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# The Economic Impact of Climate Extreme Events: A Global Perspective

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**Abstract**

*This study investigates the influence of climate extreme events on economic growth in 25 developed and 58 developing countries from 1981 to 2020, focusing on agriculture and non-agriculture sectors. Employing System GMM methodology to address endogeneity concerns, the research offers robust insights. Findings indicate that floods stimulate overall economic growth, including both sectors, likely due to post-disaster spending surges, while droughts notably hinder economic growth and the non-agricultural sector through reduced productivity and spending. Moreover, factors such as education, financial depth, and economic openness exhibit varied effects on economic growth. This study's originality lies in its sector-specific analysis and comparison between developed and developing nations, providing nuanced insights into climate-economy interactions. The research underscores the importance of targeted policies to address the multifaceted impacts of climate extremes and suggests measures focusing on education, economic openness, and inflation to mitigate adverse effects on economies.*

***Keywords:*** *climate extreme events; economic growth; floods; droughts; agriculture.*

## 1. Introduction

In recent times, there has been an increase in the research dedicated for understanding the repercussions of natural disasters (Douglas et al. (2022); (Mazikana, 2023; Mudželet Vatreš et al., 2023). This rise in studies can be attributed to the broader availability of data due to improved measurement methods and the escalation in the frequency and impact of such climate extreme events (Cremen et al., 2022; Hussain & Reza, 2023). For example the flood in Sri Lanka and neighbouring nations in May 2017, displaced over 600,000 individuals in Sri Lanka alone and affected 40 million people (Eckstein et al.). Likewise, Vietnam experienced its most severe drought in 2016 and mere 48 hours of intense rainfall in July 2018 left behind a trail of destruction amounting to $7 billion in damages. This underscores the delicate equilibrium between water resources and agricultural stability(Ngu et al., 2023). . Similarly, , in May 2016, India experienced a severe drought and heatwave, affecting a staggering 330 million people. And in August 2018, the heavy rainfall in Kerala, India lasting only two days, resulted in widespread destruction, affecting millions of people and claiming the lives of 400 people. . More recently, South Africa grappled with a prolonged drought from 2018 to 2021, resulting in dire food insecurity(Naicker et al., 2023). These events emphasizes the complex connection between climatic events and the availability of essential resources (Gagliardi et al., 2023; Lawangen & Roberts, 2023; Levy et al., 2022; Md et al., 2022). Overall, between 1999 and 2019, 11,000 climate extreme events were reported, resulting in approximately 475,000 deaths and a staggering $2.6 trillion in losses globally (Global

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Climatic Risk Index Report, 2021[3]).The transformations observed in climate patterns since 1950 stand unprecedented across both decades and millennia (Noy & Nualsri, 2007; Pörtner et al., 2022; Warsame et al., 2022). . According to the UNEP Global Adaptation Gap Report (2020), the intensification of climate extreme events escalates global adaptation costs(Neufeldt et al., 2021). Even a 1.5°C increase in temperature results in longer heatwaves and warmer seasons, posing threats to agricultural and human health thresholds at 2°C of global warming. The recent report from the Intergovernmental Panel on Climate Change (IPCC) in 2022 predicts further acceleration of global climate change in the coming decades, amplifying losses and damages(Morecroft et al., 2022).

Furthermore, the repercussions of both direct damage and indirect impacts of climate extreme events are likely to spread across labour productivity on a larger scale, causing significant decrease in output(Akram et al., 2022; Black et al., 2013; Feyen et al., 2020; Gil et al., 2013; Kousky, 2014). Simultaneously, developing countries face fiscal instability due to the heightened intensity and frequency of climate extreme events(Crawford et al., 2023; Do et al., 2023; Kousky, 2014; Lamperti et al., 2019). These countries experience the heaviest losses in output and face substantial costs for recovery(Botzen et al., 2019; Hochrainer, 2009). The increasing reliance on fossil fuels, coupled with escalating environmental pollution, has altered the climate in regions such as the ASEAN region (Shimada, 2022; Zhao et al., 2022) and other areas as well (Haseeb et al., 2019; Karki et al., 2005; Mughal et al., 2022).

Amid the growing frequency of these events, there have been continuous discussions at the global level about readiness and preparedness for the future, particularly in the context of global warming(Awuh et al., 2022; Crawford et al., 2023; Rezaei et al., 2023; Volonte, 2022). Despite the evolving landscape of climate related concerns, the study of the macroeconomic impacts of climate extreme events remains a significant gap in current research.To address this gap, our study aims to evaluate how climate extreme events could affect the economic growth trajectories of both developed and developing nations.

