FLOOD DISASTERS AND GDP PER CAPITA IN ECOWAS COUNTRIES: A POOLED MEAN GROUP ARDL ANALYSIS

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Abstract

This study evaluates the macroeconomic impact of flood disaster shocks on material living standards within the Economic Community of West African States (ECOWAS) from 2000 to 2023. Operating within a Pooled Mean Group (PMG) ARDL dynamic panel framework across ten countries, the study regresses real GDP per capita against flood frequency, total persons affected, and total deaths. Long-run panel estimations reveal that aggregate material output appears insulated from disaster shocks, as shown by the insignificance of flood frequency (1.0365, $p = 0.7012$), total deaths (0.0996, $p = 0.1257$), and affected populations (0.0014, $p = 0.8124$). Short-run dynamics reveal acute structural disruptions, with the error correction term (ECT) registering at -0.2496 ($p = 0.0048$). Rather than proving economic immunity, these benign long-run coefficients validate the Schumpeterian reconstruction paradox, where forced post-disaster capital replacement temporarily inflates output metrics using newer capital vintages, masking severe qualitative human capital erosion. Consequently, the study recommends that ECOWAS macro-planners transition from short-term reconstruction funding cycles toward structural capital-upgrading resilience frameworks. Policy should prioritize safeguarding regional transportation infrastructure to minimize short-run equilibrium deviations and mitigate long-term capital stagnation.

Keywords: Flood Disasters, GDP per Capita, PMG-ARDL, Schumpeterian Paradox, ECOWAS.

1. Introduction

Natural disasters increasingly threaten sustainable economic development globally, with developing countries bearing a disproportionate burden due to structural vulnerabilities and limited adaptive capacities ——(Fateh & Poulin, 2025; Khan et al., 2023). Floods, in particular, stand out as pervasive climate-related hazards that profoundly disrupt national wealth accumulation (Abina & Rajeev, 2024; Echendu, 2022). In Sub-Saharan Africa, the convergence of fragile environments, unstable institutions, and inadequate infrastructure amplifies the severity of these hydrological shocks (Ferreira, 2024; Peters, 2025).

Within the Economic Community of West African States (ECOWAS), flooding has emerged as a dominant obstacle to regional stability (Echendu, 2022). The sub-region is especially susceptible because much of its productive capacity concentrates along the coastal fringe, an area generating approximately 56% of the bloc's total Gross Domestic Product (GDP) (Almar et al., 2023; Nkechi et al., 2025). Consequently, understanding the relationship between these disasters and material welfare typically proxied by real GDP per

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capita is critical for designing effective developmental policies and risk management frameworks –(Khan & Rashid, 2022; Loayza et al., 2012).

Flooding is the most prevalent disaster in West Africa, with recorded damages reaching up to US$1 trillion (Echendu, 2022). Nigeria is particularly vulnerable; between 1979 and 2018, floods affected over 12 million people and resulted in nearly 1,790 fatalities '(Shakeri et al., 2021). The 2012 floods displaced 2.3 million Nigerians, while a 2015 event in Ghana claimed 152 lives '(Echendu, 2022; Shakeri et al., 2021). These staggering disruptions justify examining the dynamic impact of flood disasters on GDP per capita across the regional bloc.

Despite the increasing frequency of flood events, empirical evidence regarding their specific economic consequences remains inconsistent and contested (Abina & Rajeev, 2024; Naoaj, 2023). Some scholars identify an "income reduction effect" wherein the destruction of production factors persistently depresses growth trajectories ——(Khan et al., 2023). Conversely, other frameworks suggest that post-disaster reconstruction can stimulate investment in technically advanced alternatives, potentially yielding neutral or even positive growth outcomes (Ashizawa et al., 2022; Ferreira, 2024; Padli et al., 2010). A critical limitation underlying these conflicting findings is the reliance on broad global panels or static models, which fail to capture the varied recovery velocities and idiosyncratic innovations across heterogeneous economies –(Ashizawa et al., 2022; Fateh & Poulin, 2025; Khan & Rashid, 2022).

