pocket expenditures and lost income, particularly where financial safety nets are absent. Cosh et al. (2024), extended this evidence to mental health, showing that eco-anxiety and climate-induced psychological distress are rising, especially among economically marginalised groups with limited access to mental health services. A related strand of literature explores financial inclusion as a resilience mechanism. Chandio et al. (2020), showed that in rural China, climate-induced agricultural disruption combined with financial exclusion significantly deepened poverty. Karami (2012), and Vicedo-Cabrera et al. (2021), documented how heat-wave-affected localities with low financial protection experienced pronounced poverty escalation following climate-health shocks. Kärkkäinen et al. (2020), further showed that even where climate adaptation improved

health outcomes, inadequate financial protection prevented welfare gains from trickling down to the poorest households.

The gender dimension of climate-financial-poverty interactions is also well-documented. [Pinho-Gomes & Woodward \(2024\)](#) and [Andreevich et al. \(2020\)](#), found that low-income women in climate-exposed areas suffered disproportionately from respiratory and heat-related illnesses in the absence of financial support. [Aryal et al. \(2022\)](#) and [Bhattarai \(2020\)](#) linked lack of credit access among female-headed farming households to reduced adoption of climate-resilient practices and higher waterborne disease exposure. [Rai et al. \(2021\)](#) showed that gender-blind climate policies in Nepal constrained women's access to healthcare during climate crises, generating compounding health and income inequalities.

Country-specific and regional studies further support these cross-cutting findings. [Orji et al. \(2024\)](#), applied dynamic ARDL estimation to Nigerian data from 1981 to 2021, finding that financial inclusion consistently reduces poverty in both the short and long run. [Omenihu et al. \(2024\)](#) confirmed this for Nigeria using disaggregated access, usage, and quality dimensions of financial inclusion over 2004-2021. [Shah \(2025\)](#) synthesised global evidence through a literature review anchored in the Kuznets curve and financial intermediation theory, concluding that financial access and economic growth jointly drive poverty reduction.

Despite considerable advances, the existing literature exhibits several important gaps that motivate this study. First, the majority of studies examine financial inclusion and climate-health shocks in isolation, rarely modelling their combined effects on poverty within a unified econometric framework. The interdependence of these phenomena, whereby climate shocks erode health capital, reduce household income, and simultaneously increase the demand for financial services, has not been adequately captured. Moreover, most existing studies use static or single-country frameworks, limiting their ability to capture heterogeneity across SSA's diverse institutional and epidemiological contexts. Dynamic panel approaches that allow short-run heterogeneity while identifying long-run equilibrium relationships are conspicuously absent from this literature.

Further, the operationalisation of poverty in prior work is often inconsistent. Some studies rely on headcount ratios or income data measures subject to underreporting and distributional insensitivity, while others conflate aggregate living standards with individual poverty incidence. Per capita consumption expenditure, despite its known limitations with respect to within-country inequality, offers a more stable and internationally comparable welfare indicator suitable for cross-country panel analysis. Also, the distinction between malaria and cholera as climate-sensitive disease vectors has rarely been maintained in empirical work. Given their different epidemiological profiles malaria being endemic and climate-driven, cholera being episodic and largely water-sanitation-linked treating them symmetrically may obscure important heterogeneity in their poverty channels. Finally, the study of mobile money and non-traditional financial services as instruments of climate resilience remains underdeveloped relative to formal banking sector indicators. This is a critical gap given the rapid expansion of mobile financial services in SSA and their demonstrated role in consumption smoothing. This study directly addresses these gaps by integrating climate-induced health shock variables (malaria and cholera incidence) with a financial inclusion indicator and a government health expenditure control within a dynamic PMG-ARDL panel framework across five heterogeneous SSA economies, thereby offering a more comprehensive and methodologically rigorous assessment of the poverty-health-finance nexus.

2 Materials and Methods

Theoretical Underpinning and Model Specification

This study is anchored in the Sustainable Livelihoods Framework (SLF), developed by DFID (1999) and rooted in [Chambers & Conway \(1992\)](#). The SLF is selected over the competing theoretical candidates for its explicit focus on how households leverage available assets financial, human, and social to sustain livelihoods amid vulnerability contexts such as climate shocks and infectious disease. Its alignment with the study's core variables, its applicability to SSA country contexts, and its recognition of transformative structures (financial inclusion, health policy) as mediators of poverty outcomes make it the most appropriate theoretical lens.

varying disease burdens, differential financial sector development, and data availability. All health variables are log-transformed (LMAL, LCHO) to address skewness and stabilise variance.

