Panta Rhei benchmark dataset: socio-hydrological data of paired events of floods and droughts

IAHS Panta Rhei Flood and drought paired event community
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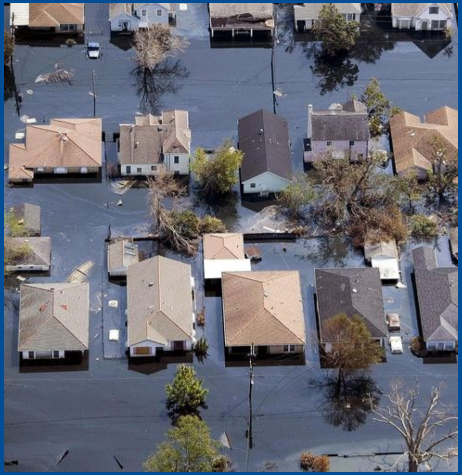
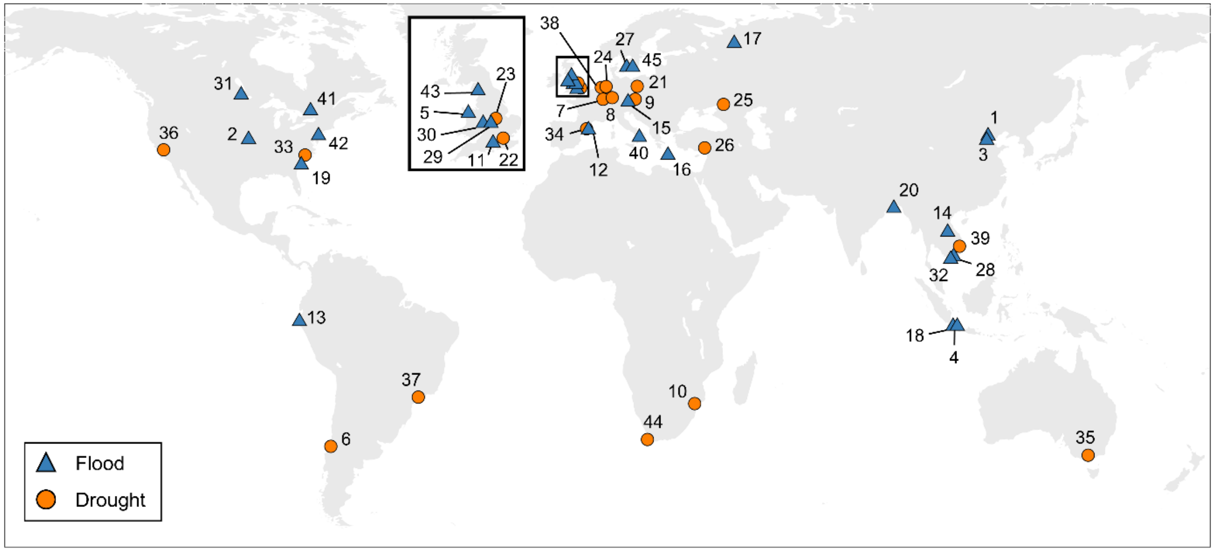
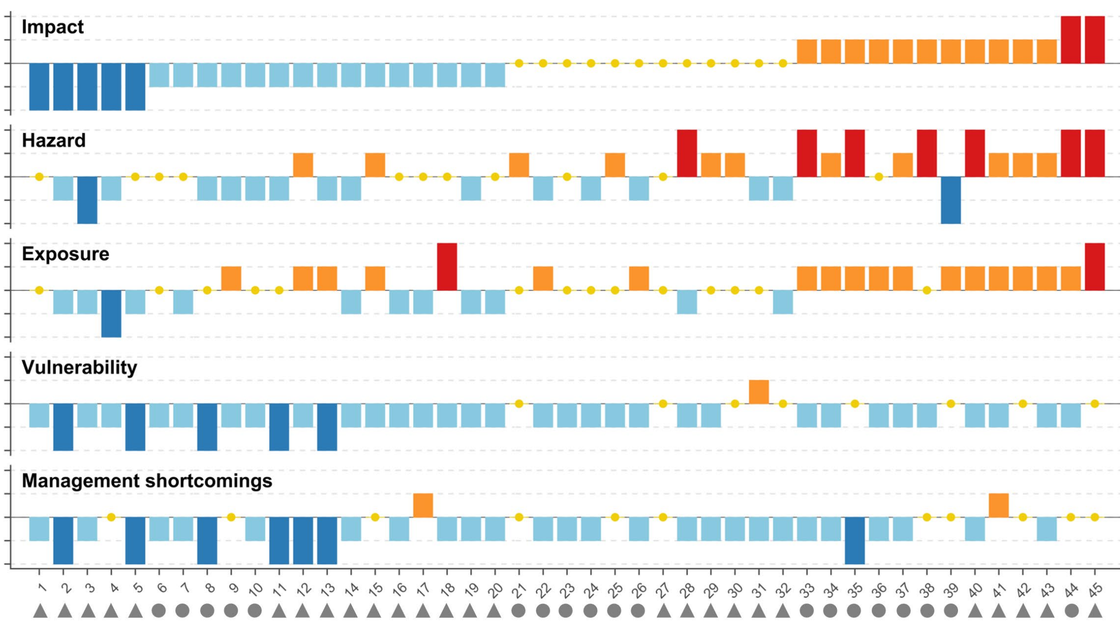




45 paired events
(26 flood & 19 drought)

1) detailed review style reports
2) key data table of management, hazard, exposure, vulnerability
3) indicators-of-change

Paired event analyses analogous to paired catchment studies:



- Risk management generally reduces the impacts of floods and droughts, but faces difficulties in reducing the impacts of unprecedented events of a magnitude not previously experienced

Kreibich et al. (2022) Nature, https://doi.org/10.1038/s41586-022-04917-5

Paired event concept

- **Paired events**, i.e. consecutive droughts or floods that occurred in the same region (analog to 'Paired catchment studies' Brown et al., 2005)
- **Trading-space-for-time approach**, understanding of spatial variability between case studies, which cover only change between two points in time, can provide a first order assessment of potential long term temporal change (Wagener et al. 2010)
- **Comparative analysis**, by analyzing a (large) set of case studies to find general patterns (analog to PUB approach Blöschl et al., 2013)

Aug 2002

Juni 2013

Paired event data

Open access: https://doi.org/10.5880/GFZ.4.4.2023.001

Data paper: Kreibich et al. 2023, ESSD, https://doi.org/10.5194/essd-2022-330

ID 1

Paired pluvial flood events: 21st July 2012 and 20th July 2016 pluvial floods in the city of Beijing, China

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Short description of both events with a focus on impacts

The 21st July 2012 and 20th July 2016 storms are two representative cases of extreme flood-producing storms in the city of Beijing, China. The two storms are comparable in storm intensity, duration and spatial coverage. Both storms set historical rainfall records in Beijing. The maximum rainfall accumulations (i.e., at point scale) for the 2012 and 2016 storms are 372 mm and 381 mm, respectively, with the return intervals of approximately 60-80 years. Extreme rainfall and flooding caused severe damages in many societal and economic sectors (e.g., agriculture, transportation, aviation, etc.). The 2012 storm is the deadliest and costliest weather disaster in Beijing since 1951, with 79 fatalities, economic loss of up to 16 billion RMB, loss of crops for 67,000 hectares, cancellation of more than 500 flights (Sun et al., 2012; Guo et al., 2015). The 2016 storm, on the other hand, did not induce as severe damages/losses as its counterpart. For instance, there were 380 flights cancelled during the 2016 storm event, loss of crops for 2,140 hectares, economic loss of less than 3 billion RMB. No fatalities were reported for the 2016 storm.

