Economics Bulletin

Volume 46, Issue 3

The macroeconomic and food security impacts of extreme precipitation shocks in Liberia

Pedro Juarros
International Monetary Fund

Suphachol Suphachalasai
International Monetary Fund

Abstract

Extreme precipitation and floods are Liberia's main climate hazards, endangering food security, health, and macroeconomic stability, and exacerbated by limited adaptive capacity. This paper estimates the short-term macroeconomic impacts of extreme precipitation shocks using newly available high-resolution, high-frequency climate data to capture short-duration, high-intensity rainfall events. The results show that such shocks reduce food production by 1.6 percentage points (p.p.), lower per capita GDP growth by 3.3 p.p., and raise inflation by about 2 p.p. These findings suggest that strengthening climate resilience may help mitigate the macroeconomic vulnerabilities associated with extreme rainfall events and highlight the potential importance of climate-resilient infrastructure, adaptive agricultural investment, and other adaptation measures.

Acknowledgments: We thank Daniel Bastidas, Berit Lindholdt-Lauridsen, Emanuele Massetti, Diego Mesa-Puyo, Michal Pietrkiewicz, Sunalika Singh, and Nuwan Suriyagoda for their comments. All errors are our own. Disclosure of interest: No potential conflict of interest was reported by the author(s). Declaration of funding: No funding was received.
Citation: Pedro Juarros and Suphachol Suphachalasai, (2026) "The macroeconomic and food security impacts of extreme precipitation shocks in Liberia", *Economics Bulletin*, Volume 46, Issue 3, pages 1202-1213
Contact: Pedro Juarros - pjuarros@imf.org, Suphachol Suphachalasai - SSuphachalasai@imf.org.
Submitted: October 08, 2025. **Published:** September 30, 2026.

,

1. Introduction

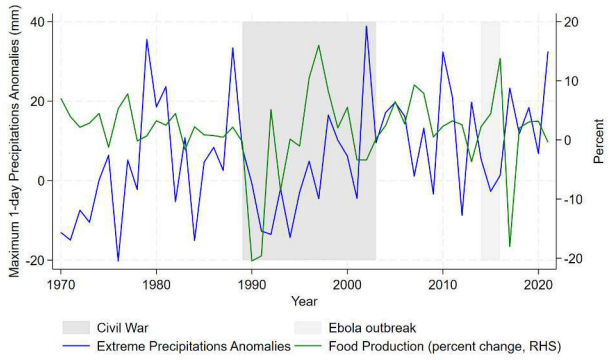
Extreme precipitation and floods are Liberia's most pressing climate hazards, threatening food security, public health, and macroeconomic stability. Intense rainfall damages crops, disrupts transport and markets, and destroys infrastructure, undermining agricultural productivity and household incomes—especially in rural areas reliant on subsistence farming. An estimated 80 percent of the population is moderately or severely food insecure (FAO 2023). Flooding also contaminates water sources, triggering outbreaks of cholera and diarrhea that disproportionately affect children and strain health systems. These risks are exacerbated by Liberia's limited adaptive capacity; the country ranked 168th of 182 on the ND-GAIN IMF-Adapted Readiness Index in 2022, reflecting weak institutional, economic, and social preparedness for climate adaptation.

From a macroeconomic perspective, floods disrupt domestic food supply, increase import dependence (Liberia already imports 70 percent of its rice), strain the balance of payments, fuel inflation, and reduce fiscal revenues while raising expenditure needs for subsidies, relief, and reconstruction—further tightening fiscal space.[1] Figure 1.A illustrates the country's exposure to past extreme precipitation events and their impact on food production. Looking ahead, Figure 1.B shows climate models under all emissions scenarios project more frequent extremes. This intensification raises flood risks and highlights the importance of understanding how extreme rainfall shocks affect food production, inflation, and GDP growth to inform fiscal planning and adaptation strategies.[2]