For this we adopt a rigorous approach, utilizing updated data to drive our findings. Given the increasing frequency of climate extreme events globally, there's a pressing need to comprehensively understand their implications. For this we adopted a robust system GMM approach and utlised a large dataset both in terms of time and crosssections. Our research aims to analyse climate extreme events(floods and droughts) and their impacts on various sectors of the economy. The primary objective of our study is to address the knowledge gap by conducting an in-depth investigation into how climate extreme events affect economic growth in both developed and developing nations, with a focus on the agriculture and non-agriculture sectors. We utilise 40 years data from 1981 to 2020, encompassing 83 nations, including 25 developed and 58 developing nations. Thus the study evaluates the potential shifts in economic growth trajectories and dissecting sector-wise ramifications and aims to inform decision-making and promote resilience in economies facing increasing climate volatility.

## 1. Economic impact of climate extreme events

There has been many studies for example Awuh et al. (2022), Clarke et al. (2022), Omer & Capaldo (2023), and Volonte (2022) and others examining the economic impact of climate extreme events. However, these studies have presented a diverse spectrum of outcomes, ranging from advantageous to detrimental consequences, and in some instances, there has been no discernible effect on regional growth trajectories, regardless

[3] The 16th edition of the Global Climatic Risk Index report leaves no room for ambiguity: climate change is a global concern that transcends geographical boundaries and socio-economic divisions. Its far-reaching consequences demand comprehensive and equitable solutions, with a particular focus on empowering vulnerable nations to weather the storms of extreme weather events and emerge stronger and more resilient.

of the timeframe analyzed. We categorized consequences into short- and medium-term (up to five years) and long-term (lasting ten years or more), in alignment with the framework proposed by Cavallo & Noy (2011). This temporal classification allows for a more detailed understanding of the processes that emerge after climate extreme events, offering insight into potential short- to medium-term fluctuations compared to longer-term impacts.

2. Short-Term Impacts

Droughts or floods can trigger a significant reduction in short-term economic activities, resulting in both direct and indirect losses. Climate extreme events occurences have a pervasive influence on economic operations, impacting production within the agricultural and industrial sectors. (Hochrainer, 2009; Klomp & Valckx, 2014; Loayza et al., 2012; Panwar & Sen, 2019).The consequences of such climate extreme events are twofold: first, there is the loss of human capital through fatalities, injuries, and impairments, representing a labor loss(Mizutori, 2020; Mudželet Vatreš et al., 2023; Neumayer & Plümper, 2007; Parmesan et al., 2022; Shi et al., 2016; You & Zhang, 2022). Second, there is the loss of physical capital, including damage to infrastructure and the depletion of productive assets, compounding the economic impact over time(Alcayna et al., 2016; Bergholt & Lujala, 2012; Felbermayr & Gröschl, 2014; Hsiang & Jina, 2014; Levin et al.; Mazikana, 2023; Pörtner et al., 2022; Toya & Skidmore, 2007).

3. Long-term Impacts

The long-term consequences of climate extreme events remain ambiguous both conceptually and empirically. The impact of such events on long-run growth and development can be positive, negative, or even inconsequential (Angeli et al., 2022; Chang et al., 2023; Farajzadeh et al., 2022; Shear et al., 2023). Endogenous growth theories, rooted in the Schumpeterian notion of creative destruction, offer an explanatory framework for the potential long-term positive influence of climate extreme events(Monllor & Altay, 2016; Nicholas, 2003; Özekin, 2023). These theories posit that post-disaster reconstruction, driven by the imperative to rebuild, can catalyze an acceleration in the affected regions. Consequently, this phenomenon is expected to stimulate heightened investments, thereby fostering more productive economic outcomes in the future(Hallegatte & Dumas, 2009; Mudželet Vatreš et al., 2023; Phoumin et al., 2021). The intricate interplay of factors and dynamics involved in this process contributes to the uncertainty surrounding the precise nature of the long-term effects of extreme weather occurrences on economic growth and development. However, there have been limited study examining the macroeconomic effects due to the climate extreme events.

## 2. Literature Review:

There are a number of studies which have explored the intersection of climate extreme events and economic growth. Here we present a breief overview of the existing literature.

