DISASTERS AND NATIONAL ECONOMIC RESILIENCE

AN ANALYSIS OF BRACED COUNTRIES

Catherine Simonet, Eva Comba and Emily Wilkinson

BRACED KNOWLEDGE MANAGER

Working paper

CONTACT THE AUTHORS

Catherine Simonet is a development economics researcher at the Overseas Development Institute. Her research focuses on climate change adaptation, environmental and economic vulnerability and food security in sub-Saharan Africa and Least Developed Countries. She holds a PhD. from the Centre d'Etudes et de Recherches sur le Développement International.

Eva Comba is a Junior Professional Officer at the United Nations Environment Programme (UNEP), previously working as a research consultant in the Adaptation and Resilience team at ODI. Her interest and expertise lie in resilience, climate change adaptation and disaster risk reduction issues.

Emily Wilkinson is a Research Fellow at the Overseas Development Institute and Head of Research for BRACED. Her research focuses on the policy and institutional dimensions of disaster- and climate-risks, including incentives for risk-informed development planning.

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Contents

Acronyms

BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CRED	Centre for Research on the Epidemiology of Disasters
GDP	Gross Domestic Product
GNI	Gross National Income
GRIP	Global Risk Identification Programme
EAP	East Asia and Pacific
ECA	Europe and Central Asia
EM-DAT	Emergency Events Database
GMM	Generalised Method of Moments
GNP	Gross National Product
IFRC	International Federation of the Red Cross and Red Crescent Societies
LAC	Latin American and Caribbean
LDC	Least Developed Country
LIC	Low-Income Country
LLDC	Landlocked Developing Country
M&E	Monitoring and Evaluation
MENA	Middle East and North Africa
OLS	Ordinary Least Squares
SAS	South Asia
SIDS	Small Island Developing States
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme

Executive summary

This paper aims to provide an analysis of economic resilience at the national level, presenting a broad picture of changes in resilience to climate extremes over a 42 year period. It focuses on 12 countries in the Sahel, East Africa and Asia that are part of the UK Government funded resilience programme BRACED (Building Resilience and Adaptation to Climate Extremes and Disasters).[1]

A cross-country statistical analysis over the period 1970–2012 reveals that BRACED countries have been disproportionally affected by disasters, particularly those related to hydro-meteorological hazards, when compared with other groups of developing countries. This suggests there are some commonalities between BRACED countries and helps justify and substantiate their selection to be included in this programme. However, when we look more closely at the types of hazards and impacts, the group is found to be heterogeneous. In Mauritania, Niger, Sudan and Kenya mortality rates are highest, whereas Ethiopia and Sudan have the largest numbers of people affected by disaster.

In this paper, authors create a typology of risk for BRACED countries that can be used to inform approaches to building resilience. Burkina Faso and Mali have a 'mono-risk' profile as they have experienced relatively few events, whereas Nepal has a 'multi-risk' profile and has experienced various disasters over the 42 year period analysed. Meanwhile, droughts have had a disproportionate effect compared with other climate-related hazards, especially in Africa, whereas floods have been very frequent in all BRACED countries.

1 The 12 BRACED countries that are a focus of this study are: Burkina Faso, Chad, Ethiopia, Kenya, Mali, Mauritania, Myanmar, Nepal, Niger, Senegal, Sudan and Uganda.

This paper looks at how the national economies of different sets of developing countries are affected by disasters and have been able to 'bounce back' afterwards. The findings confirm a negative significant effect of disasters on economic growth: a climate event that affects 1% of the population contributes to a reduction in gross domestic product of 0.05% on average. In particular, the negative effects of climate-induced events are highly significant and important in landlocked countries, a category that includes many BRACED countries. More specifically in BRACED countries, shocks seem to be absorbed one year following a disaster, but there is a negative impact on economic growth three years following a disaster. A sharp increase in international assistance could be one explanation for the upward trend witnessed in the year following the disasters; in this case, a slowdown in the third year may be happening as a result of aid withdrawal and/or the incapacity of these countries to smooth aid flows in time. Overall, the analysis suggests disasters do not prompt a temporary economic boom, as has been previously suggested (Skidmore and Toya, 2007).

This analysis of economic resilience in BRACED countries highlights a number of important issues of relevance to aid agencies engaging in resilience-building programmes. The disproportional attention paid to larger, rarer, events over smaller, more frequent, events may be misguided. There is also a clear need to consider the range of risks and types of impacts when considering interventions, as there is wide variation across the BRACED sample, despite the fact that all these countries can be broadly categorised as disaster-prone. A more in-depth analysis is also needed to assess the impact of aid on countries' economic recovery process, as this could be undermining longer-term efforts to build resilience.

Introduction

This paper assesses the impact of disasters over a 42-year period in BRACED countries. It characterises resilience by examining how national economies respond to various climate extremes, looking at information extracted from statistical analysis on how economies are affected and able to 'bounce back' after a shock. Although statistical and econometric analysis is not sufficient to identify the numerous factors that constitute resilience, it helps to identify gaps and challenges in the assessment of resilience at the national level. It can therefore be used to inform humanitarian response and recovery efforts, and in the design of monitoring and evaluation (M&E) frameworks for BRACED and other resilience programmes.

This paper identifies the groups of developing countries that have been most severely affected by disasters over a 42 year period and compares the impacts of different types of disaster on each group. The authors then take a closer look at BRACED countries to compare the direct impacts of disasters; to understand trends and disparities in the nature and characteristics of risk; and to develop historical national risk profiles and highlight which types of disasters have been most problematic. It also draws out policy-relevant implications, demonstrating that we need different approaches to strengthen resilience depending on risk levels, characteristics and profiles. The final section presents an econometric analysis of the relationship between disasters and gross domestic product (GDP) per capita, generating some important insights regarding national resilience patterns.

The data used in this paper come from the Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database (EM-DAT) on disaster loss and damage. EM-DAT is an open data source and provides international coverage, and is therefore the most appropriate dataset for our purposes. However, it also has important limitations: it is biased towards large catastrophic events and relies on 'declared information'. Information on disaster events and impacts in this paper is therefore not complete. Improved reporting techniques, boundary changes and unequal country capacity to collect data have also led to temporal and geographical biases and thus limit the scope for comparing countries and establishing historical trends. Finally, EM-DAT includes economic valuations of losses for less than 30% of its records (Guha-Sapir and Below, 2002). For this reason, this study does not use economic loss data, focusing instead on 'mortality' and 'numbers affected' as measures of disaster impact.

1. COMPARISON OF DISASTER IMPACTS

IMAGE: NOOR KHAMIS/ DEPARTMENT FOR INTERNATIONAL DEVELOPMENT

This section characterises direct disaster impacts in developing countries, highlighting the similarities and differences among different groups. Using cross-country statistical analysis, we identify which groups of developing countries have been most severely affected by disasters over a 42 year period.

Methodology

We divided a total of 136 developing countries[2] into different groups according to two criteria: development level and geographical characteristics:

2 Using the World Bank's 2014 classification, which takes low- and middle-income countries to be developing countries.

- Landlocked developing countries (LLDCs): These 29 countries face serious constraints to their overall socioeconomic development as a result of lack of territorial access to the sea, remoteness and isolation from world markets, and high transit and transportation costs. These countries are among the poorest developing countries.

- The 31 small island developing states (SIDS) have unique and particular vulnerabilities owing to their small size, remoteness, their narrow resource and export base and high exposure to external economic shocks and global environmental challenges including climate change.[3]

- The least developed countries (LDCs) group represents a UN classification that is reviewed every three years. It includes 49 countries identified according to three criteria: gross national income (GNI) per capita (providing information on income status); the Human Asset Index (measuring the level of human capita); and the Economic Vulnerability Index (EVI), which assesses the structural vulnerability of countries to exogenous economic and environmental shocks.

- Low-income countries (LICs) are a group of 82 countries that the World Bank characterises as being of low and lower-middle income, based on GNI.[4]

- BRACED countries are the 13 countries for which the UK Government selected to implement the three year BRACED resilience programme. These are: Burkina Faso, Chad, Ethiopia, Kenya, Mali, Mauritania, Myanmar, Nepal, Niger,

3 http://unctad.org/en/Pages/ALDC/Small%20Island%20Developing%20States/UN-recognition-of-the-problems-of-small-island-developing-States.aspx

4 Using the World Bank's 2014 classification.

Senegal, South Sudan, Sudan and Uganda. South Sudan is excluded from this analysis as no data are available for before 2012. As such, the number of BRACED countries – which are at the centre of this study – is 12.

Six other regional groups are based on World Bank classifications:

EAP	East Asia and Pacific
ECA	Europe and Central Asia
LAC	Latin American and Caribbean
MENA	Middle East and North Africa
SAS	South Asia
SSA	Sub-Saharan Africa

Using EM-DAT data, tables have been created by calculating the proportion of the population affected or killed by disasters every year; aggregating percentages over the period to calculate the average impact per year for each country, then over the whole period of analysis (1971–2012), taking into account the years when events occurred as well as the ones when no disaster was registered; and, finally, aggregating averages for each group of countries. The timeframe for the study is relatively short (particularly in relation to geophysical hazards, which require more than 42 years of records), but socioeconomic data for before the 1970s are either not available or unreliable (Roser and Ortiz-Ospina, 2015).

Each group contains a different number of countries. The BRACED sample has 12 countries whereas the entire group of developing countries has 136. We must take the size of each group into account when drawing comparisons: a country with a particularly high or low (extreme) value can affect the average (mean and variance) more easily if it is in a small sample. A high standard deviation shows wide heterogeneity whereas a small one demonstrates relative homogeneity between countries in the same group. The smaller the standard deviation, the less likely one country will strongly influence the group average.

Main findings

All disasters

Disasters seem to have affected BRACED countries disproportionally over the 42 year period (see Table 1). They killed 0.0057% and affected 2.818% of the population on average every year, compared with other developing country averages of 0.00203% and 1.726%, respectively. The relatively high standard deviations for BRACED countries show the group is heterogeneous with respect to both types of impacts (mortality and those affected).

Other categories stand out in terms of the size and severity of disaster impacts. The LDC group (which includes 11 of the 13 BRACED countries) suffered relatively high numbers of deaths and of those affected by disasters, at 0.00439% and 2.433% of the total population, respectively. Disasters have also affected an important part of the population in LLDCs and LICs. Many BRACED countries fall under these two categories (12 BRACED countries in LICs and 7 in LLDCs).

