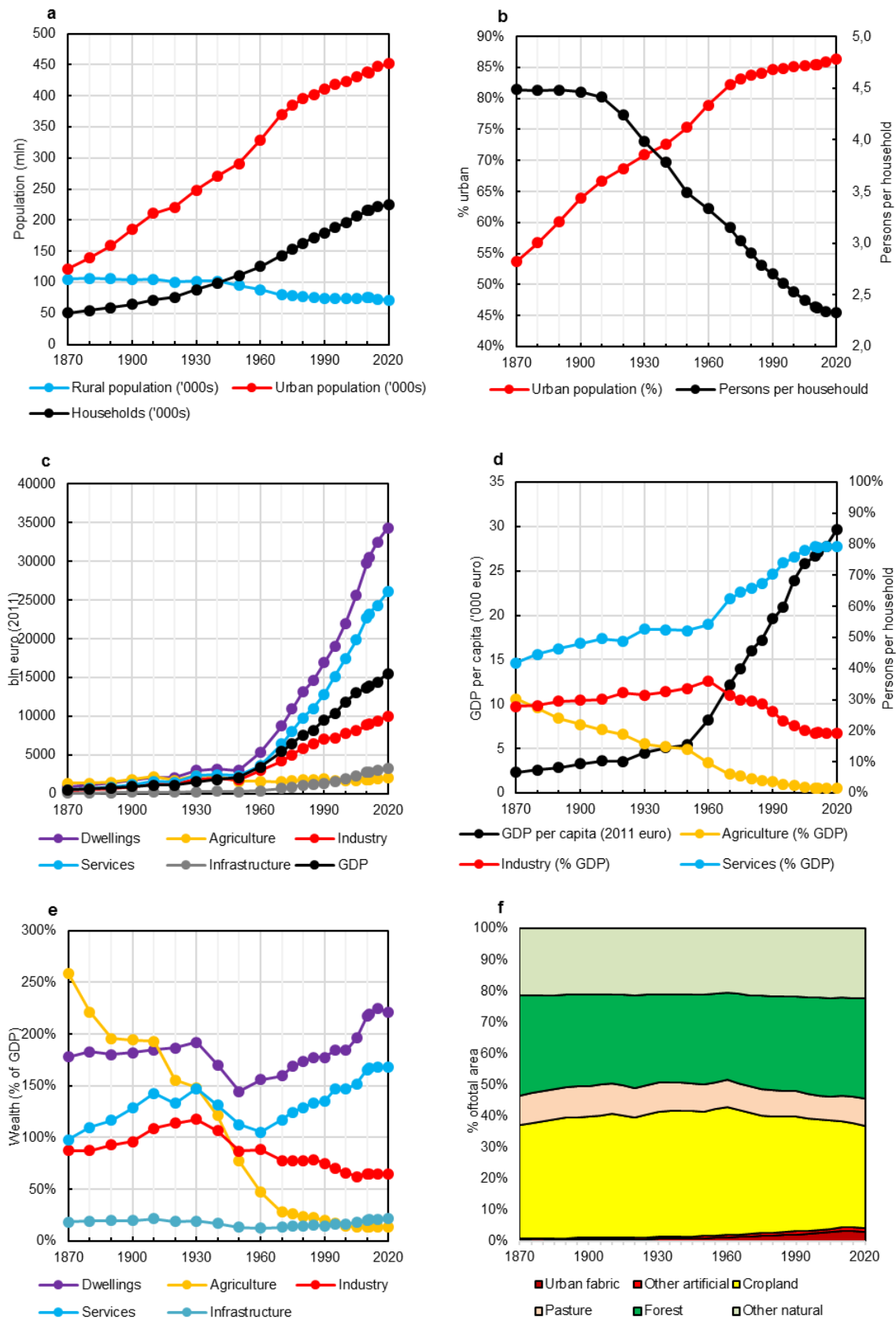
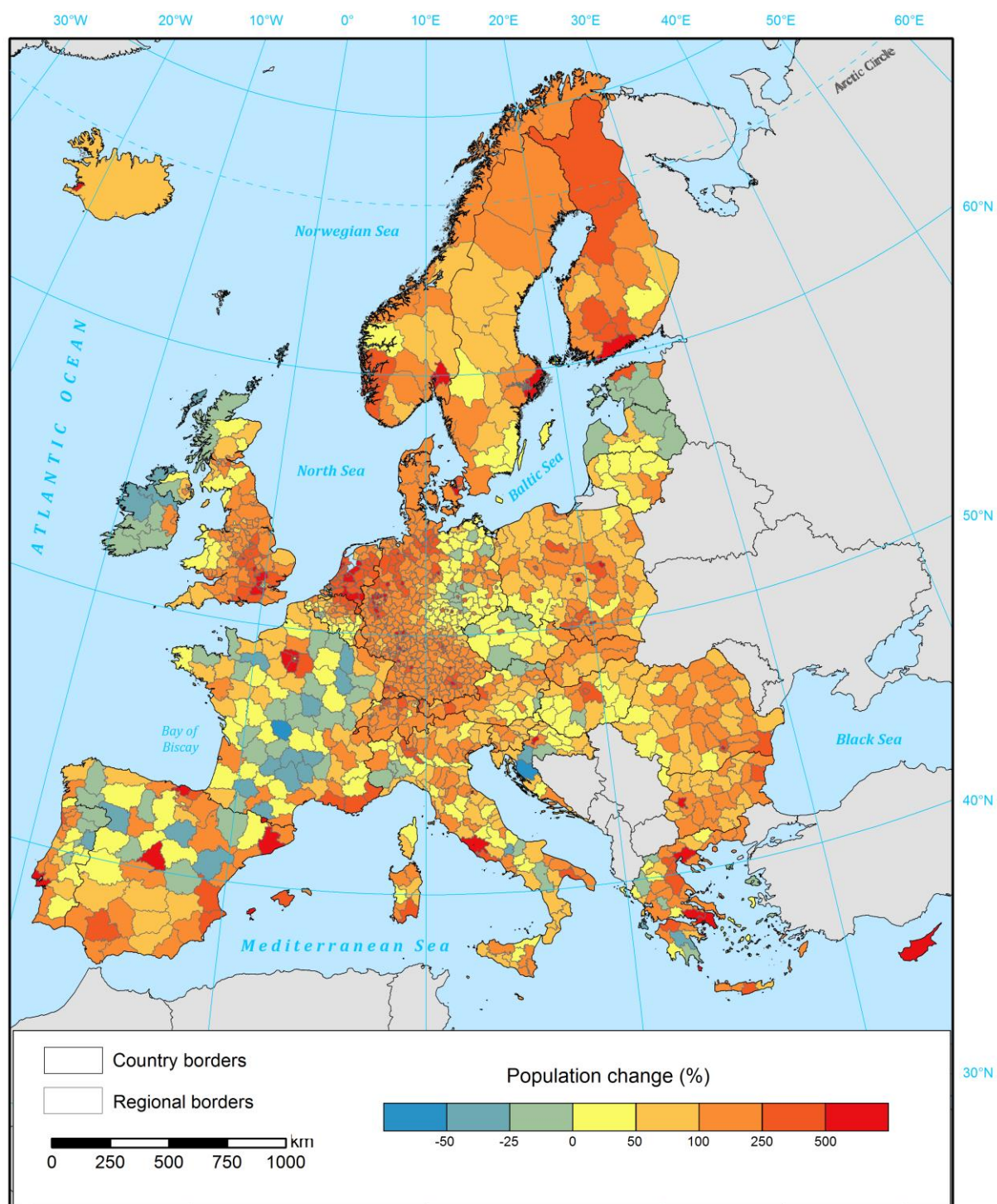