To our knowledge, no prior study has estimated the macroeconomic impacts of floods or extreme rainfall in Liberia. This paper provides the first such analysis using newly available high-resolution, high-frequency precipitation data from the FAD Climate Policy dataset (Massetti and Tagklis (2024)). Much of the existing literature identifies insignificant or positive effects of rainfall or flood-related variables on GDP growth globally and in Africa, typically measured using average precipitation (Kahn et al. (2021), Lanzafame (2014), Barrios et al. (2010)) or flood occurrence at a certain severity (Insaidoo et al. (2025), Fomby et al. (2013)). This likely reflects the beneficial role of moderate rainfall in rain-fed agricultural economies. However, such approaches often fail to capture extreme events, which have shown notable macroeconomic effects (Akyapı et al. (2025), Kotz et al. (2022)). By using high-resolution, high-frequency measures of extreme rainfall anomalies, this paper contributes to the literature by explicitly capturing the short-term macroeconomic consequences of high-intensity, short-duration rainfall shocks. We use maximum 1-day precipitation anomalies, defined as deviations from the trend, to capture extreme rainfall events and their intensity relative to a country's historical climate and adaptation conditions.[3] Unlike annual or monthly average or totals, this variable directly measures short-duration, high-intensity rainfall episodes—events that are most closely associated with flooding, infrastructure damage, crop loss, and health hazards. This approach enables the identification of shocks—rather than gradual changes—and ensures that the estimated macroeconomic effects reflect acute, weather-driven disruptions rather than longer-run climate trends. Embedding this variable into a structural VAR, we show that extreme precipitations shocks significantly reduce food production by 1.6 p.p.,

Figure 1: Extreme Precipitations, Food production and long-term trends

(a) Historical Precipitations Anomalies and Food Production



(b) Simulation of Maximum 1-day Precipitations Anomalies



Source: FADCP Climate Dataset (Massetti and Tagklis (2024)), using ERA5 reanalysis data (Hersbach et al. (2023)), and CMIP6 data (Copernicus Climate Change Service (2021)).

per capita GDP growth by 3.3 p.p. and increase inflation by about 2 p.p..

2. Data

The empirical analysis uses annual data spanning 1970 to 2021. The primary climate variable is the maximum 1-day precipitation anomaly, measured as the deviation from its 20-year moving average. This indicator is constructed from the FADCP Climate Dataset (Massetti and Tagklis (2024)), which is based on ERA5 reanalysis data from the European Centre for Medium-Range Weather Forecasts (Hersbach et al., 2023). Macroeconomic indicators include food production and world GDP growth, both sourced from the World Bank's World Development Indicators (WDI).[4] International food prices are obtained from the Food and Agriculture Organization (FAO). Key macroeconomic variables—real per capita GDP growth, and inflation —are drawn from the Global Macro Database (Müller et al. (2025)), which provides harmonized macroeconomic data across countries.

[1]World Bank Group (2024) projects rainfall-driven climate impacts could reduce Liberia's GDP by up to 9 percent by 2050, underscoring the costs of inaction.

[2]Over 40 percent of Liberians report worsening agricultural conditions and more severe flooding in the past decade, reflecting rising concerns about climate-related livelihood risks Wongbe and Samuel (2018).

[3]While we use annual data and construct the shock variable as the maximum 1-day precipitation anomaly within a given year, we acknowledge that this measure does not capture the precise timing of rainfall events within the agricultural calendar. However, in the Liberian context, where the rainy season spans April to November and key agricultural activities such as rice planting and harvesting typically occur between May and October, the likelihood is high that extreme rainfall events fall within critical phases of crop production. Historical data indicate that June through September are the wettest months, with September often recording peak rainfall. Thus, although the model operates at an annual frequency, the shock variable plausibly reflects disruptive events during agriculturally sensitive periods. Nonetheless, we note that in rare cases where the maximum rainfall occurs outside the core growing season, its impact on annual macroeconomic variables may be limited.

[4]Food production index covers food crops that are considered edible and that contain nutrients.

3. Empirical strategy

To quantify the dynamic macroeconomic effects of extreme precipitation shocks in Liberia, we estimate a Structural Vector Autoregression (SVAR) model with annual data over the period 1970–2021. The system includes four endogenous variables: extreme 1-day precipitation anomalies (*rx1daya*), real food production growth (*dfoodprod*), inflation (*infl*), and real per capita GDP growth (*drgdppc*). The structural form of the VAR can be written as:

$$A_0 Y_t = A(L) Y_{t-1} + B X_t + \epsilon_t \tag{1}$$

where $Y_t = [rx1daya, dfoodprod, infl, drgdppc]$ is the vector of endogenous variables, A_0 captures contemporaneous interactions, $A(L)$ is a matrix of lagged coefficients, X_t is a vector of exogenous control variables, and ϵ_t is a vector of structural shocks. Identification of the structural shocks relies on a Cholesky decomposition, where variables are ordered such that extreme precipitation shocks are assumed to be contemporaneously exogenous to the macroeconomic variables. This reflects the plausible assumption that rainfall anomalies are driven by meteorological processes and not immediately affected by economic conditions, whereas output, inflation, and food production may respond within the same year to climate shocks. Results are robust to different recursive ordering of macro variables.[5]