Descriptions of processes between events with a focus on risk management

The Beijing government implements several practices for flood mitigation/adaptation after the 2012 storm. Zhang et al. (2017) provided a list of the practices: (1) capacities of drainage systems are increased, especially for the areas where water-logging is common; (2) urban channels with a total length of 1460 km are cleaned up and connected to adjacent lakes/ponds; (3) 75 pumping stations are re-built through increasing drainage capacities to prevent ten-year flood events; (4) Additional 47 flood detention sites are set up in Beijing. These engineering measures effectively control inundation and its damages to societal and economic sectors during the 2016 storm. In addition, the Chinese government started great investments for flood prevention and mitigation in urban areas since 2013, the so-called "sponge-city" initiative, which increases institutional awareness for urban flooding over the entire country and promotes a favorable environment for collaborative efforts among different agencies.

Event comparison in respect to pluvial flood hazard

The 2012 and 2016 storms are comparable in storm intensity, duration and spatial extent. The storm-total rainfall accumulation averaged over the entire city is 213 mm (215 mm) for the 2012 (2016) storm. The maximum hourly rainfall is 100 mm/h for the 2012 storm, slightly larger than that of the 2016 storm (57 mm/h). Both storms persist for more than 20 hours, with the 2016 storm continuing for approximately 40 hours. Despite the comparable statistics, the synoptic conditions for the two storms are dramatically different from each other. The 2012 storm is associated with the deepening westerly trough (i.e., cold vortex) and its southward propagation. Interactions of the cold vortex and subtropical high promotes strong convergence

Review style reports (346pp.):

1) Short description of both events with a focus on impacts;
2) Description of processes between events with a focus on risk management;
3) Event comparison in respect to hazard;
4) Event comparison in respect to exposure;
5) Event comparison in respect to vulnerability;
6) Summary
7) References