Table 1. Share of population killed or affected by disasters for different groups of countries

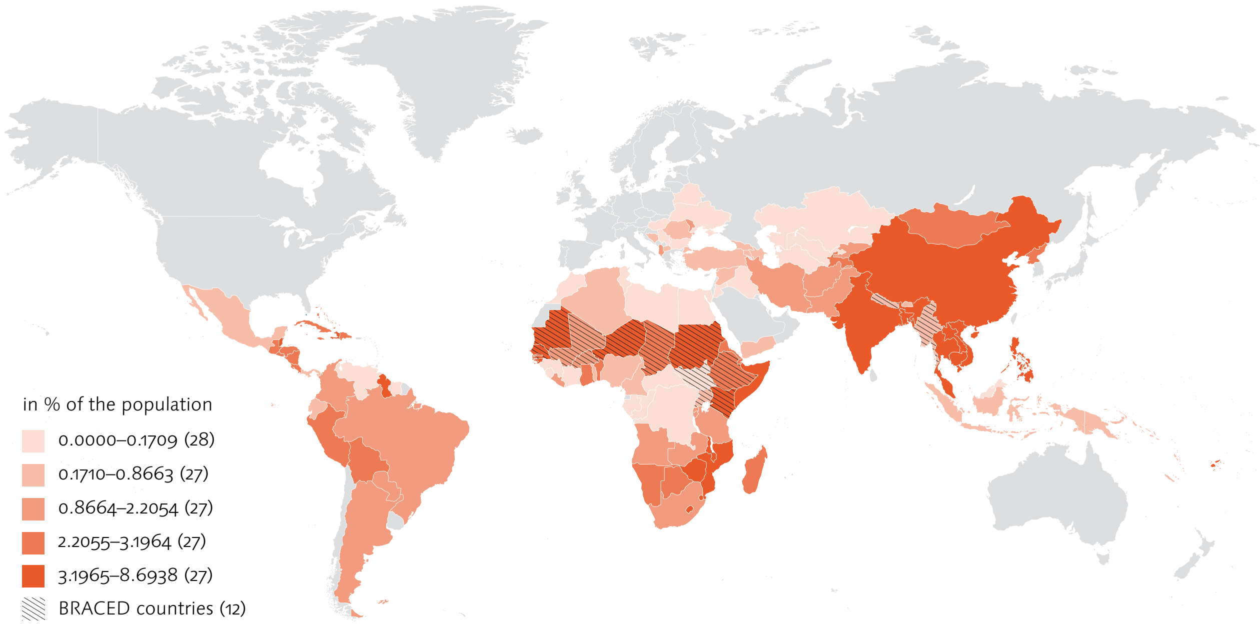
			DEATHS				AFFECTED			
	No. of BRACED countries	No. of countries	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Developing countries	**12**	**136**	**0.00235**	**0.00619**	**0.00000**	**0.05503**	**1.823**	**1.799**	**0.000**	**8.694**
LLDC	7	29	0.00178	0.00475	0.00000	0.02583	2.128	1.715	0.000	6.257
SIDS	0	31	0.00299	0.00977	0.00000	0.05503	1.783	1.422	0.000	4.371
LDCs	11	49	0.00439	0.00944	0.00000	0.05503	2.433	2.079	0.004	8.694
DCs without LDCs	1	88	0.00116	0.00258	0.00000	0.01428	1.462	1.528	0.000	6.257
BRACED	**12**	**12**	**0.00570**	**0.00881**	**0.00023**	**0.02583**	**2.818**	**1.973**	**0.321**	**6.983**
DCs without BRACED	**0**	**124**	**0.00203**	**0.00582**	**0.00000**	**0.05503**	**1.726**	**1.760**	**0.000**	**8.694**
LICs	12	82	0.00329	0.00768	0.00000	0.05503	2.216	1.955	0.005	8.694
EAP	1	24	0.00138	0.00146	0.00000	0.00622	2.343	1.915	0.000	5.813
ECA	0	19	0.00018	0.00035	0.00000	0.00134	0.632	0.860	0.000	2.950
LAC	0	26	0.00463	0.01112	0.00002	0.05503	1.819	1.091	0.091	3.772
MENA	0	12	0.00057	0.00144	0.00000	0.00509	0.241	0.430	0.001	1.560
SAS	1	8	0.00393	0.00488	0.00049	0.01549	2.705	2.869	0.361	8.694
SSA	10	47	0.00266	0.00577	0.00000	0.02583	2.295	1.921	0.005	7.770

Note: South Sudan excluded from the sample. Shaded = mean >2 for share of population affected.

Disaster mortality is higher in LAC and SAS. Countries in these regions are exposed to a wide range of hazards, including those that provoke sudden high-intensity events that exceed local response capacities, such as volcanoes, earthquakes and storms. In terms of those affected by disasters, SAS comes top, with

2.705% of the population affected by natural hazards over the period 1971–2012, followed by EAP with 2.343% and SSA with 2.295%. BRACED countries (shown with striped lines on Map 1) are among those most affected: many are in the first quintile group in terms of share of the population affected annually by natural hazards over the 42 years (Map 1).

Map 1. Share of population affected annually by disasters (1970–2012 average)



Source: Authors' calculations.

Climate-induced events

Findings illustrated in Table 2 show the impact of climate-induced events on the different groups of countries. The gap between the BRACED countries and other developing countries is wider when it comes to the impact of climate-induced hazards, in terms of both mortality and numbers affected. This means climate extremes affect BRACED countries disproportionally. The LDC group ranks second in terms of percentage of the population killed and affected by these events.

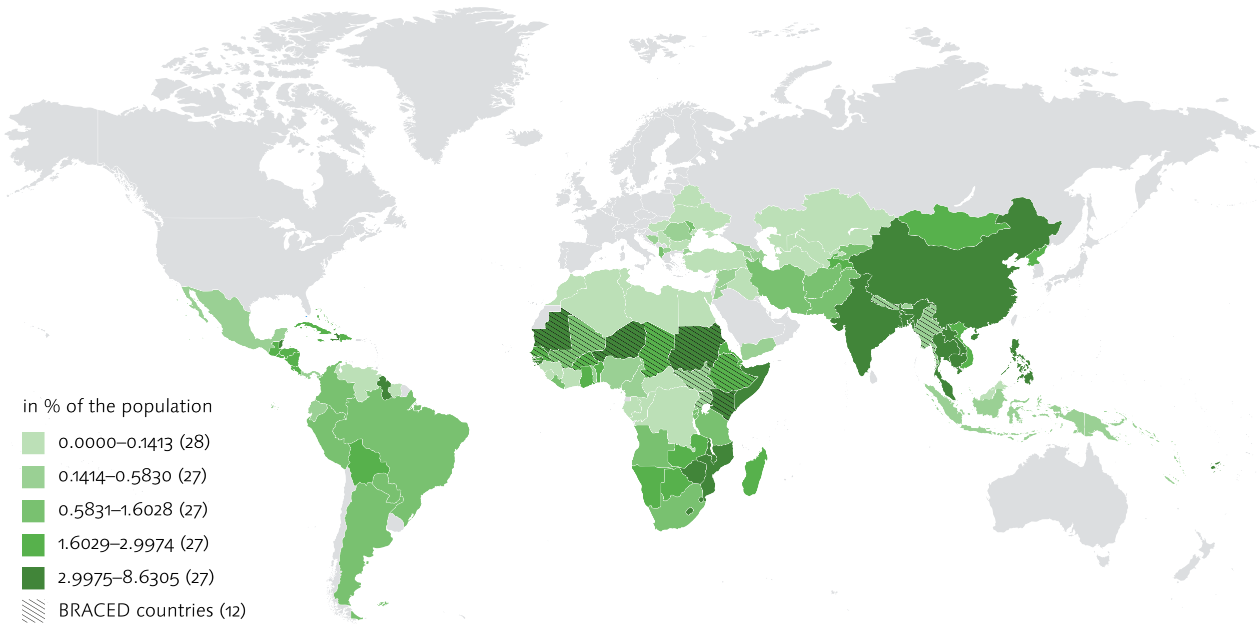
Table 2. Share of population killed and affected by climate-induced disasters, by country groups

			DEATHS				AFFECTED			
	No. of BRACED countries	No. of countries	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Developing countries	**12**	**136**	**0.00116**	**0.00381**	**0.00000**	**0.02523**	**1.704**	**1.799**	**0.000**	**8.630**
LLDC	7	29	0.00118	0.00465	0.00000	0.02523	2.074	1.728	0.000	6.246
SIDS	0	31	0.00048	0.00060	0.00000	0.00231	1.641	1.401	0.000	4.371
LDCs	11	49	0.00236	0.00583	0.00000	0.02523	2.323	2.095	0.000	8.630
DCs without LDCs	1	88	0.00048	0.00157	0.00000	0.01423	1.340	1.511	0.000	6.246
BRACED	**12**	**12**	**0.00465**	**0.00892**	**0.00002**	**0.02523**	**2.744**	**1.949**	**0.314**	**6.980**
DCs without BRACED	**0**	**124**	**0.00082**	**0.00273**	**0.00000**	**0.01871**	**1.603**	**1.759**	**0.000**	**8.630**
LICs	12	82	0.00172	0.00481	0.00000	0.02523	2.082	1.960	0.004	8.630
EAP	1	24	0.00076	0.00129	0.00000	0.00621	2.270	1.880	0.000	5.586
ECA	0	19	0.00009	0.00018	0.00000	0.00078	0.539	0.856	0.000	2.943
LAC	0	26	0.00123	0.00276	0.00002	0.01423	1.545	1.086	0.085	3.772
MENA	0	12	0.00008	0.00009	0.00000	0.00030	0.212	0.402	0.001	1.457
SAS	1	8	0.00238	0.00521	0.00000	0.01525	2.573	2.913	0.260	8.630
SSA	10	47	0.00183	0.00564	0.00000	0.02523	2.206	1.938	0.004	7.757

Note: South Sudan excluded from the sample. Shaded = mean >2 for share of population affected.

SSA comes behind SAS in terms of mortality rates linked to climate extremes. The ranking of country groups affected by climate extremes is the same as for all hazard types, with SAS at the top followed by EAP and SSA. Overall, BRACED countries are among those countries with the highest share of population affected by climate-induced disasters (Map 2).

Map 2. Share of population affected annually by climate-induced disasters (1970–2012 average)



Source: Authors' calculations.