The vector of exogenous variables, X_t, includes controls to isolate the causal effect of extreme precipitation shocks. First, we include global GDP growth and real world food price changes to account for external demand shocks and international food price pressures that could confound the domestic food production, inflation or growth response. Second, event dummies for major structural disruptions are included: 1980 coup, the civil war period 1989-2003, Ebola outbreak of 2014-2016, and the COVID-19 pandemic in 2020. These dummies control for transitory but highly disruptive shocks to supply chains, economic activity, and public health that could bias our estimates. Finally, linear and quadratic time trends address slow structural changes (e.g., infrastructure, institutions, climate adaptation) and nonlinear shifts (e.g., economic structure changes), reducing spurious climate-economic correlations. The model uses lag 1, with standard errors from 500 bootstrap replications, generating empirical impulse response distributions for robust inference accounting for small-sample variability.

[5]The precipitation shock is defined as the maximum 1-day anomaly relative to a moving average, which can take negative values and thus does not exclusively capture flood events. The linear SVAR framework implies symmetric responses to positive and negative anomalies, which may not fully capture the inherently nonlinear and asymmetric nature of flood damages. To address this limitation, we interpret the estimated impulse responses as average effects of extreme precipitation deviations, recognizing that the most economically disruptive events are likely concentrated in the upper tail of the distribution. This approach is consistent with recent literature emphasizing the macroeconomic relevance of high-frequency climate anomalies Akyapı et al. (2025), which shows that changes in weather extremes (e.g., tail-risk events) are far more important than changes in average conditions for explaining year-to-year GDP variation. This result implies that traditional macroeconomic models focusing on annual mean temperature or rainfall likely underestimate the true economic impact of climate.

4. Results

Figure 2 shows the results from a one-standard-deviation shock to extreme precipitation anomalies. Figures 2.a) and 2.b) show that extreme precipitation anomalies lead to an immediate and significant decline of 1.6 p.p. in food production. This finding is particularly concerning given Liberia's heavy reliance on rain-fed subsistence agriculture, where agricultural value added is about 40 percent of GDP and accounts for more than 40 percent of jobs. The sharp decline in food production implies immediate threats to food availability and rural livelihoods, with potential spillovers to nutrition, health, and poverty.[6] Figure 2.c) shows that inflation increases immediately by about 2 p.p. following the shock, suggesting that extreme rainfall-induced food shortages rapidly translate into higher consumer prices and a greater need for food imports, consistent with food being a large share of household consumption.

Our results align with prior evidence from Sub-Saharan Africa showing that climate extremes significantly impair agricultural productivity. At the macro-level, Akpa (2024) found that the occurrence of climate extremes, such as flood and drought, negatively affected maize and rice yields in Sub-Saharan African countries based on a panel analysis during 1990-2020, while Kunawotor (2025) shows that extreme weather events caused a decline in agricultural productivity and positively correlated with inflation across 52 African economies during 1990-2017. Wollburg et al. (2024) reported that floods and droughts reduced total crop production by 29 percent on average based on micro-level survey data covering the period of 2011-2019 in Ethiopia, Malawi, Mali, Niger, and Nigeria. Other micro-level studies reveal some nuances. For instance, the negative effects of flood and drought events (e.g. heavy rain, water logging, and dry spell) are likely to be crop-specific in Zambia Matchaya et al. (2022)), while the adverse impact of negative rainfall shocks, measured as one standard deviation below average ranfaills, are found to be both crop- and location-specific in Nigeria (Amare et al. (2018)). Flood events have negative impacts on rice production in Benin in the wet season, but positive impact during the dry season (Bonou et al. (2024)). However, this study is among the first to isolate the macroeconomic effects of intense short-duration rainfall shocks in Liberia.

