nature sustainability

Analysis

https://doi.org/10.1038/s41893-023-01107-7

The wider the gap between rich and poor the higher the flood mortality

In the format provided by the authors and unedited

Table of Contents

Sample overview

Supplementary Table 1 | Summary statistics of samples. The unit of analysis is a flood disaster occurring between 1990 and 2018. The outcome variable is the flood fatalities per event. The covariate variables use the values the year of the event.

	Mean	sd	Min	Max
Middle- and high-income countries. 573 floods in 67 countries. 51 in Africa, 186 in Americas, 134 in Asia, 166 in Europe and 36 in Oceania.				
Fatalities per event	15.7	59.6	0	900
Potentially exposed in affected region	1466.9	2860.5	0.4	32536.6
Share of potentially exposed in HDC (%)	36	33.6	0	100
Settlement area in affected region (km^2)	4054.2	9872.5	2.2	114631.2
Country Gini index (%)	39.5	8.1	24.1	63.5
Country GDP/cap (1,000 US$)	20.6	15.8	2.4	62.3
Country population ages ≥ 65 (%)	9.9	5.3	2.3	22.5
OECD member countries. 265 floods in 28 countries. 103 in Americas, 8 in Asia, 124 in Europe and 30 in Oceania.				
Fatalities per event	5.6	17.9	0	240
Potentially exposed in affected region	1805.7	3530.2	0.4	32536.6
Share of potentially exposed in HDC (%)	33	32.5	0	100
Settlement area in affected region (km^2)	6420.5	13167.2	2.2	114631.2
Country Gini index (%)	35.2	7	24.2	54.3
Country GDP/cap (1,000 US$)	33.9	13.3	7.6	62.3
Country population ages ≥ 65 (%)	13.7	4.1	4.5	22.5

Note. sd = Standard deviation. HDC = high-density cluster. Gini index refers to the Gini index of disposable income. GDP/cap refers to the per capita real GDP (2017 US$).

Supplementary Table 2 | Summary statistics of sample per country.

Country	Floods	Fatalities					Gini	GDP/cap
	n	*Sum*	*MD*	*Mean*	*Min*	*Max*	*Mean*	*Mean*
OECD member countries								
Australia	26	77	0	3	0	35	32.2	43.4
Austria	1	0	0	0	0	0	28	45.6
Belgium	7	4	0	0.6	0	2	26.2	38.6
Canada	16	14	0	0.9	0	4	31	44.5
Chile	10	163	4	16.3	0	109	49.2	13.7
Colombia	16	148	1.5	9.2	0	56	50.8	11.1
Costa Rica	8	23	1	2.9	0	9	44.6	12.4
Czechia	2	8	4	4	1	7	25.3	31.3
France	25	131	2	5.2	0	36	28.5	35.2
Germany	3	3	0	1	0	3	26.8	36
Greece	21	73	1	3.5	0	23	33.1	27.8
Hungary	1	0	0	0	0	0	27.6	20.8
Italy	16	89	2	5.6	0	35	33.3	36.7
Japan	3	9	1	3	0	8	30.2	35.7
Lithuania	1	4	4	4	4	4	33.6	22.5
Mexico	12	334	4	27.8	2	240	46.4	15.6
New Zealand	4	0	0	0	0	0	32	27.1
Norway	1	0	0	0	0	0	24.8	45.8
Poland	4	14	2.5	3.5	0	9	30.1	21
Portugal	1	43	43	43	43	43	33.4	30.5
Slovakia	5	61	2	12.2	1	54	25.4	19.8
Slovenia	2	3	1.5	1.5	0	3	25.5	31.9
South Korea	2	27	13.5	13.5	10	17	31.7	34.6
Spain	12	41	1.5	3.4	0	10	32.1	31.5
Switzerland	2	0	0	0	0	0	29.2	49.3
Turkey	3	11	2	3.7	2	7	41	14.5
United Kingdom	20	41	0	2	0	8	34	36.5
United States	41	164	2	4	0	37	37.5	51.1
Not OECD member countries								
Albania	1	0	0	0	0	0	39.1	9.1
Algeria	2	1	0.5	0.5	0	1	36	12.2
Angola	12	177	8.5	14.8	0	69	50.1	3.9
Argentina	12	88	1.5	7.3	0	52	40.9	17.6
Azerbaijan	6	16	0	2.7	0	11	30.8	4.2
Belarus	1	5	5	5	5	5	24.1	8.7
Bolivia	6	73	0	12.2	0	69	47.5	5.4