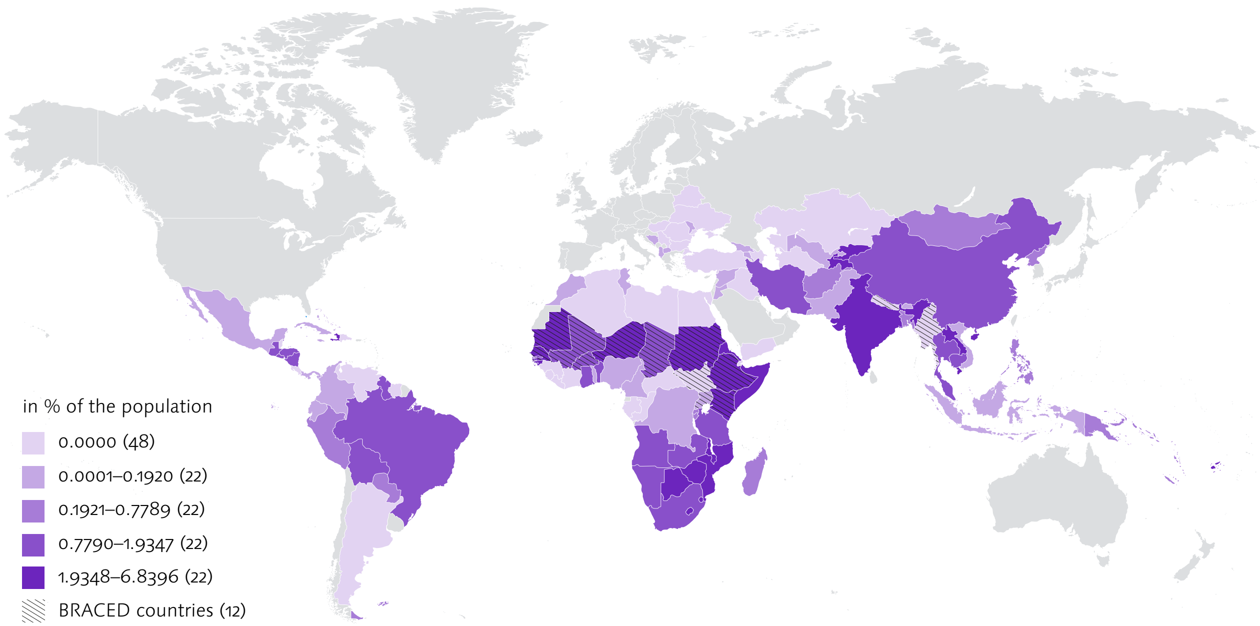
Findings by hazard type

The deadliest types of hazards over the period 1971–2012 were epidemics, which killed on average 432 people annually in developing countries. These were followed by storms and droughts, which had 266 and 231, respectively, per year. In terms of numbers affected, epidemics have the greatest impact, with 1,175,738 people suffering annually in developing countries, which represents more than half of all those affected by disasters.

Droughts and storms affect an average of 684,848 and 305,623 people, respectively.

In BRACED countries, it is droughts that have the greatest impact, with a mortality rate of 0.004% and affecting 2.503% of the population over the period 1971–2012 (see Map 3). These numbers are very high when compared with other developing countries. Floods, meanwhile, affected non-BRACED countries disproportionally because of their impacts in SAS, where only two BRACED countries (Nepal and Myanmar) are located. Landslides have affected more people on average in BRACED countries than in other developing countries, but mortality rates are higher in non-BRACED countries. The opposite is true for storms, with higher mortality rates in BRACED countries but more people affected in non-BRACED countries. The high number of people killed by one single event could explain this: Cyclone Nargis in 2008 killed more than 138,000 people in Myanmar.

Map 3. Share of the population affected annually by drought (1970–2012 average)



Source: Authors' calculations.

Key findings of the cross-country analysis

We can draw a number of key findings from the cross-country statistical analysis of disaster impacts and trends in developing countries. First, over the period 1970–2012, BRACED countries were affected disproportionally by disasters, particularly climate-related disasters such as droughts, when compared with other groups of developing countries. There is therefore some coherence in the selection of countries under the BRACED programme. These countries have high levels of risk and require a range of actions to build resilience.

Secondly, though, the relatively high standard deviation between BRACED countries demonstrates that the group is heterogeneous with respect to different types of impacts (mortality and numbers affected). Disasters have not affected the BRACED sample uniformly. Further analysis is needed to understand these variations and disparities.

2. RISK PROFILES

IMAGE: EU/ECHO/MALINI MORZARIA

This section takes a closer look at the BRACED sample in order to assess those countries that saw the most severe disaster impacts over the period 1970–2012. We highlight trends and disparities across BRACED countries and develop historical national risk profiles, identifying the types of disasters that have been most problematic for each BRACED country.

Disaster impacts in BRACED countries

Proportion of the population affected by hazards varies widely across the BRACED sample, from 0.321% for Myanmar to 6.983% for Mauritania. Mauritania, Niger, Kenya and Sudan have seen the greatest impact in terms of numbers affected, but mortality rates are higher in Sudan and Ethiopia.

Table 3. Impacts of disasters by BRACED countries (1970–2012)

	Share of population affected by year	Share of population killed by year	Share of population affected by year by climate-induced events	Share of population killed by year by climate-induced events
Burkina Faso	1.8606	0.0034	1.8236	0.0000
Ethiopia	2.6361	0.0258	2.6263	0.0252
Kenya	4.1132	0.0005	3.5302	0.0001
Mali	1.4926	0.0010	1.4862	0.0000
Myanmar	0.3212	0.0062	0.3143	0.0062
Mauritania	6.9830	0.0002	6.9800	0.0000
Niger	5.2705	0.0025	5.2072	0.0001
Nepal	1.3202	0.0015	1.2039	0.0010
Sudan	3.9617	0.0223	3.9496	0.0214
Senegal	2.9785	0.0004	2.9705	0.0001
Chad	2.2836	0.0044	2.2594	0.0016
Uganda	0.5903	0.0002	0.5719	0.0001
Total	**2.817625**	**0.0056993**	**2.743576**	**0.004645**

Note: Shading indicates maximum values.
Source: Authors' calculations.

Typology of risk within BRACED countries

We can build a typology of hazard risk across developing countries around disaster frequency and number of hazard types affecting countries over the period.

This analysis provides some greater insights into the frequency of disasters in BRACED countries. It shows that BRACED countries were each affected on average by 23 deadly events between 1970 and 2012, with climate-induced hazards triggering 16 of these. Mauritania has experienced the lowest number of deadly disasters, with only 14 events, including 8 climate-induced hazards, occurring over the period. Nepal has seen the highest number of disasters in which people were killed, including 36 that were climate-related.

BRACED countries saw on average 26 disasters (all types), of which 23 were climate-induced, over the period of analysis. If we look at all types of disasters, the lowest number is 23, for both Mali and Senegal; the highest is 35, recorded in Nepal. In terms of climate-induced disasters, Chad has experienced the lowest number of events and Nepal and Ethiopia the highest.

When taking into account the 11 disaster types classified by EM-DAT, Nepal, Ethiopia and Uganda are the most 'multi-risk' countries, with six different types of shocks resulting in deaths and seven different types affecting people. In terms of climate-induced disasters, Uganda has suffered the highest number of event types in terms of mortality. Both Uganda and Nepal have seen the greatest impacts in terms of numbers affected.

Tables 4 and 5 classify BRACED countries in terms of disaster impacts, number of disaster types experienced and shock frequency. Focusing on climate-induced disasters, these tables show trends and disparities between countries.

We allocated each country a shade of blue according to the level of impact experienced (as presented in Table 3), in terms of both the mortality rate (Table 4) and the percentage of those affected (Table 5) on average per year over the period. Then we divided the countries into groups according to the number of climate-induced disaster types they reported (from one to four) and their disaster frequency (rare, medium, frequent, recurrent) over the period.

Each country was positioned in the tables to allow for comparison and for the development of a general typology of risk. Countries were classified as 'mono-risk' or 'multi-risk' (according to the number of hazard types), and disasters as 'rare' or 'frequent' (depending on the frequency of impacts) in relation to other countries. When interpreting the tables, it is important to bear in mind that all countries in the BRACED sample have been disproportionally affected by disasters in general and climate-induced disasters in particular, and that the terms 'very low impact' and 'low impact', as well as 'rare' and 'medium frequent', are used relative to the overall BRACED sample.

Table 4. Disaster events and levels of impact – mortality

FREQUENCY / VARIETY OF DISASTER TYPES	Rare ≤10 deadly events	Medium 10–20 deadly events	Frequent 20–30 deadly events	Recurrent >30 deadly events
1 type	Burkina Faso	Mali		
2 types	Mauritania	Chad	South Sudan	
	Senegal	Niger		
3 types		Kenya	Sudan	Nepal
			Ethiopia	
			Myanmar	
Multi-risk (4 types)		Uganda		

Legend:

- Very low impact <0.00005%
- Low 0.00005–0.0002%
- Medium 0.0002–0.05%
- High 0.05–0.2%
- Very high >0.2%

Source: Authors' calculations.

Table 5. Disaster events and levels of impact – numbers affected

FREQUENCY / VARIETY OF DISASTER TYPES	Rare <20 events	Medium 20–23 events	Frequent 24–29 events	Recurrent >30 events
2 types	Burkina Faso		South Sudan	
	Mali			
3 types	Chad	Senegal	Kenya	Ethiopia
		Mauritania	Sudan	
		Niger	Myanmar	
Multi-risk (4 types)	Uganda			Nepal

Legend:

- Very low impact <1%
- Low 1–2%
- Medium 2–3%
- High 3–5%
- Very high >5%

Source: Authors' calculations.

We can highlight some broad trends. Countries with fewer kinds of risks and/or fewer events in total seem to have been less affected (in terms of mortality and numbers affected) over the period than countries with a more 'multi-risk' profile and/or that experienced more recurrent and frequent disasters. This trend is visible in Table 4 (mortality), which shows that those BRACED countries that experienced lesser impacts (highlighted with lighter shades of blue) tend to be positioned in the top-left corner, whereas countries with high and very high impact levels (highlighted with the darker shades of blue) tend to appear on the right side and/or bottom of the table. This trend is less clear in Table 5 (numbers affected), where countries of the same shade (experiencing similar levels of impact) are scattered across the table.

