Received 26 December 2023
Revised 14 July 2024
Accepted 29 August 2024

Even climate change is not fair: the impact of climate change on economic outcomes

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Abstract

Purpose – From generation to generation, the poor and less developed have always borne the negative consequences of the extravagant lifestyles of the rich. The climate seems to perpetuate this injustice by punishing the good people with the consequences of the irresponsible acts of the wealthy. Therefore, this paper aims to establish the relationship between climate risk and carbon emissions. Then, this paper investigates the economic consequences of climate risk in both developed and developing countries.

Design/methodology/approach – This paper uses robust econometrics, including fixed effect and the two-step system generalised method of moments, on a large sample of 175 countries from 2008 to 2019.

Findings – Unsurprisingly, this paper found that climate risks are negatively associated with carbon emissions, indicating that countries with lower emissions are more exposed to frequent and severe climate-related disasters than those with higher emissions. Additionally, this paper discovered that climate risk has a negative impact on economic development, which is more pronounced in developing countries. The results are robust to alternative measurement and econometric modelling, including the system-generalized method of moments.

Originality/value – These findings suggest that developing countries, the least contributors to climate change, unfairly suffer from the environmentally irresponsible actions of high-emitting developed countries.

Keywords Climate change, Climate risk, Climate disaster, Carbon emission, Developed and developing countries, Intrusion detection, Concept drift detection, Online incremental learning

Paper type Research paper

1. Introduction

Historically, the world has not been fair to all countries, from civilisation to industrialisation. This trend of unfairness has been attributed mainly to human greed and the quest for power (Hunter, 2009). From generation to generation, the poor and less developed have always borne the negative consequences of the extravagant lifestyles of the rich (Shue, 1993). Social

Conflict of Interest: There is no conflict of interest in this paper.
Funding Declaration: Princess Nourah bint Abdulrahman University Researchers Supporting Project number (PNURSP2024R391), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.
Competing Interest Information: There is no competing interest on the paper.

International Journal of Climate Change Strategies and Management
Vol. 17 No. 1, 2025
pp. 48-69
Emerald Publishing Limited
1756-8692
DOI 10.1108/IJCCSM-01-2024-0008

and political policies have structured an unfair world. During civilisation and colonisation, rich/advanced countries engaged in human slavery to build their nations at the expense of others (Alemazung, 2010). Other countries were invaded, and resources were taken for little or no cost. In the present day, these practices continue through foreign investment and trade, which exploit the poor by either dumping goods or rapidly extracting resources (Glaister *et al.*, 2020; Jauch, 2011). As if these actions were not enough, through foreign aid and international diplomacy, advanced countries directly or indirectly dictate how other nations should be governed (Alesina and Dollar, 2000).

These actions have left scars of unfairness across the world. As the world continues to battle to heal from the unfairness of past actions, climate change appears to create a new level of unfairness. In recent years, the world has seen the increasing wrath of nature towards humans through frequent disasters such as floods, droughts, bushfires and cyclones. For example, according to Eckstein *et al.* (2021), from 2000 to 2019, about 11,000 climate disasters have caused approximately 500,000 deaths and $2.56tn in property loss. Unlike existing unfairness, such as slavery and colonisation caused by greed and the quest for power (Alemazung, 2010), at face value, climate change appears to be a natural occurrence that affects every country regardless of its development status. These natural disasters are a result of our environmental irresponsibility. However, the question remains: Are these climate punishment actions fairly distributed based on our actions? Are countries receiving a fair punishment for their contributing role to climate change?

In this paper, we attempt to answer these questions by examining the global trend of carbon emissions and climate risk. Additionally, we analyse the relationship between various economic indicators and climate risk to identify the countries that are bearing the highest costs of climate change. Arguably, ensuring an equitable distribution of the consequences of climate change will be a significant factor in determining which countries will suffer the most. Essentially, countries with high carbon emissions should experience greater impacts from climate change.

Prior studies have established that developed countries are higher emitters than developing countries (Galeotti and Lanza, 1999; Mahapatra and Irfan, 2021; Wu *et al.*, 2018). For example, Wu *et al.* (2018) suggest that developed countries emit more greenhouse gases because they use a lot of electronic gadgets and travel more. Regardless of the energy efficiency of the latest gadgets, frequent usage generates more emissions than less energy-intensive gadgets used in developing countries. Furthermore, affluent people drive their cars and fly more, generating high emissions (Heil and Wodon, 1997). Therefore, in fairness, developed countries should bear more of the burden of climate change than developing countries.

Based on these arguments, we examine the relationship between carbon emission and climate risk, as well as the economic consequences of climate risks. We use the comprehensive measure of climate risk developed by Eckstein *et al.* (2021) at Germanwatch. The climate risk measure captures the frequency and severity of climate risk-related disasters in a country in both the long and short terms. Using a large sample of 175 countries between 2008 and 2019, we find that climate risk is negatively and significantly associated with carbon emission, suggesting that high-emitting countries have a lower risk of climate disaster. Thus, low-emitting countries are at a higher risk of climate-related disasters than high-emitting countries. We also establish that climate risk negatively and significantly impacts industrialisation, economic development and economic growth.

Further analysis demonstrates that our findings are more pronounced for developing countries than for developed countries. Specifically, we found that climate risk does not significantly affect developed countries, but the negative impact in developing countries is highly significant. The probability of climate-related disasters occurring in developing countries is high, and these risks are significantly detrimental to industrialisation, economic growth and economic development. We attribute the insignificant effect of climate risk in developed countries to the availability of risk-mitigating mechanisms in those countries. In effect, our results suggest that developed countries have the luxury of polluting the environment while developing countries will have to bear the wrath of climate change. Our results provide empirical support for the argument that climate change is a key variable in explaining per capita income differences between developing countries such as Africa and wealthier regions of the world (Nordhaus, 2006).

Climate change is unfair, as its impacts are felt unequally worldwide and by different populations. Historically, developed countries have been responsible for most greenhouse gas emissions that cause climate change. However, the poorest and most vulnerable communities bear the consequences. These communities often lack the resources to adapt and mitigate the effects of climate change, while developed countries have more resources to cope with the impacts and take action to reduce their emissions. Furthermore, climate change exacerbates existing inequalities and injustices, such as gender inequality and racial discrimination. Therefore, addressing climate change requires a fair and equitable approach that considers historical and current inequalities to ensure that the most vulnerable populations are not left behind. These findings offer policy implications that developing countries, the least contributors to climate change, unfairly suffer from the environmentally irresponsible actions of developed countries, which are high emitters.

The rest of the paper is structured as follows. Section 2 will provide an overview of the literature review and theoretical framework. Section 3 will cover the research design, including data selection, econometric modelling and variable definition. Section 4 will present the results and discussion of the paper. Finally, in Section 5, we will conclude with policy implications and suggestions for future research.

2. Literature review and theory

2.1 Literature review

2.1.1 Definition and description of climate injustice. Climate injustice, also known as climate inequity or environmental injustice, emphasises the disproportionate and unfair distribution of the impacts of climate change and environmental degradation among various social groups, communities and regions (Meikle *et al.*, 2016). It highlights how vulnerable and marginalised populations, often with the least responsibility for causing climate change, suffer the most from its consequences (Caney, 2021). The impacts of climate change can vary significantly between developing and developed countries because of differences in vulnerability, adaptive capacity and economic structures (*The Stern Review*, 2006; Liu *et al.*, 2023).