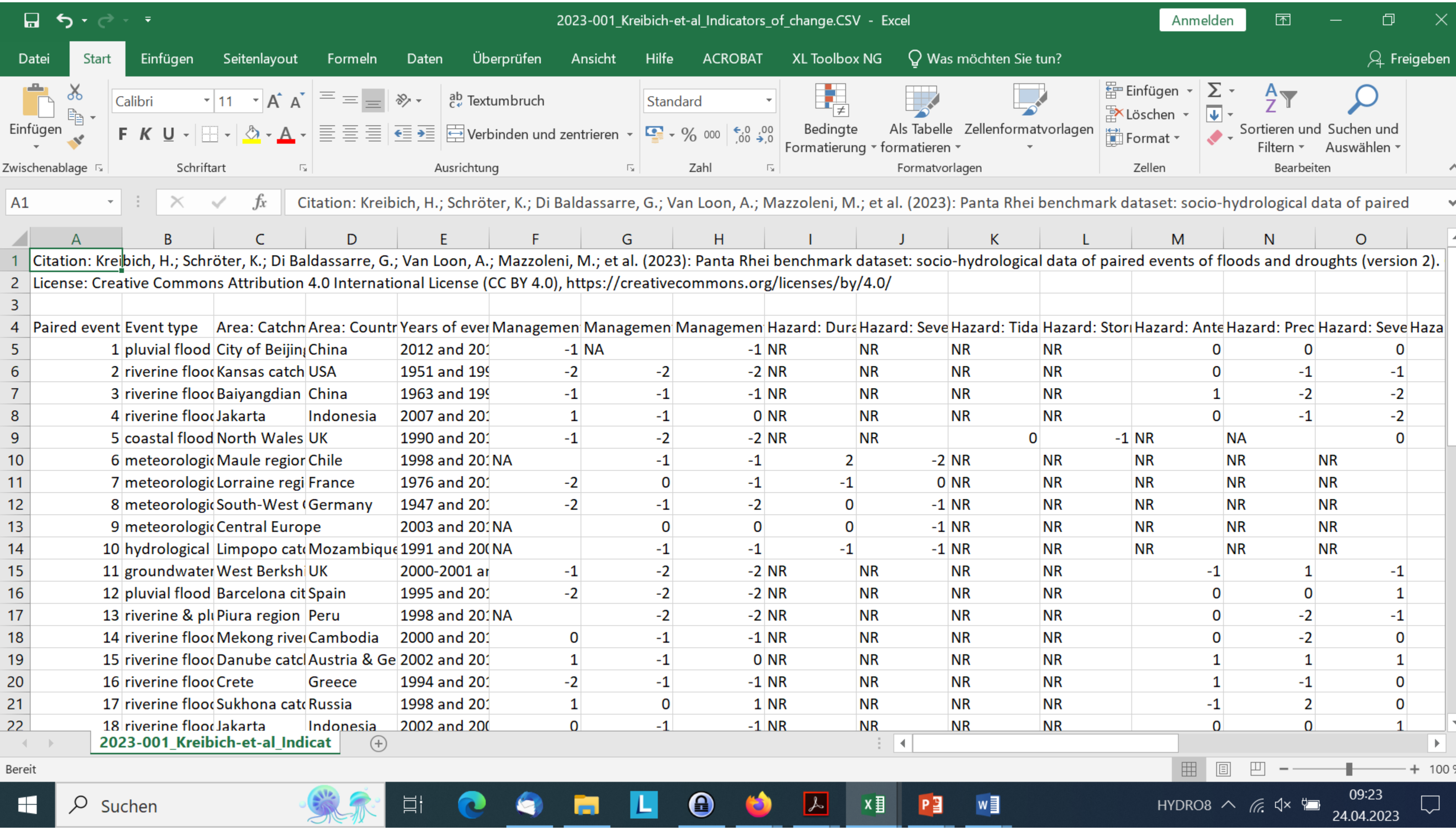
Paired event data – Key data table

2023-001_Kreibich-et-al_Key_data_table.xlsx - Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Citation: Kreibich, H.; Schröter, K.; Di Baldassarre, G.; Van Loon, A.; Mazzoleni, M.; et al. (2023): Panta Rhei benchmark dataset: socio-hydrological data of paired events of floods and													
2	License: Creative Commons Attribution 4.0 International License (CC BY 4.0), https://creativecommons.org/licenses/by/4.0/													
3														
4	Paired event	Event type	Area: Catchn	Area: Countr	Year of even	Management	Category of (	Management	Category of (	Hazard: Dura	Category of (	Hazard: Seve	Category of (	Hazard
5	1	pluvial flood	City of Beijing	China	2012	Insufficient d	*expert judge*	NA		NR		NR		NR
6	1	pluvial flood	City of Beijing	China	2016	capacities of	*scientific stu*	since 2013 th	*expert judge*	NR		NR		NR
7	2	riverine flood	Kansas catch	USA	1951	The design di	*scientific stu*	Flood storage	*scientific stu*	NR		NR		NR
8	2	riverine flood	Kansas catch	USA	1993	No levee failu	*report*	Flood storage	*report*	NR		NR		NR
9	3	riverine flood	Baiyangdian (	China	1963	319 dam-bre	*scientific stu*	Hydraulic en	*scientific stu*	NR		NR		NR
10	3	riverine flood	Baiyangdian (	China	1996	700 culvert t	*scientific stu*	Hydraulic en	*scientific stu*	NR		NR		NR
11	4	riverine flood	Jakarta	Indonesia	2007	No problems	*expert judge*	Stream-wise	*scientific stu*	NR		NR		NR
12	4	riverine flood	Jakarta	Indonesia	2013	Dike break o	*scientific stu*	Established n	*report*	NR		NR		NR
13	5	coastal flood	North Wales	UK	1990	450 m long b	*report, news*	NA		NR		NR		NR
14	5	coastal flood	North Wales	UK	2013	10 m dike br	*report*	In between th	*report*	NR		NR		NR
15	6	meteorologic	Maule region	Chile	1998	NA		Energy saving	*expert judge*	Drought ever	*scientific stu*	Average valu	*scientific stu*	NR
16	6	meteorologic	Maule region	Chile	2013	NA		Water aware	*report, exper*	Drought ever	*scientific stu*	Average valu	*scientific stu*	NR
17	7	meteorologic	Lorraine regi	France	1976	No heat warn	*report, exper*	Meteorologic	*report*	51 % of avera	*own analysis*	Exceptional r	*own analysis*	NA
18	7	meteorologic	Lorraine regi	France	2018	Since 2003 h	*scientific stu*	National hea	*report*	88 % of avera	*own analysis*	Exceptional r	*own analysis*	NA
19	8	meteorologic	South-West (	Germany	1947	No heat warn	*scientific stu*	Measuremen	*reports*	Apr-Oct: 59%	*own analysis*	Exceptional r	*own analysis*	NA