This typology helps us identify heterogeneities in the BRACED sample that were not visible in Table 3, which focused only on level of impact. Tables 4 and 5 show that countries with similar levels of impact have very different risk characteristics. This is the case for Nepal and Chad as well as Senegal and Uganda in Table 4. The disparities are even more pronounced in Table 5, in terms of people affected. Nepal, Burkina Faso and Mali have all experienced low levels of impact when compared with the other BRACED countries, yet they occupy very different positions in the table. While Burkina Faso and Mali have a 'mono-risk' profile and have experienced relatively few disasters, Nepal has a 'multi-risk' profile and disasters have been recurrent over the 42 year period.

This typology can be translated into guidance on approaches to building resilience at the national level. Interventions need to take into account not only levels of impact from disaster events, but also the country's risk characteristics. Different strategies are needed, for example, to build resilience in Mali, Burkina Faso and Nepal, as, despite their very similar levels of impact (in terms of numbers affected over the period), they have very different risk characteristics. Attention can be focused on one particular type of hazard in Burkina Faso and Mali, but this is not the case in Nepal.

Disaster types in BRACED countries

The following tables classify the different types of hazards in each BRACED country according to levels of impact and frequency. The focus is on both the impact intensity and the frequency of 11 disaster types as classified by EM-DAT (in terms of fatalities in Table 6 and numbers affected in Table 7). The tables include a larger number of events per country than those considered in the previous section (on the distribution of impacts within the BRACED category). The analysis of this section focuses on the country, but not as a relative measure to the overall BRACED sample as in previous section: the previous typologies considered the overall BRACED countries group; this analysis highlights the individual countries' vulnerability profiles. The period considered is the same.

Table 6. Impacts in terms of mortality, by events and countries

	HIGH-FREQUENCY HIGH-IMPACT*	HIGH-FREQUENCY LOW-IMPACT	LOW-FREQUENCY HIGH-IMPACT*	LOW-FREQUENCY LOW-IMPACT
1. Burkina Faso	Epidemics	Flood		
2. Chad	Epidemics	Flood	Drought (1981)	Storm
3. Ethiopia		Flood Epidemics	Drought (1983)	Volcano Mass movement (wet and dry)
4. Kenya	Epidemics	Flood		Earthquake Mass movement (wet) Drought
5. Mali	Epidemics	Flood		
6. Mauritania	Epidemics	Flood		Storm
7. Myanmar	Storm (2008)	Flood		Mass movement (wet) Epidemics Wildfire
8. Nepal	Flood Epidemics	Mass movement (wet)	Earthquake (1988)	Wildfire Storm
9. Niger	Epidemics	Flood		Storm
10. Senegal	Epidemics	Flood	Storm (1999)	
11. South Sudan**		Flood Epidemics	Drought	Wildfire
12. Sudan		Flood Epidemics	Drought (1983)	Storm Wildfire
13. Uganda	Epidemics	Flood	Mass movement (wet) (2010)	Drought Earthquake Storm

Notes: * Where one event in particular stands out because of high numbers of deaths the date of the event appears in brackets. ** The shocks of South Sudan are classified in relation to events that occurred in Sudan before the separation of the countries in 2011.

Source: Authors' calculations.

Table 7. Impacts in terms of people affected, by events and countries

	HIGH-FREQUENCY HIGH-IMPACT*	HIGH-FREQUENCY LOW-IMPACT	LOW-FREQUENCY HIGH-IMPACT*	LOW-FREQUENCY LOW-IMPACT
1. Burkina Faso	Drought	Flood Epidemics		
2. Chad	Drought	Flood Epidemics		Storm
3. Ethiopia	Drought	Flood		Epidemics Mass movement (wet and dry) Wildfire
4. Kenya	Drought (1999)	Flood		Mass movement (wet)
5. Mali	Drought	Flood Epidemics		
6. Mauritania	Drought	Flood		Epidemics Storm
7. Myanmar	Storm (2008)	Flood		Mass movement (wet) Wildfire Epidemics
8. Nepal		Flood Mass movement (wet)	Drought* (1979)	Earthquake Wildfire Epidemic Extreme temperature
9. Niger	Drought	Flood Epidemics		Storm
10. Senegal		Flood	Drought* (1977)	Storm Epidemics
11. South Sudan**	Drought	Flood		Epidemics Earthquake
12. Sudan	Drought	Flood		Storm Earthquake Epidemics
13. Uganda	Drought Flood (2007)	Epidemics		Mass movement (wet) Earthquake Storm

Notes: * Where one event in particular stands out because of high numbers of deaths the date of the event appears in brackets. ** The shocks of South Sudan are classified in relation to events that occurred in Sudan before the separation of the countries in 2011. Source: Authors' calculations.

An analysis was carried out for each BRACED country of the different shocks occurring over 1970–2012 (with countries assessed in comparison). The scale of impact was found to be very different from one country to another. In Table 6 we can see that both the 1981 Chadian drought and the 1983 Ethiopian drought were high-impact/low-frequency events, despite the fact that the first one killed 300 people (0.00065% of the population) and the second one led to 300,000 deaths (0.7841% of the population). The same is true for disaster frequency.

Epidemics and floods have been by far the most recurrent of events resulting in deaths in BRACED countries (Table 6). A few droughts have also caused fatalities in BRACED countries, and these stand out because of their devastating impacts. This is especially the case for the droughts affecting African countries in the 1980s, such as the 1981 Chadian drought and the 1983 Ethiopian and Sudanese droughts. Other disasters, such as landslides, storms, volcanoes, earthquakes and wildfires, are classified as low-frequency/low-impact, meaning they have been relatively rare in the BRACED countries and did not result in a high number of fatalities over the period. However, some exceptions are visible in Table 6: some isolated events have had a marked impact, such as the 1988 earthquake in Nepal, the 1999 storm in Senegal, 2008's Cyclone Nargis in Myanmar and the 2010 Bududa landslides in Mount Elgon, Uganda.

The analysis of the impacts described in Tables 6 and 7 is not intended for cross-country comparison but rather for the development of historical national risk profiles. For both disaster frequency and intensity, we established thresholds to classify the events of countries relative to each other. In both cases, the threshold corresponds to half of the maximum value witnessed over the period. For intensity, the maximum value corresponds to the highest number of people who either died or were affected by one particular event. For frequency, the maximum value is identified by looking at the number of times the most recurrent type of shock occurred over the period. Shocks were classified as high if they were above the established threshold; and low if their impact or frequency was under the threshold. One exception was made for the frequency of events. When shocks occurred more than once every five years on average over the period, they were automatically classified as high-frequency regardless of whether they were above or under the country threshold. This choice was made in order to avoid one recurrent event distorting the classification of other shocks, as the ranking is relative.

Overall, however, droughts have had the greatest impact on BRACED countries, with Ethiopia and Sudan the most affected in terms of fatalities: and Mauritania, Niger, Sudan and Kenya in terms of numbers affected. Floods have been the most frequent type of disaster event. Interventions aimed at building climate resilience in BRACED countries would benefit from a special focus on these two types of hazards.

Key findings from BRACED countries

Overall, we can draw from the analysis of disaster impacts in BRACED countries a number of key findings with policy relevance for resilience programmes:

- Disasters have affected some BRACED countries more severely than others. The most affected countries include Mauritania, Niger, Sudan and Kenya in terms of people affected, and Ethiopia and Sudan in terms of mortality rates.
- BRACED countries have very different characteristics in terms of disaster frequency and hazard types. Some countries that

have similar levels of impact have very different disaster characteristics. This is the case, for example, for Nepal, Burkina Faso and Mali, which have all experienced low levels of impact in terms of numbers affected when compared with other BRACED countries. Burkina Faso and Mali have a 'mono-risk' profile and experienced events relatively rarely, whereas Nepal has a 'multi-risk' profile and experienced recurrent disasters over the 42 year period.[5]

- Droughts have affected and killed more people compared with other climate-induced hazards in BRACED countries, especially in African countries. Floods have been the most frequent type of disaster, however.

5 The analysis does not take into account the two earthquakes in Nepal in April–May 2015, which had significant consequences for the national economy and affected a total of 5,621,790 people (EM-DAT accessed January 2017).

3. ANALYSIS OF DISASTERS AND ECONOMIC RESILIENCE

IMAGE: UN/TIM MCKULKA

Theoretical framework

Theories of economic growth predict a negative relationship between disasters and gross national product (GNP), but the empirical evidence is inconclusive. Felbermayr and Gröschl (2014) review the literature on the impact of disasters and economic growth to highlight this heterogeneity of results. Studies of economic impacts commonly use national economic growth or GNP as explanatory variables. The choice of disaster variables can be related to impacts of disasters (e.g. people killed or economic damage) or to the geophysical of hydro-meteorological phenomenon.

Focusing on the outcomes of disaster, Noy (2009) and Loayza et al. (2012) find a negative effect on income in developing countries, although their estimation methods are slightly different. Skidmore and Toya (2002) examine the differences between the effects of geophysical disasters (no effect) and climatic disasters (positive impact) on growth. In an analysis of impacts in developed countries, Raddatz (2007, 2009) finds no effect of geological disasters and a negative effect for climatic disasters on the GNP of various countries. This contrasts with the results of the Skidmore and Toya study, mainly because of the sample variations and the differences in econometric estimation methods. On the other hand, Fomby et al. (2013) highlight a negative effect of storms and drought but mixed evidence on earthquakes. Loayza et al. (2012) also confirm a negative effect of droughts. Other papers examine the size of shocks. Hochrainer (2009) points to negative impacts of disasters according to the size of the shocks; this is similar to findings in Cavallo et al. (2013), who highlight an effect of disasters only when very important events are selected. Finally, Noy (2009) observes a negative effect in terms of monetary damage but no effect with alternative measures (such as mortality).

Overall, these studies reveal some important trends and gaps:

- There is no clear evidence on the impact of disasters.
- The size of the impact needs to be explored.
- Different types of impacts – loss and damage – produce contrasting results but to our knowledge no study looks at the 'number of affected people' variable (EM-DAT) with significant results.
- The size and composition of the sample is important to test.

Among the papers that use geophysical databases, the work of Strobl (2011) on hurricanes demonstrates a clear effect of this kind of hazard-disaster on economic growth. Studies on the impact of drought on growth, however, using various geo-meteorological indicators, produce contrasting results (see Dell's 2009 literature review on this topic).