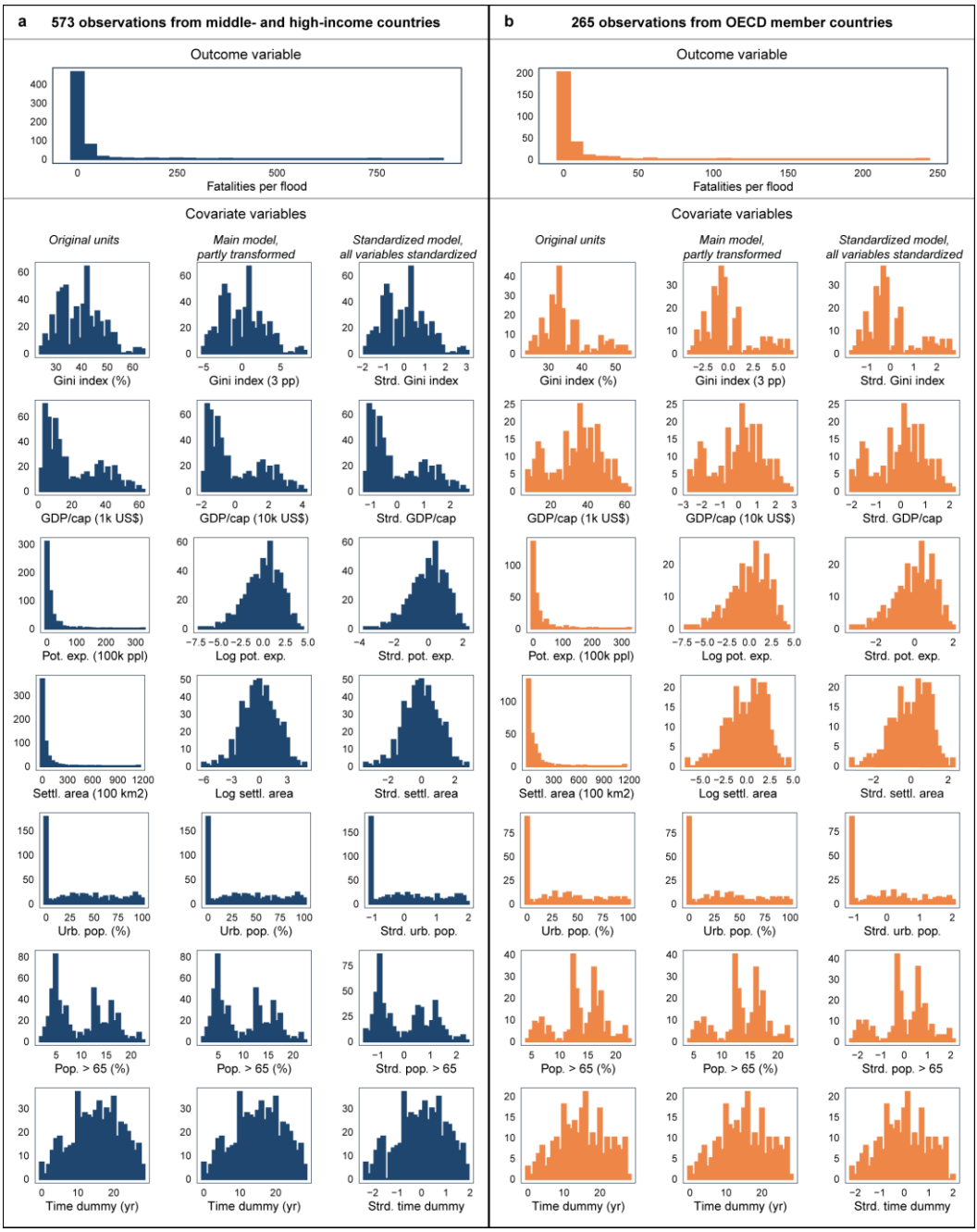
Bosnia & Herzegovina	5	1	0	0.2	0	1	39	9.1
Botswana	1	20	20	20	20	20	58	8.3
Brazil	39	1893	12	48.5	0	900	49.8	12.1
Bulgaria	1	2	2	2	2	2	33.1	11.3
Cameroon	6	71	9.5	11.8	3	30	44.9	2.8
China	12	335	12	27.9	0	199	40.4	8
Croatia	6	3	0	0.5	0	3	28.3	18.9
Ecuador	3	2	0	0.7	0	2	45	9
Egypt	1	4	4	4	4	4	41.3	5.4
Fiji	6	55	11	9.2	0	17	40.6	7.2
Georgia	4	1	0	0.2	0	1	37.9	6.1
Guatemala	1	0	0	0	0	0	48.1	6.2
Honduras	4	16	5	4	0	6	51.1	3.5
Indonesia	49	1490	13	30.4	0	291	44	6.7
Iran	10	449	7.5	44.9	1	370	40.8	11.4
Iraq	2	20	10	10	0	20	32.5	7.2
Kazakhstan	3	2	0	0.7	0	2	26.4	23.1
Malaysia	6	302	8	50.3	0	270	42.1	16.6
Morocco	18	1094	13	60.8	0	730	41.2	5.4
Nicaragua	6	177	0	29.5	0	177	44.4	4.1
Panama	2	12	6	6	0	12	51	8.5
Peru	8	106	14.5	13.2	1	22	49.6	7.4
Philippines	27	249	1	9.2	0	98	42.1	5.4
Romania	3	1	0	0.3	0	1	31.1	11.4
Russia	17	427	1	25.1	0	172	35.3	17.5
Serbia	5	5	0	1	0	4	33.9	14.4
South Africa	11	264	4	24	0	207	62.3	10.6
Sri Lanka	2	33	16.5	16.5	15	18	48	6.9
Thailand	4	43	2.5	10.8	0	38	42.5	11.1
Ukraine	3	25	5	8.3	2	18	28	8.2
Uzbekistan	1	0	0	0	0	0	32.2	6
Venezuela	2	26	13	13	0	26	41.9	8.1

Note. MD = median. The OECD membership refers to the status in 2022.

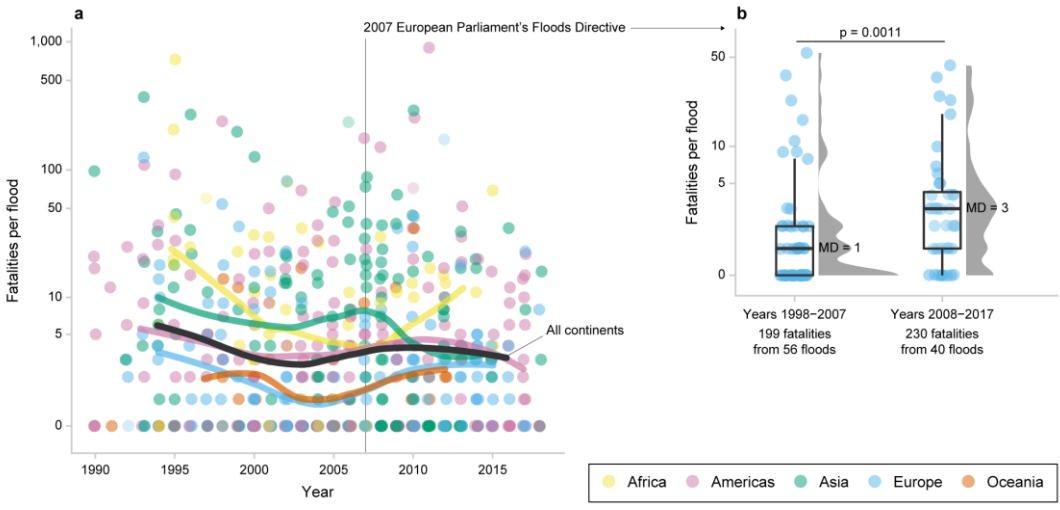
Supplementary Table 3 | Change in inequality and average living standards between 1990 and 2018. This table shows the representative changes for the sample over the period with values close to the mean absolute changes (~3 percentage points change in the Gini and ~10,000 US$ change in the per capita GDP), for which the effect on flood mortality was quantified in the regression analysis.

	Mean	sd	Min	Max
Middle- and high-income countries (n = 67)				
Change Gini index (pp)	0.6	4.5	-8.2	11.8
Absolute change Gini index (pp)	3.7	2.5	0.2	11.8
Change GDP/cap (1k US$)	12.4	8.4	-9	35.6
Absolute change GDP/cap (1k US$)	12.7	8	0.3	35.6
OECD member countries (n = 28)				
Change Gini index (pp)	1.9	3.3	-5.5	7.9
Absolute change Gini index (pp)	3.3	1.6	0.7	7.9
Change GDP/cap (1k US$)	18.9	6.8	6	35.6
Absolute change GDP/cap (1k US$)	18.9	6.8	6	35.6

Note. sd = standard deviation. pp = percentage points. 1k = 1,000. Gini index refers to the Gini index of disposable income. GDP/cap refers to the per capita real GDP (2017 US$).



Supplementary Figure 1 | Histograms of outcome and covariate variables. This figure illustrates the distributions of the outcome variable and the covariate variables in original units. The distributions of the covariate variables are also shown in the units used in the main model and as standardized variables.