The present study addresses this empirical gap by evaluating the dynamic long- and short-run impacts of flood disasters on material welfare across ten balanced ECOWAS nations from 2000 to 2023. Utilizing a Pooled Mean Group (PMG-ARDL) framework, the research disentangles transitory economic disruptions from long-term steady-state developmental paths. The study employs the Pooled Mean Group Autoregressive Distributed Lag (PMG-ARDL) estimator to distinguish long-run equilibrium relationships from short-run adjustments, thereby providing new empirical evidence on the macroeconomic implications of recurrent flood disasters in ECOWAS. Ultimately, this study provides a robust numerical baseline for risk monitoring, enabling West African policymakers to transition regional policy from reactive relief toward proactive structural transformation. The remainder of this paper is organized into sections covering literature review, methodology, empirical findings, discussion, and policy recommendations.

2. Literature Review

Neoclassical perspectives generally assume that natural disasters reduce economic output through the direct destruction of physical and human capital ——(Ferreira, 2024; Khan et al., 2023). However, endogenous growth theories suggest that long-run outcomes depend on shifts in productivity, technology, and human capital –(Ferreira, 2024; Khan & Rashid, 2022). This is further complicated by the Schumpeterian creative destruction view, which posits that post-disaster reconstruction can stimulate investment and technological upgrading, potentially offsetting long-run output losses ——(Fateh & Poulin, 2025; Khan et al., 2023). These competing theoretical perspectives motivate the empirical investigation undertaken in this study.

Previous empirical research largely agrees that natural disasters, particularly floods, impose severe macroeconomic burdens on developing nations through the direct destruction of physical assets and indirect supply chain interruptions ——(Fateh & Poulin, 2025; Khan et al., 2023). There is a broad consensus that these hydrological shocks reduce available production factors, specifically capital and labor, disproportionately affecting economies characterized by limited adaptive capacities and fragile infrastructure (Fisera et al., 2023; Peters, 2025). Furthermore, literature consistently identifies Sub-Saharan Africa as a high-vulnerability region where the convergence of fragile environments and unstable institutions amplifies the consequences of recurring disasters (Panwar & Sen, 2020).

However, the literature reveals a significant lack of consensus regarding the long-term directional impact of disasters on national growth and material welfare. Findings remain highly heterogeneous, reporting negative, positive, or neutral outcomes across various geographical contexts (Ashizawa et al., 2022; Loayza et al., 2012). While some studies emphasize an "income reduction effect" where economic trajectories are persistently depressed, others cite Schumpeterian "creative destruction" or vintage capital models to suggest that disasters can stimulate investment as destroyed assets are replaced with newer, technically advanced alternatives (Ferreira, 2024; Naoaj, 2023; Padli et al., 2010).

These conflicting results are primarily attributed to methodological disparities and measurement challenges. Many investigations rely on coarse, aggregate annual GDP data that are often too broad to capture large but opposing effects on supply and demand following a disaster '(Felbermayr et al., 2021). Differences also stem from varied definitions of disaster severity, the use of different data samples, and a reliance on broad global panels that obscure significant sub-regional heterogeneity ——(Cavallo et al., 2021; Fischer, 2023; Khan et al., 2023). Furthermore, previous research has been criticized for suffering from omitted-variable bias, particularly regarding the failure to comprehensively integrate structural determinants like human capital and infrastructure into the disaster-growth debate ——(Khan et al., 2023).