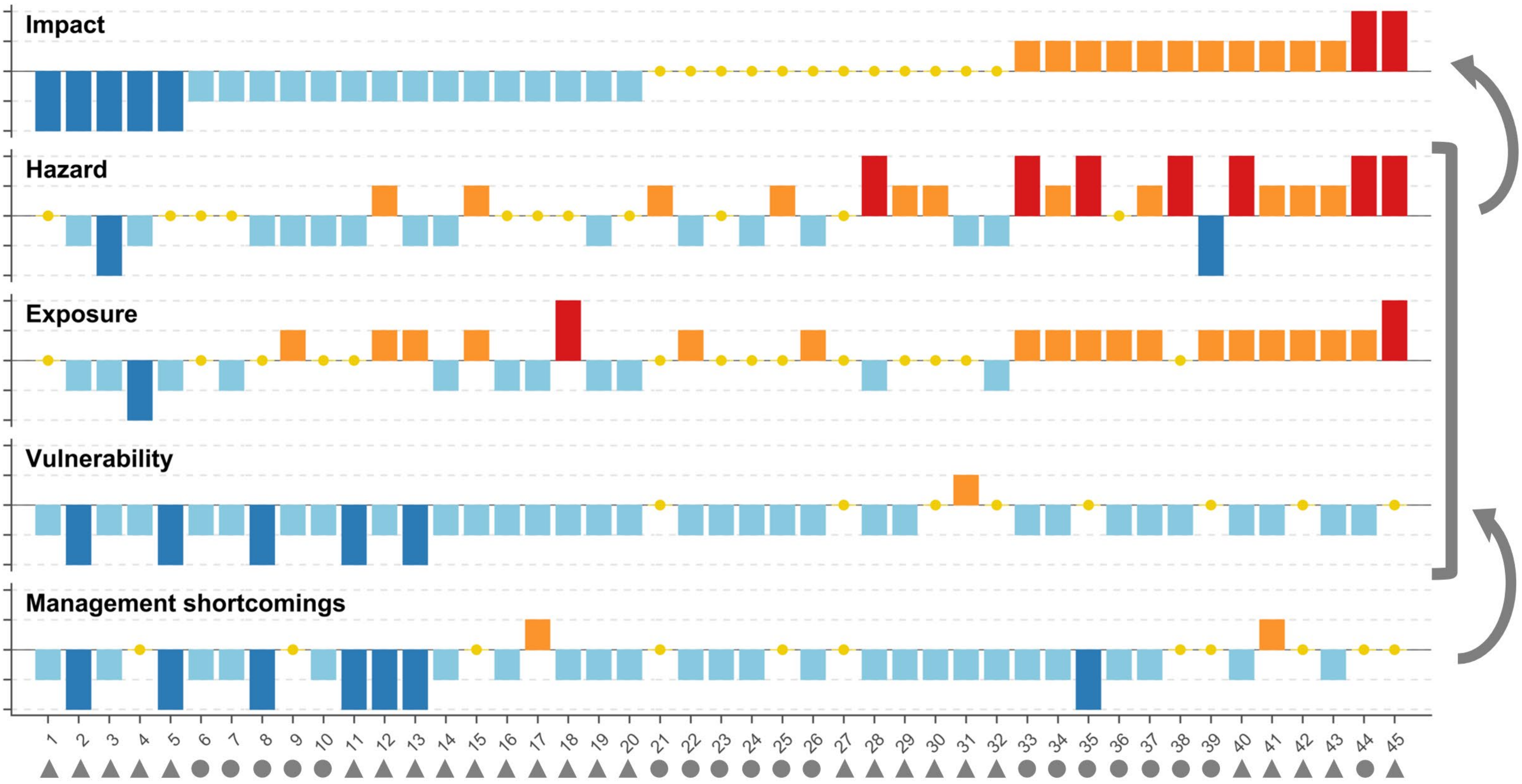
key data | references

Paired event data – indicators-of-change



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Citation: Kreibich, H.; Schröter, K.; Di Baldassarre, G.; Van Loon, A.; Mazzoleni, M.; et al. (2023): Panta Rhei benchmark dataset: socio-hydrological data of paired events of floods and droughts (version 2).														
2	License: Creative Commons Attribution 4.0 International License (CC BY 4.0), https://creativecommons.org/licenses/by/4.0/														
3															
4	Paired event	Event type	Area: Catchn	Area: Countr	Years of ever	Managemen	Managemen	Managemen	Hazard: Dura	Hazard: Seve	Hazard: Tida	Hazard: Stori	Hazard: Ante	Hazard: Prec	Hazard: Seve
5	1	pluvial flood	City of Beijin	China	2012 and 20:	-1	NA	-1	NR	NR	NR	NR	0	0	0
6	2	riverine flooc	Kansas catch	USA	1951 and 19!	-2	-2	-2	NR	NR	NR	NR	0	-1	-1
7	3	riverine flooc	Baiyangdian	China	1963 and 19!	-1	-1	-1	NR	NR	NR	NR	1	-2	-2
8	4	riverine flooc	Jakarta	Indonesia	2007 and 20:	1	-1	0	NR	NR	NR	NR	0	-1	-2
9	5	coastal flood	North Wales	UK	1990 and 20:	-1	-2	-2	NR	NR	0	-1	NR	NA	0
10	6	meteorologic	Maule regior	Chile	1998 and 20:	NA	-1	-1	2	-2	NR	NR	NR	NR	NR
11	7	meteorologic	Lorraine regi	France	1976 and 20:	-2	0	-1	-1	0	NR	NR	NR	NR	NR
12	8	meteorologic	South-West (	Germany	1947 and 20:	-2	-1	-2	0	-1	NR	NR	NR	NR	NR
13	9	meteorologic	Central Europe		2003 and 20:	NA	0	0	0	-1	NR	NR	NR	NR	NR
14	10	hydrological	Limpopo cat	Mozambique	1991 and 20(	NA	-1	-1	-1	-1	NR	NR	NR	NR	NR
15	11	groundwater	West Berksh	UK	2000-2001 ar	-1	-2	-2	NR	NR	NR	NR	-1	1	-1
16	12	pluvial flood	Barcelona cit	Spain	1995 and 20:	-2	-2	-2	NR	NR	NR	NR	0	0	1
17	13	riverine & pl	Piura region	Peru	1998 and 20:	NA	-2	-2	NR	NR	NR	NR	0	-2	-1
18	14	riverine flooc	Mekong rivei	Cambodia	2000 and 20:	0	-1	-1	NR	NR	NR	NR	0	-2	0
19	15	riverine flooc	Danube catcl	Austria & Ge	2002 and 20:	1	-1	0	NR	NR	NR	NR	1	1	1
20	16	riverine flooc	Crete	Greece	1994 and 20:	-2	-1	-1	NR	NR	NR	NR	1	-1	0
21	17	riverine flooc	Sukhona cat	Russia	1998 and 20:	1	0	1	NR	NR	NR	NR	-1	2	0
22	18	riverine flooc	Jakarta	Indonesia	2002 and 20(	0	-1	-1	NR	NR	NR	NR	0	0	1

Paired event data – indicators-of-change



Paired event analyses

- **Detailed context- and location-specific assessments and impact attribution studies**: suggestions for the attribution of changes in drought and flood impacts are provided by Kreibich et al. 2019, https://doi.org/10.1080/02626667.2018.1558367
- **Comparative analyses,** semi-quantitative based on indicators-of-change, examples: Kreibich et al. 2017, https://doi.org/10.1002/2017EF000606, 2022, https://doi.org/10.1038/s41586-022-04917-5
- **Development and calibration of socio-hydrological models**, individually per paired event, examples: Barendrecht et al. 2019, https://doi.org/10.1029/2018WR024128, Schoppa et al. 2022, DOI: 10.1080/02626667.2022.2095207
- **Benchmark the performance of socio-hydrological flood or drought risk models**