3 Results and Discussions

Descriptive Statistics

Table 1 presents descriptive statistics for all variables across the five sampled countries. Marked cross-country heterogeneity is evident. South Africa leads in both mean per capita consumption and financial inclusion, reflecting its relatively advanced financial system and higher aggregate welfare. Ethiopia records the lowest PCC (0.98) and FI (24.77), consistent with its status as one of SSA's least financially integrated economies. Ghana, Kenya, and Nigeria cluster around or below the panel means for PCC (4.73) and FI (43.96). Health burden indicators reveal equally stark disparities. Nigeria and Ghana record the highest mean malaria prevalence at 341.05 and 305.47 per 1,000 population, respectively, while Ethiopia exhibits the highest mean cholera incidence at 11,599.61 per 100,000 population. South Africa records the lowest malaria burden and the highest government health expenditure, suggesting more robust health system capacity. Nigeria's chronically low DHE reflects persistent underinvestment in public health. Across the panel, countries with lower PCC and FI tend to exhibit higher disease burdens, providing preliminary descriptive support for the study's core hypotheses.

Table 1
Descriptive Statistics Result

Country	Statistic	PCC	FI	MAL	CHO	DHE
Ethiopia	Mean	0.980	24.77	129.01	11,599.61	1.140
	Maximum	2.350	56.00	219.26	54,070.00	2.280
	Minimum	0.260	6.40	33.61	0.00	0.380
	Std. Dev.	0.720	17.33	58.47	15,674.10	0.500
Ghana	Mean	3.423	37.97	305.47	4,419.95	1.660
	Maximum	5.940	68.23	432.01	28,944.00	2.530
	Minimum	0.660	15.00	193.90	50.00	0.700
	Std. Dev.	1.751	17.98	71.85	7,769.95	0.510
Kenya	Mean	2.955	49.19	103.14	3,842.21	1.560
	Maximum	5.080	84.80	245.45	14,074.00	2.230
	Minimum	1.060	14.30	58.68	11.00	1.000
	Std. Dev.	1.421	27.90	64.97	4,910.51	0.380
Nigeria	Mean	2.734	38.56	341.05	19,310.46	0.640
	Maximum	4.210	64.10	402.01	111,062.00	1.200
	Minimum	1.180	20.00	283.81	597.00	0.450
	Std. Dev.	0.897	15.32	48.75	28,357.68	0.210
South Africa	Mean	13.491	65.88	1.870	10,062.73	3.910

Country	Statistic	PCC	FI	MAL	CHO	DHE
Panel	Maximum	19.220	91.00	5.570	106,159.00	5.840
	Minimum	5.850	46.00	0.330	468.00	2.310
	Std. Dev.	3.479	12.81	1.286	23,096.99	1.000
	Mean	4.730	43.96	176.11	9,913.96	1.780
	Maximum	19.217	91.00	432.01	111,062.00	5.840
	Minimum	0.260	6.40	0.330	0.00	0.380
	Std. Dev.	4.882	23.15	139.43	18,977.98	1.270
	J-B Prob.	0.000	0.040	0.010	0.000	0.000
	Observations	119	115	120	108	120

Source: Authors' computation (2026)

Panel Unit Root Tests

Table 2 summarises the panel unit root test results. All four tests, LLC, IPS, ADF-Fisher, and PP-Fisher, are applied to each variable, with results obtained at first differences for PCC, FI, and LMAL (I(1) variables) and at levels for LCHO and DHE. The mixed integration order confirms that neither a purely I(0) nor a purely I(1) panel framework is appropriate, validating the use of the ARDL-PMG approach.

Table 2
Summary of Panel Unit Root Test Results

Method	D(PCC)	D(FI)	D(LMAL)	LCHO	DHE
<i>LLC t^* Statistic Prob.</i>	-6.784 0.0000	-7.866 0.0000	-2.133 0.0165	-2.365 0.0090	-6.174 0.0000
<i>IPS W-stat Prob.</i>	-6.376 0.0000	-6.101 0.0000	-4.432 0.0000	-1.838 0.0331	-8.937 0.0000
<i>ADF-Fisher χ^2 Prob.</i>	54.472 0.0000	56.632 0.0000	40.355 0.0000	19.881 0.0304	79.954 0.0000
<i>PP-Fisher χ^2 Prob.</i>	54.690 0.0000	116.121 0.0000	64.314 0.0000	29.779 0.0009	71.594 0.0000
<i>Integration Order</i>	I(1)	I(1)	I(1)	I(0)	I(1)