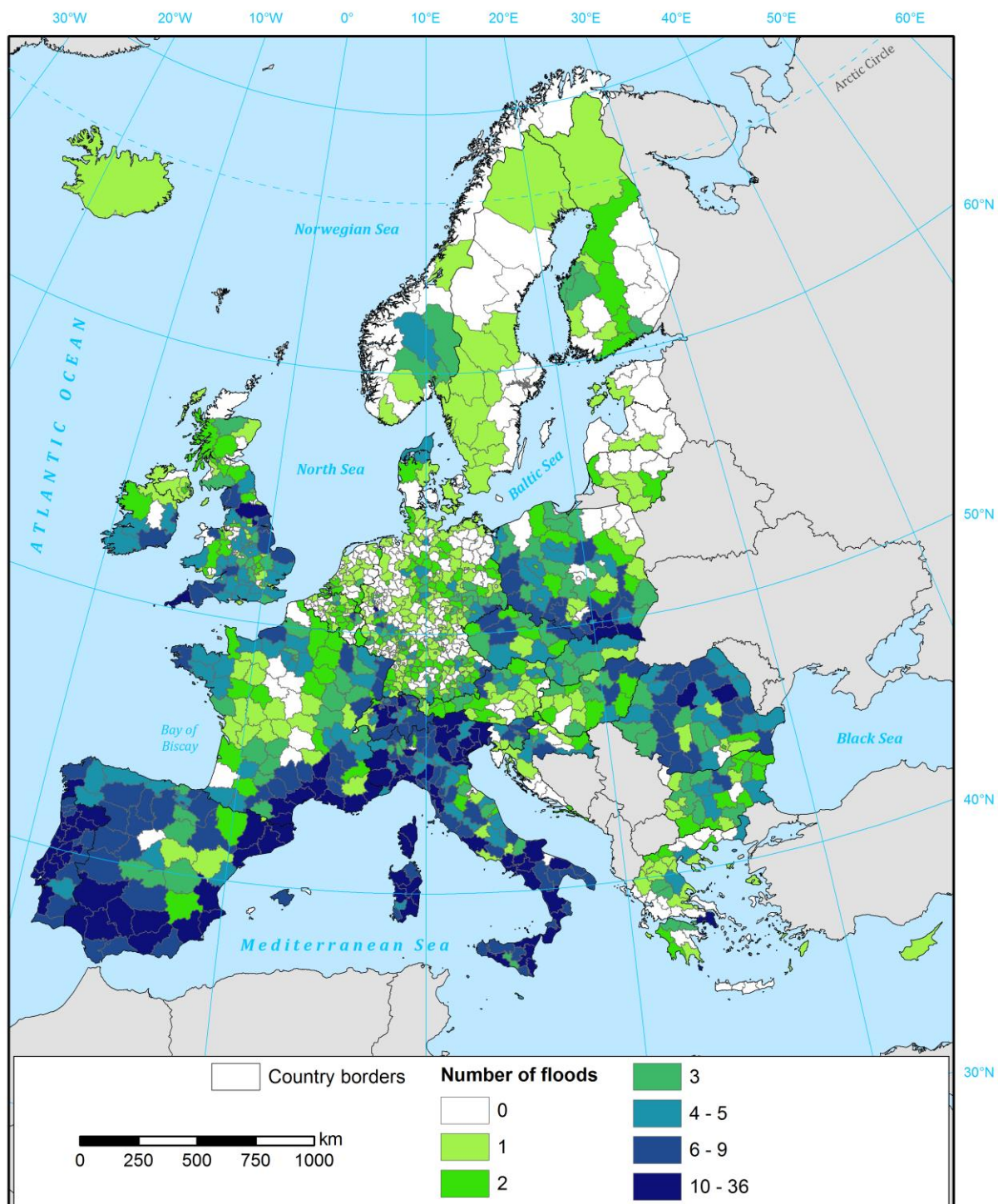
Supplemental Information to “Trends in flood losses in Europe over the past 150 years” by Paprotny *et al.*