Supplementary Figure 2 | Major flood disasters in middle- and high-income countries have generally not become less fatal since since 1990. Panel **a** shows a scatter plot of fatality numbers for 573 flood disasters (dots) over time, with the black trend line referring to all continents. Only Asia has a significant trend of decreasing fatalities according to a two-sided Mann-Kendall test ($p = 0.012$), using a 5% significance level. Supplementary Table 4 provides p values across all continents. The trend lines are fitted with local polynomial regression. Panel **b** presents a box plot showing disasters in EU states, 10 years before and after the European Parliament's Floods Directive in 2007. The period following the Directive had fewer flood disasters compared to the period before, but also more reported flood fatalities. The dots indicate individual observations, the box hinges indicate the 25th and 75th percentiles, the centre line refers to the median value (MD), and the whiskers indicate the interquartile range multiplied by a factor of 1.5. The p value refers to a two-sided Wilcoxon test comparing the group means.

Supplementary Table 4 | Resulting p-values controlling temporal trends across continents in mortality rates and fatalities per flood. Only Asia has significant temporal trends, using a 5% significance level. The p-values have been calculated using two-sided Mann-Kendall tests.

	Mortality rate	Fatalities per flood
	p	*p*
Entire sample	0.172	0.175
Africa	0.061	0.304
The Americas	0.381	0.242
Asia	**0.003**	**0.012**
Europe	0.113	0.204
Oceania	0.723	0.524

Regression result tables

Supplementary Table 5 | Results from negative binomial mixed regression models, using observations from middle- and high-income countries.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	RRs	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*
3pp Gini	**1.16 (1.01 – 1. 33)**	**0.03 2**			**1.16 (1.01 – 1. 33)**	**0.03 1**	1.14 (0.99 – 1. 30)	0.06 5	**1.15 (1.01 – 1. 32)**	**0.03 9**	**1.14 (1.00 – 1. 31)**	**0.04 9**	**1.22 (1.09 – 1. 37)**	**<0.0 01**	1.13 (1.00 – 1. 29)	0.05 9	**1.17 (1.04 – 1. 30)**	**0.0 06**
10k$ GDP /c	0.97 (0.73 – 1. 29)	0.81 9	0.95 (0.71 – 1. 27)	0.73 8			0.90 (0.68 – 1. 19)	0.46 6	0.93 (0.71 – 1. 23)	0.60 7	0.95 (0.71 – 1. 25)	0.69 4	0.87 (0.68 – 1. 10)	0.24 2	0.92 (0.70 – 1. 20)	0.53 1	0.86 (0.70 – 1. 05)	0.1 48
Log pot exp	**1.36 (1.09 – 1. 68)**	**0.00 6**	**1.32 (1.06 – 1. 64)**	**0.01 2**	**1.36 (1.10 – 1. 69)**	**0.00 4**			**1.23 (1.08 – 1. 41)**	**0.00 1**	**1.20 (1.04 – 1. 39)**	**0.01 4**	**1.35 (1.08 – 1. 67)**	**0.00 7**	**1.35 (1.09 – 1. 67)**	**0.00 7**	**1.36 (1.11 – 1. 66)**	**0.0 03**
Log settl area	0.90 (0.74 – 1. 09)	0.29 8	0.92 (0.76 – 1. 11)	0.38 6	0.90 (0.74 – 1. 08)	0.25 4	**1.12 (1.00 – 1. 26)**	**0.04 8**			0.97 (0.82 – 1. 15)	0.73 9	0.92 (0.76 – 1. 11)	0.37 6	0.91 (0.75 – 1. 11)	0.35 0	0.87 (0.73 – 1. 04)	0.1 21
HDC	0.99 (0.99 – 1. 00)	0.15 4	1.00 (0.99 – 1. 00)	0.25 2	0.99 (0.99 – 1. 00)	0.14 4	1.00 (1.00 – 1. 01)	0.34 4	1.00 (0.99 – 1. 00)	0.30 2			0.99 (0.99 – 1. 00)	0.14 6	0.99 (0.99 – 1. 00)	0.15 7	1.00 (0.99 – 1. 00)	0.2 43
Pop ≥ 65	0.94 (0.86 – 1. 02)	0.15 7	**0.89 (0.83 – 0. 96)**	**0.00 2**	0.93 (0.87 – 1. 00)	0.06 6	0.94 (0.86 – 1. 03)	0.19 9	0.94 (0.87 – 1. 03)	0.19 4	0.94 (0.86 – 1. 02)	0.15 0			0.93 (0.85 – 1. 01)	0.09 4	0.94 (0.88 – 1. 01)	0.1 00
Year	0.98 (0.96 – 1. 01)	0.19 0	0.99 (0.96 – 1. 02)	0.41 3	0.98 (0.96 – 1. 01)	0.15 2	0.98 (0.96 – 1. 01)	0.22 1	0.98 (0.96 – 1. 01)	0.21 9	0.98 (0.96 – 1. 01)	0.19 5	0.98 (0.95 – 1. 01)	0.11 4			0.99 (0.97 – 1. 02)	0.5 21
Random effects																		
σ^2	1.44		1.45		1.44		1.45		1.45		1.45		1.45		1.45			
τ_{00}	0.48 $_{country}$		0.50 $_{country}$		0.48 $_{country}$		0.49 $_{country}$		0.49 $_{country}$		0.46 $_{country}$		0.51 $_{country}$		0.47 $_{country}$			
ICC	0.25		0.26		0.25		0.25		0.25		0.24		0.26		0.24			

N	67 country	67 country	67 country	67 country	67 country	67 country	67 country	67 country	
Obs	573	573	573	573	573	573	573	573	573
AIC	3457	3460	3455	3462	3456	3457	3457	3457	3482
loglik	-1719	-1721	-1719	-1722	-1719	-1720	-1720	-1719	-1732

Note. The outcome variable in all models is fatalities per flood event, as reported in EM-DAT. Models (1) – (8) include random intercepts at country level. RRs = risk ratios (exponentiated model estimates). pp = percentage points. pot exp = potentially exposed. HDC = potentially exposed living in high-density clusters. σ^2 = residual variance. τ_{00} = between-group variance. ICC = intra-class correlation coefficient. N = groups. AIC = Akaike information criterion. loglik = Log-Likelihood. Parentheses indicate 95% CIs and bold letters indicate $p \leq 0.05$. The models were fitted using maximum likelihood estimation with the R-package 'glmmTMB'[1].