Observations: ** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Source: Authors' computation (2026)

PMG Estimation Results

The PMG estimation results are presented in Table 3. Panel A reports the long-run pooled coefficients; Panel B presents the short-run mean-group coefficients. In the long run, financial inclusion (FI) exerts a positive and highly significant effect on per capita consumption. This confirms that expanded access to formal financial services enhances households' long-run consumption capacity, consistent with the consumption-smoothing and poverty-reduction roles attributed to financial inclusion in prior literature (Orji et al., 2024; Omenihu et al., 2024; Shah, 2025). The short-run coefficient for FI is positive but statistically insignificant, indicating that the welfare gains from financial deepening materialise over time rather than instantaneously, a finding that has important implications for policy design.

Malaria incidence (LMAL) exhibits a strong and significant negative long-run effect on per capita consumption. This result underscores malaria as a persistent structural driver of economic deprivation in SSA: it erodes human capital through morbidity, reduces labour productivity, and generates catastrophic out-of-pocket expenditures that constrain household consumption (Dickerson et al., 2022). The insignificant short-run coefficient for LMAL suggests that the welfare damage inflicted by malaria accumulates gradually, with acute episodes translating into chronic welfare losses over time.

Cholera incidence (LCHO) is statistically insignificant in both the long run and short run, consistent with the episodic, geographically concentrated nature of cholera outbreaks in SSA and the effectiveness of targeted public health responses in limiting sustained economic impact (Watts et al., 2019).

Domestic health expenditure (DHE) is positively and significantly associated with per capita consumption in the long run. This indicates that public health investment supports household welfare by reducing disease burden and preserving productive capacity. However, country-level results (Table 4) reveal that sharp increases in health spending are associated with short-run consumption declines in Ethiopia and Ghana, consistent with evidence that high out-of-pocket health expenditures crowd out non-health consumption among poor households.

The error-correction term is negative and significant, confirming the existence of a stable long-run cointegrating relationship. The speed of adjustment implies that approximately 18.6% of short-run deviations from long-run equilibrium are corrected within one period, suggesting a moderately slow adjustment path consistent with the structural rigidities prevalent in SSA economies.

Table 3
Pooled Mean Group (PMG) Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Panel A: Long-Run (Pooled) Coefficients				
<i>FI</i>	0.0443***	0.0112	3.9564	0.0002
<i>LMAL</i>	-2.7548**	1.0522	-2.6180	0.0106
<i>LCHO</i>	0.0344	0.2889	0.1193	0.9053
<i>DHE</i>	1.1584***	0.3351	3.4572	0.0009
<i>Constant</i>	7.1882**	3.2973	2.1799	0.0322
Panel B: Short-Run (Mean-Group) Coefficients				
<i>ECMt-1</i>	-0.1861**	0.0818	-2.2759	0.0255
<i>D(FI)</i>	0.0419	0.0425	0.9848	0.3277
<i>D(LMAL)</i>	-0.2701	2.9042	-0.0930	0.9261
<i>D(LCHO)</i>	-0.3808	0.3927	-0.9697	0.3351
<i>D(DHE)</i>	-0.0978	0.6262	-0.1563	0.8762
Observations	85			

Source: Authors' computation (2026)

Cross-Section Error Correction Results

Country-level short-run dynamics, presented in Table 4, reveal important heterogeneity. Financial inclusion significantly raises per capita consumption in the short run for Ethiopia and South Africa, while effects are insignificant for Ghana, Kenya, and Nigeria, confirming that short-run consumption responses to financial deepening are country-specific. Nigeria's malaria burden exerts a significant negative short-run effect on

consumption, reflecting the acute welfare damage of one of the world's highest malaria burdens. South Africa shows a counterintuitive positive short-run coefficient for malaria, potentially reflecting healthcare expenditure responses that temporarily stimulate consumption in a relatively wealthy economy. Domestic health expenditure is significantly negative in Ethiopia and Ghana in the short run, consistent with catastrophic health expenditure effects on household welfare in low-income contexts. The ECM term is significant for Ghana, Kenya, and Nigeria, confirming long-run stability with heterogeneous adjustment speeds.

