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Multiple Flood Experiences and Social Resilience: Findings from Three Surveys on Households and Companies Exposed to the 2013 Flood in Germany

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ABSTRACT

Previous studies have explored the consequences of flood events for exposed households and companies by focusing on single flood events. Less is known about the consequences of experiencing repeated flood events for the resilience of households and companies. In this paper, we therefore explore how multiple floods experience affects the resilience of exposed households and companies. Resilience was made operational through individual appraisals of households and companies' ability to withstand and recover from material as well as health and psychological impacts of the 2013 flood in Germany. The paper is based on three different datasets including more than 2000 households and 300 companies that were affected by the 2013 flood. The surveys revealed that the resilience of households seems to increase, but only with regard to their subjectively appraised ability to withstand impacts on mobile goods and equipment (e.g., cars, TV, and radios). In regard to the ability of households to withstand overall financial consequences of repetitive floods, evidence for nonlinear (quadratic) trends can be found. With regard to psychological and health-related consequences, the findings are mixed but provide tentative evidence for eroding resilience among households. Companies' resilience increased with respect to material assets but appears to decrease with respect to ability to recover. We conclude by arguing that clear and operational definitions of resilience are required so that evidence-based resilience baselines can be established to assess whether resilience is eroding or improving over time.

1. Introduction

The immediate experience of a flood event is often associated with enormous financial losses and can have considerable negative health-related as well as psychologically distressing consequences resulting in anxiety, depression, or posttraumatic stress disorder, among others (Fernandez et al. 2015). For companies, floods can cause considerable costs due to business interruption as well as direct economic damage to buildings and equipment (Chinh et al. 2016). In this sense, flood experience may undermine a companies' economic prosperity or the resilience of flood-exposed people, which includes not just the immediate pathological consequences but also the wider perception of individual agency, emotions attached to the place of residency, social ties and networks, and trust in responsible institutions (Kuhlicke et al. 2011; Tapsell and Tunstall 2008; Walker-Springett et al. 2017).

At the same time, there is a rapidly growing body of research showing that flood events also offer an opportunity for change: in the aftermath of flood events, households, companies, and authorities seem to be more inclined to invest in adaptation measures in order to mitigate the consequences of future flood events (Kreibich et al. 2011; Thieken et al. 2007) and by doing so are often able to reduce the monetary damage caused by a subsequent flood event quite effectively (Bubeck et al. 2012b; Kreibich et al. 2017; Kreibich and Thieken 2009; Thieken et al. 2016b).

However, most studies treat single flood events in isolation. By relying on a cross-sectional survey design, empirical studies usually try to better understand how

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individuals withstand and recover from the impact of single flood events (Kuhlicke et al. 2011). Such event-centered studies, however, are hardly able to capture feedback effects (Bubeck et al. 2012b) or legacy effects due to the experience of frequent flood events. Therefore, little is known about how a household's or company's flood history shapes its ability to withstand and recover from a flood event. With this study, we would like to address this gap in research, which is relevant in view of future flood risk. Although there are profound regional differences and uncertainties in numerical projections of future flood risks (Kundzewicz et al. 2014), it is expected that flood risk tends to increase in the future. The reasons behind this are related to climate change (Hirabayashi et al. 2013; Milly et al. 2008) as well as the continuous increase in the population and economic assets in flood-prone areas (Jongman et al. 2012).

This study explores the cumulative effects of multiple flood experience on the resilience of affected households and companies. Resilience is understood here as a household's or a company's ability to withstand and recover from the impacts of a natural hazard. More specifically, we focus on how household members as well as companies perceive their own ability to withstand damage to immobile and mobile objects as well as to their psychological and health-related integrity. With regard to recovery processes, we focus on how long it took households to recover after the flood event (in months) and how their household situation changed as a result of the flood (i.e., worsened or improved). Companies were asked how long their business activities were interrupted or hampered as a consequence of the flood.

Empirically, the current research focuses on the 2013 flood in the Elbe and Danube catchments of Germany, which was a record-breaking event in hydrological terms (Schröter et al. 2015). With about EUR 6–8 billion it caused considerably lower direct losses than the 2002 flood, which resulted in damage costs amounting to EUR 11.6 billion (DKKV 2003, 2015). However, for many households and companies, the 2013 flood was the second or third flood event that they had experienced since 2002. In addition to the 2002 flood, floods also occurred in 1999, 2005, 2006, 2010, and 2011 in the Danube and Elbe catchments (Kienzler et al. 2015). We therefore regard the 2013 flood as a possibility for better understanding the interrelation of flood experience and resilience.

The current research is based on three different survey samples, all of them conducted and collected independently of each other. Acknowledging the differences in the ways the surveys were conducted and the different interests underlying the surveys, as well as the slightly different ways in which questions were asked and how answer categories were provided in the surveys, we do not strive for a comparison in the strict sense but rather look for common trends in our data.

Starting with a thorough literature review focusing on the interrelation between flood experience, adaptation, and resilience (chapter 2), we further specify our conceptual approach to resilience and adaptation as well as the methodology underlying the three different samples in chapter 3. In chapter 4, we present the empirical results and then summarize and discuss the methodological and policy-relevant implications of our findings in chapter 5. More detailed information on the statistical analyses is provided in the appendix.