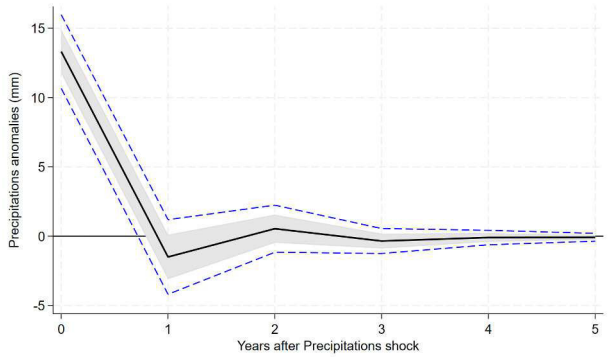
In addition to supply-side disruptions, the model reveals strong transmission effects on output, as real GDP per capita growth declines by approximately 3.3 p.p. one year after the shock, with persistent negative effects in subsequent years.[7] Despite relatively high impacts, these results align with broader evidence linking extreme weather to economic contractions in low-income countries with limited adaptive capacity. (e.g., Cavallo et al. (2022)). For example, identified disasters by the EM-DAT database after 2001 show average economic damages of 3 percent of GDP in low-income countries. This paper offers new evidence by focusing on short-duration precipitation extremes instead of annual rainfall or temperature shocks, clarifying how extreme climate impacts economic growth and price stability.

[6] Reed et al. (2022)) shows that 12 percent of individuals who experienced food insecurity between 2009 and 2020 had their status influenced by flooding events.

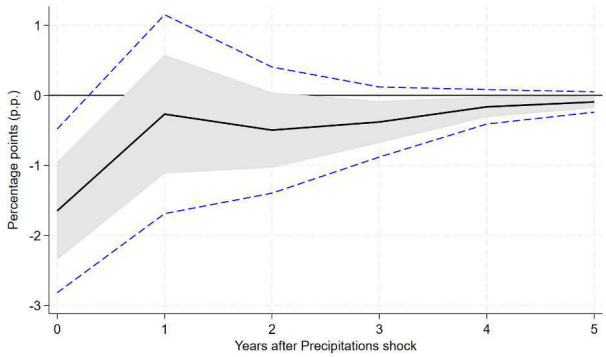
[7] Annex A shows that the results are robust to alternative specifications, including: (i) using GDP growth instead of per capita terms; (ii) excluding the COVID period; (iii) adding 2-lags to the SVAR estimation, and (iv) replacing the shock variable with maximum 5-day precipitation anomalies.

Figure 2: Impacts of Extreme precipitations shocks

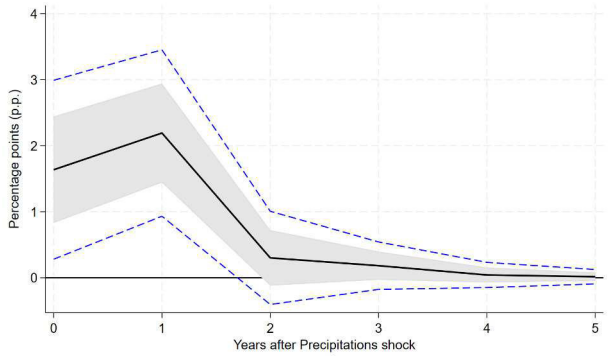
(a) Maximum 1-day Precipitation anomalies (mm)



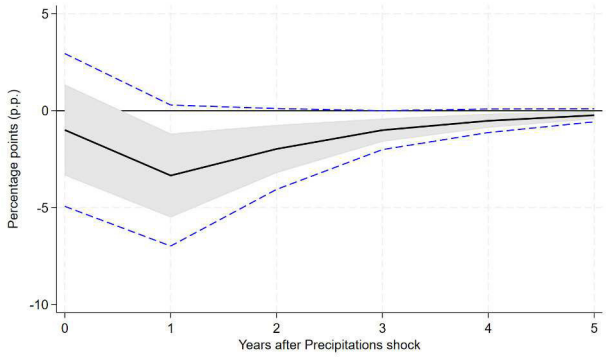
(b) Food Production



(c) Inflation



(d) GDP per capita growth



Note: Charts display impulse response functions estimated from a SVAR model described in Equation (1) covering 1970–2021. Shaded areas indicate 68% confidence intervals; dotted blue lines show 90%.

5. Conclusions

This paper shows significant negative impacts of extreme precipitation shocks on food production, per capita GDP growth, and inflation in Liberia. These findings suggest that enhancing climate resilience in the agricultural sector may help mitigate such macroeconomic vulnerabilities.