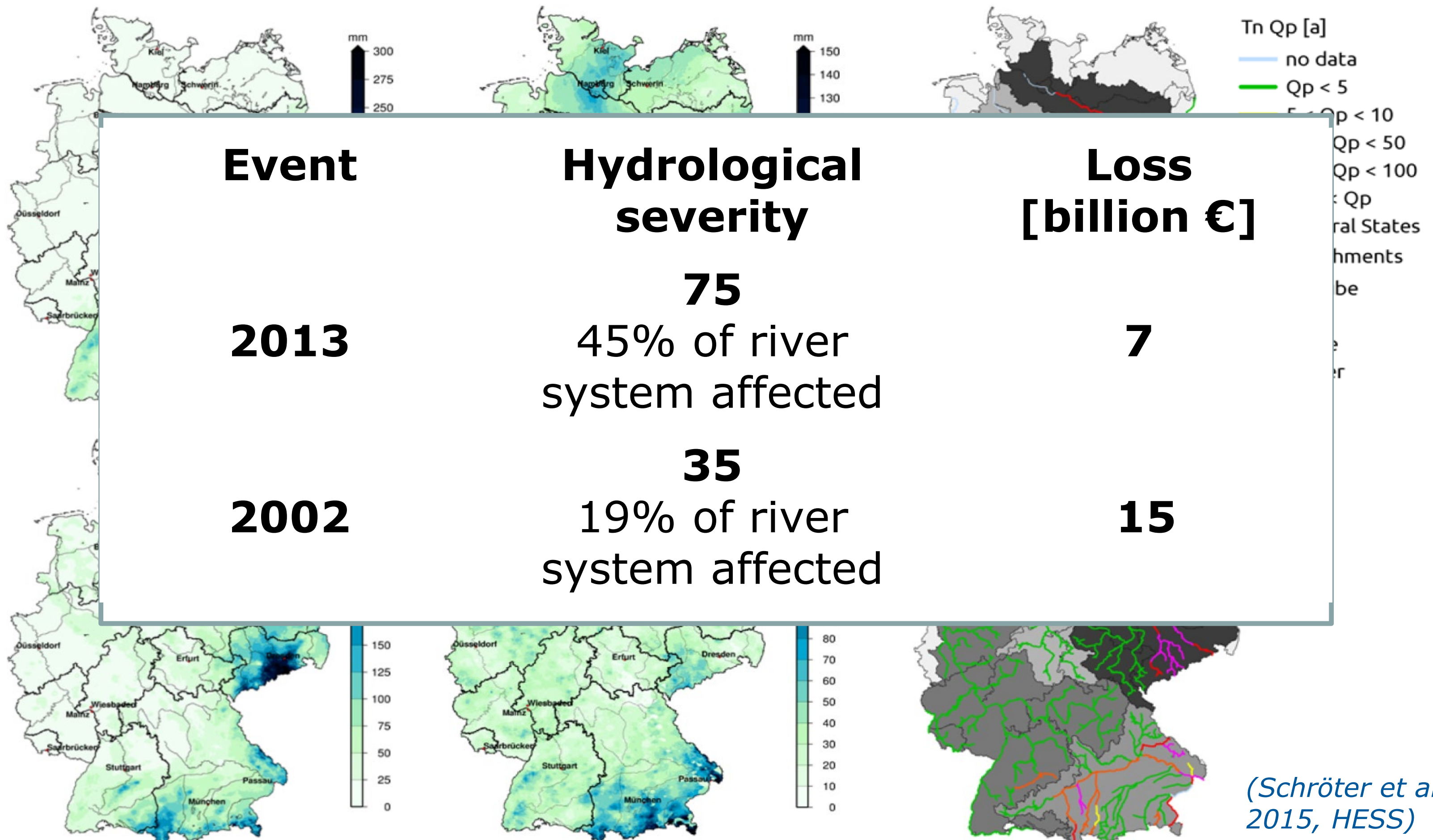
Detailed context specific analysis

Example 2002 and 2013 floods in Germany

3-day max event precipitation | Antecedent catchment wetness | Streamflow return period