Historically, industrialised nations in the Global North have been the primary contributors to the accumulation of greenhouse gases in the atmosphere (Liu *et al.*, 2023). Burning fossil fuels, deforestation and industrial activities in these countries have released significant amounts of carbon dioxide and other greenhouse gases (Sultana, 2022). For instance, Magazzino (2024) suggests that China's rapid gross domestic product (GDP) growth is driven by high electricity consumption, which causes environmental degradation. This historical responsibility raises questions about the fairness of the situation, as the impacts of climate change are felt globally (Ciplet *et al.*, 2022).

2.1.2 Impact of climate change. The impacts of climate change are not evenly distributed. Vulnerable communities, often in developing countries, are disproportionately affected because of their geographical location, poverty and lack of resources (Sultana, 2022). This raises concerns about the fairness of a situation where those who contributed least to the problem are often the most severely impacted.

Many developing countries heavily rely on climate-sensitive sectors such as agriculture, fisheries and forestry (Hertel and Rosch, 2010; Leaky *et al.*, 2021; Mendelsohn, 2009). Climate-related disruptions can result in economic losses, increased poverty and reduced access to basic services. Developing countries often lack the financial resources to invest in climate adaptation and mitigation measures, which hinders their ability to build resilience and transition to cleaner, more sustainable development pathways (Ravindranath and Sathaye, 2002). Access to technology such as AI (Magazzino, 2023) that helps mitigate or adapt to climate change, including renewable energy and early warning systems, may be unequal, leaving some communities at a disadvantage. Mele *et al.* (2021) report that the use of renewables may sustain economic growth recovery, leading to a better-performing GDP acceleration.

Climate injustice is not limited to disparities within countries; it also includes global disparities. Historically, developed countries have contributed the most to greenhouse gas emissions, yet developing countries often suffer the most from the impacts (Nath and Behera, 2011; Wood *et al.*, 2018). Despite the effects on developing countries, developed countries may also face challenges such as increased migration from climate-affected regions, which could lead to social and political tensions (Kaczan and Orgill-Meyer, 2020). They may also need to provide support for developing countries experiencing climate-induced displacement. Ahmed (2017) suggests that developed countries such as Australia and the USA should take responsibility for more than 10% of global climate refugees.

Although the above commentary suggests potential climate injustice, none of them provide empirical evidence on how climate change affects developed and developing countries differently. Empirical analysis is crucial to confirm or reject these assertions and inform policy formulation. Therefore, this paper aims to fill this gap in the literature by examining the impact of climate change on economic outcomes, with an emphasis on developed and developing countries.

2.2 Theoretical framework

2.2.1 Environmental justice theory. We use two theories to explain the unfairness of climate change. The first theory is environmental justice theory, which examines the unequal distribution of environmental hazards and benefits within society (Schlosberg, 2004, 2007). When applied to climate change, this theory emphasises the disproportionate exposure of marginalised communities to climate impacts and the need for inclusive decision-making processes that prioritise their concerns (Sze and London, 2014). This theory highlights the unequal distribution of the consequences of climate change suggesting that high-emitting countries do not bear proportionate consequences of their actions towards climate change (Schlosberg, 2004, 2007; Sze and London, 2014). Environmental justice recognises that communities may experience multiple sources of pollution and environmental stressors simultaneously, leading to cumulative health effects that exacerbate existing inequalities. Marginalised communities often face disproportionate exposure to environmental hazards, such as pollution from industrial facilities, waste disposal sites or transportation corridors. This leads to adverse health outcomes and a reduced quality of life. Environmental justice advocates for fairness in the distribution of environmental resources and risks, ensuring that vulnerable populations are not disproportionately burdened by pollution or deprived of access to clean air, water and land (Bullard, 2000). It emphasizes the inclusion of affected communities in decision-making processes related to environmental policies and projects, empowering them to voice their concerns and preferences (Schlosberg, 2007). Environmental justice efforts often involve legal and policy advocacy to address systemic inequalities and promote equitable environmental outcomes. This includes litigation, community organising and policy reform initiatives.

2.2.2 Climate debt theory. Similar to environmental justice theory, the climate debt theory asserts that developed countries owe a debt to developing countries for the historical emissions that have contributed to climate change (Warlenius, 2018). The theory posits that there is a climate injustice between developed and developing countries. This idea is consistent with environmental justice theory, which states that environmental disasters are unequal across different countries.

Climate debt theory is a concept within the broader discourse of climate justice that emphasises the historical and moral responsibility of developed countries for the greenhouse gas emissions that have led to climate change (Hickel, 2020). The theory argues that these countries, which have historically contributed the most to global carbon emissions through industrialisation and economic development, owe a debt to developing countries that are disproportionately affected by the impacts of climate change.

Developed countries, often referred to as "climate debtors," have benefitted from economic activities that generated substantial greenhouse gas emissions. These emissions have accumulated over time and significantly contributed to the current levels of atmospheric carbon dioxide. Developing countries, referred to as "climate creditors," have contributed less to global emissions but suffer the most severe consequences of climate change, including rising sea levels, extreme weather events and disrupted ecosystems. These impacts pose a threat to their development prospects, livelihoods and overall well-being (Fryett, 2021; Matthews, 2016).

As argued by Platje and Kampen (2016), the threats of climate change may be acknowledged but easily neglected. Based on both theories, we argue that the economic consequences of climate change are likely to differ between developed and developing countries. More specifically, we opined that developing countries, being the least contributors to climate change, bear the significant consequences of climate change. In contrast, developed countries bear the least negative consequences despite being the highest emitters. Therefore, we specify the hypothesis as follows:

H1. Climate change negatively affects developing (low emitters) than developed countries (high emitters).

3. Research design

3.1 Data selection

We used a large sample of 175 countries from 2008 to 2019. Our sample selection is limited to climate risk data. The climate risk data end in 2019. Notwithstanding this limitation, our sample comprises an adequate number of developed and developing countries to enable comparative analyses. We collect data from different sources, including Germanwatch, World Development Indicators and the World Governance Indicators.