Potential areas for policy consideration include strengthening domestic food systems, promoting risk-informed land-use planning, improving access to weather and climate information to support farmer adaptation, and exploring investments in climate-resilient infrastructure and shock-responsive social protection. While further research is needed, these measures could contribute to reducing Liberia's exposure to increasingly frequent extreme weather events.

References

Akpa, A. F. (2024). The effects of climate extreme events on selected food crop yields in sub-saharan africa. *Heliyon*, 10(9).

Akyapı, B., Bellon, M., and Massetti, E. (2025). Estimating macrofiscal effects of climate shocks from billions of geospatial weather observations. *American Economic Journal: Macroeconomics*, 17(3):114–159.

Amare, M., Jensen, N. D., Shiferaw, B., and Cissé, J. D. (2018). Rainfall shocks and agricultural productivity: Implication for rural household consumption. *Agricultural systems*, 166:79–89.

Barrios, S., Bertinelli, L., and Strobl, E. (2010). Trends in rainfall and economic growth in africa: A neglected cause of the african growth tragedy. *The Review of Economics and Statistics*, 92(2):350–366.

Bonou, A., Egah, J., and Aihounton, G. B. (2024). Impact of floods on rice production in west africa: Micro-evidence from benin. *Sustainable Environment*, 10(1):2356396.

Cavallo, E. A., Becerra, O., and Acevedo, L. (2022). The impact of natural disasters on economic growth. In *Handbook on the economics of disasters*, pages 150–192. Edward Elgar Publishing.

Copernicus Climate Change Service (2021). CMIP6 Climate Projections. `https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cmip6`. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.c866074c.

Fomby, T., Ikeda, Y., and Loayza, N. V. (2013). The growth aftermath of natural disasters. *Journal of applied econometrics*, 28(3):412–434.

Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., and Thépaut, J.-N. (2023). ERA5 hourly data on single levels from 1940 to present. `https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels`. Copernicus Climate Change Service (C3S) Climate Data Store (CDS).

Insaidoo, M., Kunawotor, M. E., and Ahiabor, G. (2025). Extreme weather events and economic growth: empirical evidence from africa. *African Journal of Economic and Management Studies*.

Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., and Yang, J.-C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics*, 104:105624.

Kotz, M., Levermann, A., and Wenz, L. (2022). The effect of rainfall changes on economic production. *Nature*, 601(7892):223–227.

Kunawotor, M. E. (2025). Extreme weather events, agricultural productivity and inflation in africa: does adaptive capacity play any significant role? *Interdisciplinary Environmental Review*, 24(2):124–145.

Lanzafame, M. (2014). Temperature, rainfall and economic growth in africa. *Empirical Economics*, 46(1):1–18.

Massetti, E. and Tagklis, F. (2024). Fadcp climate dataset: Temperature and precipitation. reference guide. *Fiscal Affairs Department, International Monetary Fund, Washington, DC*.

Matchaya, G. C., Tadesse, G., and Kuteya, A. N. (2022). Rainfall shocks and crop productivity in zambia: Implication for agricultural water risk management. *Agricultural Water Management*, 269:107648.

Müller, K., Xu, C., Lehbib, M., and Chen, Z. (2025). The global macro database: A new international macroeconomic dataset. Technical report, National Bureau of Economic Research.

Reed, C., Anderson, W., Kruczkiewicz, A., Nakamura, J., Gallo, D., Seager, R., and McDermid, S. S. (2022). The impact of flooding on food security across africa. *Proceedings of the National Academy of Sciences*, 119(43):e2119399119.

Wollburg, P. R., Markhof, Y. V., Bentze, T. P., and Ponzini, G. (2024). The impacts of disasters on african agriculture: new evidence from micro-data. Technical report, The World Bank.

Wongbe, T. and Samuel, M. (2018). Climate change making life worse in liberia, but only half of citizens have heard of it.

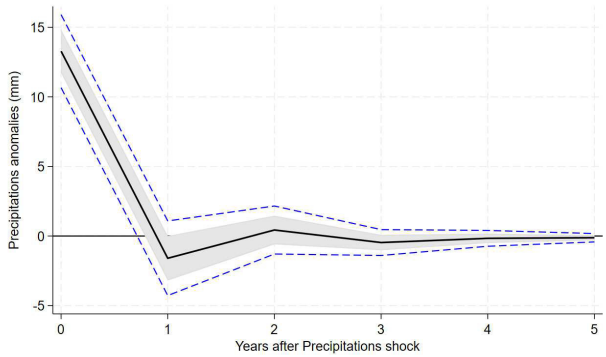
World Bank Group (2024). Liberia Country Climate Development Report. Technical report, World Bank. License: CC BY-NC-ND 3.0 IGO.