2. Literature review

a. Toward an operational definition of flood resilience

Resilience is an opalescent term that has multiple meanings in different scientific communities. Most of the contemporary work on resilience refers to the definition of ecological resilience developed by Holling (1973) who integrated three different stability properties under the unifying umbrella term resilience; that is, recovery (return to status quo after disturbance), resistance (buffering the impact of a disturbance), and persistence (staying intact as an identifiable object/subject over time) (Grimm and Wissel 1997).

This definition and its uncountable variations (Brand and Jax 2007; Fisher 2015) have become quite popular, not only among ecologists but also among social scientists (Cote and Nightingale 2012; Hutter et al. 2013; Kuhlicke 2013; Weichselgartner and Kelman 2015) as well as among scholars working at the boundary between society and ecology (Adger 2000; Folke et al. 2002; Thieken et al. 2014; Walker et al. 2004).

As an implication, there is no agreed-upon understanding let alone definition of resilience both in science and practice (Alexander 2013; Weichselgartner and Kelman 2015). To give just a few examples, it is debated whether resilience is a descriptive or a prescriptive concept (Berkes 2007; Kuhlicke 2013, 2019) and whether and how resilience differs from vulnerability (Cutter et al. 2008; Fekete et al. 2014) or adaptive capacity (Gallopín 2006). In this sense, resilience has become an all-encompassing concept overloaded with quite diverse stocks of meanings (Jones and Tanner 2017). Brand and Jax are therefore concerned that "both conceptual clarity and practical relevance of the concept of resilience are critically in danger" (Brand and Jax 2007, p. 1). Similarly, Weichselgartner and Kelman plea for more precisely defining and operationalizing resilience

in order to be able to establish a clear baseline ''against which to make decisions regarding the resilience level'' (Weichselgartner and Kelman 2015, p. 10). They consider this a relevant step forward in order to overcome the vagueness of current resilience-based analysis and to better connect the concept with ''people's experience on the ground'' (Weichselgartner and Kelman 2015, p. 15).

In this paper, we aim to take on this challenge by employing an operational definition of resilience, which draws on debates in natural hazards research (Cutter et al. 2008). It focuses on how the capacity of households' and companies' to cope with and recover from the impact of a flood is changing in consequence of experiencing multiple floods. Furthermore, we are interested in subjective interpretations of different dimensions of resilience (Jones and Tanner 2017), that means how households and companies evaluate their own ability to withstand and recover from flood-related impacts to immobile and mobile objects as well as to their psychological and health-related integrity.

The relevance of taking such a comprehensive, actor-centered perspective on resilience is highlighted by recent studies. It is apparent that flood events are associated with a range of tangible and intangible consequences (Bubeck et al. 2017; Kuhlicke et al. 2011; Thieken et al. 2016b). Next to monetary impacts (Kreibich et al. 2014; Meyer et al. 2013), this can include negative effects on physical and mental health, including injuries but also psychiatric symptoms (Ahern et al. 2005; Alderman et al. 2012): an increase in the cases of depression, anxiety, and psychosomatic symptoms (headache, bodily pain) and a higher probability of posttraumatic stress disorder (Bonanno et al. 2010; Stein et al. 2007). Furthermore, results indicate that flooding can negatively affects people's psychological well-being (Hudson et al. 2019) and leads to an increased use of medication (Fernandez et al. 2015). In addition, Thieken et al. (2016a) and Reiter et al. (2018) found that German households affected by the 2013 Elbe flood perceived psychological stress and recovery activities more seriously than financial losses. These findings underline that an approach to resilience is needed that focuses on households' and companies' perception of their own ability to withstand and recover from the different kinds of negative consequences of flood events, including not just material aspects but also psychological and health-related consequences. At the same time, resilience of households and companies depends on both prior flood experience as well as on their previous adaptive actions.

b. *Multiple flood experience, adaptation, and resilience*

In 1962 Robert W. Kates used the expression ''prison of experience'' (Kates 1962, p. 140) to highlight how future actions are guided by past experiences (Kuhlicke 2010, 2015). Since then, studies have increasingly focused on the interrelation of flood experience, adaptation, and resilience (Begg et al. 2017; Wachinger et al. 2013). Previous studies showed that direct flood experience can have a positive effect on risk awareness (Felgentreff 2003; Gotham et al. 2018; Lawrence et al. 2014; Plapp and Werner 2006), can result in a higher awareness of the potential negative consequences of climate change (Ogunbode et al. 2017; Spence et al. 2011), and can increase the motivation to take adaptive actions (Bubeck et al. 2012a; Grothmann and Reusswig 2006; Lawrence et al. 2014; Zaalberg et al. 2009). However, flood experience should not be understood as the sole driving factor for adaptive behavior; adaptive behavior is influenced by various variables including descriptive norms, negative affect, and outcome as well as self-efficacy (for an overview, see van Valkengoed and Steg 2019).