Supplementary Table 6 | Results from negative binomial mixed regression models, using observations from OECD member countries.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	RRs	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*
3pp Gini	**1.25 (1.01 – 1.54)**	**0.042**			**1.27 (1.03 – 1.58)**	**0.027**	**1.22 (1.01 – 1.48)**	**0.042**	**1.24 (1.01 – 1.52)**	**0.039**	**1.23 (1.01 – 1.51)**	**0.044**	**1.19 (1.02 – 1.38)**	**0.026**	**1.25 (1.02 – 1.52)**	**0.028**	**1.17 (1.03 – 1.34)**	**0.019**
10k$ GDP /c	0.73 (0.50 – 1.07)	0.105	0.69 (0.47 – 1.01)	0.058			0.71 (0.51 – 1.01)	0.056	**0.70 (0.49 – 1.00)**	**0.048**	0.74 (0.51 – 1.07)	0.109	0.77 (0.55 – 1.08)	0.129	0.74 (0.52 – 1.04)	0.086	0.80 (0.64 – 1.00)	0.050
Log pot exp	1.24 (0.95 – 1.63)	0.112	1.24 (0.94 – 1.62)	0.125	1.29 (1.00 – 1.68)	0.054			1.12 (0.95 – 1.33)	0.174	1.16 (0.96 – 1.41)	0.127	1.25 (0.96 – 1.63)	0.098	1.24 (0.95 – 1.63)	0.112	1.16 (0.91 – 1.47)	0.231
Log settl area	0.90 (0.71 – 1.13)	0.356	0.90 (0.71 – 1.13)	0.354	0.84 (0.68 – 1.05)	0.126	1.04 (0.90 – 1.19)	0.582			0.93 (0.75 – 1.15)	0.492	0.89 (0.71 – 1.11)	0.289	0.90 (0.71 – 1.13)	0.354	0.92 (0.75 – 1.14)	0.451
HDC	1.00 (0.99 – 1.01)	0.494	1.00 (0.99 – 1.01)	0.625	1.00 (0.99 – 1.01)	0.532	1.00 (0.99 – 1.01)	0.553	1.00 (0.99 – 1.01)	0.757			1.00 (0.99 – 1.01)	0.526	1.00 (0.99 – 1.01)	0.494	1.00 (0.99 – 1.01)	0.545
Pop ≥ 65	1.05 (0.92 – 1.20)	0.494	0.96 (0.87 – 1.06)	0.441	1.01 (0.89 – 1.15)	0.858	1.05 (0.93 – 1.19)	0.416	1.06 (0.93 – 1.20)	0.400	1.04 (0.92 – 1.19)	0.522			1.05 (0.92 – 1.19)	0.456	1.00 (0.92 – 1.09)	0.982
Year	1.00 (0.96 – 1.04)	0.961	1.02 (0.98 – 1.06)	0.333	0.99 (0.95 – 1.03)	0.551	1.00 (0.96 – 1.04)	0.934	1.00 (0.96 – 1.04)	0.919	1.00 (0.96 – 1.04)	0.957	1.01 (0.97 – 1.04)	0.751			1.00 (0.96 – 1.04)	0.896
Random effects																		
σ^2	1.37		1.39		1.38		1.39		1.37		1.37		1.38		1.37			
τ_{00}	0.36 countries		0.36 countries		0.37 countries		0.26 countries		0.33 countries		0.33 countries		0.30 countries		0.36 countries			
ICC	0.21		0.21		0.21		0.16		0.19		0.19		0.18		0.21			
N	28 countries		28 countries		28 countries		28 countries		28 countries		28 countries		28 countries		28 countries			
Obs	265		265		265		265		265		265		265		265		265	

AIC	1291	1294	1292	1291	1290	1290	1290	1289	1293
loglik	-636	-638	-637	-637	-636	-636	-636	-636	-637

Note. The outcome variable in all models is fatalities per flood event, as reported in EM-DAT. Models (1) – (8) include random intercepts at country level. RRs = risk ratios (exponentiated model estimates). pp = percentage points. pot exp = potentially exposed. HDC = potentially exposed living in high-density clusters. σ^2 = residual variance. τ_{00} = between-group variance. ICC = intra-class correlation coefficient. N = groups. AIC = Akaike information criterion. loglik = Log-Likelihood. Parentheses indicate 95% CIs and bold letters indicate $p \leq 0.05$. The models were fitted using maximum likelihood estimation with the R-package 'glmmTMB'[1].

Supplementary Table 7 | Results from negative binomial mixed regression models, using observations from middle- and high-income countries and standardizing all covariate variables.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	RRs	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*
z Gini	**1.49 (1.03 – 2. 15)**	**0.0 32**			**1.50 (1.04 – 2. 16)**	**0.0 31**	1.41 (0.98 – 2. 04)	0.0 65	**1.47 (1.02 – 2. 12)**	**0.0 39**	**1.44 (1.00 – 2. 06)**	**0.0 49**	**1.73 (1.27 – 2. 35)**	**<0.0 01**	1.40 (0.99 – 2. 00)	0.0 59	**1.52 (1.13 – 2. 05)**	**0.0 06**
z GDP /c	0.95 (0.61 – 1. 49)	0.8 19	0.93 (0.59 – 1. 46)	0.7 38			0.85 (0.54 – 1. 32)	0.4 66	0.89 (0.58 – 1. 38)	0.6 07	0.91 (0.59 – 1. 42)	0.6 94	0.80 (0.54 – 1. 17)	0.24 2	0.87 (0.57 – 1. 34)	0.5 31	0.79 (0.57 – 1. 09)	0.1 48
z log pot exp	**1.80 (1.18 – 2. 73)**	**0.0 06**	**1.71 (1.12 – 2. 60)**	**0.0 12**	**1.81 (1.21 – 2. 73)**	**0.0 04**			**1.50 (1.17 – 1. 93)**	**0.0 01**	**1.43 (1.08 – 1. 89)**	**0.0 14**	**1.77 (1.17 – 2. 70)**	**0.00 7**	**1.78 (1.17 – 2. 69)**	**0.0 07**	**1.80 (1.23 – 2. 64)**	**0.0 03**
z log settl area	0.83 (0.59 – 1. 18)	0.2 98	0.86 (0.61 – 1. 21)	0.3 86	0.82 (0.59 – 1. 15)	0.2 54	**1.23 (1.00 – 1. 51)**	**0.0 48**			0.95 (0.70 – 1. 28)	0.7 39	0.86 (0.60 – 1. 21)	0.37 6	0.85 (0.60 – 1. 20)	0.3 50	0.78 (0.56 – 1. 07)	0.1 21
z HDC	0.81 (0.61 – 1. 08)	0.1 54	0.85 (0.64 – 1. 13)	0.2 52	0.81 (0.61 – 1. 07)	0.1 44	1.09 (0.91 – 1. 32)	0.3 43	0.88 (0.69 – 1. 12)	0.3 02			0.81 (0.61 – 1. 08)	0.14 6	0.81 (0.61 – 1. 08)	0.1 57	0.86 (0.66 – 1. 11)	0.2 43
z pop ≥ 65	0.72 (0.45 – 1. 14)	0.1 57	**0.54 (0.37 – 0. 79)**	**0.0 02**	0.70 (0.48 – 1. 02)	0.0 66	0.74 (0.47 – 1. 17)	0.1 99	0.74 (0.47 – 1. 17)	0.1 94	0.72 (0.45 – 1. 13)	0.1 50			0.68 (0.43 – 1. 07)	0.0 94	0.74 (0.52 – 1. 06)	0.1 00
z year	0.89 (0.74 – 1. 06)	0.1 90	0.93 (0.78 – 1. 11)	0.4 13	0.88 (0.74 – 1. 05)	0.1 52	0.89 (0.75 – 1. 07)	0.2 21	0.89 (0.75 – 1. 07)	0.2 19	0.89 (0.74 – 1. 06)	0.1 95	0.87 (0.73 – 1. 03)	0.11 4			0.95 (0.80 – 1. 12)	0.5 21
Random effects																		
σ^2	1.44		1.45		1.44		1.45		1.45		1.45		1.45		1.45			
τ_{00}	0.48 countries		0.50 countries		0.48 countries		0.49 countries		0.49 countries		0.46 countries		0.51 countries		0.47 countries			
ICC	0.25		0.26		0.25		0.25		0.25		0.24		0.26		0.24			
N	67 countries		67 countries		67 countries		67 countries		67 countries		67 countries		67 countries		67 countries			
Obs	573		573		573		573		573		573		573		573		573	