A. Annex: Robustness

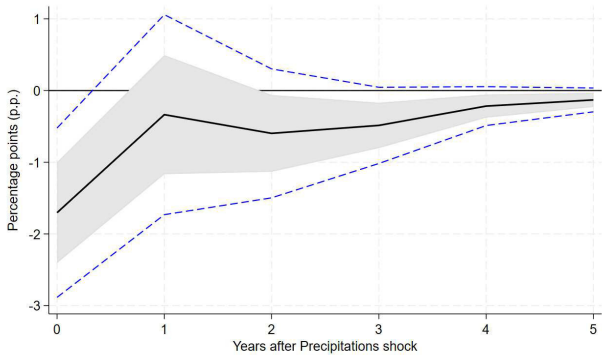
A.1 Alternative macro variable: GDP growth

Figure 3: Impacts of Extreme precipitations shocks

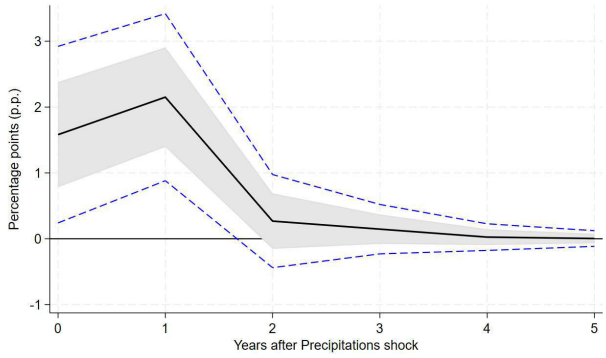
(a) Maximum 1-day Precipitation anomalies (mm)



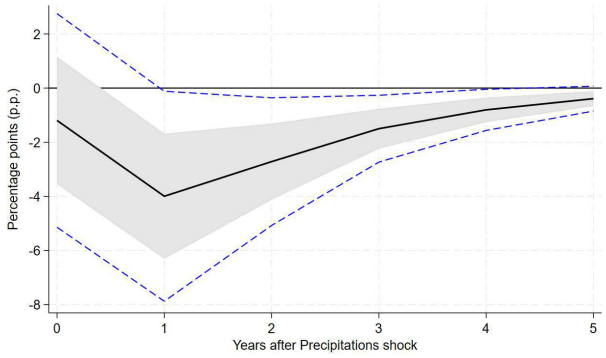
(b) Food Production



(c) Inflation



(d) GDP growth

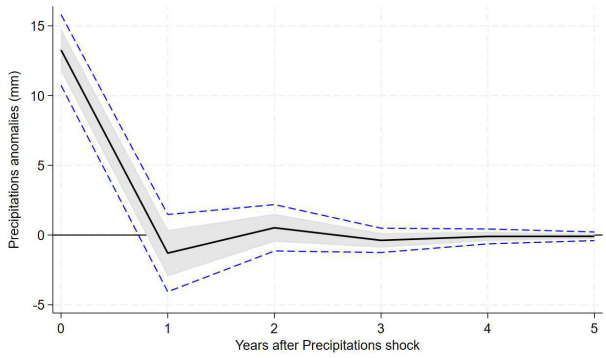


Note: Charts display impulse response functions estimated from a SVAR model described in Equation (1) covering 1970–2021. Shaded areas indicate 68% confidence intervals; dotted blue lines show 90%.