3.2 Econometric identification strategy

Consistent with prior studies, we conducted various pre-regression analyses (Tawiah *et al.*, 2021) to determine the appropriate econometric modelling. In addition to the pairwise correlation matrix, we perform the Hausman (1989) to see if there is a correlation between the unique errors and the repressors in the model. The null hypothesis was that there was no correlation between the two. The results of the Hausman test led to the rejection of the null hypothesis, therefore we decided to use the fixed effect model. We specified two models as follows: the first model was used to establish the relationship between carbon emissions and climate risk:

$$\begin{aligned} Climate\ risk_{it} = {} & a + \beta_1 Carbon\ emission_{it} + \beta_2 Economic\ development_{it} \\ & + \beta_3 Economic\ growth_{it} + \beta_4 Population_{it} \\ & + \beta_5 Urban\ population_{it} + \beta_6 Population\ grwoth_{it} \\ & + \beta_7 Industralisaton_{it} + \beta_8 Industry\ grwoth_{it} \\ & + \beta_9 Total\ resource\ rent_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

After establishing the relationship between carbon emission and climate risk, we then specify our second model to estimate the economic consequences of climate risk:

$$\begin{aligned} Economic\ outcome_{it} = {} & a + \beta_1 Climate\ risk_{it} + \beta_2 Economic\ development_{it} \\ & + \beta_3 Economic\ growth_{it} + \beta_4 International\ trade_{it} \\ & + \beta_5 Foreign\ direct\ investment_{it} + \beta_6 Population_{it} \\ & + \beta_5 Urban\ population_{it} + \beta_6 Population\ grwoth_{it} \\ & + \beta_7 Total\ resource\ rent_{it} + \beta_8 Instiutiional\ quality_{it} \\ & + \varepsilon_{it} \end{aligned} \quad (2)$$

where economic outcome takes the variables of industrialisation, industry growth, economic growth and economic development in separate estimations.

3.3 Definition of variables

3.3.1 Variables of interest (dependent and independent variables). Climate risk: Climate risk refers to the potential negative impacts of climate change on various aspects of human society, the natural environment and the economy. These risks arise from changing climate patterns, such as rising temperatures, changing precipitation patterns, sea-level rise, increased frequency and intensity of extreme weather events (such as hurricanes, floods and droughts) and other related factors (Eckstein *et al.*, 2021). Consistent with prior studies (Ding *et al.*, 2021; Huang *et al.*, 2018; Liu *et al.*, 2023), we use the climate risk index by Germanwatch. The index also has the advantage of accuracy and reliability in the measurement (Ding *et al.*, 2021; Huang *et al.*, 2018). This is a two-year lagged index; hence, the 2021 index is based on actual events from 2019. We use climate risk as a dependent variable in Model 1 (EQ1) and as an independent variable in Model 2 (EQ2).

Economic outcome: We use four proxies to measure economic outcomes. *Industrialisation* is the value of the industry as a percentage of the GDP. According to the World Development Indicator, industrialisation comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. *Industry growth* is the annual change in industrialisation. We use both industrialisation and industry growth to examine the impact of climate risk on industrialisation and private sector growth. Arguably, industrialisation and the private sector remain key sectors for every country. The next two sets of economic outcomes are economic development and economic growth. *Economic development* is measured by GDP per capita, and *Economic growth* is annualised changes in GDP. The economic outcome variables are used as dependent variables in Model 2 (EQ2) and control variables in Model 1 (EQ1).

Control variables: Consistent with prior studies, we include a battery of variables to control for factors that are likely to influence the dependent variables (climate risk and economic outcomes). These control variables include population, population growth and urban population. Highly populated countries are expected to have high exposure to climate risk. We also include institutional quality, as good institutions will have a good system to adapt to climate risk and increase economic outcomes. The endowment and extraction of natural resources are also found to affect climate risk and economic outcomes. Natural resources-endowed countries have a high risk of climate disasters. However, they also have significant wealth to increase economic outcomes. We also include international trade and foreign direct investment to control the effect of external factors on domestic outcomes. Table 1 presents the definition, measurement and sources of the variables.

4. Results and discussion

4.1 Descriptive statistics and correlation matrix

The descriptive statistic is presented in Table 2. The statistics include the mean, standard deviation, 25th percentile, median and 75th percentile of the variables. The mean of *Climate disasters* is 87.79, indicating the severity of climate-related disasters in recent years. The high value of the 75th percentile of 117.3 and standard deviation of 40.07 suggest large variations across the sample. We also observe high variations in the other dependent variables.

We use the Pearson Pairwise correlation matrix to test the suitability of our variables for regression estimation in terms of multi-collinearity. The results are presented in Table 3. None of the independent and control variables has a high correlation above the threshold to post multi-collinearity issues (Field, 2000; Tabachnick and Fidell, 2013).

4.2 Baseline results

The premise of this study is climate injustice, which means that the least contributors to climate change are the highest sufferers of climate disasters. Therefore, we begin our analyses by establishing the relationship between climate risk and carbon emission. This analysis aims to test whether high-emitting countries experience severe climate disasters. In other words, does high carbon emission lead to large negative climate outcomes? If our argument of climate injustice holds, we expect a significant inverse relationship between carbon emissions and climate risk. The results are presented in Column 1 of Table 4. We include the year effect to control for the time-variant effect in the estimations. The robust standard errors are clustered at the country level. The coefficient of carbon emission is negative and highly significant at 1%. The inverse relationship between carbon emission and climate risk suggests that high-carbon-emitting countries are less likely to experience climate-related disasters. Therefore, the results in Table 4 provide empirical support to the premise that climate change exerts unfair consequences regarding the contributors. In effect, compared with other countries, high-emitting countries experience and bear the least consequences of decades of unsustainable living. This is consistent with environmental justice and climate debt theories, which suggest that the consequences of climate change are uneven among emitting countries (Hickel, 2020; Warlenius, 2018).

Having established the relationship between carbon emission and climate risk, we examine the effect of climate risk and some key economic indicators. The purpose of these analyses is to establish the economic consequences of climate risk. We use the following variables as a proxy for development and economic indicators: industry growth, industrialisation, GDP per capita and GDP growth. The results are presented in Columns 2–4 of Table 4. The coefficient of climate risk is negative and significant in all three columns. The

Table 1. Variable definition and sources

Variable name	Definition	Source
Carbon emission	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement scaled by per capita. We use the log format	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Climate risk	The extent to which countries have suffered direct loss associated with extreme weather-related events such as storms, floods and heat waves	Germanwatch climate risk index https://www.germanwatch.org/en/cri
Economic development	Gross domestic product divided by the population (log)	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Economic growth	Annualised GDP growth rate	World development indicator https://databank.worldbank.org/source/world-development-indicators#
International trade	The sum of import and export as a percentage of gross domestic product	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Foreign direct investment	The inflow of investments from abroad as a percentage of gross domestic product	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Population	The estimated number of people living in the country	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Urban population	The estimated number of people living in the urban cities of the country	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Population growth	Annualised estimate changes in the population	World development indicators https://databank.worldbank.org/source/world-development-indicators#

(continued)

Table 1. Continued

Variable name	Definition	Source
Industrialisation	It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Industry growth	Annual growth rate for industrial (including construction) value added based on constant local currency	World development indicators https://databank.worldbank.org/source/world-development-indicators#
Institutional quality	The average of the six world governance indicators	World development indicators https://databank.worldbank.org/source/world-development-indicators#