Studies by Albala-Bertrand (1993), Skidmore and Toya (2002), and Jaramillo (2009) have shown that while climate-related disasters may exert a positive long-term impact on GDP growth, the toll on human life and property can have lasting detrimental effects. Neumayer and Plümper (2007) highlighted the gendered impact of natural disasters on life expectancy, emphasizing the need for gender-sensitive disaster response strategies.

Kahn (2005) and Raddatz (2009) revealed disparities in the ability of nations to recover from disasters, with richer countries demonstrating quicker recovery compared to developing nations. (Clarke et al., 2022) underscored the significant negative effect of intense hydrological disasters on economic growth, emphasizing the urgency of climate adaptation measures. Felbermayr and Gröschl (2014) provided insights into the short-term economic impacts of disasters, indicating a temporary lowering of GDP per capita.

Similarly, Shabnam (2014) highlighted the adverse effects of floods on livelihoods, calling attention to the need for effective disaster mitigation and response strategies.

On a broader scale,(Fankhauser, 2017, 2019; Großmann et al., 2023) emphasized the importance of integrating climate variables and natural capital into economic frameworks, as well as the trade-offs involved in investing in climate change mitigation technologies. (Buheji, 2018)stressed the significance of climate-resilient development strategies and the role of education, institutions, and access to credit in building resilience to future socio-economic crises Furthermore, (Bowen et al., 2012; Lefevre et al., 2022) delved into modelling the macroeconomic impacts of climate change, analysing structural changes in the economy, and advocating for inclusive, pro-poor growth policies to reduce vulnerability to climate change.

Collectively, these studies underscore the urgent need for proactive measures to mitigate the adverse effects of climate extreme events and promote resilience in economies and societies worldwide. They highlight the importance of integrating climate considerations into economic planning and policymaking to ensure sustainable and inclusive development in the face of climate change.

## 3. Data and Methodology

Data and variables

The sample consists of 83 countries including 25 developed and 58 developing countries[4]. The data of study variables are of annual frequency covering the period from 1981 to 2020. To analyze the medium-term effects and to take account of the missing observations, following loayza et al. (2012) and Noy (2009), we organised the observations into five-year non-overlapping intervals. We used floods and droughts as the two measures for extreme climate events. The incidents of the floods and droughts over the years are given in Figure 1.

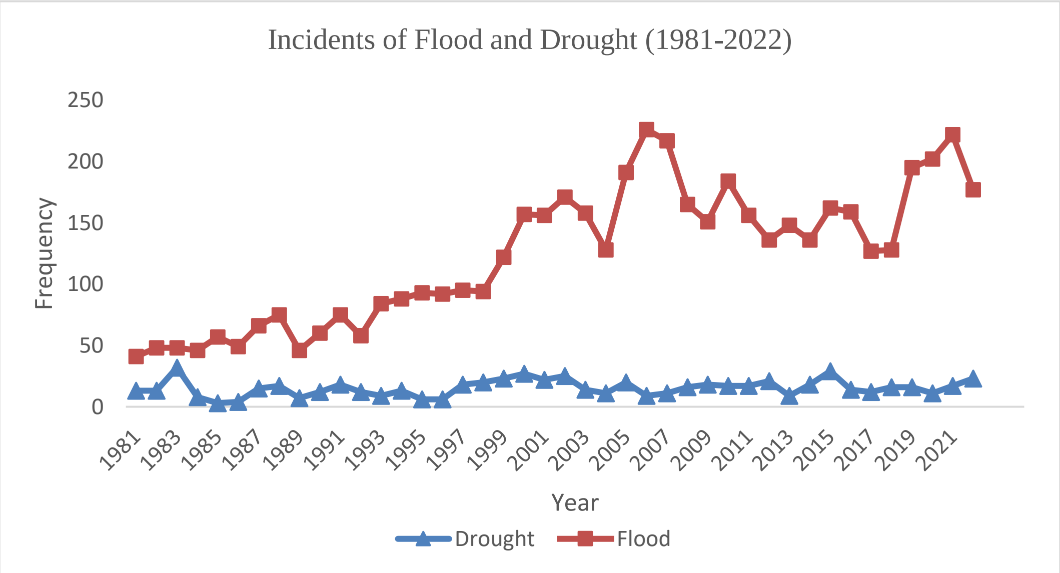


Figure 1 Incidents of floods and drought (1981-2022) using the EMDAT data.