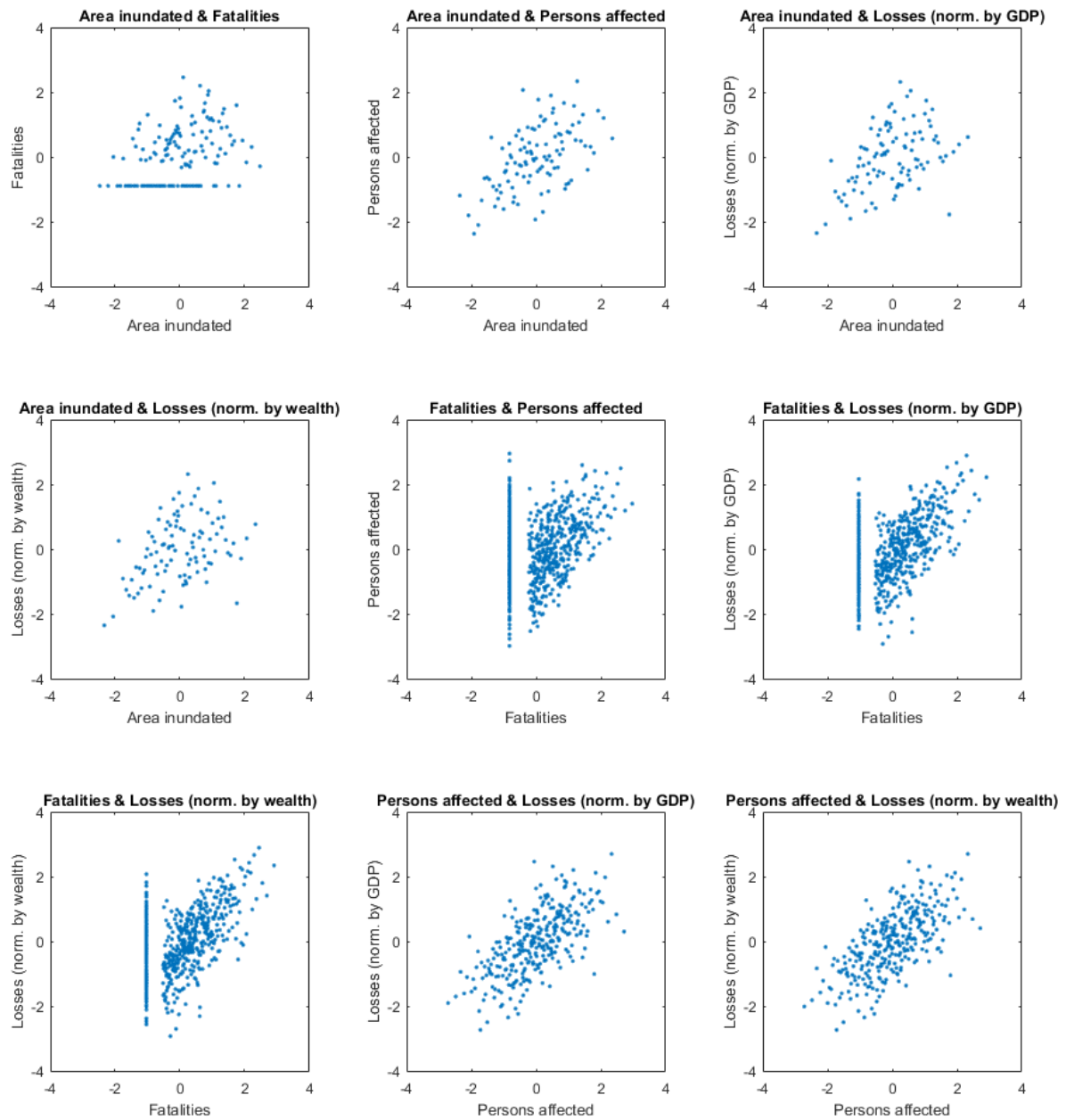
Supplementary Figure 1. Temporal trends for selected socio-economic variables since 1870: (a-b) population and households; (c) wealth by sector and GDP; (d) GDP structure; (e) wealth by sector relative to GDP; (f) Land use. Graphs include short-term projections through 2020. Aggregated for 37 European countries and territories. Source of data: HANZE database¹.