Source: Authors' own creation

Table 2. Descriptive statistics

Variables	(1) Mean	(2) SD	(3) p25	(4) p50	(5) p75	(6) Min	(7) Max
Economic growth	4.005	5.631	1.487	3.578	5.917	−50.34	1.0e + 11
Carbon emission	40.69	502.9	0.657	2.693	6.483	0.0207	9,139
Foreign direct investment	6.103	17.90	1.376	3.122	6.417	−57.53	449.1
Population growth	1.953	7.849	0.448	1.248	2.259	−5.280	109.2
Urban population	57.36	23.25	37.92	57.12	76.86	9.617	100
Industrialisation	26.26	13.06	17.92	24.37	31.40	0.008	86.67
Industry growth	3.664	10.75	−0.415	3.181	6.998	−75.05	162.3
Natural resources	7.363	11.34	0.323	2.087	9.923	0	81.91
Climate risk	87.79	40.07	56	84.50	117.3	0	179.2
Institutional quality	−0.0201	0.886	−0.666	−0.177	0.669	−2.000	1.889
Population	15.49	2.416	14.26	15.78	17.09	3.981	21.07
Economic development	8.585	1.566	7.408	8.631	9.735	−0.666	11.73
International trade	91.33	55.64	56.40	80.61	108.9	1.219	442.6

Notes: This table presents the descriptive statistics of the variables used in the estimations. The definition and measurements of the variables are presented in Table 1
Source: Authors' own creation

Table 3. Correlation matrix

Variable name	1	2	3	4	5	6	7	8	9	10	11	12
Climate risk	1											
Carbon emission	0.06	1										
Economic development	0.08	0.66	1									
Economic growth	−0.02	0.36	−0.34	1								
Population	−0.28	−0.26	0	−0.48	1							
Urban population	0.16	0.71	0.54	0.04	−0.01	1						
Population growth	0.22	0.3	−0.39	0.55	−0.44	−0.05	1					
Industrialisation	0.18	0.23	0.16	−0.14	0.3	0.18	−0.1	1				
International trade	0.2	0.33	0.35	0.02	−0.42	0.28	−0.08	−0.06	1			
Foreign direct investment	0.06	0.07	0.09	0.02	−0.14	0.09	−0.02	−0.12	0.29	1		
Industry growth	−0.01	−0.1	−0.2	0.13	−0.01	−0.14	0.15	0	0.02	0.02	1	
Natural resources	0.33	−0.02	−0.13	−0.04	0.12	0	0.05	0.65	−0.11	−0.06	0.09	1
Institutional quality	0.01	0.54	0.76	−0.04	−0.21	0.52	−0.1	−0.21	0.38	0.14	−0.13	−0.42

Notes: This table presents the Pearson pairwise correlation matrix among the variables used in the estimations
Source: Authors' own creation

results suggest that climate risk retard different areas of development, including industrialisation. The occurrence of climate-related disasters leads to loss of income and a high number of deaths.

Further, climate-related disasters such as floods and bushfires destroy major infrastructures such as transport network systems and factories. According to the Germanwatch Climate Risk Report, between 2000 and 2019, about 11,000 climate-related disasters claimed over 475,000 lives and caused losses of about $2.56tn (Eckstein *et al.*, 2021). In addition to destroying

Table 4. Baseline results

Variables	(1) Climate risk	(2) Industrialisation	(3) Industry growth	(4) Economic development	(5) Economic growth
Carbon emission	−3.911** (−2.425)				
Climate risk		−0.015** (−2.185)	−0.024** (−2.119)	−0.012*** (−3.695)	−0.008** (−1.990)
Economic development	3.285 (0.837)	4.997*** (4.502)	−1.423 (−1.343)		
Economic growth	−0.250** (−2.085)	0.048** (1.984)	1.677*** (16.848)		
International trade		0.040** (2.551)	0.016*** (2.664)	0.004*** (7.598)	0.032*** (3.501)
Foreign direct investment		0.006 (0.819)	0.009 (0.349)	0.000** (2.176)	0.002** (2.221)
Population	1.577*** (2.509)	7.869** (1.985)	2.453 (0.930)	−0.354** (−2.368)	−4.831* (−1.894)
Urban population	0.157** (2.285)	−0.139 (−1.335)	−0.107 (−0.872)	0.012 (1.585)	−0.009 (−0.137)
Population growth	−0.092 (−0.226)	0.271** (2.447)	−0.068 (−0.374)	0.010* (1.748)	−0.094 (−0.451)
Natural resources	0.023** (2.144)	0.500*** (6.218)	−0.092 (−1.512)	−0.004 (−1.573)	0.023 (0.518)
Institutional quality		2.568 (1.201)	−1.440 (−0.867)	0.337*** (5.862)	0.561 (0.464)
Industrialisation	−0.330* (−1.896)			0.017*** (6.623)	0.190*** (3.671)
Industry growth	0.105** (2.341)				
Constant	373.870* (1.917)	−216.427*** (−3.283)	−4.269 (−0.101)	13.093*** (5.895)	75.429* (1.918)
Observations	2,343	2,156	2,144	2,157	2,156
R-squared	0.048	0.493	0.551	0.595	0.145
Number of countries	175	164	163	164	164

Notes: This table presents the baseline estimations of the relationship between climate risk and economic outcomes. Robust *t*-statistics are given in parentheses: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Variable definitions and sources are presented in Table 1
Source: Authors' own creation

infrastructures, climate-related disasters also reduce consumption and cripple productivity in the country. These concomitant outcomes of climate disasters decrease a country's industrialisation and rate of growth. Our results are consistent with prior studies that climate-related disasters negatively impact the country's economic performance. Raddatz (2007) reports a decrease in GDP per capita for least developed countries. In Argentina, González *et al.* (2021) show that climate-related disaster is associated with a significant reduction in economic growth at the district level.

In addition to being statistically significant, our results provide useful information for economic decisions. Economically, a one basis point increase in climate risk will lead to a 1.95% decrease in industrialisation and a 2.58% decrease in industry growth [1]. This is alarming, given that the average industrialisation and industry growth are about 26.26% and 3.66%, respectively.

The results of many control variables are consistent with standard assumptions and existing literature. For example, we find that rapid extraction of natural resources is positive and significantly associated with high climate risk (Riebsame, 2019; Tompkins and Adger, 2004). Population and population growth increase the chances of climate-related disasters. Regarding the control variables in the effect of climate risk, we observe that trade and FDI are associated with different economic and development indicators. Industrialisation also increases economic growth and economic development. Arguably, high industrialisation creates jobs, increases consumption and thus generates high economic development.

4.3 Developed countries

In the preceding analyses, we have assumed that all countries are similar, and hence, the consequences of climate risk should be similar. Prior studies have shown that climate-related disasters are more severe for developing countries, though they are the least contributors to climate change (Auffret, 2003; Raddatz, 2007). However, the occurrence of climate-related disasters does not consider the development status of the country. Over the years, we have seen floods and droughts in the USA and Australia, which are developed countries. Similarly, we have seen the same climate-related disasters in Pakistan, Nigeria and Sudan, which are classified as developing countries. Therefore, this section tests whether the negative relationship between climate risk and carbon emission differs between developed and developing countries. We also examine the economic consequence of climate risk in these two sets of countries. The determination and classification of countries into developing and developed countries have always been a contention due to using different indicators. However, the United Nations annual outlook report has provided consistent classification over the years, which has been used widely in the literature (Tawiah, 2023; Tawiah and Gyapong, 2021). Therefore, consistent with prior studies, we group countries into developed and developing countries based on the United Nations classifications (United Nations, 2014).