AIC	3457	3460	3455	3462	3456	3457	3457	3457	3482
loglik	-1719	-1721	-1719	-1722	-1719	-1720	-1720	-1719	-1732

Note. The outcome variable in all models is fatalities per flood event, as reported in EM-DAT. Models (1) – (8) include random intercepts at country level. RRs = risk ratios (exponentiated model estimates). pp = percentage points. pot exp = potentially exposed. HDC = potentially exposed living in high-density clusters. z = standardized variable. σ^2 = residual variance. τ_{00} = between-group variance. ICC = intra-class correlation coefficient. N = groups. AIC = Akaike information criterion. loglik = Log-Likelihood. Parentheses indicate 95% CIs and bold letters indicate $p \leq 0.05$. The models were fitted using maximum likelihood estimation with the R-package 'glmmTMB'[1].

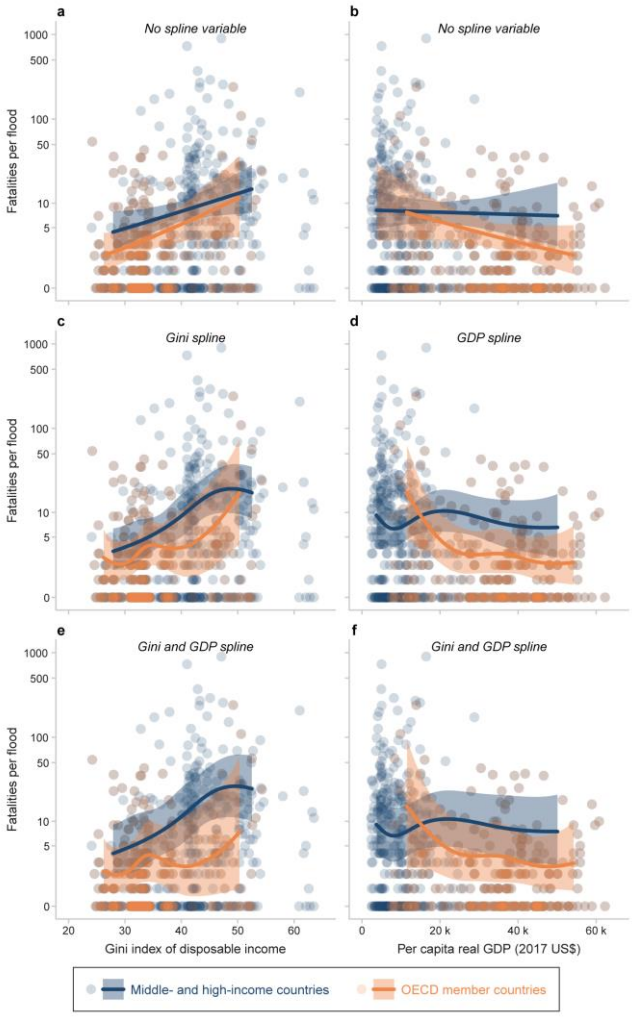
Supplementary Table 8 | Results from negative binomial mixed regression models, using observations from OECD member countries and standardizing all covariate variables.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	RRs	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*	*RRs*	*p*
z Gini	**1.66 (1.02 – 2. 71)**	**0.04 2**			**1.75 (1.07 – 2. 88)**	**0.02 7**	**1.59 (1.02 – 2. 50)**	**0.04 2**	**1.65 (1.02 – 2. 64)**	**0.03 9**	**1.62 (1.01 – 2. 59)**	**0.04 4**	**1.48 (1.05 – 2. 10)**	**0.02 6**	**1.67 (1.06 – 2. 63)**	**0.02 8**	**1.44 (1.06 – 1. 96)**	**0.01 9**
z GDP /c	0.66 (0.40 – 1. 09)	0.10 5	0.61 (0.37 – 1. 02)	0.05 8			0.64 (0.40 – 1. 01)	0.05 6	**0.62 (0.39 – 1. 00)**	**0.04 8**	0.67 (0.41 – 1. 09)	0.10 9	0.71 (0.45 – 1. 10)	0.12 9	0.67 (0.42 – 1. 06)	0.08 6	0.74 (0.55 – 1. 00)	0.05 0
z log pot exp	1.60 (0.90 – 2. 85)	0.11 2	1.58 (0.88 – 2. 82)	0.12 5	1.74 (0.99 – 3. 04)	0.05 4			1.29 (0.90 – 1. 85)	0.17 4	1.39 (0.91 – 2. 11)	0.12 7	1.62 (0.91 – 2. 86)	0.09 8	1.60 (0.90 – 2. 85)	0.11 2	1.37 (0.82 – 2. 31)	0.23 1
z log settl area	0.80 (0.50 – 1. 28)	0.35 6	0.80 (0.50 – 1. 28)	0.35 4	0.71 (0.46 – 1. 10)	0.12 6	1.08 (0.82 – 1. 43)	0.58 2			0.86 (0.56 – 1. 32)	0.49 2	0.78 (0.50 – 1. 23)	0.28 9	0.80 (0.50 – 1. 28)	0.35 4	0.85 (0.56 – 1. 29)	0.45 1
z HDC	0.89 (0.63 – 1. 25)	0.49 4	0.92 (0.65 – 1. 29)	0.62 5	0.90 (0.64 – 1. 26)	0.53 2	1.07 (0.85 – 1. 36)	0.55 3	0.95 (0.70 – 1. 29)	0.75 7			0.90 (0.64 – 1. 26)	0.52 6	0.89 (0.63 – 1. 25)	0.49 4	0.91 (0.67 – 1. 23)	0.54 5
z pop ≥ 65	1.22 (0.69 – 2. 13)	0.49 4	0.85 (0.56 – 1. 29)	0.44 1	1.05 (0.62 – 1. 77)	0.85 8	1.24 (0.74 – 2. 06)	0.41 6	1.26 (0.74 – 2. 16)	0.40 0	1.19 (0.69 – 2. 05)	0.52 2			1.22 (0.72 – 2. 07)	0.45 6	1.00 (0.69 – 1. 45)	0.98 2
z year	1.01 (0.77 – 1. 32)	0.96 1	1.14 (0.88 – 1. 47)	0.33 3	0.92 (0.72 – 1. 20)	0.55 1	1.01 (0.77 – 1. 32)	0.93 4	1.01 (0.77 – 1. 33)	0.91 9	1.01 (0.77 – 1. 32)	0.95 7	1.04 (0.81 – 1. 35)	0.75 1			0.98 (0.76 – 1. 27)	0.89 6
Random effects																		
σ^2	1.37		1.39		1.38		1.39		1.37		1.37		1.38		1.37			
τ_{00}	0.36 $_{countries}$		0.36 $_{countries}$		0.37 $_{countries}$		0.26 $_{countries}$		0.33 $_{countries}$		0.33 $_{countries}$		0.30 $_{countries}$		0.36 $_{countries}$			
ICC	0.21		0.21		0.21		0.16		0.19		0.19		0.18		0.21			
N	28 $_{countries}$		28 $_{countries}$		28 $_{countries}$		28 $_{countries}$		28 $_{countries}$		28 $_{countries}$		28 $_{countries}$		28 $_{countries}$			
Obs	265		265		265		265		265		265		265		265		265	