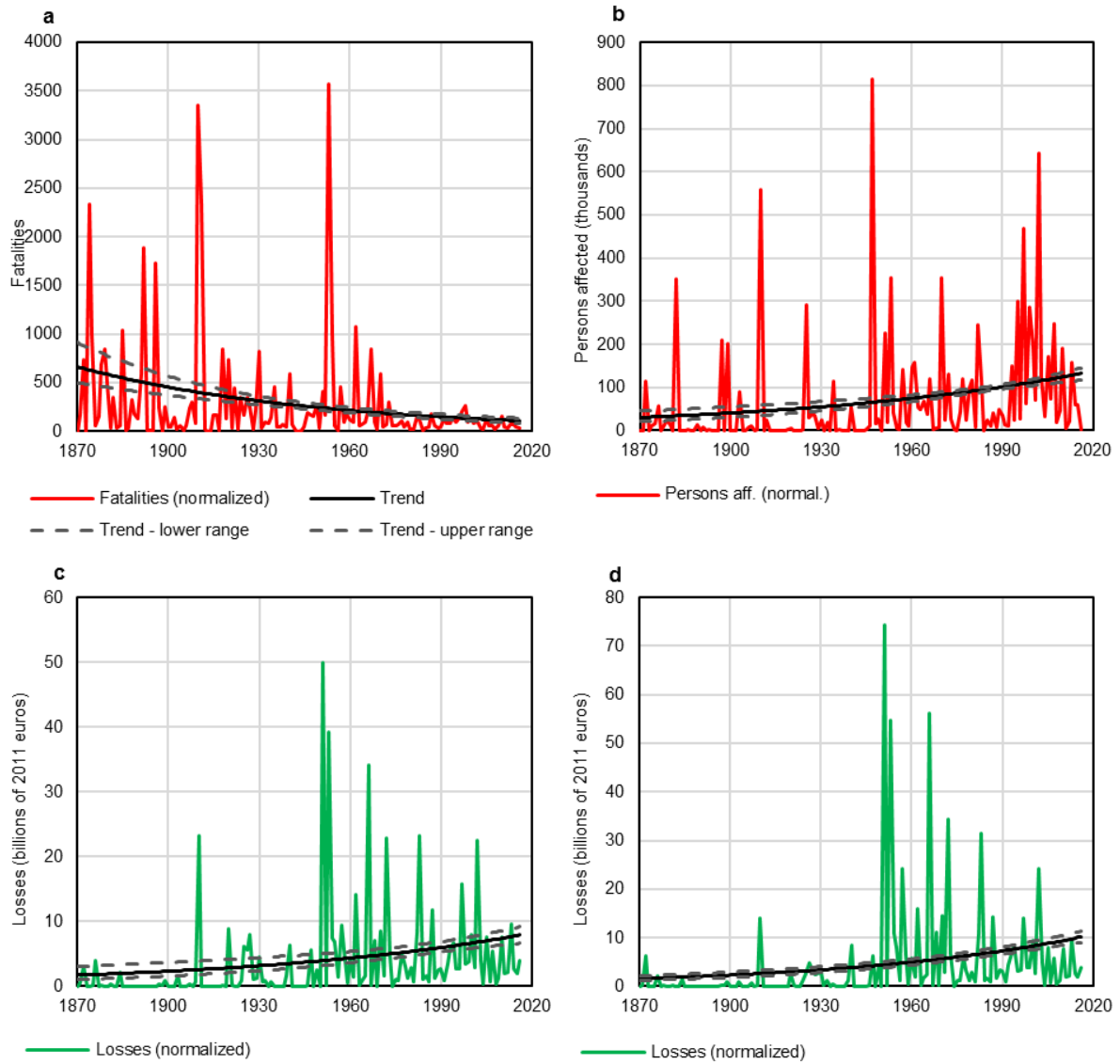
Supplementary Figure 2. Population change (%) by NUTS3 region from 1870 to 2015. Source of data: HANZE database¹, with background administrative borders from PBL data².