Table 5 presents the results for developed countries. In Column 1, we establish the relationship between carbon emission and climate risk. The coefficient of climate risk is negative, though insignificant, suggesting that the level of carbon emission does not significantly relate to the level of climate risk. In other words, a country's carbon emissions do not indicate the probability of a climate-related disaster occurring in developed countries. This confirms our baseline findings that high-emitting developed countries are not at high climate risk compared to their annual carbon emission.

In Columns 2–5, we examine the effect of climate risk on economic development in developed countries. Unsurprisingly, we find that climate-related disaster occurrence does not significantly affect the key economic development indicators. The results suggest that climate-related disasters are less likely to limit development in these countries. We attribute

Table 5. Developed countries

Variables	(1) Climate risk	(2) Industrialisation	(3) Industry growth	(4) Economic development	(5) Economic growth
Carbon emission	−4.703 (−0.560)				
Climate risk		−0.006 (−0.443)	0.023 (0.851)	0.002 (1.339)	−0.005 (−0.339)
Economic development	16.577 (1.598)	5.565** (2.503)	−3.587 (−1.269)		
Economic growth	−0.351 (−1.093)	0.095 (1.490)	1.641*** (10.736)		
International trade		0.020 (0.856)	0.027 (1.280)	0.003*** (5.800)	0.046*** (3.347)
Foreign direct investment		0.019* (1.797)	0.093** (2.063)	0.000** (1.991)	0.054* (1.759)
Population	8.708 (0.342)	−1.569 (−0.541)	11.463 (1.523)	0.086 (0.336)	−0.743 (−0.184)
Urban population	−0.139 (−0.177)	−0.215 (−1.513)	−0.005 (−0.033)	0.023 (1.049)	−0.132 (−1.188)
Population growth	0.137 (0.207)	0.186** (2.569)	0.232 (1.252)	0.007 (0.998)	0.047 (0.244)
Natural resources	0.252 (0.435)	0.662*** (10.181)	−0.121** (−2.473)	−0.009** (−2.072)	0.035 (0.390)
Institutional quality		−5.131*** (−3.178)	4.896 (0.863)	0.486*** (5.657)	1.343 (0.914)
Industrialisation	−0.138 (−0.233)			0.026*** (5.574)	0.195* (1.740)
Industry growth	0.058 (1.071)				
Constant	−201.172 (−0.444)	−74.886 (−1.065)	−103.139 (−1.017)	5.921 (1.417)	15.146 (0.226)
Year effect	Yes	Yes	Yes	Yes	Yes
Observations	628	630	631	630	630
R-squared	0.165	0.708	0.460	0.625	0.495
Number of countries	46	46	46	46	46

Notes: This table presents the baseline estimations of the relationship between climate risk and economic outcomes in developed countries. Robust *t*-statistics are given in parentheses: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. Variable definitions and sources are presented in Table 1 these results to the predictability and preparedness in developed countries towards disasters. Most developed countries have adequate systems and infrastructures to forecast and hence make necessary preparations before the occurrence of natural disasters. These strategies limit the negative impact of climate-related disasters. Furthermore, most developed countries have risk-mitigating mechanisms such as insurance and rapid government support to deal with climate-related disaster fallout. These mechanisms and systems increase the climate adaptability in developed countries compared with developing countries.

4.4 Developing countries

The results of developing countries are presented in Table 6. We conduct similar estimations as done in the baseline and developed countries. In Column 1, we observe that the coefficient of carbon emission is negative and significant, suggesting that climate risk is relatively high for low-carbon-emitting countries. That is, the probability and severity of climate-related disasters occurring increases with low carbon emitting developing countries. This is contrary to the results of developed countries, where we find an insignificant relationship between carbon emissions and climate risk. The results provide further empirical support for the climate injustice argument.

The effect of climate-related disasters on economic development in developing countries is presented in Columns 2–5 of Table 6. Contrary to the findings of developed countries, we find a negative and significant impact of climate risk on economic development in developing countries. The negative and significant coefficient of climate risk in all four columns suggests that climate disasters are a significant setback for development in developing countries. In economic terms, an increase in climate risk leads to a 0.45% decrease in economic growth and a 3.7% decrease in industrialisation. Interestingly, developing countries contribute significantly less to climate change, yet it appears they bear the highest consequence of climate risk. For instance, in 2022, there were floods in the USA and Pakistan; however, the scenes from Pakistan highlighted the plight of developing countries in terms of climate-related disasters.

Similarly, there were droughts in Australia and Sudan; the losses and the catastrophic impact of the drought in Sudan were beyond comparison to droughts in Australia. In recent years, we have seen a similar pattern between the USA and Malawi regarding cyclones. These examples have raised concerns about the unfairness of climate change and the call for climate justice. Among the variables contributing to climate injustice is the lack of adequate systems and infrastructure in developing countries to cope with climate-related disasters. Unlike developed countries, developing countries do not have an adequate system to forecast and prepare for disaster. Also, there is a limited risk-mitigating mechanism towards disasters. Most developing countries do not have insurance towards disasters. Government response to disasters is slow and inefficient because of inadequate resources.

The results on developed and developing countries provide empirical support and lead to the acceptance of the hypothesis that climate change negatively affects developing (low emitters) than developed countries (high emitters). The results also collaborate with early commentary and reviews on climate injustice (*The Stern Review*). Our findings, therefore, contribute to the ongoing discussions about the ethical and moral dimensions of climate change and underscores the need for equitable and just solutions to address the challenges posed by global warming among developed and developing countries.

4.5 Robustness check: endogeneity – system generalised method of moments

Arguably, endogeneity is less likely to be an issue because reverse causality is less likely to exist. It is less plausible for economic indicators such as industrialisation, GDP per capita

Table 6. Developing countries

Variables	(1) Climate risk	(2) Industrialisation	(3) Industry growth	(4) Economic development	(5) Economic growth
Carbon emission	−1.983 (−0.673)				
Climate risk		−0.019** (−2.062)	−0.028* (−1.959)	−0.023** (−2.381)	−0.008** (−2.331)
Economic development	1.822 (0.443)	5.154*** (3.840)	−1.074 (−0.910)		
Economic growth	−0.264** (−1.992)	0.036 (1.471)	1.677*** (15.557)		
International trade		0.045*** (2.664)	0.021 (0.582)	−0.004*** (−5.532)	0.025** (2.254)
Foreign direct investment		0.003 (0.347)	−0.010 (−0.640)	−0.000* (−1.729)	−0.008 (−1.500)
Population	−19.114 (−1.207)	11.385** (2.292)	1.067 (0.327)	−0.614*** (−3.194)	−4.857 (−1.596)
Urban population	−0.115 (−0.168)	−0.110 (−0.839)	−0.190 (−1.170)	0.006 (0.806)	0.052 (0.686)
Population growth	0.179 (0.329)	0.075 (0.791)	−0.211 (−0.683)	0.012 (1.565)	−0.131 (−0.336)
Natural resources	−0.088 (−0.531)	0.455*** (5.204)	−0.072 (−0.959)	−0.004 (−1.261)	0.032 (0.644)
Institutional quality		4.052* (1.769)	−2.853* (−1.821)	0.304*** (4.598)	0.786 (0.545)
Industrialisation	−0.387** (−2.026)			0.016*** (6.113)	0.180*** (3.055)
Industry growth	0.128** (2.281)				
Constant	391.217 (1.594)	−272.146*** (−3.177)	10.237 (0.191)	16.938*** (5.892)	74.129 (1.589)
Year effect	Yes	Yes	Yes	Yes	Yes
Observations	1,715	1,526	1,513	1,527	1,526
R-squared	0.045	0.477	0.580	0.629	0.105
Number of countries	129	118	117	118	118

