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Role of Institutions and Environmental Poverty in Influencing Climate-related Migration

Kateryna Shymanska

Prague University of Economics and Business, Faculty of International Relations, Prague, Czech Republic, email: kateryna.shymanska@vse.cz

Abstract

This study investigates the relationship between natural disasters, institutional factors, environmental poverty and climate-related migration. The analysis focuses on 112 countries, representing 95% of natural disasters globally from 1992 to 2021, using regression models and clustering countries by their vulnerability and resilience. Key findings show that although improved transport infrastructure can aid in recovery, it may also increase exposure to disaster-affected areas, causing higher mortality. At the same time, sanitation availability significantly reduces mortality and migration in affected regions. The study highlights the need for disaster response strategies tailored to countries' vulnerability levels while emphasising the role of institutions in mitigating climate-related migration and enhancing resilience. Policymakers should prioritise investments in resilient infrastructure, strengthen disaster preparedness strategies tailored to each country's vulnerability profile and focus on enhancing personal freedom, institutional trust and governance capacity. These measures can collectively reduce number of refugees, mitigate impacts of disasters and promote long-term stability in high-risk regions.

Keywords: Natural disasters, vulnerability, resilience, institution, environmental poverty, climate-related migration

JEL Classification: F22, Q54, O13

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1. Introduction

Environmental shocks and natural disasters pose significant challenges to sustainable development and human welfare. Therefore, the increasing frequency and intensity of natural disasters accompanied by inadequate institutional responses might force global migration; and the lack of effective strategies for managing displacement threatens socio-economic stability and human security. The paper aims to identify critical factors that influence migration patterns to provide actionable insights for policymakers to enhance disaster preparedness and resilience of countries for managing climate-related migration and fostering long-term stability in affected regions. This study attempts to fill gaps in the existing literature by providing a comprehensive analysis that includes economic and institutional factors influencing migration decisions.

Environmental security is increasingly prominent in global discussions on sustainable development (Biermann and Boas, 2010). Environmental events encompass short-term extreme climate occurrences, such as natural disasters, and long-term processes such as climate change. While the effects of natural disasters appear immediately, long-term climate change, including global warming, gradually transforms human environments. These transformations are driven by factors such as the reduction of habitable and arable land (Cai *et al*., 2016), rising sea levels (Lindsey, 2022), land loss (Adams and Kay, 2019), desert expansion (FAO, 2015) and degradation of natural resources, including destruction of flora and fauna, shifting climate zones and deforestation. The economic toll of extreme climate events is substantial, with estimated costs of USD 2.86 trillion between 2000 and 2019 (Newman and Noy, 2023). Natural disasters also cause imbalances and disruptions in economic structures (Gagliardi *et al*., 2022), undermining national resilience and eroding global competitiveness.

The challenging sanitary and epidemiological conditions are exacerbated by climate threats, particularly in regions with lower levels of socio-economic development. As of 2022, the UN reports that 2.2 billion people lack access to safely managed drinking water and 4.2 billion people lack access to sanitation services (UN, n.d.). Natural disasters and long-term climate change further erode or destroy the economic potential of affected countries and regions. The devastation caused by natural disasters and global climate change has intensified, with these destructive events occurring more frequently (Zaman and Raihan, 2023). Between 1992 and 2021, the world experienced 10,140 natural disasters, affecting nearly 5.9 billion people (UN, n.d.). The consequences have grown increasingly severe, mainly due to the destruction of economic resources, habitats, infrastructure and the disruption of supply chains. Sudden climatic threats, such as natural disasters, exacerbate environmental issues and accelerate destructive long-term climate change, triggering spontaneous mass migration (Oliver-Smith, 2019; Mbaye and Okara, 2023). It leads to an immediate redistribution of human resources across countries and regions, increasing the migration burden on host countries, overcrowded housing, strained transportation and social infrastructure, increased government expenditures, spread of atypical diseases and even heightened violence (Abel *et al*., 2019).

Understanding a country's risks from natural disasters and crisis response capacities is crucial for designing effective policies to manage these challenges. Developing countries are particularly vulnerable, as responding to disasters is more economically challenging (Cai *et al*., 2016). Countries must mitigate the humanitarian impacts by ensuring safety and wellbeing of affected populations while efficiently allocating resources for emergency aid, shelter and long-term solutions for displaced individuals.

According to the COP28 Declaration on Climate, Relief, Recovery and Peace, 93 countries have called for "bolder collective action to build climate resilience at the scale and speed required in highly vulnerable countries and communities, particularly those threatened or affected by fragility or conflict, or facing severe humanitarian needs" (UN, 2023). Understanding a country's role and capacities in managing the consequences of natural disasters is also vital to developing and implementing preventive and adaptive strategies that minimise the negative impacts of climate-related migration. It includes building resilient infrastructure for humanitarian and housing purposes and reducing households' vulnerability to environmental threats, enabling more effective long-term planning and crisis response. To integrate the idea discussed by Luo *et al*. (2024) into our study, we must conclude that institutional governance frameworks notably affect entities' capacities in adaptation to external shocks, such as environmental crises, by shaping their capability to manage resources and introduce responsive strategies. Therefore, assessing the risks of natural disasters and evaluating countries' resilience factors are essential for informed decision making during crises.

The primary objective of this research paper is to examine the relationship between natural disasters, institutional factors, environmental poverty and climate-related migration, focusing on:

1) Understanding variability in disaster impacts and how differences in countries' vulnerability and resilience influence disaster mortality and migration rates.
2) Investigation of how institutional factors, such as governance capacity, institutional trust and personal freedoms, mitigate the effects of disasters.
3) Evaluation of the significance of environmental poverty indicators (access to clean water, sanitation, food security) in shaping disaster consequences and migration flows.
4) Offering recommendations for policymakers on increasing the country's resilience by enhancing disaster preparedness.

Resilience theory was chosen as a theoretical framework for the present study. Based on it, the main assumptions and research questions were formulated. The contributions of this study lie in its comprehensive approach, combining quantitative analysis and clustering countries by disaster resilience. The novelty of this work is in its focus on the intersection of institutional quality, disaster management and migration, revealing how personal freedom, institutional trust and sanitation availability play critical roles in shaping migration dynamics. This research fills a gap by offering insights for policymakers on improving disaster preparedness, reducing mortality and addressing climate-related migration through targeted institutional interventions.

The study is organised into six sections, beginning with the Introduction. The following section reviews the literature on natural disasters and their consequences, climate-related migration and resilience theory, selected as a research theoretical framework; it also describes the knowledge gap, research assumptions and questions. The Methodology section outlines the research methods, data sources, limitations and hypotheses. The Results section presents data on impacts of natural disasters across countries and factors driving variations in these impacts. Discussion focuses on analysing results of previous studies regarding social and economic consequences of natural disasters and formulating possible institutional responses. The final section offers conclusions about the results, underscoring the role of institutions in managing climate-related migration and underlining the limitations of the present study and remedies to them.

2. Literature Review

2.1 Natural disasters and their consequences

According to Newman and Noy (2023), extreme weather phenomena cannot be considered disasters automatically; however, in their definition, the authors underscored that an intersection of weather-driven hazard with vulnerable and exposed population makes the extreme weather event become a disaster. Natural disasters cause significant disruptions to economic systems, negatively affecting assets, production, outputs and consumption (Hallegatte, 2014), severely affecting vulnerable populations and employment (Marchiori *et al*., 2012; Wisner *et al*., 2004), governance structures and financial markets. Sutton and Arku (2022) even classified environmental shocks, such as natural disasters, as a distinct category of external shocks destabilising economic systems.

However, Breiling (2021) and Evgenidis *et al*. (2021) explained that while disasters can disrupt value chains and production, they can also drive economic changes and innovations, depending on the strength of local infrastructure and response strategies.

Beyond economic damage, natural disasters also affect people's wellbeing and decision making. Trinh *et al*. (2021) and Davlasheridze and Miao (2021) focused on how migration and public housing are affected by severe disasters, highlighting the need for proper planning in the case of a disaster and support for vulnerable populations. Berlemann and Eurich (2021) found that people living in high-risk areas are less satisfied with their lives, showing that disaster impacts go beyond financial losses.

Herrera-Almanza and Cas (2020) analysed the long-term impacts of natural disasters on human capital in the Philippines. Miyazaki (2023) analysed the role of disaster relief in post-disaster employment recovery in Japan, finding that effective disaster relief programmes can support employment recovery. At the same time, Beine and Parsons (2017) explored the contrast between long-term climatic factors and unexpected short-term shocks (natural disasters).

General economic effects of natural disasters were investigated by Gagliardi *et al*. (2022). They indicated two types of risks caused by natural disasters: physical risks (acute and chronic) and transition risks (related to mitigation policy efforts). In their analysis, the authors concluded that physical risks are associated with adverse economic impacts (primarily shocks to supply and demand), also posing challenges to sustainability of public finances.