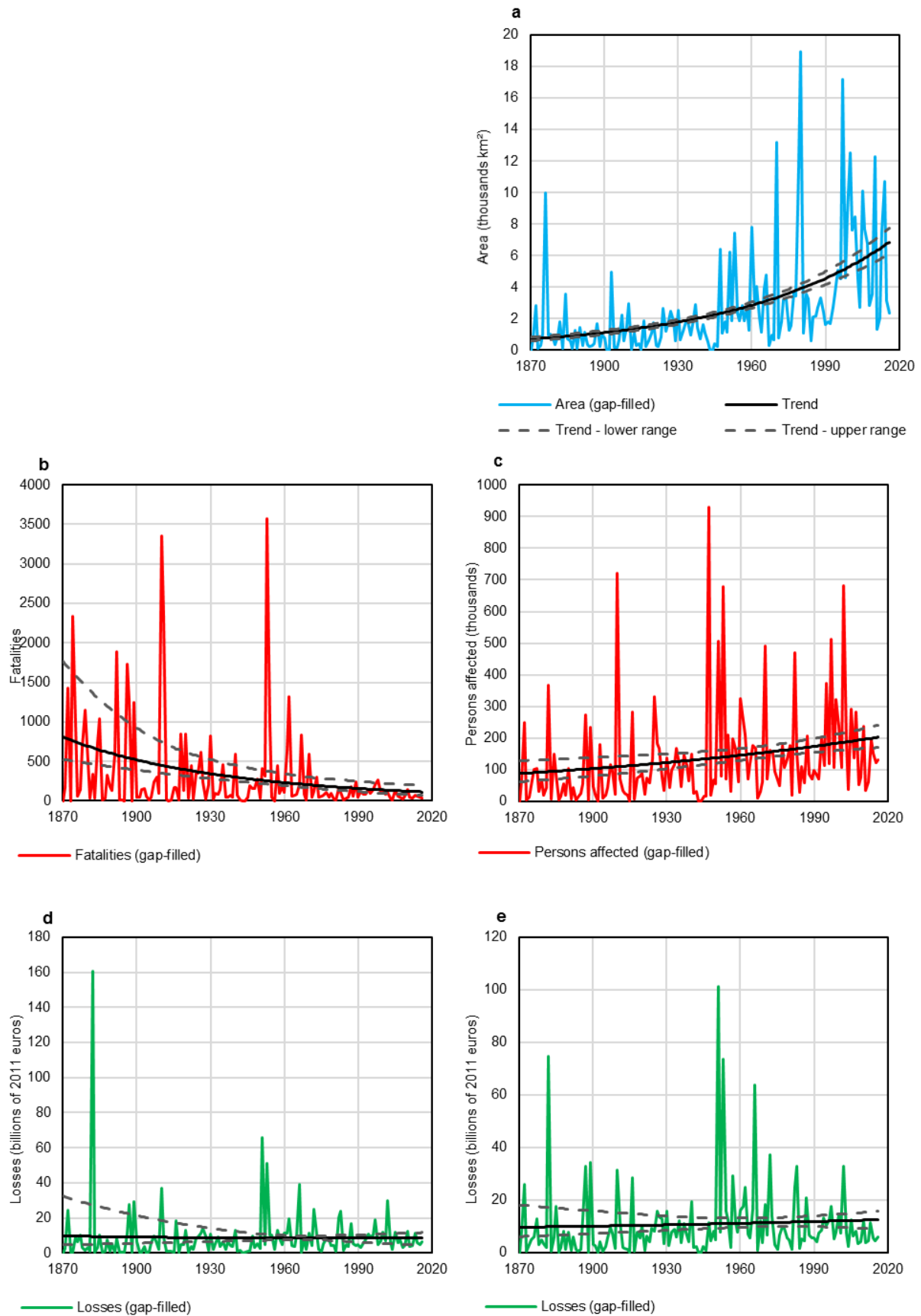
Supplementary Figure 3. Total number of floods events recorded in HANZE database by NUTS3 region (1870–2016). Source of data: HANZE database¹, with background administrative borders from PBL data².



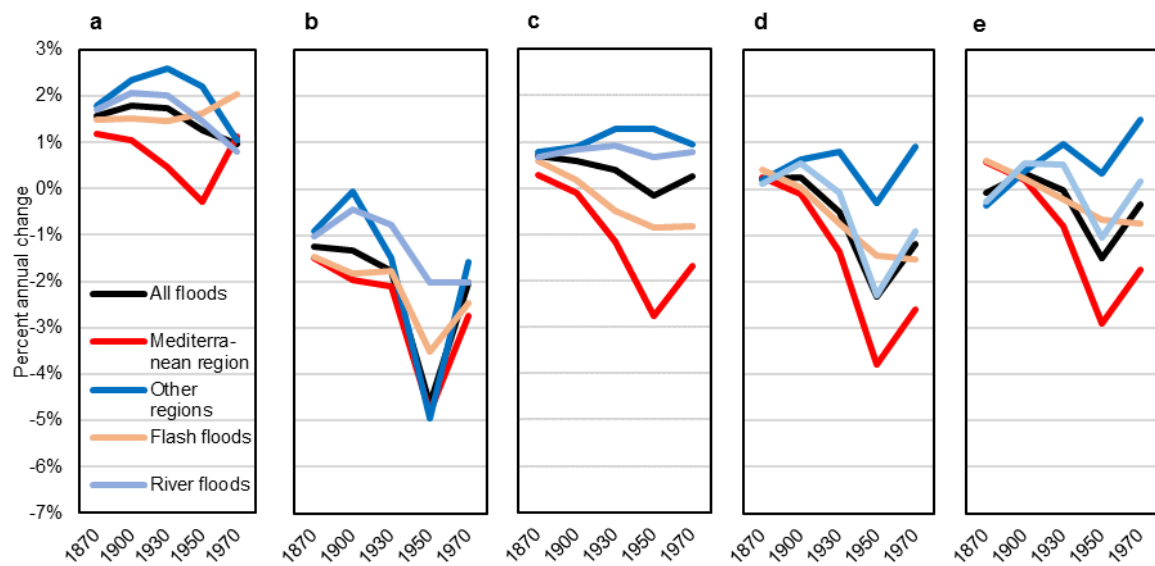
Supplementary Figure 4. Dependency between pairs of variables (normalized damage statistics relative to potential exposure per flood footprint) transformed to standard normal.