Notes: This table presents the baseline estimations of the relationship between climate risk and economic outcomes in developing countries. Robust *t*-statistics are given in parentheses: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. Variable definitions and sources are presented in Table 1 and GDP growth to increase the likelihood and severity of climate-related disasters. Further, including the country and year effect in the preceding estimations mitigates the potential endogeneity arising from the correlation between the time-invariant country fixed effect and the time-varying explanatory variables. Notwithstanding the above argument and robust estimations, there is a possible endogeneity effect because of the contemporary effects of the previous year's climate risk figures on the current year. The previous identification strategies are limited in addressing this potential issue (Arellano and Bond, 1991). Therefore, we use the two-step system generalised method of moments (S-GMM) to address this potential concern. The results are presented in Table 7. The results are qualitatively similar to the baseline results in Table 4, confirming that our negative relationship between carbon emission and climate risk and the economic effect is not sensitive to potential endogeneity.

5. Conclusion and policy implications

Climate change is often described as a global issue that affects everyone, regardless of their actions or circumstances. However, the impacts of climate change are not distributed equally across the globe or among different countries. Therefore, in this paper, we have examined the relationship between climate risk and carbon emission, as well as the economic consequences of climate risk.

We use a large sample of 175 developed and developing countries over a period of 13 years. Our results are as follows. First, we find that carbon emission is negatively and significantly associated with climate risk, suggesting that high-emitting countries are less exposed to frequent and severe climate-related disasters. Second, unsurprisingly, we find that climate risk is detrimental to industrialisation, economic development and economic growth. Third, in further analyses between developed and developing countries, we find that the results are more pronounced in developing countries than in developed countries. Climate risks do not exert any significant negative economic consequences in developed countries. Contrastingly, developing countries lose significantly because of the frequency and severity of climate-related disasters. Our results are robust to different econometric identification strategies and endogeneity checks using the system-generalised method of moments.

The unequal distribution of the impacts of climate change is primarily due to historical and current patterns of greenhouse gas emissions, which have been driven by industrialisation and economic growth in developed countries. These countries have also historically enjoyed the benefits of burning fossil fuels while emitting greenhouse gases that cause climate change. Meanwhile, many developing countries, which have contributed relatively little to greenhouse gas emissions, are now suffering the consequences of climate change. While climate change is not inherently fair or unfair, its impacts are distributed in a way that highlights existing inequalities and injustices.

Therefore, our results are consistent with the argument that climate change is unfair because those who are the most vulnerable and least responsible for it suffer the most. In contrast, those who are responsible have not always taken sufficient action to address the problem. Developing countries, for example, are often located in regions that are more susceptible to the effects of climate change, such as small island states, arid and semi-arid regions and coastal areas. They also have limited resources to adapt to the impacts of climate change or to mitigate their greenhouse gas emissions. On the other hand, developed countries have historically been responsible for the majority of greenhouse gas emissions and have had the financial and technological means to mitigate their emissions and adapt to the effects of climate change.

Our findings have significant policy implications. First, in both developing and developed countries, addressing the impacts of climate change on development requires a combination

Table 7. Robustness – endogeneity checks

Variables	(1) Climate risk	(2) Industrialisation	(3) Industry growth	(4) Economic development	(5) Economic growth
Carbon emission	−13.231*** (−5.705)				
Climate risk		−0.008*** (−2.840)	−0.009* (−1.863)	−0.001*** (−2.916)	−0.001** (2.038)
Economic development	4.215 (1.329)	3.069*** (5.281)	−0.432* (−1.668)		
Economic growth	−0.168* (−1.770)	−0.102*** (−5.989)	−0.076*** (−7.211)		
International trade		0.037*** (3.324)	0.023*** (6.265)	0.000 (0.820)	0.013*** (6.049)
Foreign direct investment		−0.024** (−2.435)	−0.010 (−0.971)	−0.001 (−0.979)	0.003 (0.680)
Population	−6.907*** (−6.994)	−1.380** (−2.099)	0.864*** (3.059)	−0.024 (−1.164)	0.367*** (4.976)
Urban population	0.601*** (4.124)	−0.005 (−0.204)	−0.043*** (−3.730)	0.030*** (15.713)	−0.037*** (−5.979)
Population growth	1.398* (1.654)	−0.279* (−1.745)	0.651*** (4.701)	−0.045*** (−2.721)	0.502*** (7.026)
Natural resources	0.842*** (3.819)	0.696*** (25.067)	0.008 (0.392)	0.005* (1.653)	−0.012 (−0.860)
Institutional quality		−3.551*** (−4.423)	−0.295 (−0.873)	0.945*** (21.541)	0.364** (2.367)
Industrialisation	0.371* (1.805)			0.021*** (6.371)	0.046*** (3.414)
Industry growth	−0.016 (−0.398)				
Constant	114.972*** (4.271)	−33.319*** (−5.294)	0.747 (0.318)	6.828*** (17.388)	−3.257*** (−2.816)
Observations	2,194	2,012	2,000	2,015	2,013
Number of countries	175	164	163	164	164

Notes: This table presents the endogeneity check using S-GMM. Robust *t*-statistics are given in parentheses: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

of strategies, including mitigation efforts to reduce emissions and adaptation measures to build resilience. International cooperation, technological innovation, financial support and policy frameworks play critical roles in helping countries navigate the challenges posed by climate change while promoting sustainable development.

Second, addressing climate injustice requires recognising disparities between developed and developing countries and taking steps to ensure that climate policies and actions prioritise the needs and rights of developing communities. This includes involving developing countries in decision-making processes, supporting adaptive capacity-building, providing financial assistance and pursuing equitable and sustainable development pathways that account for historical and current inequalities. International cooperation and global agreements, such as the Paris Agreement, aim to promote climate justice by recognising the differentiated responsibilities and capabilities of countries in addressing climate change to help achieve the Sustainable Development Goals.

Third, our results speak indirectly to why the world is not making a significant effort towards the deteriorating environment, probably because the causes of the problems are not the direct victims of its consequences. Even within the same countries, politicians and policymakers responsible for enacting regulations and tackling environmental problems are less affected by the wrath of climate change; hence, the journey towards environmental sustainability will continue to be a lip service with no significant action for better results.

Our study also extends the climate injustice theory and existing literature by empirically showing how the impact of climate change differs between developed and developing countries. Until now, climate injustice has largely taken the form of commentary without sufficient empirical evidence to support the arguments. Therefore, our study extends this line of literature and introduces new areas for future studies. We provide cross-national and comparative studies on the variations in climate impacts and best practices for addressing climate injustice in diverse contexts.