2013

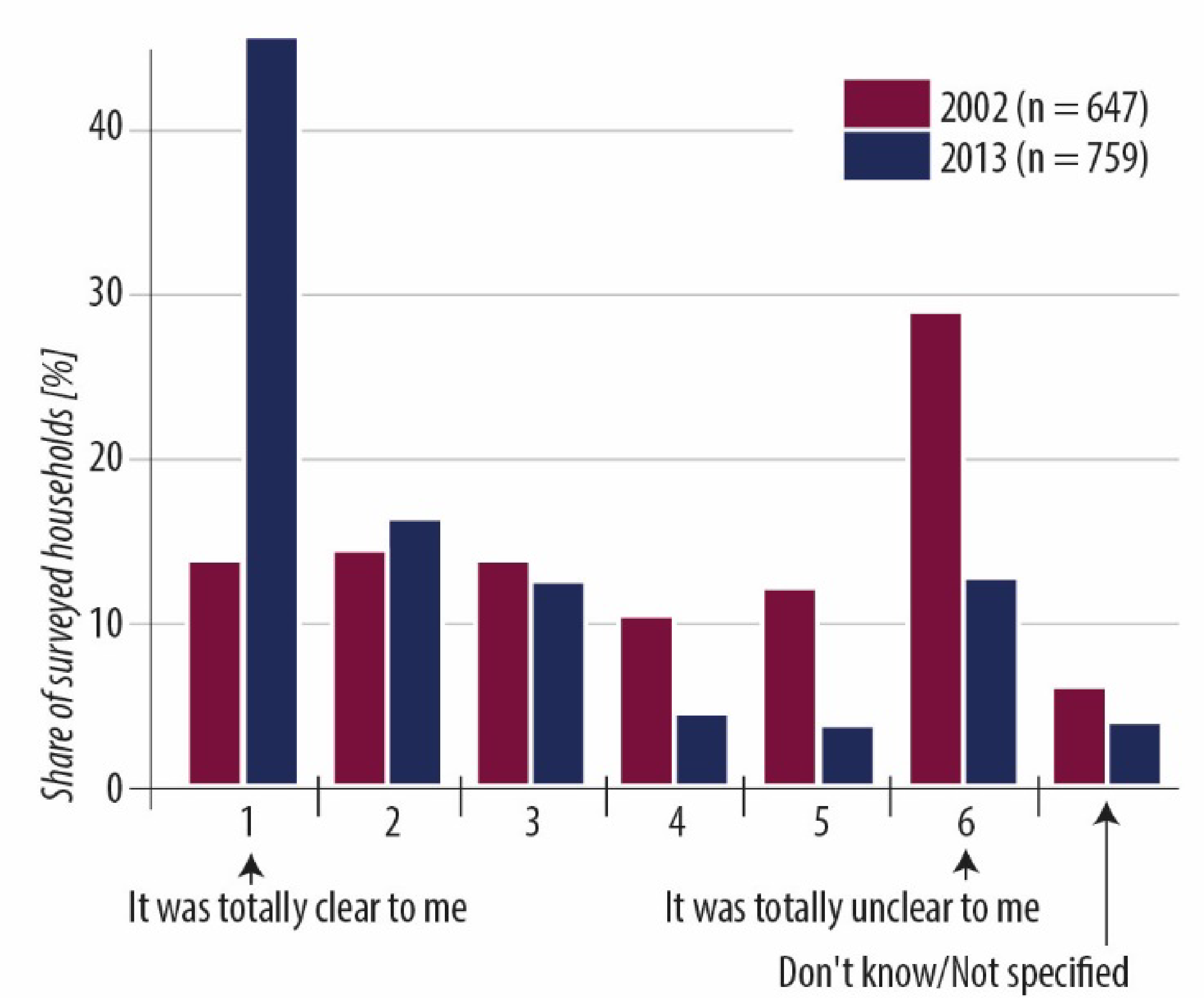
2002



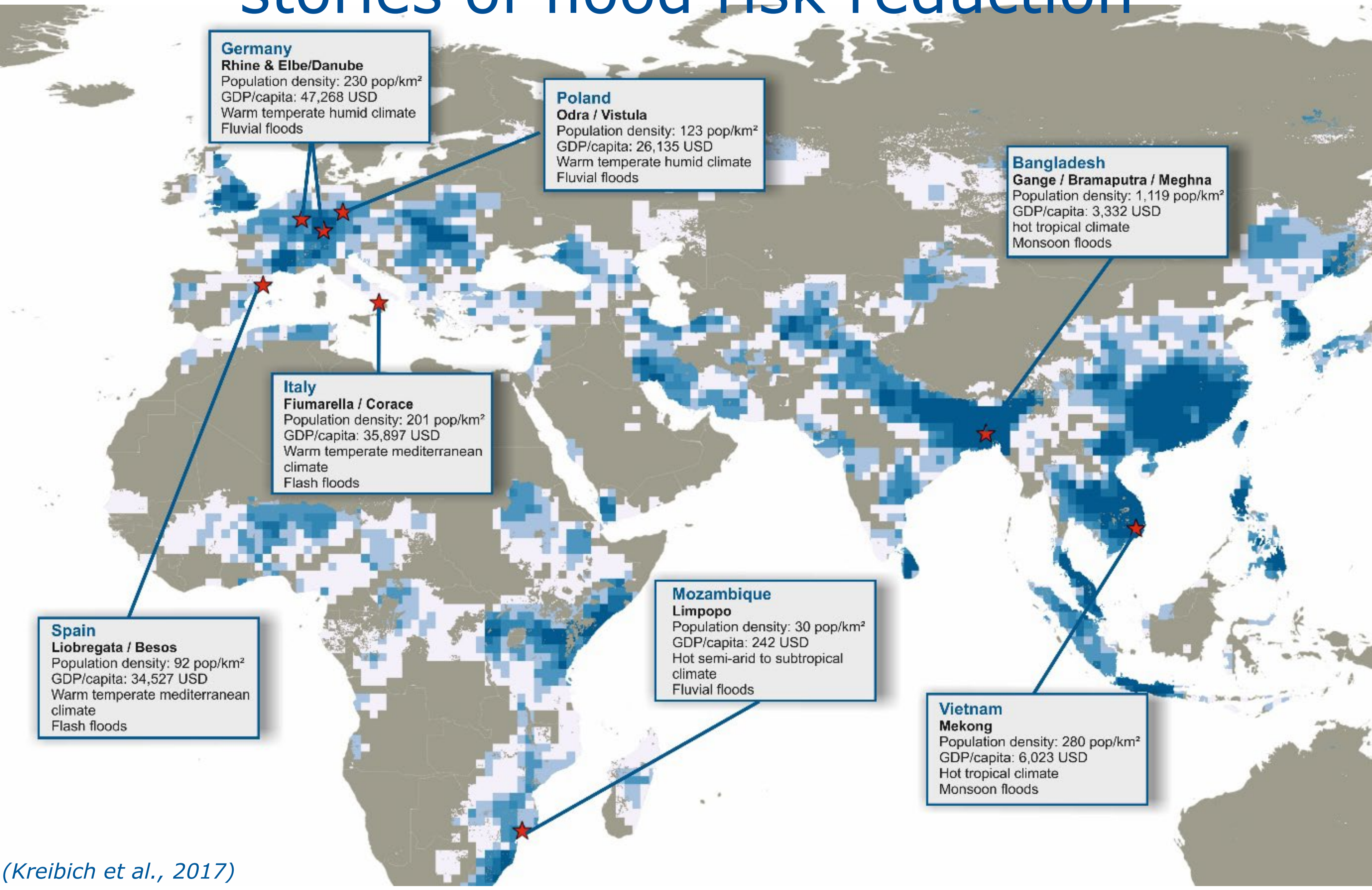
Event	Hydrological severity	Loss [billion €]
2013	**75** 45% of river system affected	**7**
2002	**35** 19% of river system affected	**15**

(Schröter et al., 2015, HESS)

Example: preparedness and warning



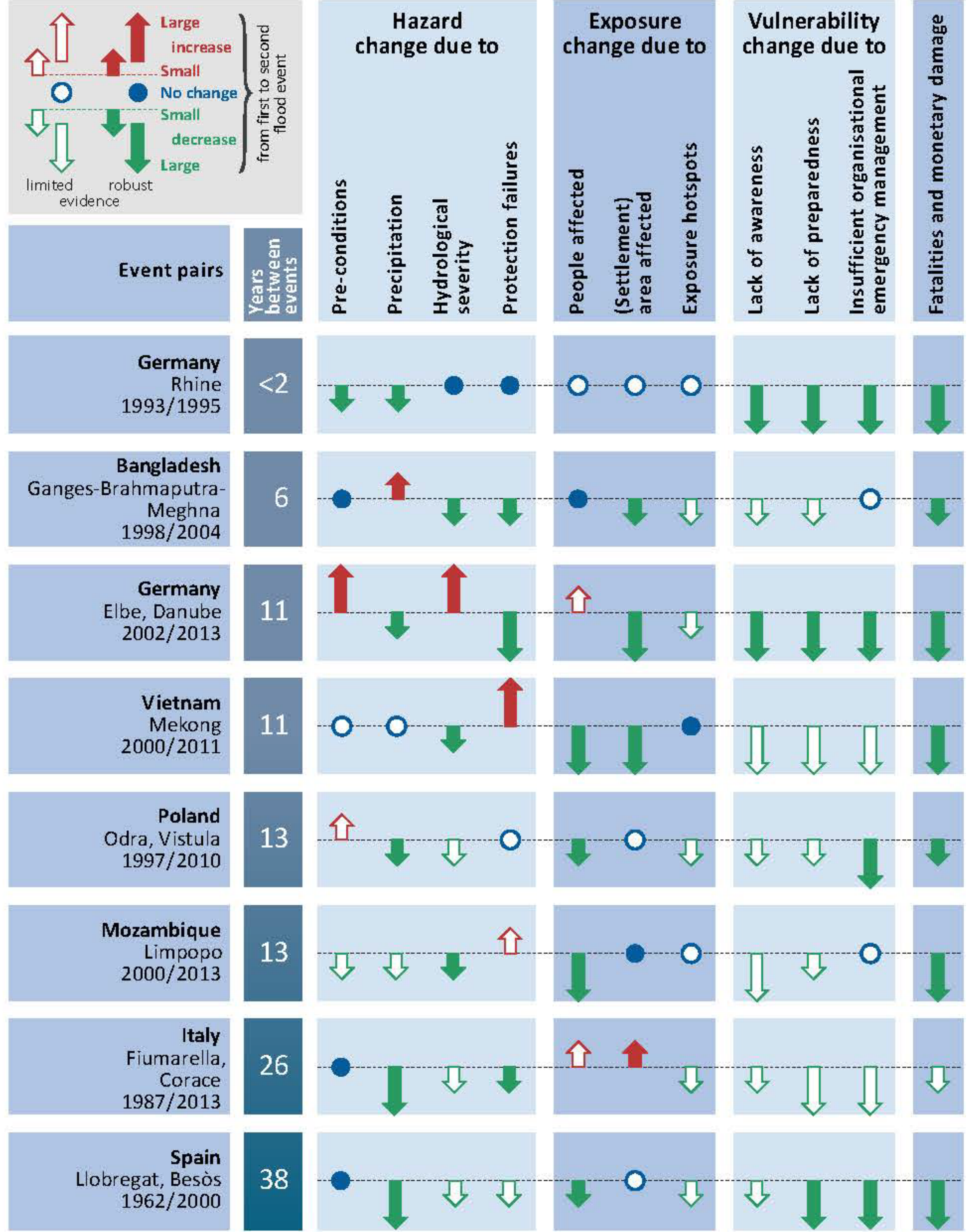
Comparative analyses: Eight success stories of flood risk reduction



(Kreibich et al., 2017)