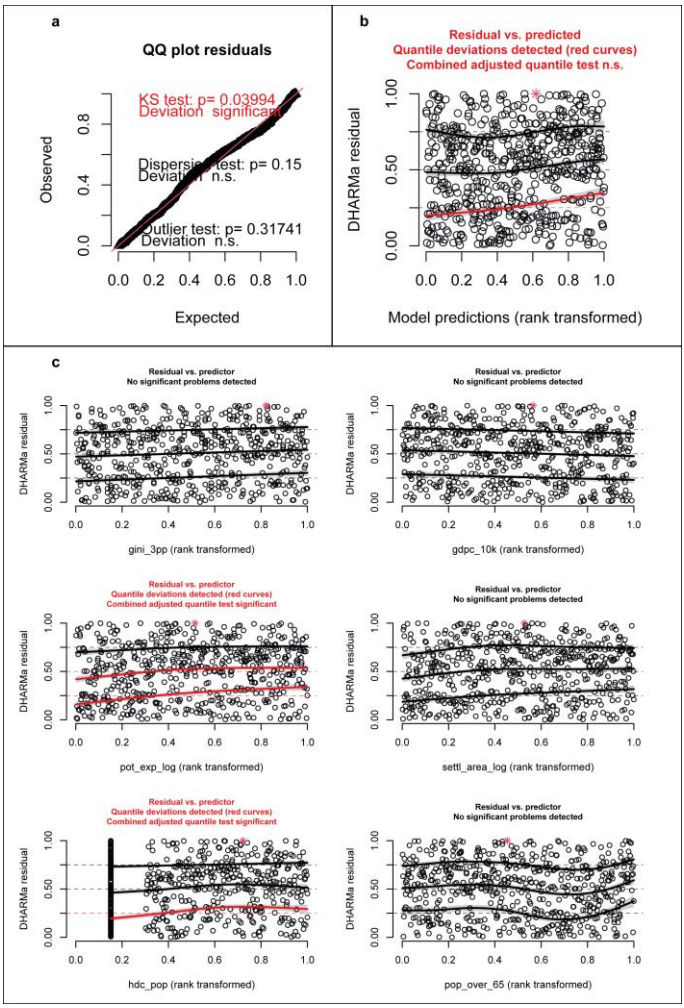
AIC	1291	1294	1292	1291	1290	1290	1290	1289	1293
loglik	-636	-638	-637	-637	-636	-636	-636	-636	-638

Note. The outcome variable in all models is fatalities per flood event, as reported in EM-DAT. Models (1) – (8) include random intercepts at country level. RRs = risk ratios (exponentiated model estimates). pp = percentage points. pot exp = potentially exposed. HDC = potentially exposed living in high-density clusters. z = standardized variable. σ^2 = residual variance. τ_{00} = between-group variance. ICC = intra-class correlation coefficient. N = groups. AIC = Akaike information criterion. loglik = Log-Likelihood. Parentheses indicate 95% CIs and bold letters indicate $p \leq 0.05$. The models were fitted using maximum likelihood estimation with the R-package 'glmmTMB'[1].