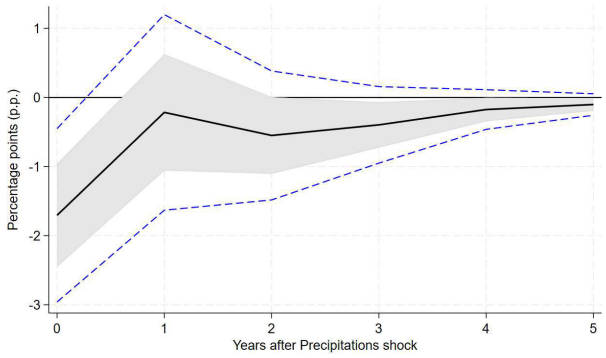
A.2 Sample period 1970-2019

Figure 4: Impacts of Extreme precipitations shocks

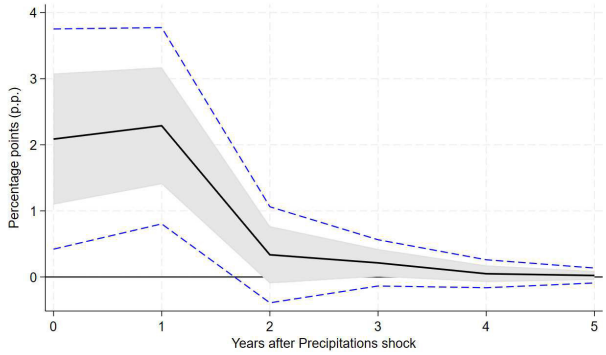
(a) Maximum 1-day Precipitation anomalies (mm)



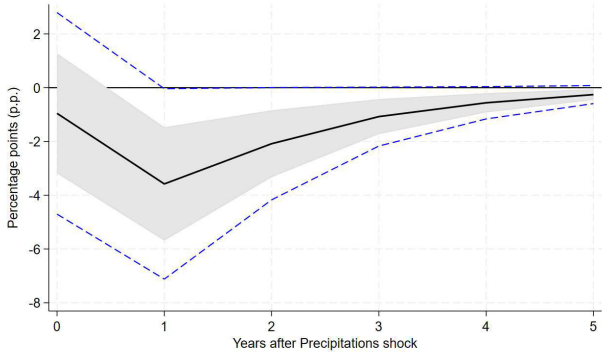
(b) Food Production



(c) Inflation



(d) GDP per capita growth

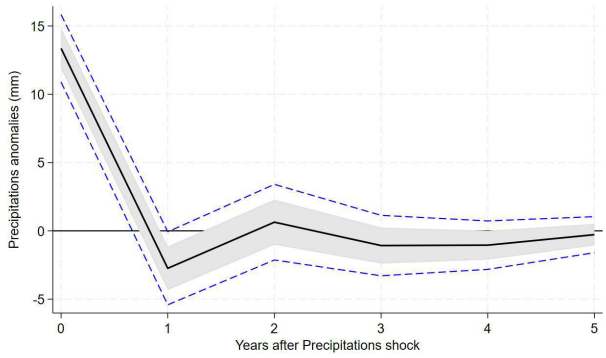


Note: Charts display impulse response functions estimated from a SVAR model described in Equation (1) covering 1970–2019. Shaded areas indicate 68% confidence intervals; dotted blue lines show 90%.

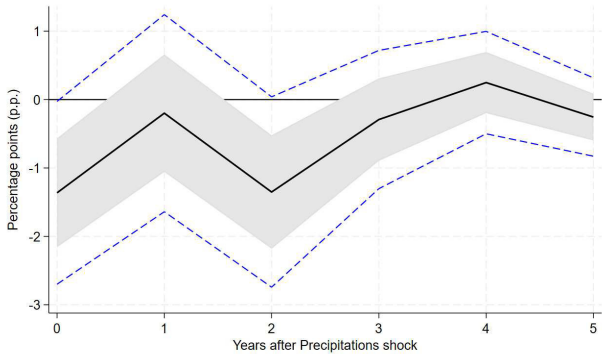
A.3 Alternative lag structure: L = 2

Figure 5: Impacts of Extreme precipitations shocks

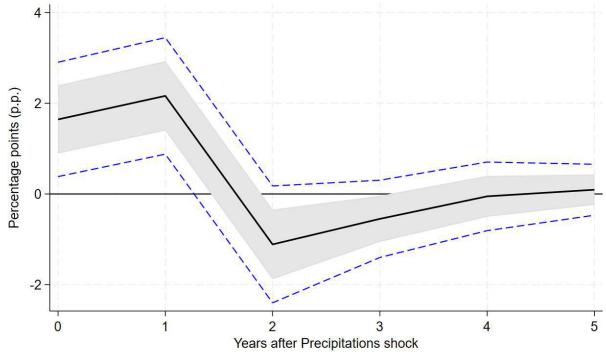
(a) Maximum 1-day Precipitation anomalies (mm)