To capture economic growth at aggregate as well at sectoral levels, we used growth rate of real GDP per capita(GDP), gross agriculture value added(Ag) and gross non-agricultural value-added(N-Ag). Further, to capture the growth dynamics, we have included following variable as control variables. a) The gross secondary enrolment ratio,

[4] Selected countries list is attached in the appendix( see table A1)

which includes both males and females, serves as a proxy for measuring educational achievement. b) In order to measure the financial burden on the government, we have included the ratio of final consumption expenditure to GDP. (c) To measure the stability of prices, we utilized the Consumer Price Index (CPI) inflation. (d) trade openness is measured as the log of the ratio of total trade volume(export plus import) to GDP. (e) log of the ratio of the total domestic credit to the private sector is used to capture the financial deepening. Data for Climate extreme events are collected from EM-DAT Database maintained by (CRED) and data of remaining variables are obtained from World Development Indicators(WDI) maintained by World Bank[5]. EM-DAT database tracks disaster-related deaths, economic losses, and people affected by natural and man-made disasters. EM-DAT is the most popular database and is being widely used in academic literature despite certain limitations[6]. we have utilized the disaster intensity measure, which is more appropriate, i.e., the total affected plus total deaths . Finally, we used the total population affected (in logs) and the number of fatalities as a continuous catastrophe intensity variables.

Descriptive statistics of the variables are presented in table 1.On an average the overall economic growth as well as growth rate of agriculture and non agriculture sectors is higher for the developed countries in comparison of developing countries. On the other hand, on average disaster intensity in terms of both flood and drought is lower for developed countries than developing countries. This reflects the disproportionate effect of climate extreme events in developed from the developing countries.

Table 1:Descriptive Statistics

| Variables Name | Mean | Std. Dev | Max | Min |
|---|---|---|---|---|
| Full Sample(N=83, n=664) | | | | |
| GDP | 7.27 | 2.67 | 11.58 | 0.00 |
| Ag | 18.3 | 8.78 | 27.6 | 0.00 |
| N-Ag | 18.2 | 9.83 | 29.3 | 0.00 |
| All disasters | 18.9 | 14.0 | 81.1 | -2.50 |
| Floods | 7.73 | 4.81 | 18.4 | -1.60 |
| Drought | 3.00 | 5.45 | 18.0 | -0.91 |
| Developed Countries(N=25,n=200) | | | | |
| GDP | 8.01 | 2.56 | 10.9 | 0.00 |
| Ag | 18.9 | 8.43 | 25.8 | 0.00 |
| N-Ag | 19.0 | 9.80 | 28.8 | 0.00 |
| All disasters | 14.4 | 11.2 | 58.7 | -2.52 |
| Floods | 5.88 | 4.22 | 14.6 | -1.60 |
| Drought | 0.42 | 2.14 | 14.1 | 0.00 |
| Developing Countries(N=58,n=464) | | | | |
| GDP | 6.95 | 2.66 | 11.5 | 0.00 |
| Ag | 18.1 | 8.93 | 27.6 | 0.00 |

[5] Description of variables((See Table A2 in the appendix)
[6] A disaster must meet at least one of the following requirements to be recorded in the EM-DAT database:
Reports of at least ten fatalities
At least 100 people have allegedly been impacted.
A state of emergency has been declared.
Call for international aid.

| | | | | |
|---|---|---|---|---|
| N-Ag | 17.8 | 9.84 | 29.3 | 0.00 |
| All disasters | 20.9 | 14.6 | 81.1 | 0.00 |
| Floods | 8.5 | 4.83 | 18.4 | -0.91 |
| Drought | 4.11 | 6.04 | 18.0 | -0.91 |

Source: Author's Collection

Estimation Methodology

For such studies often panel data techniques particularly panel fixed effect models are being used. These models effectively address time-invariant heterogeneity and shared time-invariant shocks across various cross-sectional units. However, estimation methods may introduce the problem of endogeneity and yield biased estimators known as "Nickell bias" (Nickell, 1981), leading to inconsistent results.

To overcome these shortcommings, we employ the System Generalized Method of Moments (GMM) approach. This approach resolves the endogeneity issues and mitigate biases inherent in traditional OLS estimates, thereby enhancing the robustness and reliability of our results.

Following, (Loayza et al., 2012; Noy, 2009) the model may be specified as.