Based on our findings, we offer the following recommendations to developing countries. Developing countries should actively engage in international climate negotiations to ensure that the voices and concerns of developing nations are heard. They should advocate for fair and equitable climate policies that take into account historical emissions, differentiated responsibilities and the specific vulnerabilities of developing nations. Furthermore, developing countries should prioritise sustainable development by integrating climate considerations into national development plans and policies. They should focus on sustainable development practices that promote economic growth while minimising environmental degradation and greenhouse gas emissions. Also, they should develop and implement strategies to enhance resilience to the impacts of climate change such as investing in infrastructure that can withstand extreme weather events, implementing early warning systems and promoting sustainable agricultural practices. Developing countries should also advocate for and access international climate finance mechanisms to support adaptation and mitigation efforts. They can seek financial assistance to implement projects that enhance resilience and contribute to sustainable development.

While the study establishes a relationship between climate risk and carbon emissions, the causal direction of this relationship may not be fully addressed. The study primarily focuses on the relationship between climate risk, carbon emissions and economic development. Other important factors, such as adaptation strategies, mitigation efforts and socio-political dynamics, may also play significant roles in shaping outcomes related to climate change and deserve further investigation. These are potential areas that future studies could explore.

Future research can also examine how climate risk affects small and medium enterprises in comparison to large corporations. Additionally, other studies can investigate the impact of climate risk on different sectors of the economy. Furthermore, research can be conducted to develop comprehensive and context-specific metrics for assessing climate injustice. These metrics should consider factors such as social vulnerability, adaptive capacity, historical emissions and access to resources. They can then be used to inform policy decisions and measure progress over time. Future studies can also investigate the role of local and indigenous knowledge in understanding and responding to climate injustice. By exploring how traditional ecological knowledge and community-based strategies contribute to resilience and adaptation efforts, we can gain valuable insights.

Note

1. Consistent with prior studies (Adhikari and Agrawal, 2016; Tawiah and Gyapong, 2021), we calculate economic significance as coefficient × standard deviation.

References

Adhikari, B.K. and Agrawal, A. (2016), "Does local religiosity matter for bank risk-taking? ", *Journal of Corporate Finance*, Vol. 38, pp. 272-293, doi: 10.1016/j.jcorpfin.2016.01.009.

Ahmed, B. (2017), "Who takes responsibility for the climate refugees?", *International Journal of Climate Change Strategies and Management*, Vol. 10 No. 1, pp. 5-26, doi: 10.1108/IJCCSM-10-2016-0149.

Alemazung, J. (2010), "Post-colonial colonialism: an analysis of international factors and actors marring African socio-economic and political development", *The Journal of Pan-African Studies*, Vol. 3, pp. 62-84, available at: www.semanticscholar.org/paper/Post-Colonial-Colonialism%3A-An-Analysis-of-Factors-Alemazung/3c7b2be6a73e33f366c835ce06ff8a6dd6b2cbf3

Alesina, A. and Dollar, D. (2000), "Who gives foreign aid to whom and why? ", *Journal of Economic Growth*, Vol. 5 No. 1, pp. 33-63, doi: 10.1023/A:1009874203400.

Arellano, M. and Bond, S. (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *The Review of Economic Studies*, Vol. 58 No. 2, pp. 277-297, doi: 10.2307/2297968.

Auffret, P. (2003), *High Consumption Volatility*, World Bank Publications, Washington, DC, USA.

Bullard, R. (2000), *Dumping In Dixie: Race, Class, and Environmental Quality*, 3rd ed., Westview Press, Colombia.

Caney, S. (2021), "Climate justice", in Zalta, E.N. (Ed.), *The Stanford Encyclopedia of Philosophy (Winter 2021)*. Metaphysics Research Lab, Stanford University, available at: https://plato.stanford.edu/archives/win2021/entries/justiceclimate/

Ciplet, D., Falzon, D., Uri, I., Robinson, S., Weikmans, R. and Roberts, J.T. (2022), "The unequal geographies of climate finance: climate injustice and dependency in the world system", *Political Geography*, Vol. 99, p. 102769, doi: 10.1016/j.polgeo.2022.102769.

Ding, R., Liu, M., Wang, T. and Wu, Z. (2021), "The impact of climate risk on earnings management: international evidence", *Journal of Accounting and Public Policy*, Vol. 40 No. 2, p. 106818, doi: 10.1016/j.jaccpubpol.2021.106818.

Eckstein, D., Künzel, V. and Schäfer, L. (2021), "Global climate risk index 2021 | Germanwatch e.V", available at: www.germanwatch.org/en/19777

Field, A.P. (2000), *Discovering Statistics Using SPSS for Windows: Advanced Techniques for the Beginner*, SAGE, Washington, DC, USA.

Fryett, O. (2021), "Sharing the burden: climate responsibility beyond the nation-state", *Consilience*, Vol. 25, pp. 1-23.

Galeotti, M. and Lanza, A. (1999), "Richer and cleaner? A study on carbon dioxide emissions in developing countries1This study does not necessarily reflect the views of the international energy agency or any of its member countries", *1. Energy Policy*, Vol. 27 No. 10, pp. 565-573, doi: 10.1016/S0301-4215(99)00047-6.

Glaister, K.W., Driffield, N. and Lin, Y. (2020), "Foreign direct investment to Africa: is there a colonial legacy? ", *Management International Review*, Vol. 60 No. 3, pp. 315-349, doi: 10.1007/s11575-020-00415-w.

González, F.A.I., London, S. and Santos, M.E. (2021), "Disasters and economic growth: evidence for Argentina", *Climate and Development*, Vol. 13 No. 10, pp. 932-943, doi: 10.1080/17565529.2021.1873724.

Hausman, D.M. (1989), "Economic methodology in a nutshell", *Journal of Economic Perspectives*, Vol. 3 No. 2, pp. 115-127.

Heil, M.T. and Wodon, Q.T. (1997), "Inequality in CO2 emissions between poor and rich countries", *The Journal of Environment and Development*, Vol. 6 No. 4, pp. 426-452, doi: 10.1177/107049659700600404.

Hertel, T.W. and Rosch, S.D. (2010), "Climate change, agriculture, and poverty", *Applied Economic Perspectives and Policy*, Vol. 32 No. 3, pp. 355-385.

Hickel, J. (2020), "Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary", *The Lancet Planetary Health*, Vol. 4 No. 9, pp. e399-e404, doi: 10.1016/S2542-5196(20)30196-0.

Huang, H.H., Kerstein, J. and Wang, C. (2018), "The impact of climate risk on firm performance and financing choices: an international comparison", *Journal of International Business Studies*, Vol. 49 No. 5, pp. 633-656, doi: 10.1057/s41267-017-0125-5.

Hunter, A. (2009), "Soft power: China on the global stage", *The Chinese Journal of International Politics*, Vol. 2 No. 3, pp. 373-398, doi: 10.1093/cjip/pop001.

Jauch, H. (2011), "Chinese investments in Africa: twenty-first century colonialism?", *New Labor Forum*, Vol. 20 No. 2, pp. 49-55, doi: 10.4179/NLF.202.0000008.