Okubo and Strobl (2021) demonstrated that the impact on businesses differs across sectors, indicating that recovery strategies must be specific to each industry. Leoni and Boto-García (2023) explored the short-term effects of the La Palma Volcano eruption on hotel demand and labour markets. They found significant drops in international demand and employment in hospitality, revealing the vulnerability of this sector to sudden shocks. Exploring the impact of Hurricane Katrina, Rayamajhee *et al*. (2023) illustrated that it led to significant changes in formal institutions in Louisiana, such as a reduction in the size of the public sector and increased economic freedom scores, while informal institutions remained unchanged.

2.2 Climate-related migration

Methmann and Oels (2015) noted that the term “climate refugees” has largely been replaced by the official term “climate change-induced migration”. Numerous studies explore climate-related migration and its causes. Reuveny (2007) examined 38 migration cases driven by environmental push factors, including conflict. Abel *et al*. (2019) analysed refugee flows in 157 countries between 2006 and 2015, showing how climate change and conflict influence these movements. Using data from coastal Bangladesh, Adams and Kay (2019) found that migration is driven by the balance between mobility potential and the utility of remaining in disaster-prone areas. Migration timing and outcomes depend on adaptive capacity, with more considerable hazards prompting outflows, while smaller events may not (Gröschl and Steinwachs, 2016). Koubi *et al*. (2016) focused on micro-level migration factors in Vietnam, highlighting the role of individual, household and macro-level contextual factors, such as economic and political conditions.

Marchiori *et al*. (2012) identified two migration flows driven by weather anomalies: from rural to urban areas and from urban areas abroad. Beine and Parsons (2014) also noted that climatic factors could increase urbanisation. However, in their later research they stated that "the impact of climate change on migration is likely to depend on the characteristics of the affected country, in particular with respect to their level of income and the importance of the agricultural sector in the economy" (Beine and Parsons, 2017).

Cai *et al*. (2016) linked weather variations in origin countries to migration outflows, highlighting income (GDP per capita) as a key determinant, and examined the interactions between weather and agricultural dependence. Environmental events act as "stressors", motivating migration due to risks to wellbeing, lower income and reduced employment (Koubi *et al*., 2016). However, migration may also be a short-term adaptation strategy to natural disasters and global warming, with uncertain medium- and long-term effects (Berlemann and Steinhardt, 2017).

2.3 Natural disaster response

Beine and Parsons (2014) emphasised the critical role of destination countries' migration policies in shaping migration flows. Methmann and Oels (2015) noted that climate refugees are often seen as a policy challenge requiring attention. According to Cottier *et al*. (2022), the same hazard can have varied effects, causing massive damage in vulnerable communities while leaving more secure areas unaffected. Methmann and Oels (2015) framed resilience as a form of governance where national adaptation strategies can influence the number of displaced people (Marchiori *et al*., 2012). Furthermore, transitioning to renewable energy is crucial for countries vulnerable to climate change, as it can reduce migration by ensuring sustainable livelihoods (Kartal *et al*., 2023).

While numerous studies have explored the consequences of natural disasters, climate-related migration and institutional resilience (Norris *et al*., 2007; Christopherson *et al*., 2010; Ziyath *et al*., 2013), a significant gap remains in assessing countries' institutional capacities to manage post-disaster effects, particularly climate-related migration. Although many studies focus on migration factors and effects, there is a shortage of in-depth analysis of countries' institutional preparedness to respond to climate-related migration and tailor policies to these emerging challenges.

Arambepola *et al*. (2014) focused on difficulties managing large-scale disasters in densely populated cities. Arain (2015) highlighted the need for a knowledge-based approach when managing disaster consequences. He also discussed the importance of community involvement and informed decision making, aiming to enhance resilience of post-disaster communities. In a later study, Batica and Gourbesville (2016) underscored that resilience is a crucial measure of withstanding and recovery after natural hazards.

2.4 Theoretical framework: Resilience theory

Beine and Parsons (2014) employed the utility maximisation approach to study climate factors influencing international migration, highlighting its strength in predicting migrants' choices. However, their microeconomic approach assessed individual decisions based on "push and pull" factors, such as migration costs, distance and wage ratios. Similarly, Gröschl and Steinwachs (2016) used a gravity model, assuming that reduced labour productivity and wages due to hazards drive migration decisions. Cottier *et al*. (2022) examined climate-centric impact analyses, showing how environmental changes trigger migration through social and ecological factors. Our study adopts a broader perspective on climate-related migration, focusing on how countries' vulnerability to natural disasters threatens lives, health and the viability of living in specific regions.

The literature review identified gaps, particularly regarding the role of national institutional resilience as a "push" factor influencing climate-related migration and mitigating the consequences of natural disasters for displaced populations. This study adopts economic resilience theory, which emphasises the ability of a system to absorb shocks (OECD, 2013), adapt to changing conditions (Martin-Breen and Anderies, 2011) and maintain or recover functionality, suggesting that countries can manage climate-related migration. Zaman and Raihan (2023) explored community resilience theories, selecting "adaptive capacity" as a framework for governance and community development under disaster conditions while highlighting the importance of cultural and institutional factors in community resilience to natural disasters.

According to Martin-Breen and Anderies (2011), resilience of systems refers to the capacity to function under external shocks, while vulnerability is the opposite. The authors also noted that equilibrium analysis has limitations, as it often ignores system dynamics. The equilibrium approach examines pre-shock, shock and post-shock phases, viewing the region as a "container" for disasters (Christopherson *et al*., 2010). However, resilience conditions are not constant and instabilities may shift the system into a new behavioural regime (Gunderson, 2000). This approach helps describe a country's state before and after a disaster, assuming the pre-disaster state was an equilibrium. Natural disasters act as external shocks, prompting governments to implement policies that guide the system towards a new equilibrium.

Hill *et al*. (2008) examined different interpretations of regional economic resilience, describing it as the ability of a regional economy to maintain its condition, often seen as equilibrium, despite external shocks. They suggested that economies can avoid being displaced from equilibrium by absorbing shocks with minimal impact. Briguglio *et al*. (2009) argued that resilience can be strengthened through policies that enhance the economy's recovery and shock resistance. Sutton and Arku (2022) defined robustness as the ability of businesses, institutions and labour markets within regional economies to adapt and respond to shocks.

Wisner *et al*. (2004) measured vulnerability by immediate damage from hazards and delayed impacts on future livelihoods. Foster (2007) and Bristow and Healy (2020) have discussed various approaches to measuring economic resilience, including using indicators from different dimensions or more composite measures. Referring to Gunderson (2000), resilience in systems with multiple equilibria is defined by the magnitude of disturbance absorbed before the system shifts. Bruneau *et al*. (2003) conceptualised a more applicable approach, emphasising technical, economic, social and organisational dimensions, measuring disaster performance through robustness, redundancy, resourcefulness and response speed.

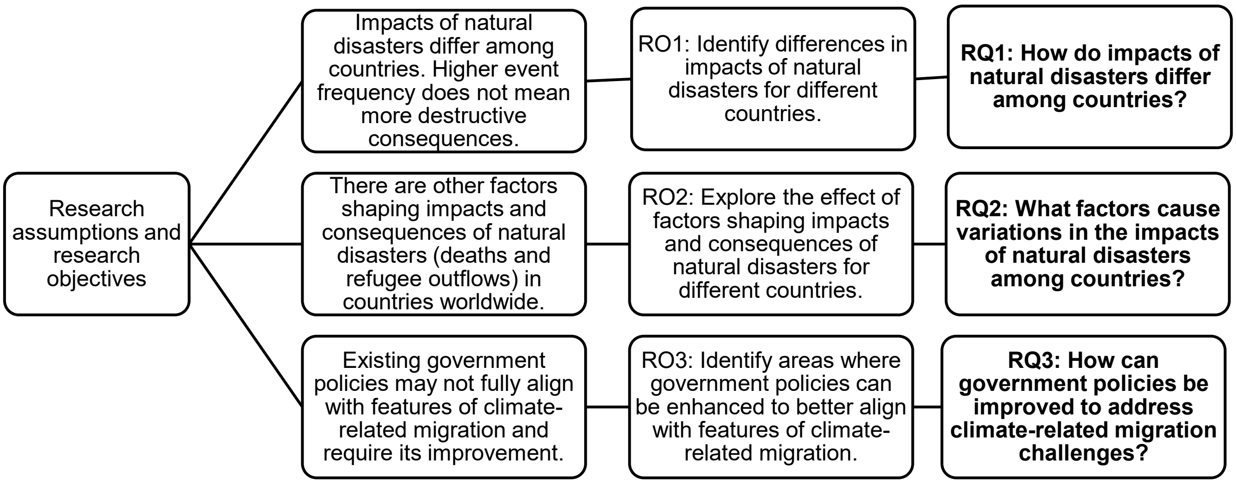
Despite the comprehensive research into impacts of natural disasters on migration and institutional resilience (Akter *et al*., 2023; Aslam *et al*., 2021; Breiling, 2021; Davlasheridze and Miao, 2021; Evgenidis *et al*., 2021; Herrera-Almanza and Cas, 2020; Miyazaki, 2023) and the drivers of climate-related migration (Abel *et al*., 2019; Adams and Kay, 2019; Beine and Parsons, 2014; Cai *et al*., 2016; Gröschl and Steinwachs, 2016; Koubi *et al*., 2016; Martínez-Zarzoso *et al*., 2023), several limitations in the existing studies must be underscored:

1) While emphasising the effects of environmental factors, there remains a notable gap in understanding how institutional frameworks in their multidimensional aspects (particularly the role of governance, level of institutional trust and spreading of personal freedoms) help mitigate environmental crisis risks and consequences.
2) Existing analyses often do not consider links between vulnerability and respective resilience across diverse economies due to limited data for some, especially low-income ones.
3) There is a lack of longitudinal studies discussing relationships between short-term disaster responses and long-term migration trends.
4) Existing studies assume that migration drivers are homogeneous across countries, ignoring the influence of demographic, infrastructural, political and cultural factors on migration motives.