Felbermayr and Gröschl (2014)[6] are the first to provide a worldwide physical database for various kinds of disasters in a large number of countries. However, their drought variables are relatively simple and do not represent the complexity of the rainfall series in semi-arid and arid areas. In addition, there is a significant gap in knowledge on how drought affects economic growth. In particular, the literature finds that:

- Rainfall has an ambiguous impact on growth.
- There is little evidence of the transmission channels of drought impact from the microeconomic to the macroeconomic levels (Wilkinson and Peters, 2015).
- Droughts are key drivers of disaster in BRACED countries, but their impact at the national level is still unclear (even though the microeconomic consequences are well understood).

Methodology

The econometric analysis presented in this section assesses the resilience of BRACED countries to environmental hazards by examining economic recovery. Economic growth is here considered as an index of the overall socioeconomic situation

6 The econometric analysis presented here draws on Felbermayr and Gröschl (2014) on the impact of disasters on growth, by testing the specific impact of climate-induced events. The sample is restricted to developing countries and BRACED countries and, because of lack of access to the GeoMet database, we propose a complementary approach with variables on loss and damage.

of the country. The purpose of this section is to understand the causal relationship between the shocks and economic growth – or national capacity to absorb the shocks.

The choice of the disaster variables is important in econometric analysis. Loss and damage databases are easy to access, covering large temporal and geographical areas. They allow aggregation of various events (droughts, floods, earthquakes, etc.) and focus on outcomes, in terms of loss and damage. However, using these databases to understand causal relationships between disasters and impacts on economic growth is problematic as the loss hazard data are not exogenous, making it more difficult to assess causality. Data on the physical phenomenon (such as strength, speed and intensity) are an alternative but have the drawback of not including any information on exposure of the population.

The option of using retrospective analysis to deal with resilience-related questions could also be discussed, given the changing nature of resilience as a concept. However, the use of predictive models to assess the impact of climate events on socioeconomic dimensions is difficult because of their high uncertainty (Wilkinson et al., 2015). Therefore, a retrospective analysis appears to be the most appropriate approach.

Outcomes of disasters: The loss and damage database

Most of the studies described above use disaster data from loss and damage datasets owned by insurance companies such as Munich Re and Swiss Re. The EM-DAT database, however, offers free access to loss and damage data (see Annex 1 for more detail). There are problems with using this database, however, including its bias towards large catastrophic events and reliance on 'declared information'. Information on disaster events and impacts should therefore not be considered complete.

Improvements in reporting techniques, boundary changes and unequal country capacity to collect data also produce temporal and geographical biases and limit scope for comparing countries and establishing historical trends. The selection bias is likely to be more important in less developed countries than in developed countries (given reporting means). The probability of selection bias owing to the importance of the non-response rate is also reduced for large-scale disasters.

We used these hypotheses to define the estimation strategy and robustness tests (see Annex 2). We chose outcomes data on mortality and numbers affected, rather than damage, as these seem to be more exposed to selection bias. We also test for any differences in the size of the shocks.

Another potential criticism of the outcome measure is that it encompasses both the risk of the disaster happening and the impact it would have on the country. Indeed, this measure reflects more the consequences of the disaster than its likelihood of occurring.[7]

Physical measurement of disasters: The alternative option

There is a possibility that the nature of loss and damage could be responsible for biases in estimations of the relationships between disasters and economic growth. For this reason, comprehensive physical disaster intensity measures are used. Noy (2009) and Felbermayr and Gröschl (2014), for example, adopt this strategy to ensure exogeneity of the independent variable and to reduce

7 The physical measurement of disasters would therefore appear to be a better option, as it would offer a totally exogenous measure by not taking into account any dimension of countries' vulnerability.

problems of selection bias in the loss and damages database. GeoMet data compiled by Felbermayr and Gröschl encompass various kinds of hazard types and are available for a large number of countries. Unfortunately, the GeoMet database is not publically available at this time.

We focus on drought, as it is a key hazard in many developing countries and particularly BRACED countries.[8] Dell (2013), for example, notes that the impact of drought is unclear at the national level, owing to difficulties in accessing drought indicators for all countries at the national level.

Sample and sub-sample

The sample is composed of developed and developing countries, but the analysis is restricted to developing countries.[9] Several sub-samples are created for the statistical analysis and estimations performed over the period 1980–2012.

Estimation method

In the first estimation, a regression of growth measured as the first difference of GDP[10] – that is, $GDP_{i,t}$-$GDP_{i,t-1}$[11] – is carried out against the lagged level of GDP per capita (Mankiw et al., 1992; Islam, 1995), the disaster variables and the usual control variables. We do not use the estimation method with instrumentation since the bias-necessitating instrumentation

8 As one of the weaknesses of the GeoMet database is in the assessment of drought, we focus on this for the econometric analysis, with the aim of filling a gap in the existing literature.

9 Using EM-DAT, we exclude territories that are not independent (Reunion) without grouping them with the national country.

10 All measures of GDP are expressed in logarithm.

11 $GDP_{i,t}$ refers to the GDP of the country i in the year t.

(the Nickell bias; Nickell, 1981) is not statistically important because of our panel characteristics. Indeed, as we have more than 30 years of panel data, we adopt the same hypothesis as Felbermayr and Gröschl (2014), based on Judson and Owen's (1999) paper. Therefore, we consider the Nickell bias as small, in spite of the presence of the lagged endogenous variable on the right-hand side of the equation. Regressions are run using the Ordinary Least Squares (OLS) estimation method.

Following Skidmore and Toya (2002), Noy (2009), Loayza et al. (2012) and Felbermayr and Gröschl (2014), control variables are the total population (in log), a measure of openness to trade (imports plus exports divided by GDP), inflation, domestic credit, gross capital formation, foreign direct investment and real interest rates.[12] We also introduce country fixed effects and year fixed effects in order to control for national characteristics that could influence growth. In order to respond to all concerns regarding endogeneity and the Nickell bias, we run various robustness regressions using Generalised Method of Moments (GMM) methodologies.

Results of the estimations

Results confirm the finding of Felbermayr and Gröschl (2014): there is no significant effect in terms of damages (in US dollars), number of fatalities or occurrence of natural disasters on economic growth for the sample of developing countries. However, we do find a significant effect on number of people affected by disasters on economic growth (Table 8). This makes

12 We do not include the current balance account and the polity index variables for availability reasons in BRACED countries. In the robustness analysis, we introduce these two variables that restrict our sample and find similar results.

intuitive sense, as people affected will experience further negative impacts in terms of health, education and productivity, which in turn affect the economic development of the country for several years. This is an interesting finding and one that has not been picked up by other studies, to our knowledge.

Climate-induced disasters seem to have a higher impact on growth than other disaster types, but the differences between the two coefficients are not significant. Effects are similar for all countries and the restricted sample of developing countries (columns 1 and 2). Unfortunately, the small size of the BRACED countries sample and the high heterogeneity within the group make it difficult to highlight a relationship between the impacts of climate-induced events and economic growth.

For the developing countries sample and climate-induced disasters, we can see that events affecting 1% of the population contribute to a reduction of economic growth of 0.05% on average. Control variables are mostly significant, with the sign expected. The R-squared variable has a value similar to the Felbermayr and Gröschl (2014) estimations.

Table 8. Effects of disasters on economic growth (1980–2012)

	ALL DISASTERS			CLIMATE-INDUCED DISASTERS		
	All countries	Developing countries	BRACED countries	All countries	**Developing countries**	BRACED countries
Variables	(1) Δln GDP per capita	(2) Δln GDP per capita	(3) Δln GDP per capita	(4) Δln GDP per capita	**(5) Δln GDP per capita**	(6) Δln GDP per capita
ln GDP per capita$_{i,t-1}$	-0.0485** (0.021)	-0.0795*** (0.028)	-0.0835 (0.062)	-0.0487** (0.021)	**-0.0798*** (0.028)**	-0.0810 (0.068)
ln Population$_{i,t-1}$	0.0024 (0.032)	-0.0652* (0.036)	0.1350 (0.303)	0.0025 (0.032)	**-0.0651* (0.036)**	0.1379 (0.316)
Trade openness$_{i,t-1}$	0.0003 (0.000)	0.0002 (0.000)	-0.0005 (0.000)	0.0003 (0.000)	**0.0002 (0.000)**	-0.0004 (0.000)
Interest rate$_{i,t-1}$	0.0000 (0.000)	0.0002 (0.000)	-0.0003 (0.000)	0.0000 (0.000)	**0.0002 (0.000)**	-0.0003 (0.000)
Domestic credit$_{i,t-1}$	-0.0002** (0.000)	-0.0002 (0.000)	0.0010 (0.001)	-0.0002** (0.000)	**-0.0002 (0.000)**	0.0010 (0.001)
Gross capital formation$_{i,t-1}$	0.0002*** (0.000)	0.0001** (0.000)	0.0003 (0.000)	0.0002*** (0.000)	**0.0001** (0.000)**	0.0003 (0.000)
Foreign direct investment$_{i,t-1}$	0.0011** (0.000)	0.0012** (0.001)	0.0029*** (0.001)	0.0011** (0.000)	**0.0012** (0.001)**	0.0028*** (0.001)
ln Inflation$_{i,t-1}$	-0.0056** (0.002)	-0.0035 (0.002)	0.0003 (0.012)	-0.0056** (0.002)	**-0.0034 (0.002)**	0.0014 (0.012)
ln Share pop. affected$_{i,t}$	-0.0459*** (0.015)	-0.0413** (0.017)	0.0349 (0.070)			
ln Share pop. affected by CE$_{i,t}$				-0.0550*** (0.016)	**-0.0506*** (0.018)**	0.0135 (0.077)
Constant	0.4265 (0.629)	1.7424** (0.707)	-1.5992 (4.655)	0.4264 (0.629)	**1.7423** (0.707)**	-1.6675 (4.829)
Observations	1.378	976	77	1.378	**976**	77
R-squared	0.216	0.244	0.627	0.217	**0.245**	0.624
Number of country	126	82	7	126	**82**	7

Note: Robust standard errors in parentheses; *** p <0.01, ** p <0.05, * p <0.1.
CE: climate extremes.

Owing to the high heterogeneity of the BRACED countries, we use various other geographical and economic sub-samples of countries to analyse some of these homogeneities and discrepancies (Table 9). For some samples, we find a negative and significant impact on economic growth of the share of the population affected.