At the same time, research has shown that personal adaptive measures (e.g., measures taken to protect and prepare one's house before a flood event) have positive effects on flood related damage as they reduce flood-related financial damage up to 50% (Kreibich et al. 2015; Poussin et al. 2015). Furthermore, there is an emerging field of research researching the nonmaterial benefits of individual-level adaptation strategies (Lamond et al. 2018) by focusing on how adaptive actions are able to prevent negative psychological impacts or to provide a greater sense of security (Hudson et al. 2019; Joseph et al. 2015).

However, in most cases flood experience is treated in isolation. The dominant practice of conducting cross-sectional surveys with a focus on single flood events usually neglects that adaptive behaviors, flood experience, and resilience are not just developing dynamically over time, they are also mutually influencing each other. Although it is meanwhile acknowledged that the interrelation between adaptive behavior and risk awareness is shaped by feedback effects and recursive processes (Siegrist 2013, 2014), little is known about the feedback of flood experience on resilience. A study conducted by Begg et al. (2017) suggests that perceived severity of an actual flood experienced has a significant influence on relevant motivational factors shaping the willingness to take adaptive actions. Households that perceived health and stress-related consequences due to the 2013 flood in Germany and that took adaptive measure before the 2013 flood report significantly lower response efficacy as well as lower individual responsibility after the flood than respondents who implemented measures but perceived the consequences to be less severe.

However, to our knowledge, there is not a single study published that focuses on how the frequency of flood experience influences the ability of households and companies to withstand and recover from flood events. Based on the literature, we can only put forward the hypothesis that flood experience might be an important factor that enhances the ability of households to withstand flood related impacts and to recover quicker as they might have developed some kind of routine-based knowledge to cope more effectively with the immediate flood situation. At the same time, each flood event might also be associated with an enormous physical, mental, and collective encumbrance resulting in possibly negative effects in the long run. In this sense, multiple flood experiences can also be understood as a burden for affected households. For companies, the situation might be different, as they might systematically improve their coping and adaptive capacities. However, these are only speculative thoughts, as there is no empirical evidence available so far. With this study, we address this gap in knowledge by providing empirical insights on the interrelation of multiple flood experience and resilience.

3. Theoretical constructs and methodology

a. Theoretical constructs

This study is based on three different theoretical constructs (Fig. 1). Based on Cutter et al. (2008), we distinguish conceptually between 1) adaptive actions and emergency actions on the one hand and 2) resilience on the other hand. 3) The third relevant construct was respondents' prior flood experience. Figure 1 provides a model underlying the analysis.

Individual adaptation and emergency actions are understood as actions that aim at preventing or minimizing the anticipated or actual negative consequences of future flood events. They comprise long-term precautionary measures such as informative measures (e.g., gathering information on flood loss mitigation, joining neighborhood flood networks), constructional measures (e.g., adapted interior fittings, sealing the cellar) and taking out natural hazard insurance. They also include emergency measures that are undertaken just before or during a flood event such as moving contents upstairs or protecting the building against inflowing water (Kreibich and Thieken 2009). Early warning is an important prerequisite for undertaking emergency measures; however, it was not part of this study.

Resilience is understood as a household's or a company's ability to withstand and/or recover after a disturbing event. While resistance describes the ability to buffer the negative consequences of a disturbing event, recovery is understood as the ability to return to daily life after a disturbing event. More specifically, we operationalized the construct ''withstand'' how households and companies rated the perceived impacts on immobile and mobile objects as well as to households' respondents psychological and health-related integrity. This includes information about monetary losses (e.g., overall, building, household contents, equipment, goods, business interruption) as well as information about perceived consequences associated with a flood event indicated on ordinal scales (overall, building, household contents, material objects, sentimental objects, health, mental consequences/stress, personal strain, business interruption). The construct ''recovery'' was made operational by asking households how long it took them to recover after the flood event (in months) and how their situation changed as a result of the flood, whereas companies were asked how long their business activities were interrupted or hampered.

Flood experience was taken into account by focusing on households' and companies' prior flood experience. However, we did not analyze the total number of floods experienced, but rather used the 2013 flood as the reference event in all samples and grouped respondents for which the 2013 flood was the first, second or third flood event or more.

We included *additional variables*, such as sociodemographic variables (i.e., age, tenure, gender, and building type), companies' characteristics (size, sector, tenure, spatial situation) as well as flood characteristics.

b. Case study areas

Empirically, the paper is based on *three different surveys.* The surveys were collected in the German states most affected by the 2013 flood, among these, the states of Saxony (EUR 1.9 billion direct losses in 2013) and Bavaria (EUR 1.3 billion direct losses) (DKKV 2015; see Fig. 2).

The 2013 flood caused with about EUR 6–8 billion lower direct losses than the 2002 flood, which resulted in damage costs amounting to EUR 11.6 billion (DKKV 2003, 2015). Damage on the household level usually results from demolished building structures as well as repair work, including replacing broken windows, repairing heating systems, etc. In addition, households needed to repair or replace damaged contents, such as domestic appliances, telephone and computer systems, furniture or carpets. Losses for companies related also to different aspects refer above all to building losses; equipment losses; losses to goods, products, and stock; and losses due to business interruption (Thieken et al. 2016b).