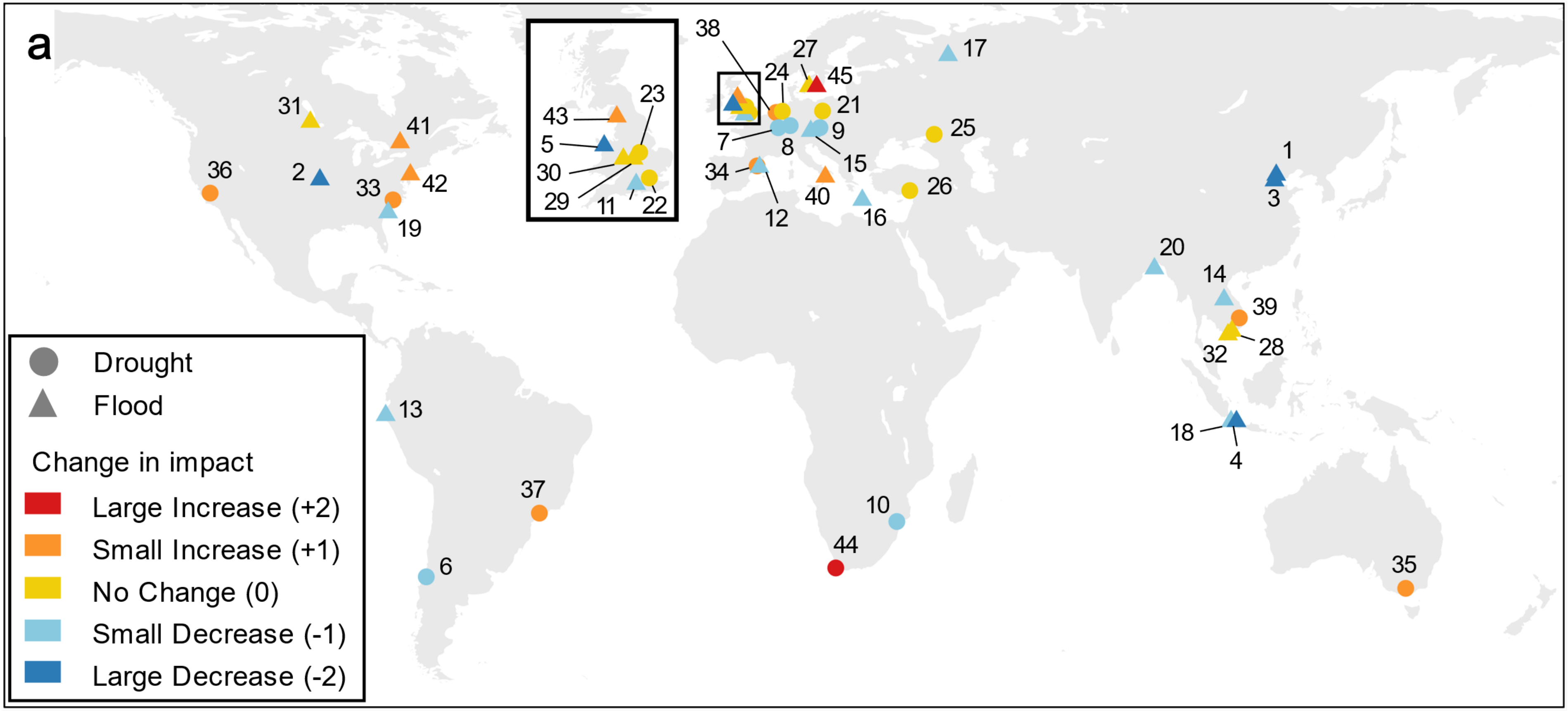
Pattern of paired flood event analyses

- Across different socio-economic and hydro-climatic contexts vulnerability reduction is key for successful risk management