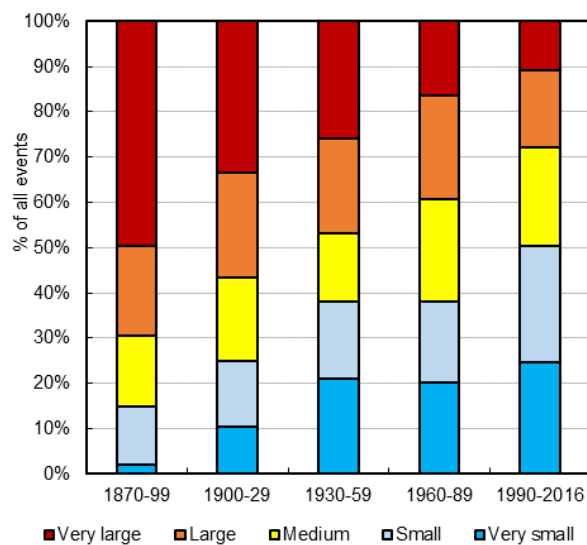
Supplementary Figure 5. Trends in normalized flood losses with 95% confidence intervals, for (a) fatalities; (b) persons affected; (c) financial value of losses with normalization by GDP and (d) financial value of losses with normalization by wealth.



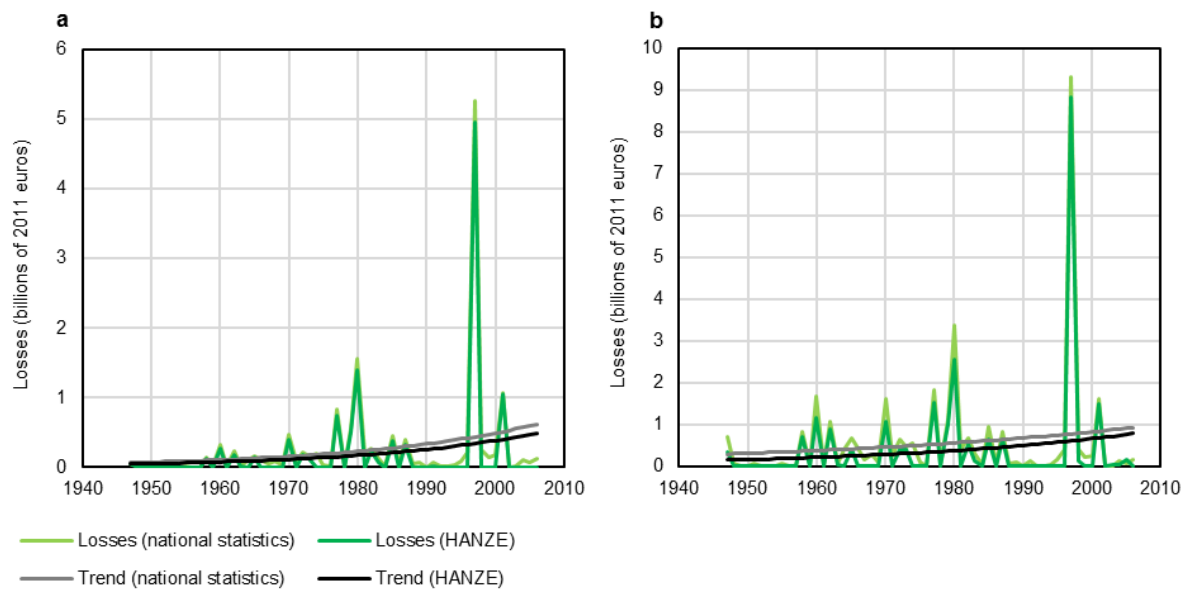
Supplementary Figure 6. Trends in normalized and gap-filled flood losses with 95% confidence intervals, for (a) area inundated; (b) fatalities; (c) persons affected; (d) financial value of losses with normalization by GDP and (e) financial value of losses with normalization by wealth.