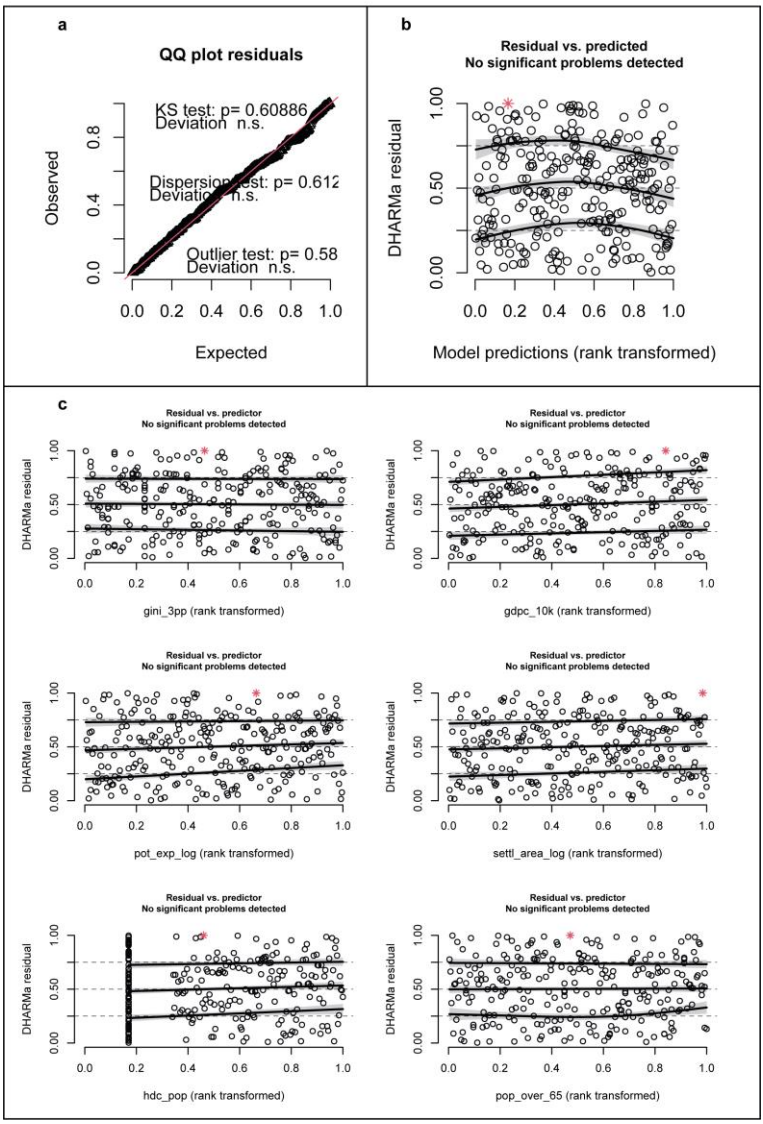
Model diagnostics



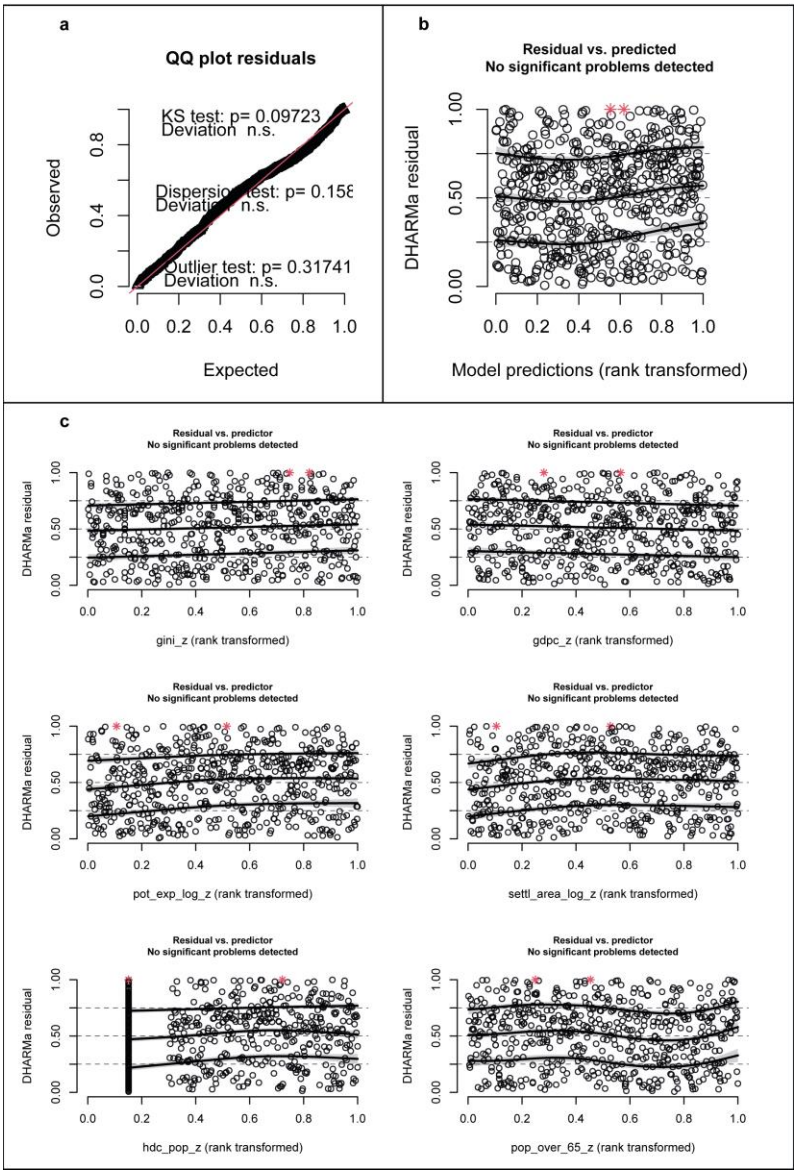
Supplementary Figure 3 | Model estimations without and with spline terms. This figure shows a spline regression analysis evaluating the robustness of the linearity assumption of the negative binomial regression model (**a**, **b**). Natural cubic splines with three knots replace the Gini variable (**c**), the GDP variable (**d**), and both the Gini and GDP variables in the same model (**e**, **f**). The linearity assumption holds well for models including observations from all 65 middle- and high-income countries. The orange models, using records from the OECDs, have less statistical power and the model estimations hence become more variable and uncertain. Each dot represents a flood event between 1990 and 2019, and the lines represent the mean estimations of the negative binomial models (all covariate variables included, unstandardized) with 95% CIs.



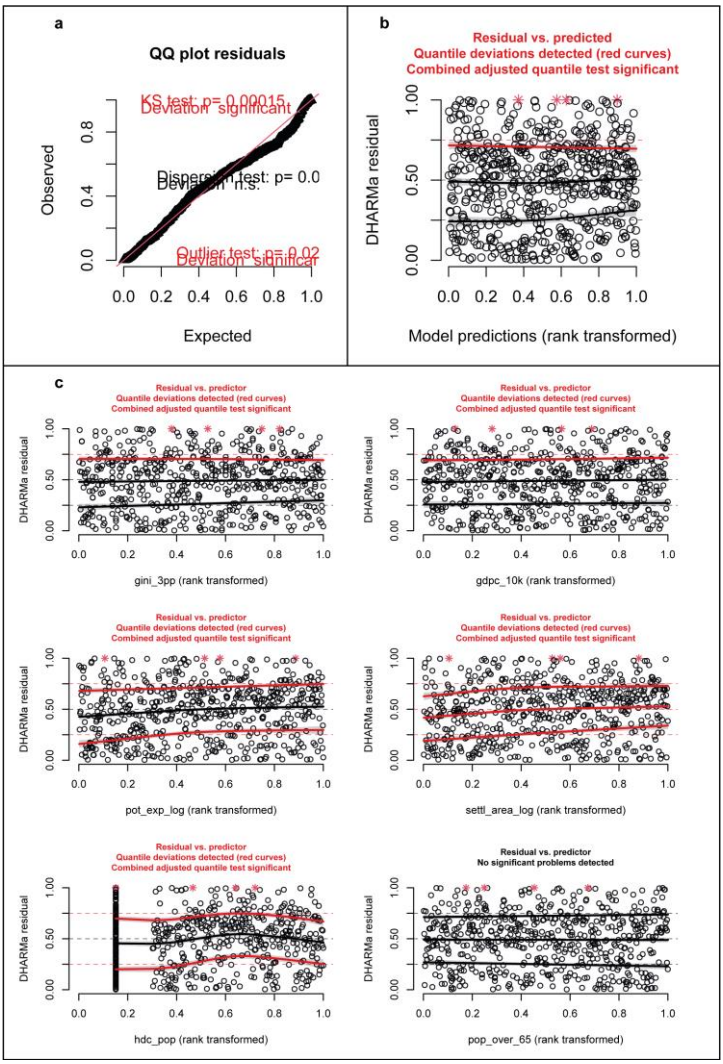
Supplementary Figure 4 | Residual diagnostics for the main model using observations from middle- and high-income countries. This figure presents the results of residual diagnostics performed using the R-package 'DHARMa'[2] with 1,000 iterations. The Kolmogorov-Smirnov (KS) test indicates a significant deviation from the expected negative binomial distribution, but the corresponding qq-plot does not exhibit a large deviation from the straight line (**a**). Significant quantile deviations were detected when plotting the standardized residuals against the model predictions (**b**) and against two of the covariate variables (**c**). The residual plot in panel **b** typically indicates a significant problem in terms of overdispersion of error, while the plots in panel **c** control for heteroscedasticity.