These limitations result in a fragmented understanding of how governance structures in diverse economies and specific levels of institutional trust and personal freedoms influence resilience and the population's adaptive capacities during natural disasters. The present study aims to fill this gap by analysing institutional factors and their influence on climate-induced migration. It also offers new insights into migration management through enhancing disaster preparedness.

This study primarily focuses on two key terms: resilience and vulnerability, which form the basis for examining the institutional role of the state in climate-related migration. Applying this framework aims to help policymakers design strategies to mitigate natural disaster shocks and minimise the effects of climate-induced migration. In response to the outlined research gaps and based on the above-mentioned primary research objective, the following assumptions and research questions (RQ) have been developed (Figure 1).

Figure 1: Research assumptions, research objectives and research questions



Source: Author's own elaboration

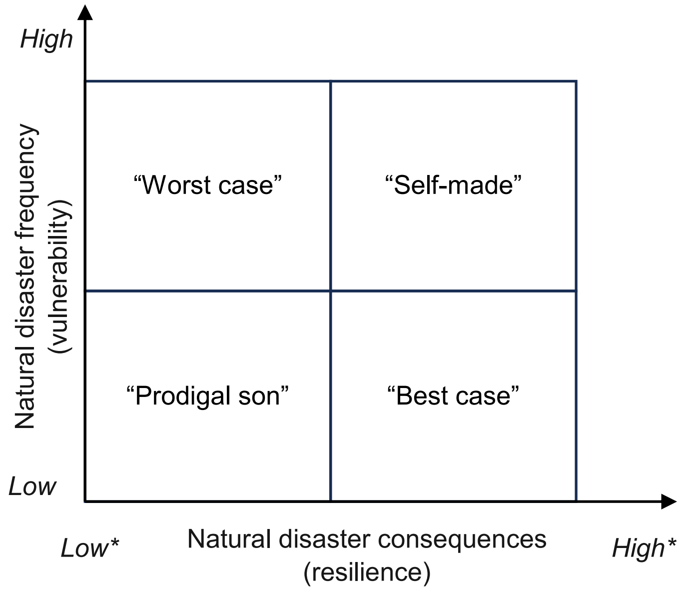
3. Methodology and Data

According to the research objectives, we use a mixed methodology, described below for the specific research questions.

3.1 Differences in impacts of natural disasters among countries

Hazards often have asymmetric impacts across affected populations and migration may be driven more by perceived problems than the hazard itself (Koubi *et al*., 2016). Sutton and Arku (2022) identified three possible regional economic reactions to shocks: resistance (minimal impact), resilience (significant impact but recovery) and non-resilience (severe impact with no recovery). Briguglio *et al*. (2009) referenced Briguglio (2004), categorising countries into four scenarios: "best case", "worst case", "self-made" and "prodigal son", based on their vulnerability and resilience. Wisner *et al*. (2004) defined vulnerability as the ability to foresee, manage, resist and recover from natural hazards. In natural disasters, vulnerability may be measured by frequency, while resilience can be assessed by the inverse relationship between casualties and injuries (UNDRR, 2020). For data comparability, the number of injuries is calculated per disaster. Using this approach, we conduct a cluster analysis to group countries based on vulnerability and resilience to natural disasters (Figure 2).

Figure 2: Four scenarios of countries' resilience against natural disasters



Notes: * Related to the level of resilience (opposite to the level of mortality caused by natural disasters). Clusters are named according to Briguglio *et al.* (2009).

Source: Author's own elaboration

Description of data used: To address RQ1, we employ a comparative analysis of appearance and consequences of natural disasters in countries worldwide. Natural disaster frequency and consequences are measured using data aggregated as of 31 March 2022 by the UN Statistics Division (Environment Statistics Section) and based on hazard definition and classification (UNDRR, 2020); (Figure 3).

Figure 3: Natural disasters covered in research

Climatological hazards (*CH*)
- Drought
- Glacial lake outburst
- Wildfire

Geophysical disasters (*GD*)
- Earthquakes
- Mass movements
- Volcanic activities

Hydrological disasters (*HD*)
- Flood
- Landslide
- Wave action

Meteorological disasters (*MD*)
- Extreme temperature
- Fog
- Storm

Source: Author's own elaboration based on UNDRR (2020)

Data were obtained from the UN (n.d.), which offers historical information about the above-mentioned hazards on a global scale, with a decade of periodicity. The current version of the dataset covers the period 1992–2021 and 214 countries and territories. For clustering countries according to their vulnerability to and resilience against natural disasters, we use the following formula, which assesses for the country *i* an average number of casualties and injured people (*DM*) per natural disaster based on occurrence (*O*) of all types of disasters during the three observed decades ($d = 3$).

$$DM_i = \frac{\sum_{d=1}^{3}(I_{HD} + I_{GD} + I_{CH} + I_{MD})}{\sum_{d=1}^{3}(O_{HD} + O_{GD} + O_{CH} + O_{MD})} \tag{1}$$

At the same time, to statistically smooth out the difference in the absolute values of the data, we use normalisation of the stimulator indicator for the average number of casualties and injured people (*DM*) and the number of disasters that occurred (*O*):

$$\overline{DM_i} = \frac{DM_i - DM_{min}}{DM_{max} - DM_{min}} \tag{2}$$

if $DM_i = DM_{min}$, then $\overline{DM_i} = 0$ and if $DM_i = DM_{max}$, then $\overline{DM_i} = 1$.

$$\overline{O_i} = \frac{O_i - O_{min}}{O_{max} - O_{min}} \tag{3}$$

if $O_i = O_{min}$, then $\overline{O_i} = 0$ and if $O_i = O_{max}$, then $\overline{O_i} = 1$

Our research focuses on the impact of natural disasters and the sample was selected to capture the most relevant observations. We ensured statistical significance by selecting countries that represent 95% of all natural disasters, resulting in a sample of 112 countries covering 99.7% of affected individuals. This approach allowed us to focus on the most vulnerable countries and draw meaningful conclusions. Using normalised indicators from Equations (2) and (3), we calculated an aggregate vulnerability index and ranked countries, grouping them into quartiles for further analysis.

An alternative clustering approach, based on statistical division by quartiles, is used to group countries and reflect the actual impact on them. Appendix 1 details the groups and sample characteristics. These clusters classify countries' resilience levels and assess the impact of climate-related migration.

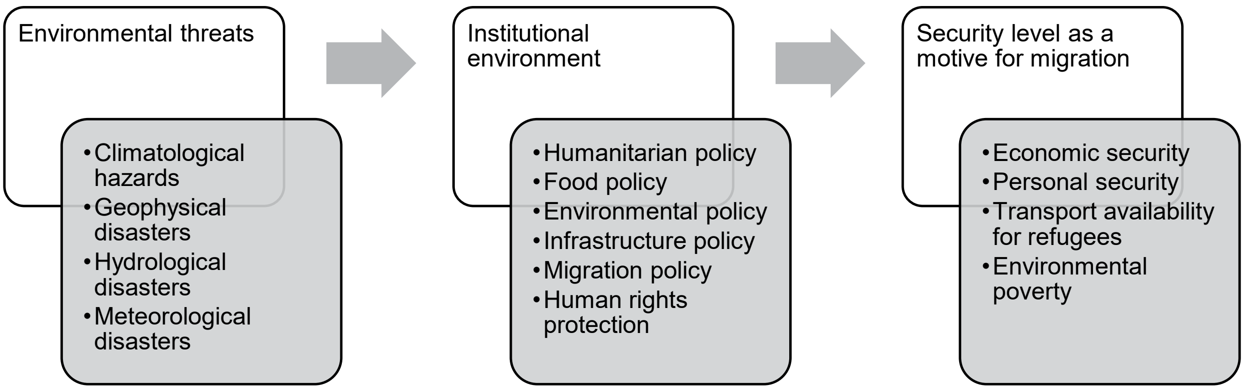
3.2 Factors of variation in impacts of natural disasters among countries

The literature review identified a range of factors considered in existing research. For instance, Reuveny (2007) highlighted side factors that increase migration incentives, such as overpopulation, underdevelopment, civil war, persecution, wealth disparity, poverty, unemployment and inflation. Marchiori *et al*. (2012) suggested that short-term migration would increase, but the poorest and most vulnerable might be unable to migrate. Martínez-Zarzoso *et al*. (2023) incorporated annual temperature, precipitation, hazard occurrences and development levels. However, Marchiori *et al*. (2012) also emphasised that good governance can counteract environmental migration drivers.