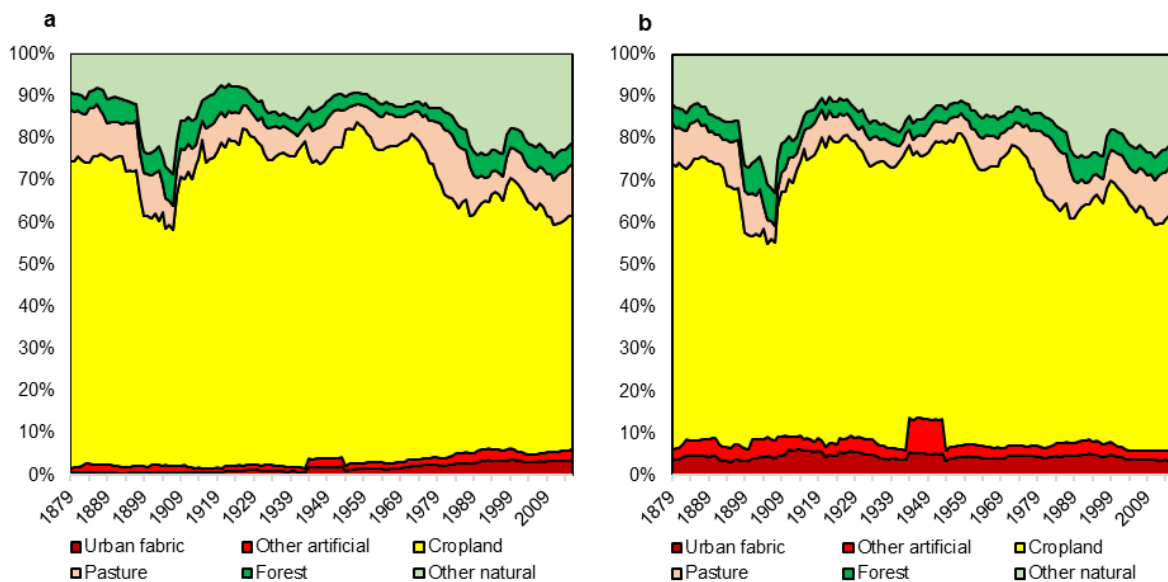
Supplementary Figure 7. Trends in normalized and gap-filled losses for different starting years. Data for all flood events, two subdomains (Mediterranean regions and other parts of Europe) and two types of floods (river and flash), for (a) area inundated; (b) fatalities; (c) persons affected; (d) financial value of losses with normalization by GDP and (e) financial value of losses with normalization by wealth.



Supplementary Figure 8. Flood events classified by severity per time period.



Supplementary Figure 9. Annual financial losses to floods in Poland, 1947–2006, (a) reported and (b) normalized and gap-filled. The trends were calculated using Poisson regression. Source of data: national statistics²⁻⁴ and HANZE database¹.



Supplementary Figure 10. Annual land use structure of flood footprints. Graphs are for 10-year moving average (ending on the year indicated), (a) with reconstructed land use at the time of flood events and (b) using 2011 land use. Source of data: HANZE database¹.

Supplementary Table 1. Correlation and best-fitting copulas for pairs of variables (normalized damage statistics).

Pair of variables	Spearman's rank correlation	Best-fitting copula type
Area inundated & Fatalities	0.352	Frank
Area inundated & Persons affected	0.527	Clayton
Area inundated & Losses (norm. by GDP)	0.431	Clayton
Area inundated & Losses (norm. by wealth)	0.376	Clayton
Fatalities & Persons affected	0.272	Normal
Fatalities & Losses (norm. by GDP)	0.469	Gumbel
Fatalities & Losses (norm. by wealth)	0.473	Gumbel
Persons affected & Losses (norm. by GDP)	0.667	Frank
Persons affected & Losses (norm. by wealth)	0.677	Frank

Supplementary Table 2. Trends in losses in different aggregations. Data are for reported, normalized and gap-filled annual losses during five periods in the historical record.

(a) Mediterranean countries (Cyprus, Greece, Italy, Malta, Portugal, Spain)

Starting year	Reported					Normalized				Normalized and gap-filled				
	Events	Area	Fatalities	Affected	Losses	Fatalities	Affected	Losses ₁	Losses ₂	Area	Fatalities	Affected	Losses ₁	Losses ₂
1870	*1.2	*1.6	-0.5	*1.6	*2.3	*-1.5	*1.2	1.1	1.2	*1.2	*-1.5	0.3	0.3	0.6
1900	*0.8	*2.6	-0.1	*1.6	*1.9	*-2.2	*1.3	0.7	0.8	*1.0	*-2.0	-0.1	-0.1	0.2
1930	0.2	1.9	-1.0	0.6	0.9	-2.3	0.1	-1.0	-0.8	0.5	*-2.1	-1.2	*-1.3	-0.8
1950	*-0.6	1.4	*-3.1	-1.5	-1.1	*-4.5	-2.2	*-4.7	-4.3	-0.3	*-4.7	*-2.7	*-3.8	*-2.9
1970	0.3	6.8	-2.2	-1.7	-3.1	-2.4	-2.5	-6.0	-5.3	1.1	-2.7	-1.7	-2.6	-1.7

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

(b) Non-Mediterranean countries (other than above)

Starting year	Reported					Normalized				Normalized and gap-filled				
	Events	Area	Fatalities	Affected	Losses	Fatalities	Affected	Losses ₁	Losses ₂	Area	Fatalities	Affected	Losses ₁	Losses ₂
1870	*2.1	*1.4	-0.2	*2.1	*3.7	-0.7	*1.0	*1.5	0.9	*1.8	-0.9	*0.8	0.2	-0.3
1900	*2.5	*2.0	0.6	*2.1	*3.6	0.1	1.1	*1.2	0.4	*2.3	0.0	*0.9	0.6	0.4
1930	*3.0	1.6	-0.8	*2.1	*3.7	-1.5	1.4	0.9	0.8	*2.6	-1.5	*1.3	0.8	1.0
1950	*3.0	0.5	*-3.5	*2.6	*3.2	*-5.0	2.1	-0.5	-0.1	*2.2	-5.0	1.3	-0.3	0.3
1970	*2.5	-2.0	-1.4	2.0	*4.0	-1.6	1.8	1.7	2.3	1.0	-1.6	1.0	0.9	1.5