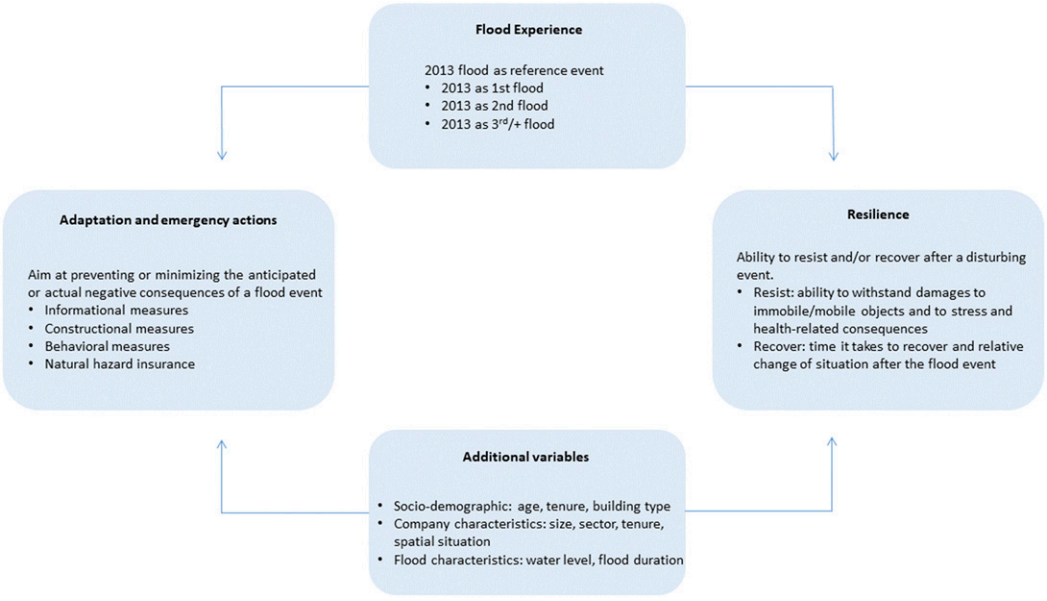

FIG. 1. Theoretical constructs and their relationship.

In Germany, private adaptation measures are requested by law from flood prone property owners in accordance with their resources and capabilities (Begg et al. 2017). Flood insurance penetration in Germany has increased gradually over recent years (Surminski and Thieken 2017), with large regional differences due to past compulsory flood insurance in the former German Democratic Republic and in the federal state of Baden-Wuerttemberg (Seifert et al. 2013).

c. *Methodology*

The different surveys were conducted independently of each other. Table 1 provides an overview of the distribution of the three surveys and their sampling procedures.

Table 2 gives a detailed overview of how the single theoretical constructs were made operational in the different samples. All surveys addressed the overarching conceptual constructs of ''adaptation'' and ''resilience,'' however, there are differences in the items and scales used to operationalize the constructs; there are also differences in how the single questions were asked and what kind of answer categories the surveys provided. While in sample 1 households, respondents were asked to report about the consequences of all flood events experienced, respondents in samples 2 households and 3 companies were asked to report only about the 2013 flood. Prior flood experience was taken into account by asking respondents whether they had experienced a flood before and if yes, how many and when (before 2013). Furthermore, the extent to which adaptation and emergency measures were enquired about differed between sample 1 households on the one hand and sample 2 households and 3 companies on the other. The implications of the outlined differences are discussed more in depth in chapter 5).

Due to the differences in the design of the questionnaires and the data collection processes as well as the different operationalization of the central constructs/measures, we chose not to combine the samples but applied a sample-based approach to look for *converging evidence* or *discrepancies* across the three samples.

Sample 1 households was collected by employees of the Helmholtz Centre for Environmental Research and includes households that experienced repetitive flooding between 2002 and 2013. The survey was distributed personally and conducted in the German states of Saxony and Bavaria. All towns surveyed have experienced at least one flood event, and most of them two or even three. Flood risk maps from Zürs Public (since 2014 renamed Kompass Naturgefahren; www.kompass-naturgefahren.de) and flood risk maps produced by the Saxon government were used to identify the affected areas in Saxony. For Bavaria, local councils were approached to identify areas that experienced flooding in 2013. These councils provided us with detailed lists of those streets that had been affected by flooding in 2013 and before.

A total of 6502 questionnaires were distributed personally between six and eight months after the 2013 flood (see Begg et al. 2017 for details). This included a prepaid reply envelope and a letter explaining the