Table 4
Cross-Section Short-Run Error Correction Results by Country

Country	Variable	Coefficient	t-Statistic	Prob.
Ethiopia	<i>ECMt-1</i>	-0.0173	-1.3708	0.2640
	<i>D(FI)</i>	0.0198*	2.9437	0.0603
	<i>D(LMAL)</i>	0.4921	1.5817	0.2119
	<i>D(LCHO)</i>	-0.0034	-0.0799	0.9414
	<i>D(DHE)</i>	-1.7277***	-4.9784	0.0156
Ghana	<i>ECMt-1</i>	-0.4596***	-3.9493	0.0015
	<i>D(FI)</i>	-0.0193	-0.9880	0.3399
	<i>D(LMAL)</i>	4.2925	1.1434	0.2721
	<i>D(LCHO)</i>	-0.1312	-1.4450	0.1705
	<i>D(DHE)</i>	-0.7675**	-2.0335	0.0614
Kenya	<i>ECMt-1</i>	-0.0327**	-2.4856	0.0244
	<i>D(FI)</i>	0.0095	1.6380	0.1209
	<i>D(LMAL)</i>	-1.0669	-1.4531	0.1655
	<i>D(LCHO)</i>	0.0233	0.6114	0.5495
	<i>D(DHE)</i>	0.3830	1.6843	0.1115
Nigeria	<i>ECMt-1</i>	-0.2637**	-2.1931	0.0425
	<i>D(FI)</i>	-0.0104	-1.2727	0.2203
	<i>D(LMAL)</i>	-10.7926**	-2.2360	0.0390
	<i>D(LCHO)</i>	0.1488*	1.9605	0.0665
	<i>D(DHE)</i>	-0.3830	-1.0583	0.3047
South Africa	<i>ECMt-1</i>	-0.1572	-1.1305	0.2847
	<i>D(FI)</i>	0.2099**	2.2228	0.0505
	<i>D(LMAL)</i>	5.7243**	2.3084	0.0436
	<i>D(LCHO)</i>	-1.9418*	-2.0173	0.0713

Source: Authors' computation (2026)

Granger Causality Analysis

Table 5 presents panel Granger causality results. Malaria incidence significantly Granger-causes per capita consumption, confirming that malaria dynamics have predictive power over aggregate welfare outcomes across the panel. Government health expenditure also Granger-causes per capita consumption, underscoring the role of public health investment in shaping household welfare trajectories. A reverse causality from PCC to DHE is also observed, suggesting that poverty levels themselves influence government health spending, possibly through pressure on social protection budgets or reactive health policy responses. Financial inclusion and cholera show no significant predictive relationships with per capita consumption in either direction, corroborating the PMG findings.

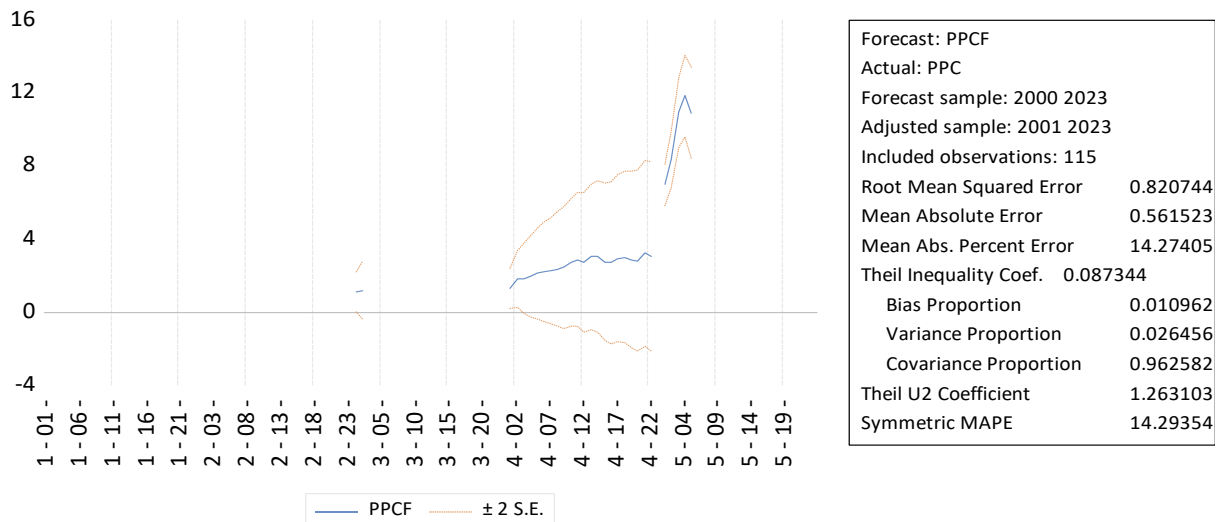
Table 5
Panel Granger Causality Tests: Stacked Common Coefficients