Environmental threats strain a country's capacity to provide secure habitats due to economic resource, infrastructure damage and human capital losses, leading to uneven relocations. These disruptions could be mitigated by data-driven policies addressing humanitarian, food, environmental, infrastructural and migration challenges. However, migration flows are difficult to predict due to various factors, such as destination countries, distance, diasporas and cultural proximity.

A connection between the environmental threats and the migration caused can be illustrated as follows (Figure 4).

Figure 4: Connection between environmental threats and institutional environment for ensuring human security



Source: Author's own elaboration

Data sources and limitations: The International Organization for Migration (2009) defined environmental migrants as individuals or groups forced to leave their homes due to sudden or gradual environmental changes that negatively affect their lives. Biermann and Boas (2010) recommended using the term "climate refugees" for those displaced by sea-level rise, extreme weather events or drought and water scarcity due to climate change. Our modelling framework aims to quantitatively assess the factors influencing refugee flows during the observed period (1992–2021).

Refugee flow data: Refugees are defined in this study according to the WB Group (2023), focusing on their numbers to measure climate-related migration, as refugee movements are more closely tied to natural disasters than to economic or social migration. Statistical data on refugee flows are only available as annual stock from a specific country of origin (WB Group, 2023). To address this, we calculate the average annual growth rate of refugee numbers (*RG*), which assesses the yearly change in refugee stock (*RS*) from the country *i* over a decade (from the year $t - 10$ to the year *t*), using the following formula:

$$RG_i = \sqrt[10]{\frac{RS_t}{RS_{t-10}}} \tag{4}$$

Natural disaster mortality data: Given the variation in natural disaster mortality data (per disaster), we use normalisation to scale this indicator from 0 to 100 within the country's sample (see Equation 2). This approach helps smooth out data variation, minimise its impact on the dependent variable and allow a comparative analysis using the model.

Environmental poverty: Environmental poverty, defined by a lack of access to clean water, sanitation and food insecurity, is assessed using indicators from the WB Group (2024a; 2024b; 2024c). These indicators reflect the percentage of the population without access to basic water and sanitation services and those experiencing insufficient food consumption.

Institutional development data: Assessing the influence of the institutional environment is challenging due to its intangible nature. For this research, we define institutions based on North (1990), referring to rules that structure human interactions. We use the Legatum Prosperity Index (Legatum Institute, 2024), which assesses a country's prosperity beyond economic indicators. This index covers key pillars such as governance, education, health, safety, personal freedom and social capital, providing a broad perspective on the institutional environment.

Based on the above data, the lists of variables included in the study are presented in Tables 1 and 2.

Table 1: Description of dependent variables

Variable (symbol)	Description (source) and anticipated impact
Natural disaster mortality (*DM*)	The impact of mortality due to natural disasters is calculated as a normalised indicator of the average number of people who died and were injured per disaster (varying from 0 to 100) in the present study (see Equation 2).
Average annual growth rate of refugee numbers (*RG*)	The annual stock growth of refugees worldwide from a particular origin country is calculated as an average annual growth rate (%) in the present study (see Equation 4).

Source: Author's own elaboration

Table 2: Description of independent variables included

Factor categories	Variable (symbol)	Description (source) of variable	Anticipated impact	
			Disaster mortality (***DM***)	Refugee numbers (***RG***)
Security level as a motive for migration				
Transport availability	**Transport availability (*TA*)**	Overall availability of different transport modes (based on logistics performance, airport and liner shipping connectivity, seaport services, quality of roads, road and rail density). Retrieved from Legatum Institute (2024): element "Infrastructure and Market Access".	$\beta_{TA,DM} < 0$	$\gamma_{TA,RG} > 0$
Economic security	**Macro-economic Stability (*MS*)**	Stability of overall economic conditions (based on GDP per capita growth and inflation volatility). Retrieved from Legatum Institute (2024): element of "Economic Quality" pillar.	$\beta_{MS,DM} < 0$	$\gamma_{MS,RG} > 0$
Personal security	**Personal freedom (*PF)***	The extent to which individuals enjoy personal freedom and liberties (absence of legal discrimination, individual rights, freedom of movement). "Personal Freedom" pillar is retrieved from Legatum Institute (2024).	$\beta_{PF,DM} < 0$	$\gamma_{PF,RG} > 0$
Institutional environment				
Institutional trust (*IT*)		The level of trust in institutions within the country (confidence in local police, politicians, financial institutions and banks, judicial system and courts, government and military). Retrieved from Legatum Institute (2024): element of "Governance" pillar.	$\beta_{IT,DM} < 0$	$\gamma_{IT,RG} > 0$
Environmental poverty				
Lack of clean water	**Water availability (*W*)**	% of people using at least basic water services. Retrieved from WB Group (2024a).	$\beta_{W,DM} < 0$	$\gamma_{W,RG} > 0$
Lack of sanitation	**Sanitation availability (*S*)**	% of people using at least basic sanitation services. Retrieved from WB Group (2024b).	$\beta_{S,DM} < 0$	$\gamma_{S,RG} > 0$
Food insecurity	**Under-nourishment (*H*)**	% of population whose habitual food consumption is insufficient. Retrieved from WB Group (2024c).	$\beta_{H,DM} < 0$	$\gamma_{H,RG} > 0$

Source: Author's own elaboration

Developing a regression model, we intend to analyse the relationship between the average annual growth rate of refugee numbers (*RG*) and the factors mentioned above:

$$DM = \beta_0 + \beta_1 \times TA + \beta_2 \times MS + \beta_3 \times PF + \beta_4 \times IT + \beta_5 \times W + \beta_6 \times S + \beta_6 \times H + \varepsilon \quad (5)$$

$$RG = \gamma_0 + \gamma_1 \times TA + \gamma_2 \times MS + \gamma_3 \times PF + \gamma_4 \times IT + \gamma_5 \times W + \gamma_6 \times S + \gamma_6 \times H + \varepsilon \quad (6)$$

We also need to mention the existing limitations of available data (Appendix 1), which led to the necessity of data clearance and using a narrower sample. The final sample for the analysis includes the following countries (Table 3).

Table 3: Quartiles of observed countries retained for further research

	Quartile 1 (Q1)	Quartile 2 (Q2)	Quartile 3 (Q3)	Quartile 4 (Q4)	Total
Number of countries	28	28	28	28	112
Share of natural disasters worldwide, % (N = 9280)	50.90	18.86	10.95	10.82	91.52
Share of casualties and injured people worldwide, % (N = 9280)	95.33	2.73	0.81	0.14	99.01

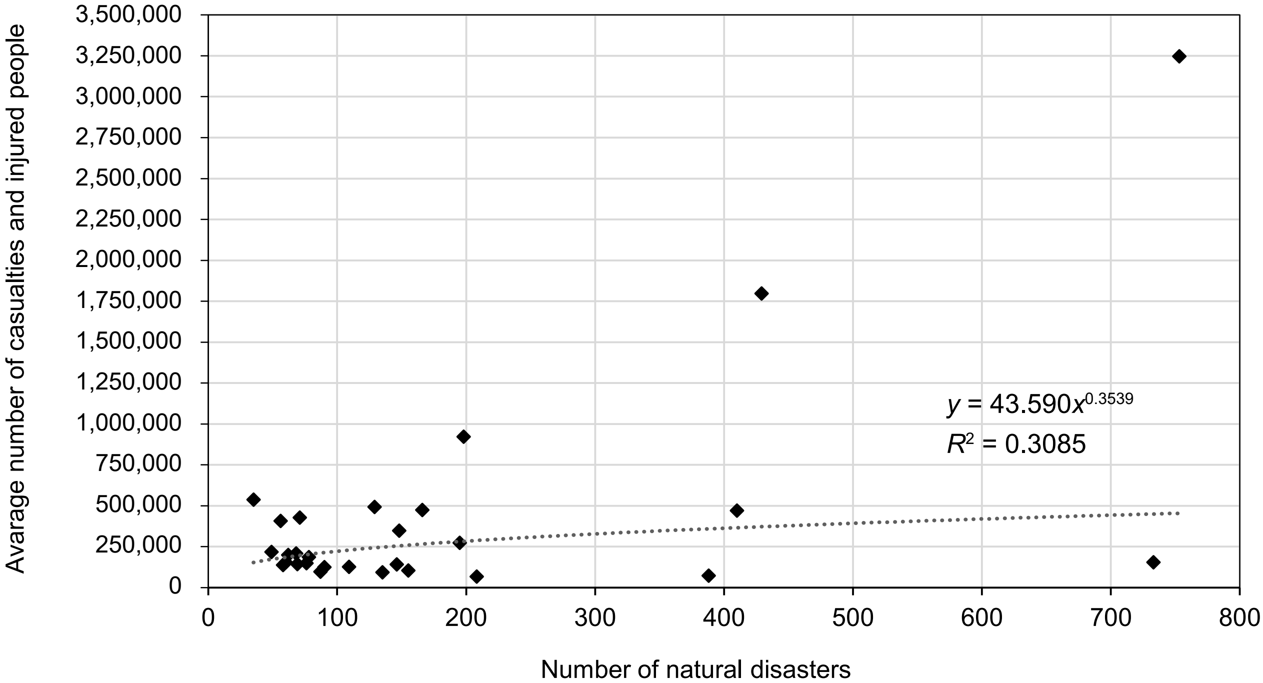
Source: Author's own calculations

4. Results

4.1 Differences in impacts of natural disasters among countries

Addressing RQ1, the following graphs depict the relationship between the number of disasters (*x*-axis) across countries and the average disaster mortality and injuries per event (*y*-axis) (Figures 5–8). Notably, Q1 represents the highest share of natural disasters among the quartiles. These 28 countries experience 50.9% of global natural disasters and suffer the most destructive consequences, namely 95.3% of global deaths and injuries. It is the so-called "worst case" scenario as described by Briguglio *et al*. (2009).