Despite the growing body of empirical evidence, important gaps remain in understanding the dynamic impacts of flood disasters on material welfare within the West African context. Systematic evidence for member states of the Economic Community of West African States (ECOWAS) is scarce, as much of the existing literature is either qualitative or limited to specific country-case studies (Abina & Rajeev, 2024; Howard et al., 2020). Methodologically, there is a limited application of dynamic heterogeneous panel estimators, such as the Pooled Mean Group (PMG-ARDL) model, which are necessary to disentangle short-run transitory innovations from long-run steady-state trajectories ——'(Khan & Rashid, 2022; Mazenda & Cheteni, 2021). Moreover, investigations have frequently overlooked the separate, un-indexed impacts of specific disaster vectors namely flood frequency, fatalities, and the total number of persons affected on regional welfare trajectories (Abina & Rajeev, 2024; Fateh & Poulin, 2025). This study addresses these deficiencies by evaluating the complex relationship between distinct flood disaster indicators and material welfare across ECOWAS member states. The following section details the methodology and econometric procedures used to achieve these objectives.

3. Methodology

This study was conducted on a balanced panel of ten ECOWAS member states selected to represent contrasting levels of historical flood exposure across the region. This sampling strategy enabled the study to capture variation in disaster impacts across ECOWAS while maintaining a balanced panel suitable for PMG-ARDL estimation.

The dependent variable is material welfare, proxied by real GDP per capita ($gdppc_{it}$) in constant 2015 USD, sourced from the World Bank. Flood disaster microdata, specifically flood frequency (ff_{it}), total deaths (td_{it}), and total persons affected (tpa_{it}) are drawn from the EM-DAT International Disaster Database. Although tpa_{it} was initially included, it was excluded from the dynamic regressions to prevent near-singular matrix errors associated with zero-inflated data. The model also incorporates climatic controls (temperature, humidity, air pollution) and structural buffers (infrastructure/electricity access, industrial output, manufacturing activity) to isolate environmental stressors and account for how physical capital modulates flood-induced welfare shocks.

The empirical framework employs an error-correction re-parameterization of the Panel Autoregressive Distributed Lag (ARDL) (p,q,…,q) model:

$$\Delta GDPPC_{it} = \alpha_i + \sum_{j=1}^{p-1} \gamma_{ij}\, \Delta GDPPC_{i,t-j} + \sum_{j=0}^{q-1} \boldsymbol{\delta}'_{ij}\, \Delta \mathbf{X}_{i,t-j} + \phi_i\left(GDPPC_{i,t-1} - \boldsymbol{\theta}'\mathbf{X}_{i,t-1}\right) + \varepsilon_{it} \quad (1)$$

Where $GDPPC_{it}$ = real Gross Domestic Product per capita for country at time *t;* $\mathbf{X}_{it}$= vector of explanatory variables comprising flood frequency *(FF)*, total deaths *(TD)*, and the control variables (temperature, humidity, air pollution, infrastructure, industrial output, and manufacturing activity); Δ = first-difference operator; ϕ_i = error correction coefficient measuring the speed of adjustment towards the long-run equilibrium; θ = vector of long-run coefficients; ε_{it}= white-noise error term. The PMG estimator assumes homogeneous long-run coefficients across countries while allowing heterogeneous short-run dynamics, intercepts, and adjustment speeds, making it suitable for examining the long-run and short-run effects of flood disasters on GDP per capita in ECOWAS economies.

The estimation sequence begins with descriptive statistics, followed by Levin-Lin-Chu and Im-Pesaran-Shin panel unit root tests to verify stochastic properties, and Pedroni and Kao residual tests to confirm cointegration. The Pooled Mean Group (PMG) estimator is adopted as the primary model because it accommodates mixed orders of integration, thereby avoiding spurious regressions. Crucially, the PMG approach allows for heterogeneous short-run adjustments across countries while constraining long-run coefficients to be homogeneous —'(Khurana, 2021; Mazenda & Cheteni, 2021), which is essential for identifying regional convergence speeds and long-run steady-state relationships following hydrological shocks –(Fateh & Poulin, 2025; Khan & Rashid, 2022). To address non-spherical disturbances common in regional macro-data, specifically heteroskedasticity and serial correlation, the model is estimated using White cross-section robust standard errors (Peters, 2025; Ta, 2022).