Null Hypothesis	Obs.	F-Statistic	Prob.
<i>FI does not Granger-cause PCC</i>	98	0.1504	0.8606
<i>PCC does not Granger-cause FI</i>	98	0.5766	0.5638
<i>LMAL does not Granger-cause PCC</i>	109	4.9452***	0.0089
<i>PCC does not Granger-cause LMAL</i>	109	0.8673	0.4231
<i>LCHO does not Granger-cause PCC</i>	80	1.1369	0.3263
<i>PCC does not Granger-cause LCHO</i>	80	0.1094	0.8965
<i>DHE does not Granger Cause PCC</i>	109	5.2410***	0.0068

Source: Authors' computation (2026)

Forecast Analysis

The forecast analysis reveals that model-predicted PCC closely tracks actual values from 2001 to approximately 2019, affirming within-sample fit during relatively stable economic conditions. However, post-2020 actual PCC values substantially exceed model forecasts, breaching the ± 2 standard error bands. This divergence is consistent with structural shocks associated with the COVID-19 pandemic and subsequent inflationary pressures, which disrupted established relationships between health shocks, financial inclusion, and consumption. The result highlights both the structural vulnerabilities of SSA economies to compounding crises and the limitations of historical-data-based models in capturing abrupt structural breaks. It further underscores the value of adaptive econometric frameworks and improved high-frequency data integration for forward-looking policy analysis.



4 Conclusion

This study has examined the dynamic interactions among climate-induced health shocks, financial inclusion, and poverty dynamics across five SSA countries using PMG-ARDL panel estimation from 2000 to 2023. Three principal empirical findings emerge. At first, financial inclusion significantly improves per capita consumption in the long run, confirming its role as a structural poverty-reduction mechanism in SSA. Malaria incidence exerts a strong and persistent negative long-run effect on household welfare, confirming it as a major climate-sensitive driver of poverty. Cholera incidence, by contrast, yields no significant long-run effect, consistent with its episodic and localised epidemiological profile. Moreover, domestic government health expenditure positively influences long-run welfare, though country-level heterogeneity suggests that both the volume and efficiency of spending matter.

These findings carry several important policy implications. At the country level, Ethiopia should scale up both public health investment and financial inclusion, especially for rural and underserved populations. Ghana should improve the efficiency and pro-poor targeting of health expenditures while restructuring financial inclusion programmes to reach the economically vulnerable. Kenya should prioritise malaria control and close financial access gaps through low-cost digital technologies. Nigeria must urgently invest in malaria prevention infrastructure and redesign financial access frameworks to be pro-poor and gender-sensitive. South Africa, with relatively stronger baseline indicators, should consolidate financial inclusion gains while proactively strengthening public health preparedness for climate-related threats.

At the regional level, five strategic imperatives are identified. Financial inclusion programmes must prioritise marginalised groups women, rural populations, and the economically excluded to ensure that expanded financial access translates into tangible poverty reduction. Also, public health investments must be efficiently targeted and monitored to serve the poor directly, avoiding urban-centric bias. At the same time, regional collaboration on malaria control is essential given the transboundary nature of climate-sensitive disease dynamics. Ditto for climate adaptation strategies must be embedded within both health and financial planning frameworks, recognising the interconnected nature of environmental shocks and economic vulnerability. Hence, institutional delivery mechanisms must be strengthened to ensure accountability and efficiency in translating policy investment into welfare outcomes.

This study has several limitations that suggest directions for future research. The financial inclusion proxy used here, bank account penetration, does not capture mobile money adoption, active usage rates, or the distributional reach of financial services across gender and geographic dimensions. Future research should incorporate multidimensional financial inclusion indices that better reflect the breadth and depth of financial access in SSA. Similarly, the analysis does not explicitly model the channels through which malaria affects welfare, for example, via labour supply, human capital, or healthcare expenditure pathways. Structural

modelling of these transmission mechanisms represents a promising avenue for future work. Finally, the potential endogeneity between health expenditure and poverty, partially addressed through the dynamic panel framework, warrants further investigation using instrumental variable or difference-GMM approaches in contexts where suitable instruments are available.

Acknowledgments

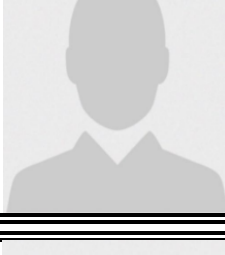
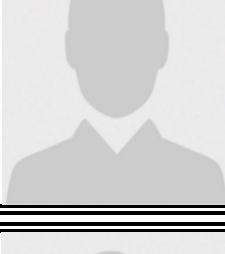
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