The effects of climate-induced disasters on economic growth are significant and important for LLDCs, despite its small size. These results are of particular interest as most of the BRACED countries are LLDCs. We note also that there is no significant difference in the coefficient (impact of climate events) between the various samples tested.

Table 9. Effects of climate-induced disasters on economic growth (1980–2012) – sample specification

	Developing countries	BRACED countries	LDCs	LLDCs	LIC	SSA
Variables	(1) Δln GDP per capita	(2) Δln GDP per capita	(3) Δln GDP per capita	(4) Δln GDP per capita	(5) Δln GDP per capita	(6) Δln GDP per capita
ln GDP per capita$_{i,t-1}$	-0.0798*** (0.028)	-0.0810 (0.068)	-0.2291*** (0.080)	-0.0921*** (0.018)	-0.1208*** (0.036)	-0.2035** (0.077)
ln Population$_{i,t-1}$	-0.0651* (0.036)	0.1379 (0.316)	0.0435 (0.084)	0.0415 (0.027)	-0.1315*** (0.046)	0.0900 (0.063)
Trade openness$_{i,t-1}$	0.0002 (0.000)	-0.0004 (0.000)	0.0004 (0.001)	0.0004** (0.000)	0.0004 (0.000)	0.0004 (0.000)
Interest rate$_{i,t-1}$	0.0002 (0.000)	-0.0003 (0.000)	-0.0018** (0.001)	-0.0001 (0.000)	0.0003 (0.000)	-0.0010 (0.001)
Domestic credit$_{i,t-1}$	-0.0002 (0.000)	0.0010 (0.001)	0.0022 (0.001)	0.0005 (0.000)	-0.0000 (0.000)	0.0009 (0.001)
Gross capital formation$_{i,t-1}$	0.0001** (0.000)	0.0003 (0.000)	-0.0001 (0.000)	0.0001 (0.000)	0.0000 (0.000)	-0.0000 (0.000)
Foreign direct investment$_{i,t-1}$	0.0012** (0.001)	0.0028*** (0.001)	0.0019*** (0.001)	0.0008 (0.001)	0.0015** (0.001)	0.0014** (0.001)
ln Inflation$_{i,t-1}$	-0.0034 (0.002)	0.0014 (0.012)	-0.0045 (0.007)	-0.0029 (0.006)	-0.0029 (0.004)	-0.0036 (0.005)
ln Share pop. affected by CE$_{i,t}$	**-0.0506*** (0.018)**	0.0135 (0.077)	-0.0672 (0.047)	**-0.0431* (0.023)**	**-0.0424** (0.019)**	-0.0298 (0.026)
Constant	1.7423** (0.707)	-1.6675 (4.829)	0.8907 (1.319)	0.0908 (0.462)	3.1142*** (0.907)	0.0862 (1.044)
Observations	976	77	229	200	595	288
R-squared	0.245	0.624	0.482	0.427	0.300	0.404
Number of country	82	7	26	22	52	31

Note: Robust standard errors in parentheses; *** p <0.01, ** p <0.05, * p <0.1.
CE: climate extremes.

The response delay of economic growth to climate shocks is also analysed by introducing lags in the share of the population affected in the estimation (Table 10). As proposed by Felbermayr and Gröschl (2014), we introduce five lags in the estimation and find a direct and immediate impact on the developing countries sample and the LLDCs. The lag effect after three years is also significant and negative on the BRACED sample, although results remain weak and should be treated with some caution because of the small sample size.

Table 10. Effects and lags effects of climate-induced events on economic growth (1980–2012)

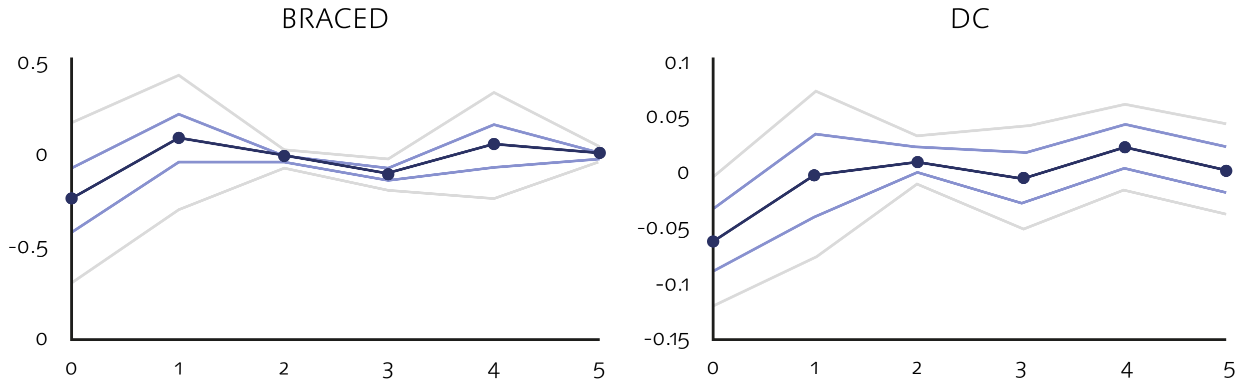
	Developing countries	BRACED countries	LDCs	LLDCs	LIC
Variables	(1) Δln GDP per capita	(2) Δln GDP per capita	(3) Δln GDP per capita	(4) Δln GDP per capita	(5) Δln GDP per capita
ln Share pop. affected by $CE_{i,t}$	-0.0619** (0.028)	-0.2613 (0.163)	-0.1447 (0.091)	-0.0759* (0.041)	-0.0545 (0.038)
ln Share pop. affected by $CE_{i,t-1}$	-0.0022 (0.037)	0.0686 (0.139)	-0.0905 (0.109)	0.0796 (0.114)	0.0089 (0.041)
ln Share pop. affected by $CE_{i,t-2}$	0.0106 (0.011)	-0.0215 (0.021)	-0.0195 (0.051)	0.0843 (0.073)	0.0198 (0.017)
ln Share pop. affected by $CE_{i,t-3}$	-0.0056 (0.023)	-0.1173** (0.033)	0.0481 (0.029)	0.1608*** (0.035)	0.0058 (0.026)
ln Share pop. affected by $CE_{i,t-4}$	0.0225 (0.019)	0.0374 (0.107)	0.0595 (0.045)	0.1443 (0.080)	0.0088 (0.021)
ln Share pop. affected by $CE_{i,t-5}$	0.0024 (0.020)	0.0004 (0.011)	0.0311 (0.061)	0.0341 (0.050)	0.0176 (0.022)
Observations	545	47	114	83	337
R-squared	0.298	0.956	0.514	0.729	0.310
Number of country	58	6	17	12	39

Note: Robust standard errors in parentheses, *** p <0.01, ** p <0.05, * p <0.1. CE: climate extremes. Control variables as presented in Table 8.

The lags illustrate the time evolution of disaster effects (see Hochraine, 2009). In Figure 1 we reproduce the various coefficients and levels of significance for each of the lags used. The figure demonstrates some of the problems with the BRACED sample and the high heterogeneity of the countries. That said, the analysis produces a number of important findings:

- The coefficients are very similar to those found in developing countries (negative important effect immediately after the shocks, absorption of the shock in the second year and then a slowdown in the third year).
- The small sample size and its heterogeneity make thresholds of significance very important.
- We cannot conclude that there is a significant contemporary impact of climate disasters on economic growth in BRACED countries. However, in LLDCs there is a negative effect, and many of the BRACED countries fall into this category.
- The introduction of lags contributes to understanding the evolution of post-disaster resilience (coping capacity after a shock).

Figure 1. Contemporary and lags effects of climate induced events



Note: The line with the dots shows the impact of disasters over the five-year time period following the occurrence of the shocks in time t=0. Dots are points estimated. In blue is the standard deviation of the coefficient estimated. In grey are the 95% confidence intervals.

Studying resilience and the 'bounce back' period is almost impossible in econometrics without looking at shocks. With a shock (in this case a climate extreme), we can assess the causal relationship between events and socioeconomic variables (in this case economic growth). Introducing a lag effect in the analysis of economic impacts allows us to better understand stages of shock impacts and to characterise coping capacity. We find a significant important negative impact immediately after the shock (contemporaneous effect). The non-lag effects of the shocks can be interpreted as either 1) the full capacity of the countries to recover quickly after shocks or 2) the external assistance effect helping them recover quickly. These two options can be investigated for different sizes of shocks (see Annex 2).

In a theoretical framework, total resilience describes a situation where a country immediately and fully absorbs externals shocks, meaning that its economic growth will not suffer a decline. The fact that we can observe an immediate negative impact on countries' growth reveals that there is some resilience deficit. This indicates that the preparedness and immediate response capacity of these countries could be strengthened, although this kind of measure would be expensive and total absorption is obviously impossible. The delayed negative impact of disasters on economic growth in BRACED countries highlights the need for longer-term consideration – and management – of impacts. Short-term humanitarian aid may not be sufficient in building effective resilience, although this needs to be investigated in more detail, using longitudinal humanitarian and development aid data to explore the relationship between disasters/aid and growth.

An important finding from the five-year lag analysis is therefore that disasters do not generate a temporary economic boom, as some observers argue (Skidmore and Toya, 2007). On average, in our country sample, disasters are seen to be detrimental to the economy.

Section 2 showed us the significance of droughts and flood events in BRACED countries; hence, the decision was taken to investigate further the specific impacts of these on economic growth. Overall, we find a significant negative contemporaneous effect of both droughts and floods on economic growth. Drought effects are more important than floods for developing countries. Although results for the BRACED sub-sample need to be interpreted with caution, the relation seems to be inverse (i.e. flood effects are more important than those of droughts). Because of the small sample size, we cannot conclude which events have the most serious consequences for BRACED countries.