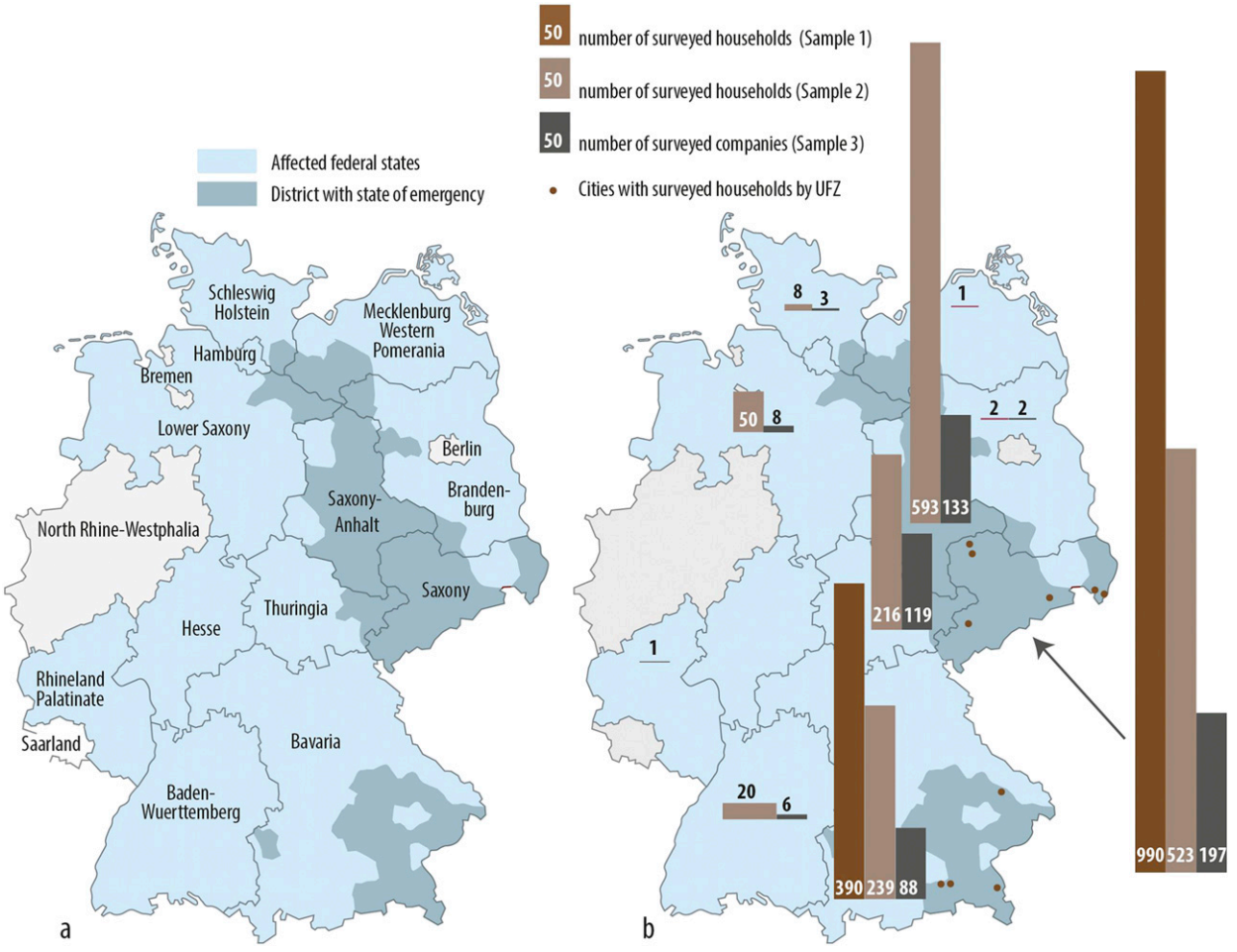

FIG. 2. Areas affected by the 2013 flood and the number of questionnaires completed.

background of the survey and asking residents to return the survey to the Helmholtz-Centre for Environmental Research (Zentrum fur Umweltforschung) (UFZ) within the next days. In total, 1380 completed surveys were returned, which provided an overall response rate of 21.2%. Of the 1380 surveys, 990 were completed by residents in Saxony (response rate of 21.7%), while 390 were completed by residents in Bavaria (response rate of 20%). 65% of respondents were affected by the 2013 flood (N = 889). Therefore, only these surveys were used in this analysis. The questionnaire included detailed questions about every single flood event experienced since 2002 in a chronological order to better understand the cumulative effects of repeated flood experience (1999 was neglected as it was considered as a rather minor flood even in comparison to the 2002 and subsequent flood events). This included questions about financial losses, financial support, and perceived consequences. The survey also contained questions about adaptation actions and about individual attitudes to the distribution of responsibility as well as about decision-making processes in flood risk management (Begg et al. 2017).

The dataset sample 2 households was collected under the responsibility of the University of Potsdam, Geoforschungs Zentrum (GFZ) German Research Centre for Geosciences and the reinsurance company Deutsche Rückversicherung (DKKV 2015; Thieken et al. 2016b). It was based on computer-aided telephone interviews (CATI) with residents that suffered from (financial) property damage due to flooding in 2013 in Germany. The interviews were conducted around nine months after the flood event. Based on information from affected districts and municipalities, flood reports, press releases, or flood maps [e.g., ZÜRS or flood masks derived from satellite data provided by German Aerospace Center (Deutschen Zentrum für Luft- und Raumfahrt) (DLR), Centre for Satellite Based Crisis information; http://www.zki.dlr.de/], street lists were compiled, which served as a basis for looking up the telephone numbers of

TABLE 1. Overview of the main commonalities and differences of the samples.