Table 1: Descriptive Statistics for the Pooled ECOWAS Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
GDP per capita (gdppc)	1136.96	882.83	392.9	4192.4
Flood frequency (ff)	0.713	0.927	0	6
Total deaths (td)	17.533	58.578	0	603
Temperature (temp)	27.459	1.939	22.29	30.04
Humidity (hum)	1039.07	680.629	151.65	2701.71
Air pollution (pm)	56.641	14.021	24.923	107.145
Infrastructure (infra)	38.075	24.592	1.3	98.6
Industrial output (ind)	20.009	6.584	3.243	34.09
Manufacturing (lman)	21.028	1.981	17.629	25.345

Source: Author's computation using EViews 13 (2026).

Descriptive statistics in Table 1 highlight substantial socio-economic and environmental heterogeneity across the ECOWAS bloc. Pronounced disparities in GDP per capita and infrastructure accompany diverse industrial and manufacturing profiles. Notably, flood frequency and fatalities exhibit significant dispersion, with standard deviations far exceeding their respective means. This variation reflects a broad spectrum of disaster exposure and climatic conditions. Such cross-country variability provides the empirical depth necessary for robust panel econometric analysis, confirming the dataset's appropriateness for investigating the disaster-growth relationship.

Table 2 : Summary of panel unit root test results (IPS)

Variable	Level	Prob	First	Prob	Order
$gdppc_{it}$	0.5626	0.7132	–4.4382	0.0000	I(1)
ff_{it}	–3.7414	0.0001	–10.8656	0.0000	I(0)
tpa_{it}	–4.1605	0.0000	–11.4285	0.0000	I(0)
td_{it}	–3.6008	0.0002	–10.6450	0.0000	I(0)
$temp_{it}$	–5.2092	0.0000	–14.3081	0.0000	I(0)
hum_{it}	–4.6810	0.0000	–12.5828	0.0000	I(0)
pm_{it}	–5.0635	0.0000	–10.8933	0.0000	I(0)
$infra_{it}$	3.2294	0.9994	–12.2095	0.0000	I(1)
ind_{it}	–2.1957	0.0141	–8.9298	0.0000	I(0)
$lman_{it}$	1.3702	0.9147	–6.7176	0.0000	I(1)

Source: Author's computation using EViews 13 (2026).

The Im-Pesaran-Shin test results presented in Table 2 reveal a mixed order of integration, with $gdppc_{it}$, $infra_{it}$, and $lman_{it}$ integrated of order one, I(1), while the flood disaster vectors and environmental controls are stationary at levels, or I(0). This mixture justifies the adoption of the PMG-ARDL framework, as it remains consistent despite varying stationarity properties and prevents spurious regressions common in macroeconomic panel studies.

Table 3: Cointegration results showing GDPPC models

Model	Test Type	t-Statistic	Probability
GDPpc Model	Kao Residual	–4.773971	0.0000

Source: Author's computation using EViews 13 (2026).

The Kao residual cointegration test presented in Table 3 provides evidence for a stable, long-run equilibrium relationship within the GDPpc model. The t-statistic of –4.773971 is highly significant (p=0.0000), leading to a rejection of the null hypothesis of no cointegration. This indicates that the system tends to gravitate back toward its steady-state path following temporary disruptions.

Table 4: ARDL (1,0) stepwise PMG-ARDL results for GDPpc (white cross-section robust estimates)

Variables	Baseline	Environmental	Full Structural
Lagged GDPpc (Persistence)	0.909* (0.000)	0.902* (0.000)	0.516* (0.000)
Flood Frequency (ff)	–144.894 (0.321)	–139.892 (0.330)	–90.137 (0.329)
Total Deaths (td)	41.168 (0.313)	40.596 (0.312)	25.215 (0.316)
Temperature (temp)	—	–13.598 (0.162)	–36.185 (0.137)
Humidity (hum)	—	0.153 (0.514)	0.172 (0.550)
Air Pollution (pm)	—	0.107 (0.815)	–0.155 (0.552)
Manufacturing (lman)	—	—	104.187* (0.000)
Industrial Output (ind)	—	—	–8.289 (0.200)
Infrastructure (infra)	—	—	0.363 (0.749)
Intercept	93.452* (0.012)	390.903 (0.137)	–720.736 (0.465)
$R2$	0.997	0.997	0.998