$Y_{i,t} = \alpha + \beta_0 Y_{i,t-1} + \beta_1 D_{i,t+} \beta_2 X_{i,t+} u_1 + \theta_t + \varepsilon_{i,t}$ ......(I)

Where country and year are indicated by the subscript i and t, respectively, $Y_{i,t}$ represents the dependent variable(Growth variables), the first lag of $Y_{i,t}$ is represented as $Y_{i,t-1}$ , $D_{i,t}$ indicates the explanatory variables(Climate extreme events) and $X_{i,t-1}$ are the control variables (determinants of growth), $u_1$ indicates the country-specific heterogeneity; and $\theta_t$ denotes year-fixed effects, and $\varepsilon_{i,t}$ is the stochastic term.

Diagnostic tests

In this study, we conducted a comprehensive series of diagnostic tests to ensure the reliability and consistency of our results. To address potential non-stationarity issues, we employed the Levin Lin Chu (LLC) and Im Pesaran Shin (IPS) unit root tests. These tests were chosen for their suitability in detecting non-stationarity and addressing cross-sectional dependence in the selected panel data, thereby enhancing the robustness and reliability of our analysis.

## 4. Results and Discussion

The results are discussed in three sub asections. First, we have examined the effect of climate extreme events for the full sample. Next, to examine the effect contingent upon the level of development of countries, we stratified the countries into developed and developing countries on the basis of World Bank classification. In the second subsection we analyse the results for the developed countries followed by the discussion of results for the developing countries.

However, before applying the system GMM model, we assessed the stationarity of study variables using Levin Lin Chu (LLC) and Im Pesaran Shin (IPS) unit root tests. Findings reveal variables are stationary at first difference. Detailed results are provided in Table A3 in the appendix, affirming the suitability of our chosen model specification and ensuring the integrity of our subsequent analyses.

Effect of climate extreme events on economic growth for the full sample.

Table 2 displays the results investigating the effects of floods and droughts on the economic growth of 83 nations from 1981 to 2020. The study examines the effect of climate extreme events represented with floods and droughts on economic growth. Further we have examined the effect st the sectoral level that is on agricultural and non-agricultral growth.we have incorporated number of factors into the analysis to mitigate potential confounding effects on economic growth, including inflation, trade openness, financial depth, education, and government final consumption expenditure.

The analysis reveals significant findings regarding the impact of floods and droughts on economic growth. Floods demonstrate a statistically significant positive effect on economic growth, echoing previous studies which attribute this to various factors such as infrastructure investment, insurance payouts, government stimulus, and resource reallocation (Deryugina & Hsiang, 2014; Kunreuther & Michel-Kerjan, 2011; Skidmore & Toya, 2002). Furthermore,(Klomp & Valckx, 2014) highlighted the resilience of economies in the aftermath of natural disasters. Conversely, droughts exhibit a significant negative impact on GDP growth. This could be the result of decreased agricultural productivity, reduced farmer incomes, and constrained consumer spending (Burke et al., 2015; Lobell et al., 2011). Furthermore, studies by(Amarasinghe et al., 2020; Easterling et al., 2007; Fomby et al., 2013; Khan et al., 2017) highlight how droughts can lead to increased food prices, food insecurity, and adverse health outcomes, further exacerbating economic downturns. For the control variables the results are statistically significant as per the therotical expectations. The study identifies education as a significant positive correlate of GDP growth, indicating the productivity and adaptability benefits of an educated workforce, consistent with the research by(Hanushek & Woessmann, 2008, 2023). The coefficient of financial depth is positive and signficant on economic growth. Economic openness emerges as a significant driver of GDP growth by facilitating innovation and competition through international trade, aligning with prior research. The effect of government final consumption expenditure is negative on economic growth, but lacks of significance implies the presence of other dominant factors. Inflation exhibits a significant positive impact on economic growth, as inflation stimulates spending and investment, as discussed by (Romer, 1993)

In the non-agricultural sector, floods demonstrate a notable positive impact, attributed to increased government spending on infrastructure development post-floods, as emphasized by(Ceesay, 2020; Kunreuther & Michel-Kerjan, 2011) Droughts do not exhibit a significant impact, potentially due to the sector's resilience. Education emerges as a significant contributor to sectoral growth, supported by (Hanushek & Woessmann, 2023) highlighting the importance of a skilled workforce. Financial depth and economic openness both positively influence the non-agricultural sector, consistent with previous research. However, government financial consumption expenditure does not show a significant impact, suggesting inefficiencies or the presence of other influential determinants. Inflation, while showing a significant positive impact, underscores the importance of moderate levels to stimulate demand and investment, as outlined by Romer (1993).