Figure 5: Quantitative overview of disaster-induced injuries: quartile 1 ("worst case")

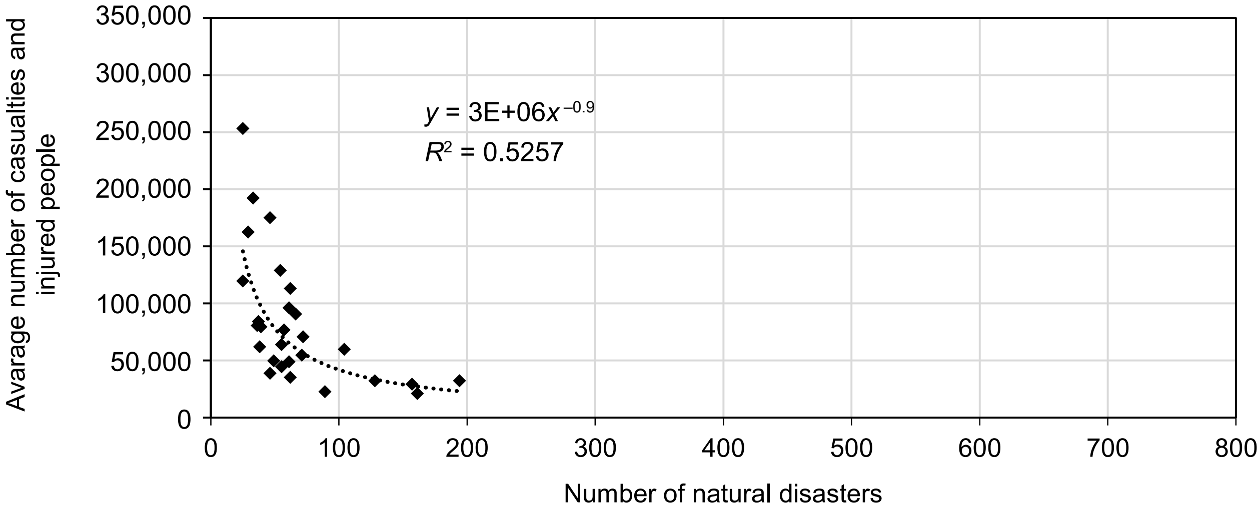


Source: Author's own calculations based on UN (n.d.)

Countries in this group show a slight increase in disaster mortality with more events, though the relationship is weak. Additional disasters likely strain resources, and despite improved response mechanisms, they are insufficient to significantly lower mortality rates given the frequency of events. It suggests a baseline level of vulnerability that maintains consistent mortality rates, regardless of the number of disasters.

Countries in Q2 generally show lower mortality per disaster as events increase. These 28 countries account for 18.86% of global natural disasters and 2.73% of worldwide deaths and injuries. It is called the "prodigal son" scenario (Briguglio *et al.*, 2009). Compared to Q1, Q2 experiences a smaller but notable share of natural disasters.

Figure 6: Quantitative overview of disaster-induced injuries: quartile 2 ("prodigal son")

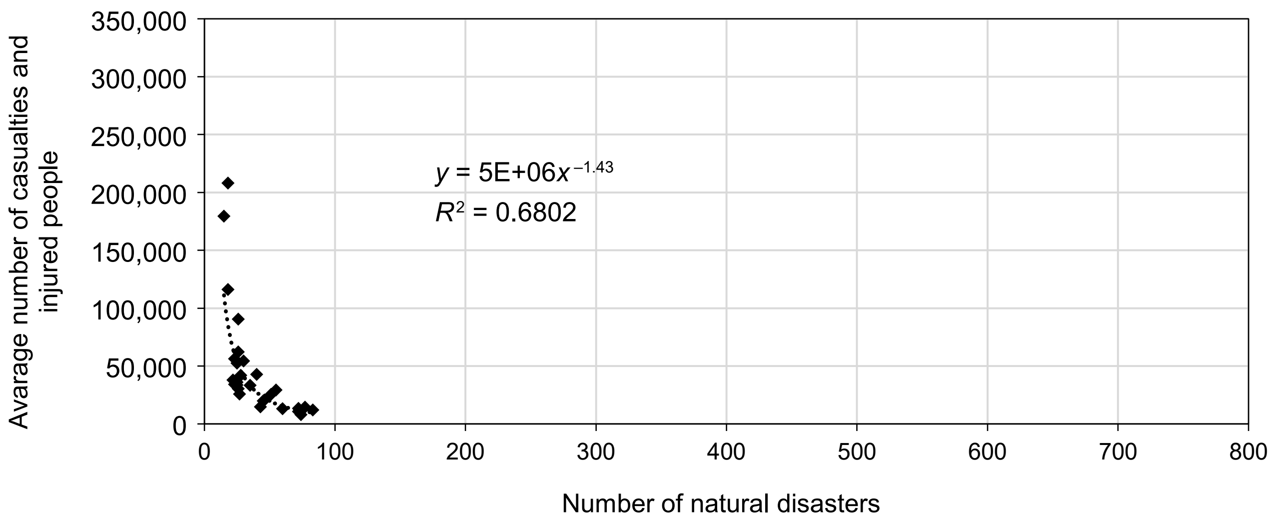


Source: Author's own calculations based on UN (n.d.)

These countries may develop better response strategies as they face disasters more frequently. The power law relationship indicates that the average mortality per event tends to decrease in countries with higher disaster frequency. With an exponent close to 1, this suggests that as disasters increase, average mortality declines slightly, implying that improved disaster management or preparedness reduces deaths per event.

Countries in Q3 experienced 10.95% of natural disasters worldwide and 0.81% of casualties and injured worldwide, which can be called "self-made" (Briguglio *et al.*, 2009).

Figure 7: Quantitative overview of disaster-induced injuries: quartile 3 ("self-made")

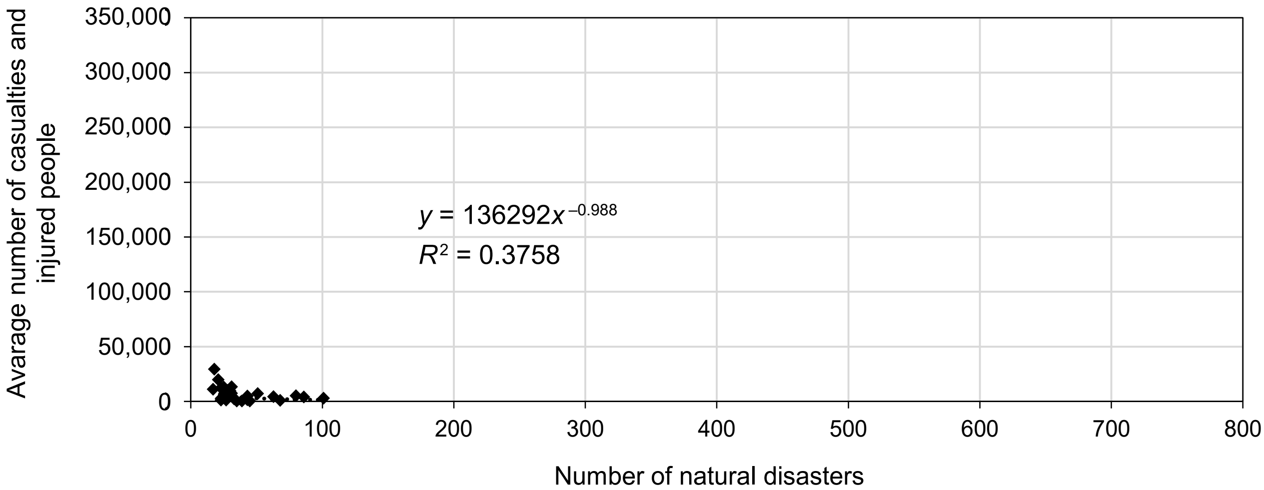


Source: Author's own calculations based on UN (n.d.)