	Sample 1 households	Sample 2 households	Sample 3 companies
Survey	Personally distributed, prepaid reply envelope; two weeks later reminder was sent	Computer-aided telephone interviews, lasted between 20 and 40 min	Computer-aided telephone interviews, lasted on average 34 min
Sampling/screening	Households surveyed located in affected areas	Only households that had suffered financial flood losses were surveyed	Only companies that had suffered financial flood losses were surveyed
Persons addressed	Person that had birthday most recently before the distribution of the survey and who is older than 18	Most competent person in households with regard to flooding	Most competent person in company with regard to flood damage

potentially affected residents from the public telephone directory. All 43 281 searched telephone numbers were contacted, from which 16 554 numbers were either not recognized or available during the campaign. Another 16 721 households stated that they had not been affected by the flood, with "affected" being defined as having suffered (financial) flood damage. In total 1652 interviews were completed between 18 February and 24 March 2014.

The questionnaire represented a modified version of previous surveys (Kienzler et al. 2015; Kreibich et al. 2005; Thieken et al. 2017). Overall, it addressed a broad range of topics such as flood impact characteristics, physical and financial flood losses to buildings and household contents, flood experience and flood awareness, precautionary measures, early warning, emergency measures, evacuation, contamination of the flood water, cleanup, recovery of the affected household, general characteristics of the building and household contents, nonmaterial flood effects (on health), aid and financial compensation, and sociodemographic variables. At the beginning of the interview, the interviewer asked to question the person in the household with the best knowledge about the flood event.

The dataset sample 3 companies focused on small companies and was also collected by a joint venture of the University of Potsdam, GFZ, and Deutsche Rückversicherung (DKKV 2015; Thieken et al. 2017, 2016b). The list of affected streets that was compiled for sample 2 households formed the basis for generating property-specific random samples of companies (i.e., their telephone numbers). Additional effort was undertaken to increase the number of large companies in the sample. Therefore, expert interviews were undertaken and flood and press reports were analyzed to identify flood-affected large companies. All companies irrespective of their size were interviewed between May and July 2014 using a standardized survey, which resulted in 557 completed interviews. However, for these analyses only small companies with ≤10 employees and ≤EUR 1 million damage (n = 328) were selected since we assume that smaller companies behave similarly to households. The person with the most knowledge about the flood damage was interviewed.

The questionnaire addressed the following topics: flood impact (e.g., water depth, contamination), flood warning, emergency measures, evacuation, cleaning up, characteristics of and damage to company assets (buildings, equipment, goods, products, and stock, etc.), recovery, precautionary measures, flood experience and awareness, and characteristics of the company (sector, number of employees, etc.). Further details about the approach, partly based on preceding surveys, are published in Kreibich et al. (2007), Thieken et al. (2016a, 2017), and Sieg et al. (2017).

d. Statistical analysis

The surveys were coded and analyzed using the statistics software SPSS and R Version 3.3.2. For statistical analysis, we used correlational analysis (Spearman correlations) to test for bivariate relationships between flood experience and our outcome variables (uptake of adaptation and emergency actions, resilience indicators). For multivariate relationships, we applied multiple linear regression analysis or logistic regression analysis for dichotomous outcome variables. We included the adoption of adaptation measures (constructional adaptation actions, insurance), the adoption of emergency measures and resilience indicators (overall flood consequences, financial damage, property damage, loss of material objects, health- and stress-related consequences) as dependent variables as well as respondents' sociodemographic characteristics (age, tenure, building type) and their previous flood experience as independent variables in the analysis. To test for possible nonlinear (i.e., quadratic) effects of previously experienced floods on household resilience, we included the number of previous flood experiences and its quadratic term in the regression (Miller et al. 2013). This strategy has been applied in previous research (Klein et al. 2011). Following Miller et al. (2013), we mean centered the data

TABLE 2. Detailed overview on questions and answer categories provided in the samples.

Sample 1 households	Sample 2 households	Sample 3 companies
	Prior flood experience	
Affected by a flood? (yes; no; year) → 2013 as the first, second, or third flood	How often have you been affected by a flood before May/June 2013? (number)	Was this commercial property affected by a flood before May/June 2013? (number)
	When was the last time you were affected by a flood before May/June 2013? (month, year)	When was the last time this commercial property was affected by a flood before May/June 2013? (month, year)
	Adaptation and emergency actions	
Did you undertake any measure to protect your property in the last years (yes; no; year; description of measure)	Which of the following precautionary measures have you already implemented *before* the flood event in May/June 2013, have you implemented *during/after* this flood, are you planning to implement *in the next 6 months*? [implemented before the flood; during/after the flood; planned within the next 6 months; not (yet) intended/not possible; provided list of 16 measures with regard to information precaution, property-level mitigation measures, contract insurance, others]—multiple answers possible	When did you implement the following precautionary measure: *xxx*[a]. Or are you planning to implement the measure in the next 6 months, or are you currently not intending to implement the measure. Please provide the year when you have implemented the measure, or answer "planned in the next 6 months," or "not intended."
Construction measures: Ex-post categorization based on the answer provided to previous question (description of measures)	Did you, or someone else, undertake emergency measures to mitigate damage to the building or household contents? I will now quote some of these measures. Please tell me what applies to you. (provided list of emergency measures: safeguard documents and valuables; drive vehicles to a flood-safe place; put moveable contents upstairs; protect oil tanks; install water pump; safeguard domestic animals/pets; protect the building against inflowing water; redirect water flow; switch off gas/electricity; gas/electricity was switched off by public services; others)—multiple answers possible	Were damage reduction measures undertaken before or during the flood in your company; for instance, did you try to protect goods and material by raising, removing, etc. these. Or did you try to prevent water from entering the building? (yes; no)
Insured against natural hazards? [contracted an insurance in (year); did apply for an insurance but did not receive one; interested, but too expensive; terminated contract, since personally not satisfied; the insurance terminated the contract (year); do not want to have one; took other measures; others]—multiple answers possible		
Did you undertake any action during the flood in order to reduce damage from flooding? (yes; no; informed about flood, sandbags, put valuables upstairs, moved car/motor vehicle out of the flood zone, others)—multiple answers possible (number of measures taken)		
Did you inform yourself about the flood risk before the flood event (yes; no)		
	Resilience	
Monetary damage (yes; no; overall sum of damage in EUR)	If you include the cost (material and labor) for all necessary repair work at/within the building, what was the overall building loss? (sum of damage in EUR)	How high was the total building damage? (sum of damage in EUR)
Perception of consequences (for the overall household; physical consequences; psychological consequences, loss of valuable objective, loss of sentimental objects (Likert-scale from 1–5)	How do you estimate the total cost for restoring your damaged household contents? (sum of loss in EUR)	How high was the total equipment damage (without motor vehicles)? (sum of damage in EUR)