Table 11. Effects and lags effects of climate-induced events on economic growth (1980–2012)

	Developing countries	BRACED countries	Developing countries	BRACED countries
Variables	(1) Δln GDP per capita	(2) Δln GDP per capita	(3) Δln GDP per capita	(4) Δln GDP per capita
ln Share pop. affected by drought $_{i,t}$	**-0.1059**** **(0.052)**	-0.2534 (0.169)		
ln Share pop. affected by drought $_{i,t-1}$	0.0255 (0.062)	-0.0250 (0.174)		
ln Share pop. affected by drought $_{i,t-2}$	0.0241 (0.020)	0.0000 (0.019)		
ln Share pop. affected by drought $_{i,t-3}$	-0.0057 (0.038)	**-0.0980**** **(0.031)**		
ln Share pop. affected by drought $_{i,t-4}$	0.0156 (0.023)	0.0547 (0.096)		
ln Share pop. affected by drought $_{i,t-5}$	-0.0060 (0.025)	0.0164 (0.013)		
ln Share pop. affected by flood $_{i,t}$			**-0.0766*** **(0.043)**	**-2.1230**** **(0.616)**
ln Share pop. affected by flood $_{i,t-1}$			-0.0392 (0.053)	-1.8744 (1.316)
ln Share pop. affected by flood $_{i,t-2}$			-0.0280 (0.034)	**-2.5900**** **(0.678)**
ln Share pop. affected by flood $_{i,t-3}$			-0.0380 (0.032)	**-1.8447**** **(0.489)**
ln Share pop. affected by flood $_{i,t-4}$			0.0171 (0.033)	0.0761 (0.724)
ln Share pop. affected by flood $_{i,t-5}$			0.0129 (0.031)	-0.8898 (0.598)
Constant	0.8749 (0.848)	-15.0517 (14.072)	1.1990* (0.706)	-7.9048 (8.228)
Observations	545	47	545	47
R-squared	0.300	0.950	0.293	0.958
Number of country	58	6	58	6

Note: Robust standard errors in parentheses, *** p <0.01, ** p <0.05, * p <0.1. Control variables as presented in Table 8.

Looking at the two climate events together in the estimation we find that floods are more important for developing countries (Table 12).

Table 12. Effects of climate-induced events on economic growth (1980–2012), by event

Developing countries	(1) Δln GDP per capita
ln Share pop. affected by drought $_{i,t}$	**-0.0504**** **(0.021)**
ln Share pop. affected by extreme temperature $_{i,t}$	**-0.1245*** **(0.070)**
ln Share pop. affected by flood $_{i,t}$	**-0.1245***** **(0.037)**
ln Share pop. affected by wet mass movement $_{i,t}$	0.1378 (0.639)
ln Share pop. affected by storm $_{i,t}$	0.0190 (0.030)
Constant	1.7794** (0.703)
Observations	976
R-squared	0.249
Number of countries	82

Note: Robust standard errors in parentheses, *** p <0.01, ** p <0.05, * p <0.1. Control variables as presented in Table 8. Control variables as presented in Table 8.

Table 13 shows the impact of large events on economic growth. The large events have a significant negative impact on developing countries' growth. The interesting result is that small events (even if results need to be taken with caution owing to the risk of selection bias) have a significant negative impact on the BRACED sample but without the lags' positive effect. A potential explanation could be that the assistance countries receive after a disaster is proportionally greater for large events than it is for smaller ones. Again, the small size of the BRACED sample means we should interpret these results with caution, suggesting a need for further investigation in the future.

Table 13. Effects of climate-induced events on economic growth (1980–2012), large and small events

	ALL DISASTERS				CLIMATE-INDUCED DISASTERS			
	All countries	Developing countries	BRACED countries	BRACED countries	All countries	Developing countries	BRACED countries	BRACED countries
Variables	(1) Δln GDP per capita	(2) Δln GDP per capita	(3) Δln GDP per capita	(3) Δln GDP per capita	(4) Δln GDP per capita	(5) Δln GDP per capita	(6) Δln GDP per capita	(6) Δln GDP per capita
ln Share pop. affected by $\text{disasters}_{i,t}$	**-0.0466*** **	**-0.0425** **	0.0363					
LARGE EVENT	**(0.015)**	**(0.017)**	(0.070)					
ln Share pop. affected by $\text{CE}_{i,t}$					**-0.0565*** **	**-0.0528*** **	0.0152	
LARGE EVENT					**(0.016)**	**(0.018)**	(0.077)	
ln Share pop. affected by $\text{disasters}_{i,t}$				**-2.6649***				
SMALL EVENT				**(1.184)**				
ln Share pop. affected by $\text{CE}_{i,t}$								**-2.6433***
LARGE EVENT								**(1.203)**
Observations	1.378	976	77	77	1.378	976	77	77
R-squared	0.216	0.244	0.627	0.635	0.217	0.245	0.624	0.635
Number of country	126	82	7	7	126	82	7	7

Note: Robust standard errors in parentheses, *** p <0.01, ** p <0.05, * p <0.1.
Control variables as presented in Table 8.

Key findings from the econometric analysis

We can draw from the econometric analysis a number of key findings of relevance to understanding and enhancing national capacity to absorb disaster impacts:

- Disasters have an immediate (contemporary) negative effect on developing countries' growth. There is a negative significant effect of the share of the population affected by disasters on economic growth. A climate event affecting 1% of the population contributes to a reduction of economic growth of 0.05% on average. The negative effects of climate-induced events on economic growth are particularly significant and important for the LLDC sub-sample, which includes most BRACED countries.

- Climate-induced events have lag effects in BRACED countries. Although shocks seem to be absorbed the year following the event, there are significant negative impacts on economic growth three years after the disaster. A sharp increase in international assistance could be one of the explanations for the upward trend witnessed in the year following the disaster, in which case the slowdown in the third year following a disaster may be related to the withdrawal of aid after the crisis and/or the incapacity of the country to smooth aid and income over time. This interesting hypothesis will be the object of a forthcoming study.

- Disasters do not appear to boost economic growth. On average, in our country sample, disasters rather seem to be harmful to development.

4. IMPLICATIONS FOR BRACED

IMAGE:
LAXMI PRASAD NGAKHUSI/UNDP NEPAL

This study of disaster impacts and resilience at different scales generates a number of important findings for the BRACED programme and beyond. BRACED countries have been disproportionally affected by disasters, particularly climate-induced ones, when compared with other groups of developing countries. This finding suggests there is some coherence across BRACED countries, justifying to some extent their inclusion within the BRACED programme. With high levels of risk, BRACED countries are particularly in need of initiatives that help build economic resilience so they can bounce back from the shocks they experience, reducing longer-term macroeconomic impacts.

Nonetheless, the BRACED sample is heterogeneous with respect to both the level of impact and their risk characteristics (disaster frequency and number of disaster types experienced). In comparing impacts over the past four decades, we find that disasters have had a more severe effect on some BRACED countries than they have on others. The countries experiencing more severe effects include Mauritania, Niger, Sudan and Kenya (when looking at numbers affected) and Ethiopia and Sudan (when looking at mortality rates). This finding is of importance for deciding where to allocate resources across these countries, and in particular to support action at the national level to build resilience.

This paper also reveals the disproportionate impact of drought compared with other climate-induced disaster types in BRACED countries, particularly in Africa. Floods have resulted in fewer deaths and lower numbers affected than droughts have, but floods have been very frequent in all BRACED countries. Special attention therefore needs to be paid to vulnerabilities and capacities relevant to these hazards within broader resilience programmes.

The findings presented cannot be disaggregated at the subnational level, but shocks are not equally distributed across territories and impacts will be uneven. Agencies implementing projects at subnational levels should keep in mind the scale of analysis when supporting resilience, to make sure the metrics/indicators used are consistent with the purpose of their projects.

The econometric analysis conducted for this study points to a negative significant effect of the share of the population affected by disasters on economic growth. A climate-induced disaster affecting 1% of the population contributes to a reduction in economic growth of 0.05% on average. The negative effects of the climate-induced disasters on economic growth are particularly significant and important in LLDCs, (a group that includes most BRACED countries). These impacts are rarely the focus of resilience-building programmes, but they are important. Livelihoods and government programming will be undermined by poor economic performance and currently, international assistance in the form of post-disaster aid is not protecting economies from these impacts.

This study of resilience at the national scale highlights disparities between countries. Indeed, some countries have greater economic resilience than others. Therefore, identifying the structural characteristics of these countries is of particular relevance. Policies that target structural weaknesses could be particularly effective in reducing climate disruption. Economic diversification and trade openness, or insurance coverage could be important determinants of national capacity to absorb external shocks and could consequently represent a path to be followed to improve national resilience.

Statistical and econometric analysis is not sufficient, however, to identify the numerous factors that constitute resilience, as these are multiple and complex and vary from one region, country, district, community and even household to another. More mixed-method case study work is needed to understand these factors. The BRACED programme will generate important data for research thanks to the myriad of initiatives being implemented at the community level, many of them with interventions targeted at the subnational and national levels. Further support to policy, economic and institutional development is, however, also needed to avoid these negative economic impacts.

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Annex 1. Databases on disasters: Availabilities and caveats

Disaster loss and damage databases

Several databases exist with disaster loss and damage data at the global, regional, national and subnational levels. The UN Development Programme Global Risk Identification Programme (GRIP) identifies 62 disaster loss databases worldwide among which 5 are global, 2 regional, 50 national, 4 subnational and 1 event-based (Hurricane Mitch) (UNDP BCPR, 2013). If national disaster databases are known to better capture extensive disaster risks and their impacts on societies than global databases, they do not allow for the cross-country analysis that needs to be carried out in this study. Despite the fact that the majority of existing national databases use a common methodology and definition called DesInventar (disaster inventory), comparison and cross-border studies are still limited owing to inconsistencies in levels of quality, different focuses in terms of outcome variables and limited geographical coverage (more than three-quarters of countries do not have any kind of national disaster database).

The three most comprehensive global databases are EM-DAT maintained by CRED at the Université Catholique de Louvain; NatCatSERVICE (NatCat) maintained by Munich Re; and Sigma maintained by Swiss Re. Conceived for different purposes and clients, these three databases vary in their content. Essentially designed to provide services to their client insurance companies, Sigma and NatCat prioritise detailed economic losses, whereas EM-DAT, which was conceived for the development and scientific research communities, focuses more on human losses.

Two main issues prevent NatCat and Sigma from being used in this study. First, both of these databases give priority to insured losses and are therefore seriously limited by the weak levels of insurance penetration in developing countries. Second, both databases restrict access to their datasets to Munich Re and Swiss Re clients. EM-DAT is therefore the most appropriate available disaster loss and damage database for this study.