When analysing the share of global deaths and injuries, Q3 shows a significantly lower percentage than Q2. It indicates that while Q3 experiences fewer natural disasters, its share of deaths and injuries is three times lower. Countries in Q3 may face challenges different than those in Q1 and Q2, suggesting that factors beyond disaster frequency, such as stronger institutions and resilience, play a role. These countries are likely better prepared, with efficient disaster response systems that reduce mortality as they gain more disaster experience.

Q4 has the lowest share of natural disasters among the four quartiles, representing the "best case" scenario (Briguglio *et al*., 2009). These countries account for 10.82% of global natural disasters but only 0.14% of worldwide deaths and injuries.

Figure 8: Quantitative overview of disaster-induced injuries: quartile 4 ("best case")



Source: Author's own calculations based on UN (n.d.)

These countries face much lower environmental risks and may not need to implement specific measures for national disasters. However, in Q4, the relationship between disaster frequency and mortality is less predictable. Despite overall stability, these countries can still experience high mortality during rare but extreme events.

This division of countries is used to study the effect of the mentioned factors on the number of people who died and were injured and the number of refugees from the entire area.

4.2 Factors of variation in impacts of natural disasters among countries

Many researchers investigate climate-related migration and its short-term and long-term drivers, including climate, economic and political factors. Cai *et al*. (2016) found a significant positive effect of rising temperatures on migration outflows in countries dependent on agriculture. Martínez-Zarzoso *et al*. (2023) confirmed this effect across most country groups, except upper-middle-income countries. However, when poverty is considered, higher average temperatures are linked to decreased emigration (Martínez-Zarzoso *et al*., 2023).

Gröschl and Steinwachs (2016) found that bilateral migration increases by 1.7% with a one-percentage-point rise in hazard events at the place of origin. They also noted that income levels shape migration motives: individuals from low-income countries typically do not migrate internationally after natural hazards. In contrast, outmigration from high-income countries decreases, possibly due to higher insurance coverage. Middle-income countries, however, show a 1.4% increase in international migration due to hazards. Coniglio and Pesce (2015) described migration as a population adaptation strategy to climate shocks, following Reuveny's (2007) approach. They identified conditions where migration is optimal for adaptation, depending on available resources such as financial assets, land, health, education and adaptability. For example, households with significant property ownership are less likely to migrate, whereas its absence increases migration potential.

Using the methods and data described above, we obtained results from multifactorial regressions for two dependent variables: natural disaster mortality (*DM*) and the average annual growth rate of refugee numbers (*RG*) across four quartiles of countries. The detailed results for each model and quartile are presented in Tables 4 and 5.

Analysing the full sample and the impact of factors on natural disaster mortality, we found somewhat controversial results. A positive and highly significant $\beta_{TA,DM}$ indicates that better transport availability is linked to higher disaster mortality, particularly in the most vulnerable Q1. It suggests that frequent disasters may hit densely populated or more accessible areas, leading to higher mortality. Conversely, a negative effect was observed in Q2 and Q3, where disasters were less frequent or better managed. It implies that other protective and welfare measures should complement transport availability during disasters.

Table 4: Regression results for Model 1: OLS, using observations 1–112 (dependent variable: *DM*)

	Full sample	Q1	Q2	Q3	Q4
Constant	−18.5091	−60.9204*	4.42306	−0.168559	0.809872*
TA	0.286329***	0.802613**	−0.0682958**	−0.0242772*	−0.00273440
MS	0.441476***	0.972075**	−0.0260895	0.0129319	0.00491198
PF	−0.337365***	−0.603679***	0.000800952	0.00982824	−0.00255172
IT	−0.0553231	−0.0517714	0.0712586**	−0.00297658	−0.00127893
W	0.269864*	0.515565	0.00172120	0.0328976	−0.00804496
S	−0.233764***	−0.500932*	−0.00469752	−0.0243260**	0.00264518
H	0.0690278	0.215776	−0.0651726	0.00829510	−0.00304929
Observations	102	28	24	24	26
R^2	0.336827	0.635794	0.608638	0.538422	0.466124

Notes: The estimation period is 1992–2021. Columns 1–4 give regression indicators for entire countries' quartiles defined in Appendix 2. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Names of quartiles are according to Briguglio *et al*. (2009).

Source: Author's own calculations

A positive and highly significant $\beta_{MS,DM}$ suggests that increased macroeconomic stability is linked to higher disaster mortality. It does not imply that wealthier, more stable countries necessarily face higher mortality; in Q1, larger and denser populations could be driving this effect. As expected, the coefficient for personal freedom ($\beta_{PF,DM}$) is negative and highly significant, indicating that greater personal freedom correlates with lower disaster mortality. This effect, confirmed in both Q1 and the general sample, suggests that countries with higher personal freedom may have better governance and disaster preparedness, reducing mortality.

Regarding environmental poverty, sanitation availability has a negative and highly significant coefficient (in the general sample, Q1 and Q3), indicating that better sanitation is linked to lower disaster mortality. It likely reflects the role of improved health infrastructure in mitigating disaster impacts.

In Q2, transport availability ($\beta_{TA,DM}$) shows a significant negative effect, suggesting that better access to transport reduces disaster mortality, likely due to improved evacuation and response capabilities. Personal freedom (*PF*) and sanitation availability (*S*) have minimal influence, implying that other factors may play a greater role in mortality outcomes for this group. Notably, the positive and significant effect of institutional trust ($\beta_{IT,DM}$) suggests that people in these countries may overly rely on institutions, underestimating disaster risks and leading to inadequate personal preparedness.

Q3 is notable for how countries manage natural disasters and reduce average mortality rates. In these countries, transportation and sanitation availability have the expected negative effect on mortality, reflecting a more robust population protection system, better disaster management capabilities and improved public health infrastructure contributing to disaster resilience.

In the most resilient Q4, we did not find any significant effects, most likely because of the low frequency of natural disasters and their low impact on life and wellbeing in these countries.

The next part of the analysis will focus on how the identified key factors affect refugee migration from their home countries.

Table 5: Regression results for Model 2: OLS, using observations 1–112 (dependent variable: *RG*)

	Full sample	Q1	Q2	Q3	Q4
Constant	1.43343	1.35571***	1.14699***	1.37040	2.16963***
TA	−2.54725e-05	−0.00137519	−0.00236778	−0.00136257	0.00636160
MS	−0.00133935	−0.00129400	−0.000513417	−0.00455614	0.00155084
PF	−0.00245937**	−0.00232091	−0.00188691	−0.00088869*	−0.00646217*
IT	−0.00229855*	−0.00276703	−0.00172570	−0.00183768*	−0.00827989*
W	−0.000351118	0.00415386	−0.000626281	−0.00374479	−0.00748382
S	−0.000575111	−0.00364550*	0.00255131	0.00208098	−0.000555165
H	−0.00114884	−0.00303546	0.00592042	−0.000873101	−0.00353555
Observations	102	28	24	24	26
R^2	0.181974	0.421313	0.467094	0.273749	0.312289

Notes: The estimation period is 1992–2021. Columns 1–4 give regression indicators for entire countries' quartiles defined in Appendix 2. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Names of quartiles are according to Briguglio *et al*. (2009).

Source: Author's own calculations

The results for the full sample show that transport availability, macroeconomic stability, personal freedom, water access, sanitation access and undernourishment all have negative but insignificant coefficients, indicating minimal impact. However, institutional trust has a significant negative coefficient at the 10% level, suggesting that higher trust slightly reduces refugee growth, though the effect is small.

The results for Q1 show that in the most vulnerable countries, only sanitation availability has a significant negative effect (at the 10% level), indicating that better sanitation reduces refugee migration in this quartile. Although the institutional trust coefficient is not statistically significant, it suggests a slight reduction in refugee growth with higher trust.

Statistically significant results (at the 10% level) were found for Q3 and Q4, with personal freedom and institutional trust both having negative coefficients ($\gamma_{PF,RG} < 0$ and $\gamma_{IT,RG} < 0$). It indicates that higher personal freedom and greater trust in institutions reduce refugee migration. Thus, we conclude that institutional trust and personal freedom significantly reduce refugee migration, especially in Q4 (the most resilient countries). Stronger institutions and personal freedoms enhance resilience, lowering the need for migration due to natural disasters or other crises.

Sanitation availability is significant in Q1, suggesting that improving basic infrastructure could reduce refugee migration in specific contexts. However, other environmental poverty indicators did not significantly influence refugee migration from disaster-affected countries. The differences observed across quartiles indicate that policies addressing disaster consequences should be tailored to each country group's needs and conditions.