TABLE 2. (*Continued*)

Sample 1 households	Sample 2 households	Sample 3 companies
How long did it take to return to daily life? (less than a month; 1–2 months; 3–5 months; more than 6 months; did not yet return; it will never return)	To what extent the flood event of May/June 2013 still puts a strain on you? [scale from 1 (it doesn't strain me at all anymore/I feel like before the event) to 6 (it strains me still a lot)]	How high was the total damage to goods, products and stock? (sum of damage in EUR)
How did household situation change in consequence of the flood? (considerably worse than before the flood; worse; similar; better)	I now call you possible damage caused by flooding. How serious did you perceive each of the witnessed damage types [scale from 1 (not serious at all) to 6 (very serious); provided list of consequences, e.g.,: health complaints; psychological or other forms of stress; damage to buildings and household contents; other financial damage (like cars, outdoor facilities); loss of items of special personal significance]	How high were the damage due to business interruption? (sum of damage in EUR)
	How many months did it take you after the event to completely restore your building/household contents? (less than a month; 1–2 months; 3–6 months; more than 6 months)	How long was the business operation interrupted? (time in days)

[a] Question was stated for 13 different precautionary measures ranging from insurance, to property-level mitigation measures to relocation to a flood safe area.

for the number of previously experienced floods prior to computing the quadratic term.

4. Results: Flood experience, adaptation, and resilience

a. Sociodemographic characteristics

The comparison of the main sociodemographic characteristics of the two different samples related to households (samples 1 households and 2 households) revealed quite profound differences (see appendix for details, Table A2). Sample 2 households is characterized by a higher mean age, a higher proportion of female respondents, a higher share of homeowners, a higher share of detached houses, and a higher share of people with lower flood experience. Some of the differences can be traced back to differences in the sampling and screening procedures of the surveys, as well as the techniques of the survey. Telephone surveys are increasingly hampered by the substitution of landlines by mobile phones. Younger adults (<30 years), especially, tend to live in wireless-only households, leading to an underrepresentation of this age group in landline-only surveys (Greenberg and Weiner 2014). As a result, the average age in sample 2 households is higher than in sample 1 households; the latter was based on a paper-and-pencil questionnaire (see Table 1). Furthermore, the use of the term "flood-affected" differs across the three samples: while sample 1 households uses a broad interpretation of "flood-affected," including residents that (only) suffered from no power supply or traffic disruptions, sample 2 households and 3 companies define "flood-affected" as having suffered (financial) flood damage. This resulted in high screen-out rates of almost 40% (see description of sample 2 households above) and probably led to a higher share of homeowners—and consequently to a higher share of detached and terraced houses—in sample 2 households compared to sample 1 households (Table 3). Finally, the design of the surveys differs across the three samples: sample 1 households was based on a lumped approach focusing on hot spot areas that have experienced repeated flooding, while samples 2 households and 3 companies aimed at surveying all areas that were flooded in 2013 including regions that had not been affected by the flood of 2002, for example, in the federal state of Baden-Wuerttemberg, Thuringia, most of Lower Saxony, and some regions in Saxony-Anhalt (along the river Saale). Consequently, the share of residents that experienced flooding for the first time is higher in sample 2 households than in sample 1 households (Table 3). Despite these differences, we think that the conceptual commonalities across the three samples are sufficient to jointly explore the effect of repeated flooding on adaptation and resilience.

b. Multiple flood experiences and adaptation

Based on previous findings (see section 2), the study is based on the hypothesis that the experience of (multiple) flood events leads to an increasing capacity to act before, during and after an event. This assumption was tested by analyzing how the number of floods that respondents experienced between 2002 and 2013 correlates with adaptation actions taken before or during the 2013 flood (see Tables A1–A3 for details).