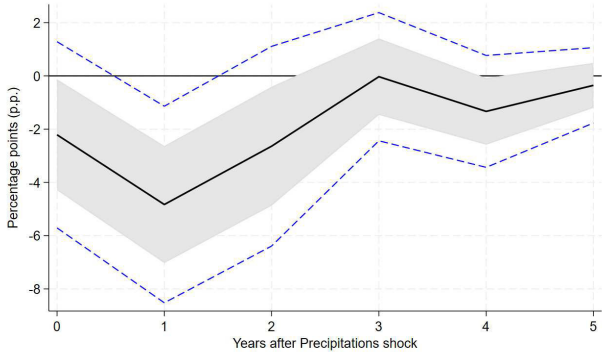
(b) Food Production



(c) Inflation



(d) GDP per capita growth

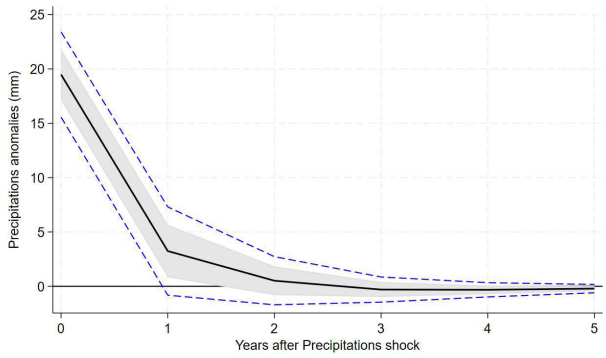


Note: Charts display impulse response functions estimated from a SVAR model described in Equation (1) covering 1970–2021, with alternative lag structure (L=2). Shaded areas indicate 68% confidence intervals; dotted blue lines show 90%.

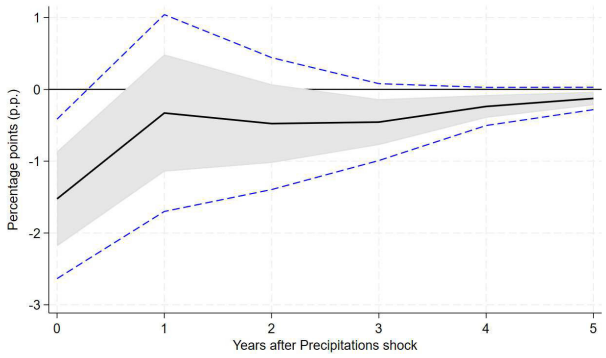
A.4 Alternative shock variable: Maximum 5-day precipitation anomalies

Figure 6: Impacts of Extreme precipitations shocks

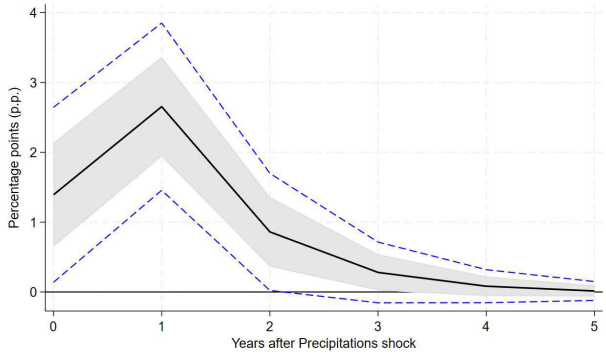
(a) Maximum 5-day Precipitation anomalies (mm)



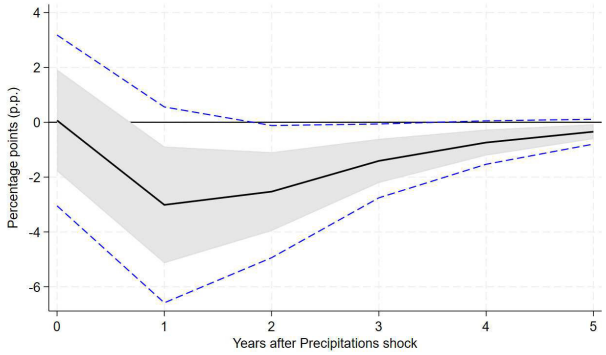
(b) Food Production



(c) Inflation



(d) GDP per capita growth



Note: Charts display impulse response functions estimated from a SVAR model described in Equation (1) covering 1970–2021, where the shock variable is the maximum 5-day precipitation anomalies (mm). Shaded areas indicate 68% confidence intervals; dotted blue lines show 90%.