5. Discussion

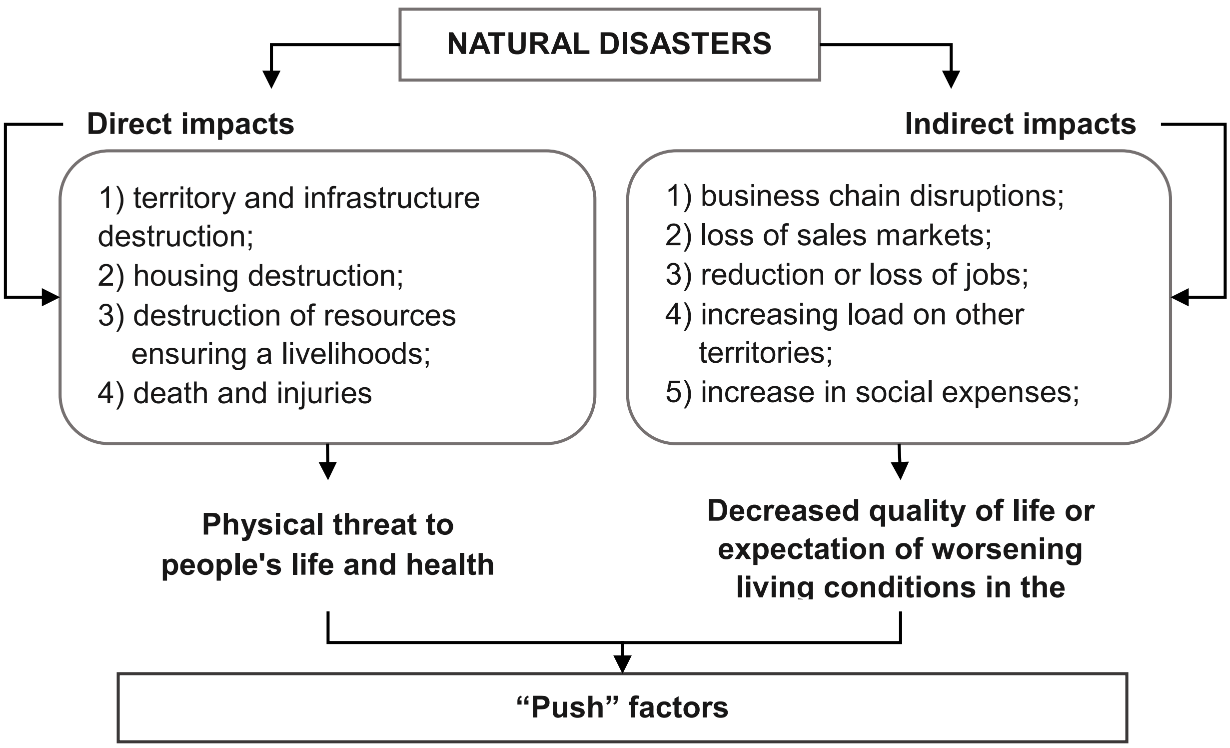
Natural disasters have severe consequences, affecting a community's economic resources and significantly damaging its territory, infrastructure (transportation, telecommunications, social) and housing, making the area unsafe for living. It also reduces the resources needed to address disaster impacts. Hallegatte (2014) emphasised asset losses (a reduction in the stock of assets) and output losses (a decline in income flows, including business and supply-chain disruptions and long-term negative effects on economic growth). As a result, intensive migration becomes more likely, with the scale of destruction determining whether it is internal or external. Akter *et al*. (2023), studying impacts of disasters on financial markets, showed that disasters can lead to increased market manipulation due to heightened investor sentiment and information asymmetry.

Natural disasters can drive people to migrate, but this depends not only on disaster intensity but also on socio-economic factors such as welfare levels, infrastructure, access to energy sources and environmental poverty, influencing people's ability to overcome the negative impacts. Paudel

(2023) added to the discussion by examining how disasters affect water and sanitation services in Nepal, showing that severe earthquakes negatively affected water treatment and sanitation access.

Similarly to Trinh *et al*. (2021), our study indicates that the severity of disasters, rather than mere occurrence, significantly influences migration patterns, highlighting the need for nuanced disaster response strategies that consider local vulnerabilities. Countries with varying levels of economic development and institutional maturity are expected to have different levels of vulnerability to natural disasters, leading to asymmetric consequences. Each country's territorial and sectoral economic structure, along with population and production factor distribution, determines the extent of potential destruction and casualties. Based on the above literature review, the potential consequences of natural disasters are outlined in Figure 9.

Figure 9: Natural disasters and their impacts



Source: Author's own elaboration

Addressing RQ3, it must be mentioned that potential mobility shapes people's attitudes towards adaptation in disaster areas and their responses to exposure intensity (Adams and Kay, 2019). In our opinion, this attitude (even apart from its dependence on one's perception of one's situation) is based on people's readiness for adaptation to new conditions:

1) economic readiness (people's welfare, permanent employment, household equipment, existing economic deprivation);
2) social and demographic readiness (labour competitiveness, personal network development, existing economic deprivation and environmental poverty, *e.g.*, access to sanitation facilities and clean drinking water; numbers of children in households, elderly people or people with disabilities);
3) infrastructural and energy readiness (availability of transport infrastructure, range of transport modes, electricity, gas and water supply). Improper access to infrastructure during and after a natural disaster leads to a lack of health care, sanitation, personal safety and impossibility of emergency communication;
4) cross-cultural adaptability (proficiency in foreign languages, personal tolerance and cultural awareness). It will generally determine the difficulty of migrants' adaptation in the destination country as a result of natural disasters;
5) institutional resilience (availability and ease of legal and illegal ways of migration abroad, level of safety of migration through the country, human rights protection, *e.g.*, for ethnic or other minorities, gender equality).

The socio-economic characteristics of the country of origin, such as economic development, poverty, population deprivation, density and regional imbalances, shape its readiness to handle the consequences of natural disasters. However, since climate refugees often reside in poorer developing countries and tend to seek refuge within their own or neighbouring countries, funding will largely need to come from the international community (Biermann and Boas, 2010).

Marin *et al*. (2021) agreed that risk assessments should include natural and social factors to understand community needs better. Methmann and Oels (2015) argued that "resilience is sold as a strategy of empowerment" by offering affected populations the "free choice" to migrate. However, Biermann and Boas (2010) proposed principles for institutional responses to natural disasters, including resettlement over temporary asylum, protection of locals' collective rights, use of international aid for domestic measures and international burden-sharing.

Our findings are consistent with previous studies, such as Aslam *et al*. (2021), who found that policymakers' early experience with disasters can shape their decisions, showing that the effects of disasters can last for years. These studies showed that successful disaster management must include economic, social and psychological support to ensure long-term recovery and resilience. Also, McInerney *et al*. (2022) considered migration as a proactive adaptation strategy to climate change; however, they highlighted that weak governance and lack of resources in sending and receiving communities complicate this process, and our research provides further evidence to support this, particularly in the field of environmental poverty effects. The similarity between our findings strengthens the validity of our conclusions about institutional resilience during and after natural disasters and confirms the importance of institutional capacity in managing climate-induced migration.

Evgenidis *et al*. (2021) highlighted the resilience of critical infrastructure emerging as a crucial factor in disaster recovery, underscoring the importance of targeted investments in maintaining post-disaster regional stability. Herrera-Almanza and Cas (2020) underscored the value of strategic investments in education and infrastructure to reduce disaster vulnerability and promote resilience. Our research reaffirms the approaches demonstrated above but also extends into the context of the importance of infrastructural and energy readiness.

6. Conclusion

Disproportionate population growth in high-risk regions and increasing natural disasters have highlighted the need for a strategic institutional response. Key challenges include mortality, injuries and uncontrolled refugee migration, underscoring the importance of understanding the role of institutions in addressing these issues. This study examined the effect of various factors, including institutional ones, on mortality and migration rates due to natural disasters, contributing to understanding the role of institutions in disaster response. Our results may provide policymakers with valuable information on the effects of institutions and other factors in addressing disaster-induced mortality and migration:

Firstly, our findings reveal that improved transport availability may increase mortality rates, especially in Q1 – the most vulnerable countries – likely due to challenges evacuating densely populated or accessible areas during disasters. However, transport availability was linked to lower mortality in less vulnerable countries (Q2 and Q3), likely due to better disaster management. Personal freedom showed a negative relationship with mortality, suggesting that societies with more freedom may be better prepared for disasters, as confirmed in the full sample and in Q1. Sanitation availability, a measure of environmental poverty, emerged as a key factor in reducing mortality, particularly in the full sample, Q1 and Q3, highlighting the resilience of countries with better health infrastructure. Interestingly, the positive effect of institutional trust on mortality in Q2 might indicate overreliance on institutions, leading to underestimation of personal disaster risks and inadequate preparedness.

Secondly, our results suggest that societies with greater personal freedom and institutional trust experience fewer refugee outflows during natural disasters. This effect was most significant in more resilient countries (Q4), implying that stronger institutions and greater freedoms enhance a population's adaptive capacity. In Q1, sanitation availability significantly reduced refugee migration, confirming that improving basic infrastructure in vulnerable regions can lower displacement due to disasters.