Table 2:Effect of Climate extreme events on Economic Growth for the full sample.

| Depenedent/Independent Variables | GDP | | NAG | | AG | |
|---|---|---|---|---|---|---|
| | Coefficient | P-Value | Coefficient | P-Value | Coefficient | P-Value |
| Flood | 0.048 | 0.027 | 0.289 | 0.000 | 0.458 | 0.000 |
| Drought | -0.043 | 0.022 | -0.035 | 0.618 | -0.050 | 0.410 |

| | | | | | | |
|---|---|---|---|---|---|---|
| EDU | 0.011 | 0.000 | 0.037 | 0.000 | 0.032 | 0.000 |
| FD | 0.020 | 0.064 | 0.078 | 0.047 | 0.010 | 0.764 |
| EO | 0.080 | 0.000 | 0.150 | 0.000 | 0.060 | 0.098 |
| GFB | -0.037 | 0.419 | -0.094 | 0.580 | 0.700 | 0.000 |
| INF | 0.008 | 0.000 | 0.032 | 0.000 | 0.028 | 0.000 |
| C | 4.445 | 0.000 | 8.860 | 0.000 | 8.847 | 0.000 |
| Number of Observations | 664 | | 664 | | 498 | |
| Number of Countries | 83 | | 83 | | 83 | |
| Hansen test (P-Values) | 0.534 | | 0.246 | | 0.464 | |
| Arellano Bond Test for AR(1) and AR(II) | | | | | | |
| In First Differences | 0.066 | | 0.002 | | 0.000 | |
| In Second Differences | 0.453 | | 0.552 | | 0.518 | |

Source: Authors' preparation.

Notes: GDP: economic growth, AG: agricultural sector; NAG: non agricultural sector, EDU : education, INF: Inflation, GFB: Government Financial Burden, EO: Economic openness, FD: Financial depth)

In agriculture sector, floods exhibit a significant positive impact due to increased water availability for irrigation(Ceesay, 2020; Cunado & Ferreira, 2014; Mujahid et al., 2016) ( This fosters long-term benefits, enhancing crop yields and agricultural productivity, as documented in previous studies (Cunado & Ferreira, 2014; Mujahid et al., 2016). Droughts have a negative and insignificant impact on the agriculture sector. Education emerges as a crucial determinant of agricultural success, with higher levels positively impacting productivity through improved techniques and technology adoption. Government expenditure plays a pivotal role in stimulating agricultural development, with increased spending associated with substantial sectoral growth. Additionally, inflation positively correlates with agriculture, likely due to increased farm gate prices and revenues. The positive but statistically insignificant impact of financial development on agricultural growth could be attributed to the multifaceted nature of their relationship. Financial development may facilitate access to credit and investment in the agricultural sector, yet its effects might be moderated by various factors such as institutional constraints or market conditions (Beck et al., 2007). Overall, this study underscored the multifaceted dynamics between climate extreme events, education, economic policies, and inflation in shaping economic growth across different sectors and highlights the importance of targeted policy interventions to mitigate the adverse effects of climate extreme events on economic development.

Effect of Climate extreme events on Economic Growth for Developed Countries

In this section, we delved into the effects of floods and droughts on the economic growth of 25 developed nations over the period spanning from 1981 to 2020. Our analysis, as depicted in Table 3, elucidates the impact of these climate extreme events and their ramifications on economic growth and sectoral dynamics.

Flood occurrences manifest a positive insignificant impact on economic growth, particularly in the non-agricultural domain, echoing previous research that underscores the stimulative effects of post-disaster reconstruction endeavors, augmented governmental expenditures, and insurance disbursements (Barrios et al., 2010; Fomby et al., 2013). Furthermore, floods seem to engender a favorable impact on the agricultural sector, engendering heightened demand for infrastructure rehabilitation and agricultural output enhancement owing to soil rejuvenation and augmented water availability (Ceesay, 2020; Dell et al., 2012; Hallegatte, 2016; Hasler et al., 2019). Drought episodes wield a negative impact on economic growth and the non-agricultural sector, mirroring a plethora of studies illustrating diminished agricultural productivity, dwindling output in water-dependent industries, and a general downturn in productivity during periods of drought (Burke & Emerick, 2016; Burke et al., 2015). Notably, the unexpected revelation of a positive yet insignificant coefficient for droughts in the agricultural sector suggests a nuanced relationship possibly shaped by adaptive measures employed by farmers and the integration of novel technologies.