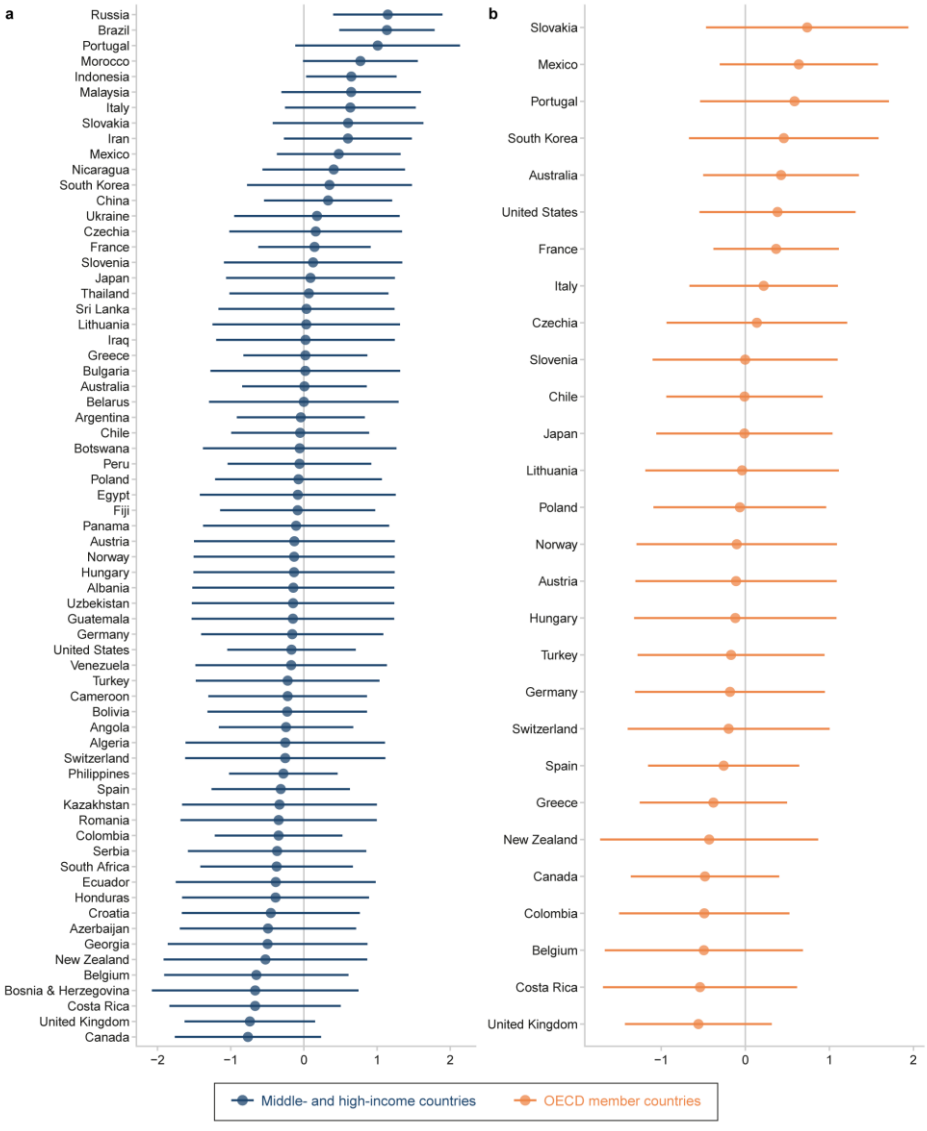
Supplementary Figure 5 | Residual diagnostics for the main model using observations from OECD member countries. This figure illustrates that the OECD member country observations yields less problematic residuals compared to when all observations from middle- and high-income countries are used (as in Supplementary Figure 4). We did not detect any significant problems for this model in terms of deviation from the expected distribution, overdispersion of error, outliers or heteroscedasticity (**a**-**c**). The residual diagnostics were performed using the R-package 'DHARMa'[2] with 1,000 iterations.



Supplementary Figure 6 | Residual diagnostics for the full model specification, but with all covariate variables standardized, using observations from middle- and high-income countries. This figure illustrates that standardizing all covariate variables yields less problematic residuals (compare with Supplementary Figure 4). We did not detect any significant problems for this model in terms of deviation from the expected distribution, overdispersion of error, outliers or heteroscedasticity (**a**-**c**). The residual diagnostics were performed using the R-package 'DHARMa'[2] with 1,000 iterations.



Supplementary Figure 7 | Residual diagnostics for the full model specification, but without the random effect, using observations from middle- and high-income countries. This figure illustrates that omitting the random effect yields more problematic residuals (compare with Supplementary Figure 4). The Kolmogorov-Smirnov (KS) test indicates a significant deviation from the expected negative binomial distribution, and the corresponding qq-plot exhibits some deviation from the straight line (**a**). The outlier test also indicates a significant deviation (**a**), which in this context means an observation outside of the simulation envelope[2]. Significant quantile deviations were detected when plotting the standardized residuals against the model predictions (**b**) and against five of the covariate variables (**c**). The residual diagnostics were performed using the R-package 'DHARMa'[2] with 1,000 iterations.



Supplementary Figure 8 | Random intercepts per country. This figure presents dumbbell plots showing the mean random intercept model estimates (dots) with 95% CIs (lines) from the model with floods from the 67 middle- and high-income countries (**a**) and the 28 OECD member countries (**b**), respectively. The random intercept estimates are expressed as relative to the overall model estimate, represented by the zero on the x-axis. The CIs indicate that most estimates are not significantly different from the estimation of the model. These results refer to the negative binomial main models. Supplementary Table 2 presents the sample size per country.

References

1. Brooks, M. E. *et al.* glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling. *R J.* **9**, 378–400 (2017).
2. Hartig, F. DHARMa: Residual diagnostics for hierarchical (multi-level / mixed) regression models. R package version 0.4.5. (2022).