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

(c) Flash floods

Starting year	Reported					Normalized				Normalized and gap-filled				
	Events	Area	Fatalities	Affected	Losses	Fatalities	Affected	Losses ₁	Losses ₂	Area	Fatalities	Affected	Losses ₁	Losses ₂
1870	*1.4	*2.9	-0.7	*2.2	*3.1	*-1.6	*1.7	1.5	1.5	*1.5	*-1.5	0.6	0.4	*0.6
1900	*1.3	2.7	0.2	*2.5	*2.9	*-2.1	*2.0	1.3	1.1	*1.5	*-1.8	0.2	0.0	0.2
1930	*0.9	2.3	-0.5	1.8	*2.3	-1.9	1.2	0.2	0.3	*1.4	-1.8	-0.5	-0.8	-0.2
1950	*0.6	2.2	-2.2	0.6	1.2	-3.2	0.2	-1.3	-0.9	*1.6	*-3.5	-0.9	-1.4	-0.7
1970	*0.9	2.8	-1.7	-0.8	-0.8	-2.1	-1.3	-3.0	-2.3	*2.0	-2.5	-0.8	-1.5	-0.8

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

(d) River floods

Starting year	Reported					Normalized				Normalized and gap-filled				
	Events	Area	Fatalities	Affected	Losses	Fatalities	Affected	Losses ₁	Losses ₂	Area	Fatalities	Affected	Losses ₁	Losses ₂
1870	*1.7	*1.4	0.0	*2.0	*3.5	-0.8	*0.9	*1.3	0.9	*1.7	-1.0	*0.7	0.1	-0.3
1900	*1.9	*2.1	0.7	*2.1	*3.4	-0.3	1.1	1.0	0.5	*2.1	-0.4	0.8	0.6	0.6
1930	*1.9	1.7	0.1	*2.0	*3.4	-0.8	1.3	0.2	0.5	*2.0	-0.8	0.9	-0.1	0.5
1950	*1.6	0.8	-0.4	2.2	*2.7	-1.9	1.7	-2.0	-1.2	*1.5	-2.0	0.7	-2.3	*-1.1
1970	*2.1	-1.7	-2.1	1.7	2.3	-2.0	1.4	-1.1	0.0	0.8	-2.0	0.8	-0.9	0.2

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

(e) River, coastal and compound floods

Starting year	Reported					Normalized				Normalized and gap-filled				
	Events	Area	Fatalities	Affected	Losses	Fatalities	Affected	Losses ₁	Losses ₂	Area	Fatalities	Affected	Losses ₁	Losses ₂
1870	*1.7	*1.4	0.1	*1.9	*3.0	-0.5	*0.9	*1.2	0.9	*1.6	-0.7	0.6	0.1	-0.2
1900	*1.8	2.0	0.3	*1.9	2.8	-0.4	1.0	0.8	0.4	*1.9	-0.4	0.6	0.3	0.3
1930	*1.8	1.6	-1.2	*1.7	2.4	-1.9	1.0	-0.4	-0.1	*1.8	-1.9	0.7	-0.5	0.0
1950	*1.4	0.6	*-4.5	1.6	1.3	*-6.4	0.9	-3.3	-2.6	1.2	*-6.4	0.0	*-3.3	*-2.2
1970	*2.1	-1.6	-1.8	1.6	2.4	-1.7	1.3	-1.0	0.1	0.7	-1.7	0.7	-1.0	0.0

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

(f) Flash floods (under assumption of flood footprints equalling whole area of affected regions)

Starting year	Normalized			
	Fatalities	Affected	Losses ₁	Losses ₂
1870	*-1.9	*1.3	1.4	1.5
1900	-0.3	*2.0	1.4	1.2
1930	-1.0	1.3	0.3	0.3
1950	-3.0	0.0	-1.4	-1.1
1970	-2.5	-1.5	-3.5	-2.8

¹ normalized by wealth, ² normalized by GDP, * significant at $\alpha = 0.05$.

Supplementary Table 3. Flood footprint characteristics and relative losses. The table shows rank correlation between relative losses (reported versus potential) for the 310 major floods in the uppermost quintile as shown in Supplementary Fig. 8.

Relative losses	Flood footprint characteristics										
	GDP per capita	Popu- lation density	Land use structure (% share)				Wealth structure (% share)				
			urban fabric	other artificial	agri- cultural	natural	agri- culture	industry	services	housing	infra- structure
Area inundated	-0.18	0.07	0.11	0.07	-0.06	0.06	0.01	0.10	0.16	-0.08	-0.22
Fatalities	-0.29	-0.26	-0.34	-0.12	0.10	-0.02	0.30	0.12	-0.14	-0.23	-0.23
Persons affected	-0.23	-0.40	-0.30	-0.20	0.07	0.03	0.29	0.12	-0.06	-0.17	-0.31
Losses (relative to GDP)	-0.41	-0.30	-0.31	-0.24	0.19	-0.07	0.38	0.18	-0.03	-0.26	-0.28
Losses (relative to wealth)	-0.41	-0.33	-0.34	-0.24	0.19	-0.08	0.38	0.16	-0.01	-0.28	-0.28

Supplementary references

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