Table 3: Effect of Climate extreme events on Economic Growth for Developed Countries

| Depenedent/Independent Variables | GDP | | NAG | | AG | |
|---|---|---|---|---|---|---|
| ` | Coefficient | P-Value | Coefficient | P-Value | Coefficient | P-Value |
| Flood | 0.038 | 0.378 | 0.144 | 0.355 | 0.572 | 0.000 |
| Drought | -0.249 | 0.000 | -0.751 | 0.000 | 0.219 | 0.191 |
| EDU | 0.002 | 0.740 | 0.048 | 0.006 | 0.024 | 0.081 |
| FD | 0.068 | 0.001 | 0.062 | 0.412 | 0.043 | 0.485 |
| EO | 0.023 | 0.308 | 0.121 | 0.140 | 0.107 | 0.108 |
| GFCE | -0.148 | 0.081 | -0.594 | 0.053 | 0.297 | 0.231 |
| INF | 0.015 | 0.000 | 0.054 | 0.000 | 0.042 | 0.000 |
| C | 5.643 | 0.000 | 10.351 | 0.000 | 8.307 | 0.000 |
| Number of Observations | 200 | | 200 | | 200 | |
| Number of Countries | 25 | | 25 | | 25 | |
| Arellano Bond Test for AR(1) and AR(II) | | | | | | |
| In First Differences | 0.005 | | 0.011 | | 0.047 | |
| In Second Differences | 0.349 | | 0.451 | | 0,954 | |

Source: Authors' preparation.

Notes: GDP: economic growth, AG: agricultural sector; NAG: non agricultural sector, EDU: education, INF: Inflation, GFB: Government Financial Burden, EO: Economic openness, FD: Financial depth)

Furthermore, our analysis unveils the impact of education levels on economic growth where as it is positive and insignificant but in the sector wise it is positive and significant. Financial depth has a positive impact on economic growth. However, when analyzing financial depth impact on specific sectors, such as agriculture and nonagriculture, the relationship becomes positive but lacks of statistical significance. This suggests a nuanced interaction between financial development and sectoral dynamics, possibly influenced by factors like sector-specific investment patterns or regulatory frameworks. Economic openness, governmental financial consumption expenditure, and inflation also emerge as pivotal determinants of economic outcomes, each wielding varying degrees of significance. Particularly noteworthy is the consistent and statistically significant adverse effect of inflation on economic growth across all models, underscoring its detrimental implications for economic stability and progress.

Effect of Climate Extreme Events on Economic Growth for Developing Countries

In this section, we delved into the repercussions of floods and droughts on the economic growth of 58 developing nations over the period spanning from 1981 to 2020. Specifically, floods demonstrate a notable positive significant impact on economic growth as well as the agriculture and non agriculture sector. This suggests the potential for post-flood economic revitalization, in line with prior research by(Cunado & Ferreira, 2014; Hallegatte, 2016; Halsnæs et al., 2023; Usta & Gök, 2023) which highlight floods' role in stimulating increased governmental investment in reconstruction and infrastructure, ultimately bolstering overall economic productivity. However, droughts reveals a negative insignificant impact on economic growth and sectoral performance.This underscores the multifaceted and occasionally unpredictable nature of drought-induced economic effects in the respective countries.

Table 4:Effect of Climate extreme events on Economic Growth for Developing Countries

| Depenedent/Independent Variables | GDP | | NAG | | AG | |
|---|---|---|---|---|---|---|
| | Coefficient | P-Value | Coefficient | P-Value | Coefficient | P-Value |
| Flood | 0.074 | 0.003 | 0.366 | 0.000 | 0.496 | 0.000 |
| Drought | -0.011 | 0.589 | 0.062 | 0.418 | -0.079 | 0.256 |
| EDU | 0.011 | 0.001 | 0.029 | 0.023 | 0.026 | 0.023 |
| FD | -0.001 | 0.918 | 0.061 | 0.181 | -0.022 | 0.589 |
| EO | 0.082 | 0.000 | 0.120 | 0.015 | 0.039 | 0.380 |
| GFCE | 0.008 | 0.884 | 0.144 | 0.475 | 0.827 | 0.000 |
| INF | 0.005 | 0.003 | 0.025 | 0.000 | 0.025 | 0.000 |
| C | 4.271 | 0.000 | 8.765 | 0.000 | 8.841 | 0.000 |
| Number of Observations | 464 | | 464 | | 464 | |
| Number of Countries | 58 | | 58 | | 58 | |
| Arellano Bond Test for AR(1) and AR(II) | | | | | | |
| In First Differences | 0.006 | | 0.002 | | 0.054 | |
| In Second Differences | 0.801 | | 0.673 | | 0.779 | |

Source: Authors' preparation.