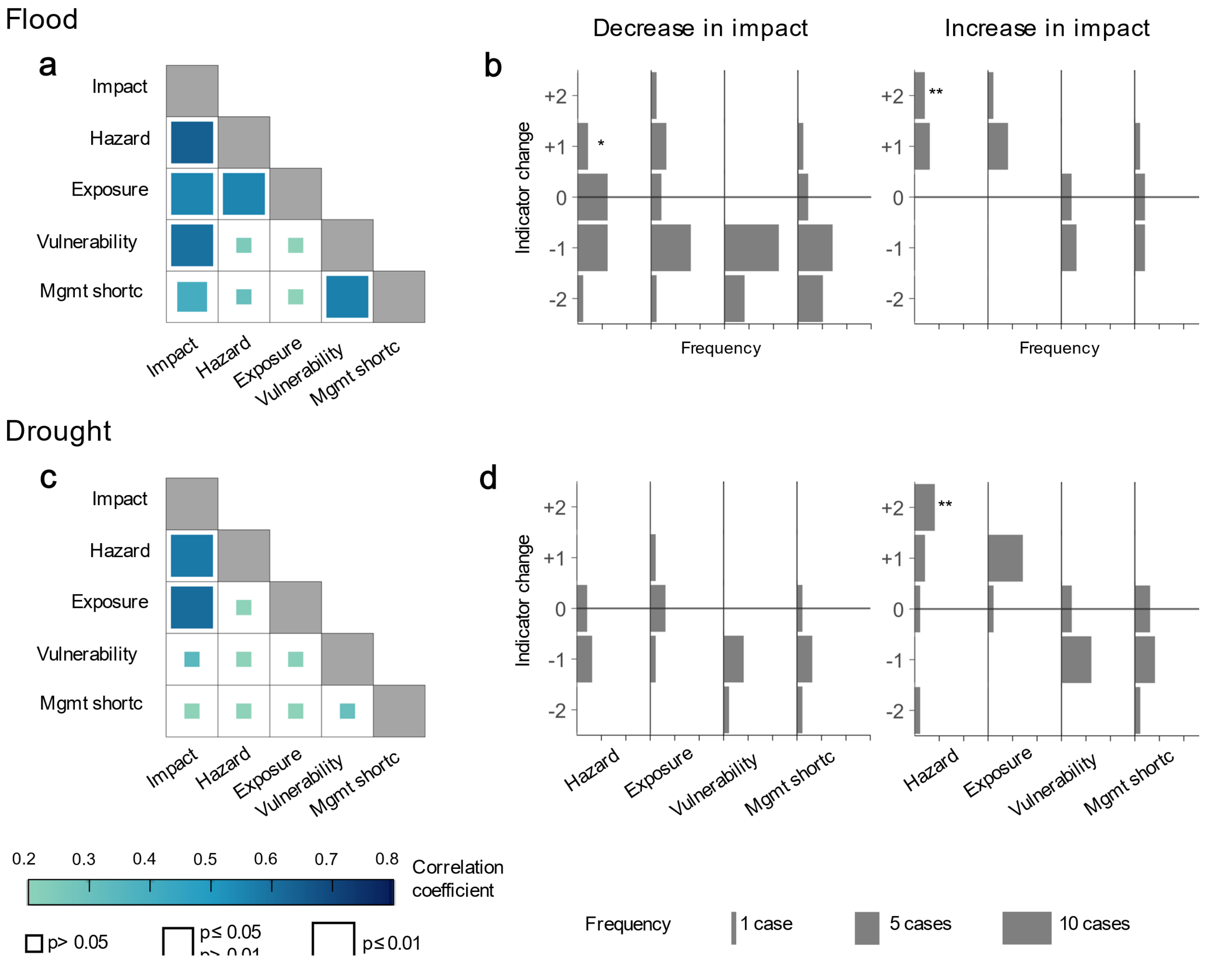
(Kreibich et al., 2017

Comparative analyses: Floods & Droughts



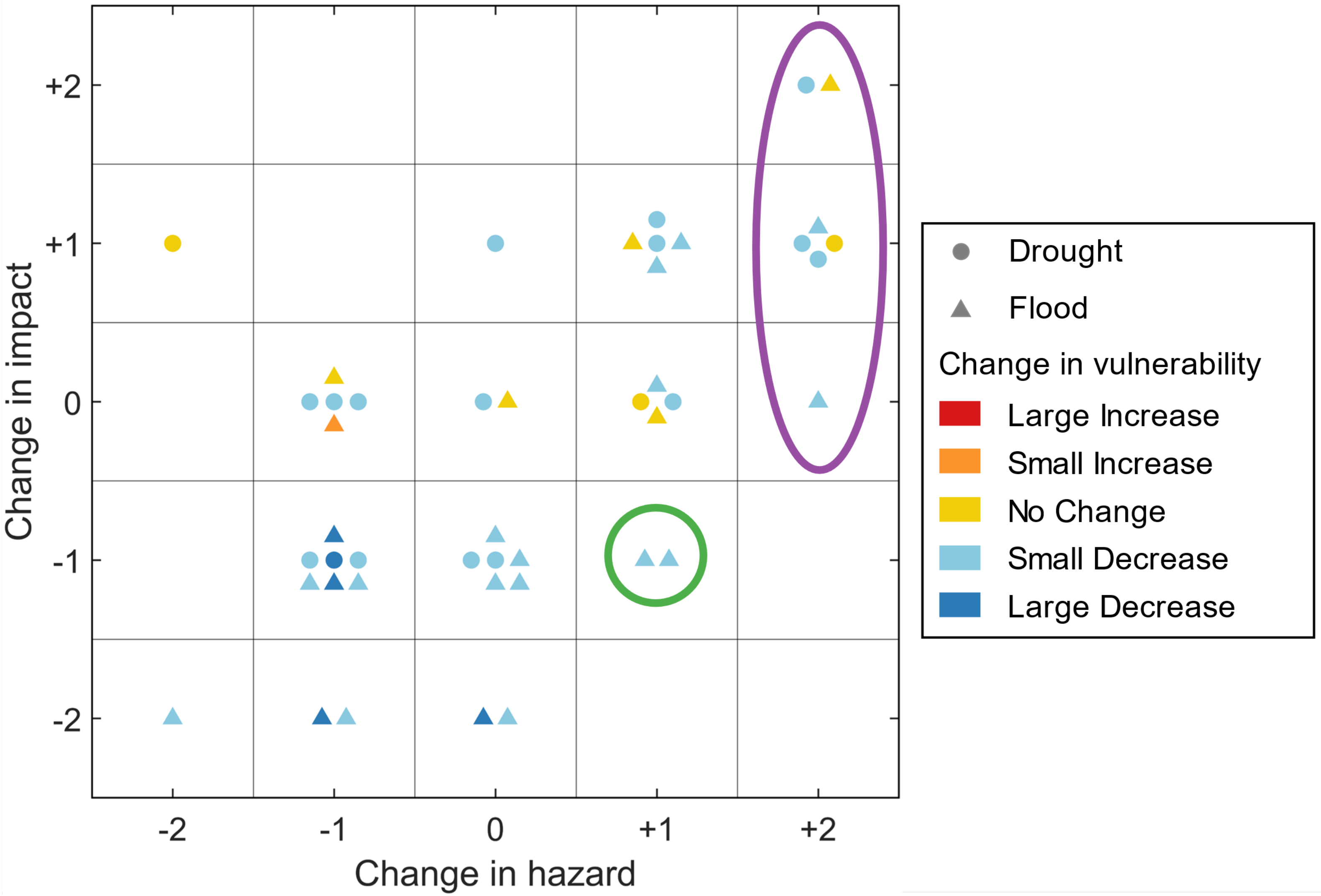
(Kreibich et al., 2022)

Comparative analyses: Floods & Droughts



(Kreibich et al., 2022)

Comparative analyses: Floods & Droughts



(Kreibich et al., 2022)

Comparative analyses: Floods & Droughts

Box 1

Success stories of decreased impact despite increased hazard

The dataset includes two cases in which a lower impact was achieved despite a larger hazard of the second event, making these interesting success stories (Fig. 3). Both cases are flood paired events, but of different types (that is, pluvial and riverine floods (Table 1)). These cases have in common that institutional changes and improved flood risk management governance were introduced and high investments in integrated management were undertaken, which led to an effective implementation of structural and non-structural measures, such as improved early warning and emergency response to complement structural measures such as levees (Table 1).

Table 1 | Characteristics and commonalities in flood management of the two success stories.

	Pluvial floods in Barcelona, Spain (ID 12)		Riverine floods in Danube catchment in Germany and Austria (ID 15)	
Event characteristics	**1995**	**2018**	**2002**	**2013**
Hazard (hazard indicator-of-change +1)	Duration, 4 h; average event precipitation, 38 mm	Duration, 21 h; average event precipitation, 45 mm	7,700 m^3s^{-1} peak discharge at gauge Achleiten	10,100 m^3s^{-1} peak discharge at gauge Achleiten
Impacts (impact indicator-of-change −1)	€33.6 million[a]	€3.5 million	€4 billion[a]	€2.32 billion
Commonalities in management changes: potential factors of success				
Institutional changes, improved governance	Reorganization of early warning and emergency response after 1995, with improved collaboration between municipality, Catalonia and State Agency of Meteorology		Flood information service (HORA) for Austria went online in 2006; reorganization of flood warning and emergency response units with improved collaboration across federal states and transnationally	
High investments in structural and non-structural measures	About €136 million[a] invested in structural measures alone, following the Integrated Sewerage Plan of Barcelona		Around €3.6 billion[a] invested in flood risk management between events on structural and non-structural measures, including new legislation and building codes in Germany and Austria	
Strongly improved early warning and emergency response	New radar and lightning network plus operative mesoscale meteorological models in Catalonia, real-time control system based on rain gauge network and water level monitoring in Barcelona		Technical improvements in weather forecasting in Germany, much higher penetration rate of flood warnings and more effective flood response actions among citizens	

[a]Calculated as costs at the time of the second event.

Common features of success stories:

1) Institutional changes and improved flood risk management governance
2) High investments in integrated management
3) Effective implementation of structural and non-structural measures, such as improved early warning and emergency response

(Kreibich et al., 2022)

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