Kaczan, D.J. and Orgill-Meyer, J. (2020), "The impact of climate change on migration: A synthesis of recent empirical insights", *Climatic Change*, Vol. 158 No. 3, pp. 281-300, doi: https://doi.org/10.1007/s10584-019-02560-0.

Liu, F., Tawiah, V., Zakari, A. and Alessa, N. (2023), "The impact of climate disaster on international trade: evidence from developed and developing countries", *Journal of Environmental Management*, Vol. 342, p. 118308, doi: 10.1016/j.jenvman.2023.118308.

Magazzino, C. (2023), "The inextricable link among climate change, pandemic, migrations, and geopolitics: how artificial intelligence can help us", in Benítez-Andrades, J.A., García-Llamas, P., Taboada, Á., Estévez-Mauriz, L. and Baelo, R. (Eds), *Global Challenges for a Sustainable Society*, Springer International Publishing, London, UK, pp. 216-222, doi: 10.1007/978-3-031-25840-4_26.

Magazzino, C. (2024), "Ecological footprint, electricity consumption, and economic growth in China: geopolitical risk and natural resources governance", *Empirical Economics*, Vol. 66 No. 1, pp. 1-25, doi: 10.1007/s00181-023-02460-4.

Mahapatra, B. and Irfan, M. (2021), "Asymmetric impacts of energy efficiency on carbon emissions: a comparative analysis between developed and developing economies", *Energy*, Vol. 227, p. 120485, doi: 10.1016/j.energy.2021.120485.

Matthews, H.D. (2016), "Quantifying historical carbon and climate debts among nations", *Nature Climate Change*, Vol. 6 No. 1, p. 1, doi: 10.1038/nclimate2774.

Meikle, M., Wilson, J. and Jafry, T. (2016), "Climate justice: between mammon and mother earth", *International Journal of Climate Change Strategies and Management*, Vol. 8 No. 4, pp. 488-504, doi: 10.1108/IJCCSM-06-2015-0089.

Mele, M., Gurrieri, A.R., Morelli, G. and Magazzino, C. (2021), "Nature and climate change effects on economic growth: an LSTM experiment on renewable energy resources", *Environmental Science and Pollution Research*, Vol. 28 No. 30, pp. 41127-41134, doi: 10.1007/s11356-021-13337-3.

Mendelsohn, R. (2009), "The impact of climate change on agriculture in developing countries", *Journal of Natural Resources Policy Research*, Vol. 1 No. 1, pp. 5-19, doi: 10.1080/19390450802495882.

Nath, P.K. and Behera, B. (2011), "A critical review of impact of and adaptation to climate change in developed and developing economies", *Environment, Development and Sustainability*, Vol. 13 No. 1, 141-162, doi: 10.1007/s10668-010-9253-9.

Nordhaus, W.D. (2006), "Geography and macroeconomics: new data and new findings", *Proceedings of the National Academy of Sciences*, Vol. 103 No. 10, pp. 3510-3517, doi: 10.1073/pnas.0509842103.

Platje, J. (Joost) and Kampen, R. (2016), "Climate justice from a club good perspective", *International Journal of Climate Change Strategies and Management*, Vol. 8 No. 4, pp. 520-538, doi: 10.1108/IJCCSM-11-2014-0131.

Raddatz, C. (2007), "Are external shocks responsible for the instability of output in low-income countries?", *Journal of Development Economics*, Vol. 84 No. 1, pp. 155-187, doi: 10.1016/j.jdeveco.2006.11.001.

Ravindranath, N.H. and Sathaye, J.A. (2002), "Climate change and developing countries", in Ravindranath, N.H. and Sathaye, J.A. (Eds), *Climate Change and Developing Countries*, Springer Netherlands, pp. 247-265, doi: 10.1007/0-306-47980-X_9.

Riebsame, W.E. (2019), *Drought And Natural Resources Management In The United States: Impacts And Implications of The 1987-89 Drought*, Routledge.

Schlosberg, D. (2004), "Reconceiving environmental justice: global movements and political theories", *Environmental Politics*, Vol. 13 No. 3, pp. 517-540, doi: 10.1080/0964401042000229025.

Schlosberg, D. (2007), *Defining Environmental Justice: Theories, Movements, and Nature*, OUP Oxford.

Shue, H. (1993), "Subsistence emissions and luxury emissions", *Law and Policy*, Vol. 15 No. 1, pp. 39-60, doi: 10.1111/j.1467-9930.1993.tb00093.x.

Sultana, F. (2022), "Critical climate justice", *The Geographical Journal*, Vol. 188 No. 1, pp. 118-124, doi: 10.1111/geoj.12417.

Sze, J. and London, J.K. (2008), "Environmental justice at the crossroads", *Sociology Compass*, Vol. 2 No. 4, pp. 1331-1354, doi: 10.1111/j.1751-9020.2008.00131.x.

Tabachnick, B.G. and Fidell, L.S. (2013), *Using Multivariate Statistics*, Pearson Education, New York, USA.

Tawiah, V. (2023), "The impact of IPSAS adoption on corruption in developing countries", *Financial Accountability and Management*, Vol. 39 No. 1, pp. 103-124, doi: 10.1111/faam.12288.

Tawiah, V. and Gyapong, E. (2021), "International financial reporting standards, domestic debt finance and institutional quality: evidence from developing countries", *International Journal of Finance and Economics*, Vol. 28 No. 3, pp. 2915-2936, doi: 10.1002/ijfe.2575.

Tawiah, V.K., Zakari, A. and Khan, I. (2021), "The environmental footprint of China-Africa engagement: an analysis of the effect of China – Africa partnership on carbon emissions", *Science of The Total Environment*, Vol. 756, p. 143603, doi: 10.1016/j.scitotenv.2020.143603.

Tompkins, E.L. and Adger, W.N. (2004), "Does adaptive management of natural resources enhance resilience to climate change?", *Ecology and Society*, Vol. 9 No. 2, available at: www.jstor.org/stable/26267677

United Nations (2014), "World economic situation and prospects 2014", *United Nations*, available at: www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf

Warlenius, R. (2018), "Decolonizing the atmosphere: the climate justice movement on climate debt", *The Journal of Environment and Development*, Vol. 27 No. 2, pp. 131-155.

Wood, B.T., Stringer, L.C., Dougill, A.J. and Quinn, C.H. (2018), "Socially just triple-wins? A framework for evaluating the social justice implications of climate compatible development", *Sustainability*, Vol. 10 No. 1, p. 1, doi: 10.3390/su10010211.

Wu, Y., Zhu, Q. and Zhu, B. (2018), "Comparisons of decoupling trends of global economic growth and energy consumption between developed and developing countries", *Energy Policy*, Vol. 116, pp. 30-38, doi: 10.1016/j.enpol.2018.01.047.

Further reading

Leakey, R.R.B., Mabhaudhi, T. and Gurib-Fakim, A. (2021), "African lives matter: wild food plants matter for livelihoods, justice, and the environment—a policy brief for agricultural reform and new crops", *Sustainability*, Vol. 13 No. 13, p. 13, doi: 10.3390/su13137252.

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