Notes: GDP: economic growth, AG: agricultural sector; NAG: non agricultural sector, EDU: education, INF: Inflation, GFB: Government Financial Burden, EO: Economic openness, FD: Financial depth)

Moreover, the positive influence of education on economic growth and in the agricultural and nonagricultural sector. This finding aligns with existing literature emphasizing education's pivotal role in augmenting productivity(Hanushek & Woessmann, 2008) . Similarly, economic openness emerges as a significant driver of economic growth and non-agricultural sectors, supporting theoretical frameworks that suggest trade liberalization fosters economic development (Wacziarg & Welch, 2008). But in the agriculture sector economic openness is positive but insignificant and this could be due to several factors such as unequal access to global markets, inadequate infrastructure, or vulnerability to international price fluctuations (Jayanthakumaran et al., 2012) Financial depth has a negative and insignificant impact on the economic growth and in the agriculture and non agriculture sector and this could be due to presence of structural issues such as financial market imperfections or the dominance of informal financial channels, which hinder the effectiveness of formal financial institutions (Beck et al., 2007). Inflation exerts a significant positive impact on economic growth, agricultural, and non-agricultural sectors, indicative of its effects on purchasing power and investment (Ghosh & Phillips, 1998). However, the influence of government consumption expenditure appears mixed, suggesting potentially varying efficacy in stimulating economic activity (Afonso & Sousa, 2012). These findings collectively highlight the intricate interplay between environmental phenomena, policy variables, and economic performance in developing countries, providing valuable insights for policymakers and stakeholders seeking to enhance resilience and foster sustainable growth.

## 5. Conclusion and policy implications

The study's findings offer valuable insights into the impact of climate extreme events on economic growth, and sectoral performance across nations. Floods emerge as a catalyst for economic growth, primarily through heightened government spending on infrastructure reconstruction and a subsequent surge in demand for goods and services. Additionally, floods positively impact both the non-agricultural and agricultural sectors by enhancing water availability for irrigation and stimulating post-disaster agricultural productivity. Moreover, droughts contrast with floods, as they impose a substantial adverse effect on economic growth and the non-agricultural sector. This impact stems from reduced agricultural output and constrained consumer spending. Nevertheless, the influence of droughts on agriculture reveals intricate nuances, reflecting a complex relationship influenced by adaptive strategies and technological innovations among farmers.

Education emerges as a pivotal determinant of economic growth and sectoral performance, underscoring the critical importance of investing in human capital to bolster workforce productivity and adaptability. Moreover, the study highlights the positive contributions of financial depth and economic openness to economic resilience and competitiveness. Policies aimed at fostering financial market development and trade liberalization can further fortify these pillars of economic growth, enhancing overall economic stability and performance. However, effective fiscal management remains paramount, with prudent government expenditure and inflation control measures essential for sustaining long-term economic growth while mitigating inflationary risks.

In conclusion, this study highlights the impact of climate extreme events on economic growth and sectoral resilience, alongside the influence of education, economic policies, and inflation on shaping economic trajectories. By gaining a comprehensive understanding of the impacts of floods and droughts on economic growth and implementing tailored policy interventions, policymakers should prioritize investments in post-disaster reconstruction and infrastructure to capitalize on the potential economic stimulus provided by floods, while implementing proactive measures to mitigate the adverse effects of droughts on agricultural productivity and consumer spending. Investments in education and promotion of economic openness are essential for fostering sustainable economic growth, while measures to control inflation and optimize government expenditure are crucial for maintaining economic stability. Additionally, tailored policy interventions based on the specific vulnerabilities and resilience capacities of each country are necessary to address cross-country variations in the impact of floods and droughts on economic growth. By considering factors such as geographical location, economic structure, and institutional capacity, policymakers can enhance resilience and foster sustainable growth in the face of climate extreme events.

Declarations

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