As a recommendation, institutional responses to migration challenges from natural disasters should address: (1) establishing and maintaining civil protection systems to reduce push factors; (2) facilitating migrant registration to ensure proper rights protection; and (3) assisting migrants' return to their homeland while providing necessary humanitarian aid to mitigate disaster impacts. National border control systems and the capacity of relevant authorities are crucial for monitoring migration and addressing illegal migration threats. However, these systems must be flexible during emergencies, enable easing border crossing while collecting accurate data on migrants' demographics and needs to ensure proper protection and humanitarian support.

We should note that several **limitations** exist:

Firstly, while the sample includes 112 countries representing 95% of global natural disasters, smaller countries with limited data may be underrepresented, potentially introducing biases in understanding the full scope of migration and mortality caused by disasters and environmental poverty. Countries can experience varying degrees of destruction and injuries within their territories.

Secondly, the study relies on decade-aggregated data from the UN for natural disasters, which limits the temporal precision of the analysis. This aggregation may smooth out variations in disaster occurrences and impacts within each decade, potentially underestimating the frequency and severity of certain events. Besides, the available data on disasters, migration flows, environmental poverty and institutional factors were sourced from multiple databases, requiring harmonisation, which may have resulted in a loss of nuance in temporal and spatial dynamics. Additionally, the normalisation techniques applied to variables such as disaster mortality may not fully capture the actual scale and intensity of disasters.

Thirdly, focusing solely on refugee migration caused by natural disasters excludes other forms of migration, such as economic or social migration, which may also be influenced by disaster consequences, potentially overlooking the broader impacts of environmental events. Besides, the Legatum Prosperity Index used to assess institutional factors (*e.g.*, institutional trust, personal freedom, macroeconomic stability) offers a broad view of countries' institutional environments but does not capture the full complexity of institutional responses or local legal nuances in addressing environmental crises.

Finally, quartile analysis of countries by their vulnerability and resilience to natural disasters simplifies the complexity of climate-related migration and may overlook important variations within each group. While the chosen OLS models help identify potential relationships, they do not fully account for all possible confounding variables (*e.g.*, international aid, pre-existing migration trends, the strength of diaspora ties), making it difficult to establish precise causality.

Remedies to limitations: One way to overcome these issues is to use a mix of methods, such as combining quantitative data with interviews or case studies, to enhance the understanding of how communities respond to climate challenges. More advanced statistical models that address gaps or inconsistencies in the data could be applied. Moreover, adding more variables (for example, local economic conditions, health indicators, income disparities, gender gap, *etc*.) could improve the analysis, making the results more reliable and giving a broader view of climate-related migration factors. Adding predictions based on climate change scenarios could also help understand future risks better and enable policymakers to see how migration trends might develop and prepare accordingly. The differences across quartiles highlight the need to tailor disaster response policies to each country group's specific needs and conditions based on their vulnerability to natural disasters and environmental poverty. Policymakers should improve disaster preparedness and response strategies, particularly in economically stable regions with better transport infrastructure. Enhancing personal freedom and building institutional trust could reduce refugee numbers caused by natural disasters.

Future scope of study: The study opens new possibilities for further research, especially into adaptation of local communities to environmental risks and effects of community responses on migration choices, particularly in high-risk areas. It would help create better policies to support sustainable development and reduce the risk of forced migration due to climate change. Further research should explore comparative regional studies, focusing on the role of international institutions and how different institutional frameworks and policy responses shape resilience and migration outcomes from natural disasters. This area is critical as it highlights the influence of international policies and cross-border cooperation on migration patterns and future stability, helping mitigate environmental poverty. Additionally, future research could examine the links between urbanisation, population density and disaster consequences, as these factors may affect population welfare, vulnerability and migration dynamics.

Table 6: Abbreviations used (in alphabetical order)

Acronym	Explanation
CH	Climatological hazards
DM	Average number of casualties and injured people per natural disaster (dependent variable)
GD	Geophysical disasters
H	Undernourishment, hunger (independent variable)
HD	Hydrological disasters
IT	Institutional trust (independent variable)
MD	Meteorological disasters
MS	Macroeconomic stability (independent variable)
O	Disaster occurrence
PF	Personal freedom (independent variable)
RG	Average annual growth rate of refugee numbers (dependent variable)
RS	Refugee stock from the country of origin
S	Sanitation availability (independent variable)
TA	Transport availability (independent variable)
W	Water availability (independent variable)

Source: Author's own elaboration

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Appendixes

Appendix 1

Table 7: Specification of data limitations

Variable (abbreviation)	Available period	Data periodicity	Countries covered
Natural disaster mortality (*DM*)	1992–2021	Ten years	132 countries (sample used above for clustering)
Average annual growth rate of refugee numbers (*RG*)	1992–2021	Yearly	266 countries, territories, regions
Transport availability (*TA*)	2007–2021	Yearly	167 countries
Macroeconomic stability (*MS*)	2007–2021	Yearly	167 countries
Personal freedom (*PF*)	2007–2021	Yearly	167 countries
Institutional trust (*IT*)	2007–2021	Annual	167 countries
Water availability (*W*)	1992–2021	Yearly	266 countries, territories, regions
Sanitation availability (*S*)	1992–2021	Yearly	266 countries, territories, regions
Undernourishment (*H*)	1992–2021	Yearly	266 countries, territories, regions

Source: Author's own elaboration

Appendix 2

Table 8: Division of countries by quartiles

Quartiles	Countries (in decreasing order of occurrence of natural disasters)	Number of countries
Q1	China, India, Philippines, Bangladesh, United States, Pakistan, Thailand, Vietnam, Iran, Indonesia, Kenya, Brazil, Cuba, Australia, Mexico, Peru, Sri Lanka, Cambodia, Mozambique, Colombia, Nigeria, Haiti, Nepal, Ethiopia, Malawi, Honduras, Guatemala, Somalia	28
Q2	Japan, Sudan, Madagascar, Turkey, Myanmar, Tajikistan, Tanzania, Afghanistan, Chile, Laos, France, Dominican Republic, Bolivia, Russia, Zambia, Nicaragua, Mongolia, Ecuador, Niger, Morocco, Uganda, Ukraine, El Salvador, Argentina, Papua New Guinea, Venezuela, Ghana, Costa Rica	28
Q3	Democratic Republic of the Congo, Chad, Paraguay, South Sudan, Angola, Czechia, Malaysia, South Africa, Bosnia and Herzegovina, South Korea, Rwanda, Burundi, Yemen, Senegal, Albania, United Kingdom, Algeria, Benin, Namibia, Germany, New Zealand, Georgia, Burkina Faso, Zimbabwe, Mauritania, Moldova, Kazakhstan, Jamaica	28
Q4	Romania, Canada, Poland, Italy, Hungary, Greece, Mali, Cameroon, Egypt, Guinea, Kyrgyzstan, Panama, Netherlands, Croatia, Central African Republic, Uruguay, North Macedonia, Serbia, Spain, Iraq, Bulgaria, Austria, Slovakia, Hong Kong, Saudi Arabia, Portugal, Belgium, Switzerland	28

Source: Author's own elaboration

Appendix 3

Table 9: Sample characteristics

Quartiles	Mean	Median	Standard deviation	Coefficient of variation	5% percentile	95% percentile	Interquartile range
Occurrence							
Full sample	79.580	46.000	111.698	1.404	18.000	208.000	47.000
Q1	184.321	119.000	190.250	1.032	41.300	744.000	127.000
Q2	68.286	56.000	43.091	0.631	25.000	179.150	32.500
Q3	39.226	30.000	19.626	0.500	16.800	79.400	23.500
Q4	36.906	29.000	21.072	0.571	17.000	91.250	20.000
Average number of injured people (DM)							
Full sample	136,152	42,650	355,696	0.383	1,039	348,277	96,419
Q1	420,296	192,523	654,309	0.642	44,749	517,330	108,862
Q2	82,858	67,385	56,458	1.468	21,949	232,791	47,972
Q3	59,632	33,623	88,883	0.671	3,539	295,362	27,340
Q4	8,286	7,150	8,300	0.998	263	146,972	12,491

Source: Author's own elaboration

Appendix 4

Table 10: Correlation coefficients, using observations 1–112 (5% critical value (two-tailed) = 0.1857 for *n* = 112)

DM	***TA***	***MS***	***PF***	***IT***	***RG***	***W***	***S***	***H***	
1.0000	0.1128	0.2905	−0.2710	0.2084	0.0066	0.0237	−0.0515	−0.0001	***DM***
–	1.0000	0.3295	0.5383	0.2749	−0.3345	0.6832	0.6704	−0.5643	***TA***
–	–	1.0000	0.2565	0.3485	−0.2956	0.4063	0.3328	−0.3376	***MS***
–	–	–	1.0000	−0.0728	−0.3465	0.4837	0.4089	−0.4042	***PF***
–	–	–	–	1.0000	−0.1795	−0.0309	0.0066	−0.0596	***IT***
–	–	–	–	–	1.0000	−0.3031	−0.2829	0.1786	***RG***
–	–	–	–	–	–	1.0000	0.9133	−0.7485	***W***
–	–	–	–	–	–	–	1.0000	−0.6753	***S***
–	–	–	–	–	–	–	–	1.0000	***H***

Source: Author’s own elaboration