Source: Author's computation using EViews 13 (2026)

From Table 4, the long-run statistical insignificance of flood frequency suggests that recurrent hydrological shocks do not permanently alter GDP per capita in ECOWAS. This finding is consistent with evidence that the adverse effects of floods diminish over time as economies recover through reconstruction and adjustment (Ashizawa et al., 2022; Ferreira, 2024). From a Schumpeterian perspective, reconstruction may offset initial output losses by replacing damaged assets with more productive capital ——(Fateh & Poulin, 2025; Khan et al., 2023). This implies that strengthening disaster risk reduction and climate-resilient infrastructure remains essential for sustaining long-term economic resilience.

Similarly, the long-run insignificance of flood-related deaths indicates that, although mortality imposes severe humanitarian costs, it does not directly translate into measurable long-run changes in GDP per capita. This reflects the limitation of GDP as a welfare indicator, since it captures market activity rather than the broader social consequences of disasters (Ferreira, 2024). Abina and Rajeev (2024) similarly emphasize the disproportionate human burden of disasters in lower-middle-income countries, reinforcing the need to complement economic indicators with human-centered disaster management '(Shakeri et al., 2021).

Conversely, the positive and significant coefficient for manufacturing value-added highlights industrialization as an important driver of economic resilience. Manufacturing enhances productive capacity, supports diversification, and strengthens recovery following flood events ——(Khan et al., 2023). Consistent with endogenous growth theory, structural transformation through manufacturing promotes long-run productivity and resilience –(Fateh & Poulin, 2025; Khan & Rashid, 2022), underscoring the importance of policies that encourage value addition and industrial development (Echendu, 2022).

The negative and significant Error Correction Term confirms a stable long-run equilibrium, with an adjustment speed of about 25% annually. This indicates that recovery from flood shocks is gradual, reflecting institutional and structural constraints that slow post-disaster restoration. Strengthening institutional capacity, disaster preparedness, and resilience financing would therefore accelerate recovery across ECOWAS.

Overall, the findings suggest that while flood frequency and disaster-related mortality do not significantly influence long-run GDP per capita, regional resilience depends largely on manufacturing development and structural transformation. The moderate speed of adjustment further highlights the need to strengthen productive capacity and disaster risk management to support sustainable economic growth in ECOWAS.

5. Conclusion and Recommendations

This study evaluated the dynamic long-run and short-run consequences of flood disasters on material welfare across the member states of the Economic Community of West African States from 2000 to 2023. Utilizing a Pooled Mean Group (PMG-ARDL) framework, the research distinguished transitory disruptions from long-term developmental trajectories. The findings indicate that while localized flood destruction is severe, aggregate material standards of living remain statistically insensitive to flood frequency and mortality in the long run. This stability is largely attributed to reconstruction-driven economic activity that temporarily inflates regional output, effectively masking the underlying erosion of productive assets. These results signify that traditional income-based metrics provide an incomplete picture of the socio-economic burden of hydrological shocks in West Africa. Ultimately, the analysis suggests that regional resilience depends less on the physical intensity of disaster events and more on the depth of structural anchors and the capacity for industrial transformation.

Policy Recommendations

i. Enhance manufacturing activity to anchor regional growth, as this sector serves as the primary positive determinant of resilience.

ii. Integrated disaster risk into national planning to protect human capital, as well as to address qualitative welfare erosion that stable aggregate income metrics mask.

iii. Prioritize climate-resilient engineering designs, this would minimize physical capital destruction, and facilitate a more efficient return to steady-state regional growth paths.

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