EM-DAT description and limitations

Created by CRED in 1988, EM-DAT contains data on the date, impact and location of natural and technological disasters in the world from 1900 to the present. The natural disaster category is divided into five sub-groups, which in turn cover twelve disaster types and more than thirty sub-types. The database is built from various sources, including UN agencies (the UN Environment Programme, the Office for the Coordination of Humanitarian Affairs, the World Food Programme, and the Food and Agricultural Organization), non-governmental organisations (the International Federation of the Red Cross and Red Crescent Societies (IFRC)), insurance companies, research institutes and the media. Priority is given to data from UN agencies, followed by Office of US Foreign Disaster Assistance governments and the IFRC. EM-DAT provides free access to data by country, disaster profile or timeframe. Once a month after validation of the entries, systematically reviewed for redundancy, inconsistencies and incompleteness, new data are made available without restriction on the website. The interface is user-friendly and provides various analyses, maps and related documents for research using outputs of the database.

Despite CRED efforts to improve the quality and accuracy of data it routinely registers, key challenges remain (Guha-Sapir et al., 2012). As do many disaster databases, EM-DAT suffers important limitations, of which end users must be aware when interpreting hazard loss information (Gall et al., 2009).

EM-DAT contains better information on large-scale, acute, intensive disasters than it does on small-scale, low-impact, extensive and chronic disasters[13] (Gall and Kreft, 2013). This bias towards large catastrophic events can be explained in part by the fact that EM-DAT maintains a global and national observation level, making it difficult to record small-scale localised events. This bias owes also to the presence of inclusion thresholds, which are the minimum criteria that any event must meet to be entered in the dataset. CRED includes in its database only events that triggered more than 10 fatalities, that affected more than 100 people or that led to a declaration of state of emergency or a call for international assistance (UNISDR a, 2013). Events that caused significant monetary losses and/or led to drastic increase of poverty levels without exceeding local response capacities are therefore not recorded in EM-DAT.

EM-DAT relies on 'declared information', meaning that the absence of disaster in EM-DAT can have two different significations – first that no disaster has occurred and second that the disaster has not been reported. The rate of non-response can be high in EM-DAT, and the probability of non-response increases for small-scale events. This issue becomes visible when comparing EM-DAT with national disaster databases. While the US national disaster database (Sheldus) contains more than 600,000 records of disasters at all scale, CRED records only 1,200 events for the US in EM-DAT. The same trend can be noticed for Colombia and Sri Lanka, where national databases record 30,000 and 10,000 disasters, respectively, whereas EM-DAT captures

13 Although extensive risk events cause only 13% of total mortality they are responsible for more than 42% of total economic losses (UNISDR, 2013a).

only 230 and 103 events. Information collected by EM-DAT should therefore not be considered as representing the full set of disasters witnessed in one particular country.

Another limitation is linked to the definition of variables and the quality of loss data reported. Existing estimates in disaster loss databases are fraught with difficulties. Some problems remain over the adoption of commonly accepted definitions of the different variables. Should death include missing people? Should the injured category also take into account mental health effects? How long should people be away from their home to be characterised as displaced? Should 'affected' define all persons leaving the disaster location or should it be more specific? Moreover, it is often difficult to avoid double counting, as the same person can fit into more than one variable. While there is uncertainty about mortality data (absence of death certificates), the quality of data on morbidity and economic losses is even poorer. EM-DAT includes economic valuations of losses in less than 30% of its records (Guha-Sapir and Below, 2002), making the economic damage variable unreliable if not unusable. For this reason, this study does not take into account estimated disaster damage reported by EM-DAT.

Some temporal and geographical biases are also witnessed when dealing with disaster loss data. If an upward trend of hazard impacts can owe to an increase in disaster scope and scale, wealth, population or vulnerability, it can also be the effect of better reporting technics. The quality of EM-DAT data has witnessed a drastic increase since creation of the database in 1988. Users have to be aware of this limitation when comparing historical and current data. Boundary changes at the country or sub-country levels also have to be taken into account as they introduce spatial inconsistencies in the assignment of losses and may result in double counting (Gall et al., 2009). Furthermore, it is important to recognise that countries and regions do not have the same levels of technical capacities and resources to assess disaster impacts. Producing reliable loss and impact information remains a challenge, especially in difficult environments, such as those encountered in many developing and post-conflict countries. This may lead to important discrepancies in the reporting, which must be taken into account when comparing countries.

A last limitation is linked to data collection and sources (Gall et al., 2009). Disaster data can be collected on different dates, leading to over or underestimation of the losses. Timing is particularly important when looking at extensive disasters that may not have significant direct impacts but tend to have long-term indirect effects on societies. Another issue for EM-DAT that relies on 'declared data' is linked to data sources, as certain interest groups can manipulate information to amplify losses, in order to obtain more international aid, or understate them, in order to conceal deficiencies in disaster preparedness, mismanagement or corruption (Kron et al., 2012). EM-DAT does not specify the data sources for its estimates, which makes loss verification extremely difficult (Gall et al., 2009).

A physical disasters database for a complementary approach

To overcome a number of key limitations inherent to all loss and damage databases presented above, two alternative options could be used. The first alternative is to focus only on EM-DAT's occurrence variable, while leaving out of the analysis the nature and size of disaster impacts. If this method allows us to avoid most issues directly related to the recording of disaster impacts, it does not address the bias related to the selection of events. In other words, with this method, only disasters that have been recorded by EM-DAT will appear in the analysis, excluding many small-scale low-impact extensive disasters. Another problem with this option is that focusing only on whether or not an event has happened drastically reduces the information available. No information on the size and intensity of the events is visible and usable.

A second option could be to use along with EM-DAT a database recording the geophysical and meteorological intensities of natural hazards rather than their socioeconomic impacts, such as the GeoMet dataset created by Felbermayr and Gröschl (2014). Covering the period 1979–2010, GeoMet uses data recorded by geophysicists and meteorologists to report information on intensity, month, year and country of occurrence in an exogenous way. This new database contains measures of disaster strength, such as Richter scale and wind speed. A comparison of GeoMet and EM-DAT shows that, if almost all disasters recorded by EM-DAT can be found in GeoMet, the opposite is not true. Out of the 10,448 earthquakes recorded by GeoMet ranking at least 5 on the Richter scale, only 6.2% were included in EM-DAT (Felbermayr and Gröschl, 2014). However, this methodology also presents its own limitations. The main issue with the GeoMet database is that it is unable to capture the characteristics of the environment in which natural hazards strike. GeoMet reports in an identical way two events of the same intensity without taking into account population exposure, for instance. It cannot differentiate an event hitting a desert area with very few disperse populations from an event of the same intensity striking a densely populated urban area.

It is therefore very interesting to use both databases, as they complement each other. While GeoMet measures the physical intensity of natural hazards independently of countries' socioeconomic conditions, EM-DAT provides key additional information on society exposure and disaster impacts.

Annex 2. Robustness

In order to check the robustness of the estimations, a number of tests have been carried out on the sample, the estimations methods and the control variables.

Period sampling

In order to test the robustness of the period sampling, all the previous estimations are run over the period 1980–2012. Robustness estimations over the period 1970–2012 provide similar results. Then the model is tested on two different sub-periods – 1980–1995 and 1996–2012. The results are not significant for the first time period. However, this is more likely to be the result of a statistical effect rather than a real changing relationship between natural disasters and economic growth over time. Indeed, the estimation on the first time period offers only 132 observations, against 844 for the second one. This is corroborated by several tests for temporal breaks that do not give significant results. Significant differences over time in the coefficient could be an illustration of a better response by the countries (countries more prepared and able to recover more quickly from a shock). We do not see statistically this kind of break in the trends in the estimations.

Estimation method

In our baseline estimations, we rely on the hypotheses of Felbermayr and Gröschl (2014), and the relatively long time dimension of our sample (30 years) allows us to consider the Nickell bias as a minimum. The Nickell bias considers that the presence of lagged dependent variables renders the OLS estimator biased since the lagged dependent variable is correlated with the error term (Nickell, 1981).

We run GMM estimations in order to confirm the results with estimations specifically dealing with this issue. We use the two commonly used estimators: the difference-GMM (Arellano and Bond, 1991) and the system-GMM (Arellano and Bover, 1995; Blundell and Bond, 1998). For both estimations, we limit the number of lags of the explanatory variables to reduce the proliferation of instruments and the 'over-fitting' bias (Roodman, 2009). The difference-GMM estimator uses the first differences of the baseline estimation (to remove country fixed effects), and the variables differentiated are instrumented by their lagged values in level. The first difference the model captures is unobserved heterogeneity. In the system-GMM estimation, we combine in a system, equations in levels and in difference. The instrumentation is done by lagged differences and lagged levels of the explanatory variable. In the two estimations we apply the Sargan/Hansen test of over-identifying restrictions, which gives us the results expected to test the instrument validity.

In both cases, the indices based on the affected people produce significant, negative effects of disasters on growth, whereas the alternative measures do not yield statistically significant results.

We finally test for a specification that regresses the log level of GDP per capita on disasters and the other controls used in Table 12 but that does not include the lagged value of the dependent variable on the right-hand side (as Felbermayr and Gröschl (2014) propose for validation). All results estimated are similar.

Large vs. small events

Different behaviours may indeed exist towards large and rare disasters and small but more frequent disasters. As suggested by the literature, large and small events can have differentiated impacts on growth. We classify large events in the same way as the UN. Where one of the following conditions is respected, the event is considered large: at least 100,000 people are affected; more than 1,000 people are killed; and/or the damage involves more important than US$1 billion. The first objective of this distinction is to test the impact of large events, as they are believed to be more important (Cavallo et al., 2013). This distinction also helps to control for a likely biased selection, which is important for small events (particularly the non-response rate).

BRACED aims to build the resilience of up to 5 million vulnerable people against climate extremes and disasters. It does so through a three year, UK Government funded programme, which supports more than 120 organisations, working in 15 consortiums, across 12 countries in East Africa, the Sahel and Southeast Asia. Uniquely, BRACED also has a Knowledge Manager consortium.

The Knowledge Manager consortium is led by the Overseas Development Institute and includes the Red Cross Red Crescent Climate Centre, the Asian Disaster Preparedness Centre, ENDA Energie, ITAD, Thomson Reuters Foundation and the University of Nairobi.

The BRACED Knowledge Manager generates evidence and learning on resilience and adaptation in partnership with the BRACED projects and the wider resilience community. It gathers robust evidence of what works to strengthen resilience to climate extremes and disasters, and initiates and supports processes to ensure that evidence is put into use in policy and programmes. The Knowledge Manager also fosters partnerships to amplify the impact of new evidence and learning, in order to significantly improve levels of resilience in poor and vulnerable countries and communities around the world.

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