TABLE 3. Main sociodemographic characteristics of household samples.

	Sample 1 households	Sample 2 households
Age	Mean: 56.2 years (n = 889)	Mean: 59.3 years (n = 1328)
Gender	Female/male: 43.2%/56.8% (n = 902)	Female/male: 59.1%/41.9% (n = 1433)
Tenure	Renter/owner: 37.1%/62.9% (n = 881)	Renter/owner: 17.4%/82.6% (n = 1433)
Building type	Detached/row/multifamily house: 32.7%/16.7%/50.6% (n = 856)	Detached/row/multifamily house: 44.0%/27.9%/28.2% (n = 1428)
Flood experience	2013 flood as first/second/third + flood: 36.8%/44.7%/18.5% (n = 889)	2013 flood as first/second/third + flood: 45.8%/31.3%/22.9% (n = 1433)

It is noteworthy, that the general percentage of interviewees who implemented adaptation actions and thus responded positively to the questions is higher in sample 2 households (see Table 4). We attribute this difference predominantly to two factors: first, the considerably higher share of homeowners in sample 2 households—homeowners usually have more possibilities (particularly in respect to constructional measures) and a higher motivation to implement adaptation measures (Bubeck et al. 2012a,b); second, to the way in which the questions were asked in the survey. While in sample 1 households, households were openly asked about whether and which adaptation actions they had taken, sample 2 households provided respondents with a prepared list of specific measures they could choose from. This influences the response behavior. For example, in a survey distributed in 2002, water pumps and backflow preventers were not included and therefore only a few household (less than 5%) mentioned these measures. In subsequent surveys, these measures were included and more than 20% (backflow preventer) and even 50%–70% (water pumps) stated they had these measures in place (Kienzler et al. 2015).

Generally, the empirical results indicate a rather robust, but modest, significant positive correlation between flood experience and the adaptation/emergency actions of households and companies (for more details see Tables A1–A3). There are significant correlations in all three samples for almost all of the tested variables indicating that the more often households experienced a (damaging) flood event, the more likely they were to take action in order to adapt. In addition, there is also a significant positive correlation with regard to taking out insurance and flood experience among the surveyed households. However, while households tend to take out insurance after experiencing their first flood, their opportunity to do so is decreased after the second flood (see Table 3). It is often the case that insurance companies do not insure buildings with prior flood damage, or only with high premiums (Seifert et al. 2013), although the assessment of insurability according to the hazard zoning system ZÜRS is gaining more importance than the number of previous claims (DKKV 2015).

In addition, we conducted a regression analysis to investigate which of the tested variables influence adaptation actions (see Table 5; for more details see Tables A4–A6). For households, this included age, tenure, and building type in addition to flood experience. For companies, this included flood experience, size of the company, sector, spatial situation, and tenure.

The regression analysis for sample 1 households revealed that all tested adaptation and emergency measures show a positive relationship between flood experience and adaptation. There is also a positive relationship between tenure and adaptation (i.e., homeowners adopted adaptation measures more often than renters). The analysis for sample 2 households showed that being a homeowner and having experienced (multiple) floods before 2013 increases the likelihood for households to take adaptation and emergency measures, with the exception of taking out flood insurance, which is only influenced by tenure. In addition, both in sample 1 households and 2 households, age was negatively correlated with undertaking emergency measures during the flood and implementing constructional adaptation measures, respectively (sample 2 households).

Results for sample 3 companies revealed that flood experience has a significant positive influence on adaptation and emergency actions taken by companies, but again not on insurance. The only significant influence on the decision to take out natural hazard insurance was "tenure," which seems to be plausible, since tenants are not likely to insure the respective building of their company (although they can insure their contents).

c. *Households: Multiple experience and resilience*

In a first step, we analyzed the *ability of households to withstand damage to immobile objects (i.e., buildings)*. Figure 3 reveals that financial damage to a building fell considerably between the first and the second flood. The third flood was again associated with higher damage than the second flood. A drop in the amount of financial damage thus pointed toward an increased ability of households to withstand damage to buildings and other rather immobile objects. We attributed the higher financial damage in sample 2 households to the higher

TABLE 4. Adaptation/emergency actions and previous flood experience (2013 as reference flood).

	Sample 1 households			Sample 2 households			Sample 3 households		
2013 as . . .	First flood	Second flood	Third+ flood	First flood	Second flood	Third+ flood	First flood	Second flood	Third+ flood
Adaptation actions/yes (general)	42.2%	53.8%	70.6%	87.4%	93.3%	93.2%	55.4%	71.6%	75.0%
	n327	n383	n163	n650	n447	n324	n139	n109	n92
Adaptation actions/yes (constructional)	12.5%	16.4%	35.0%	54.9%	63.6%	78.4%	22.6%	35.8%	39.1%
	n327	n383	n163	n645	n445	n324	n137	n109	n92
Insurance/yes	35.1%	60.7%	54.3%	53.4%	63.5%	60.6%	24.5%	33.0%	35.9%
	n305	n359	n151	n627	n439	n317	n139	n109	n92
Emergency actions 2013/yes	90.8%	96.7%	98.1%	90.1%	96.0%	96.6%	79.1%	99.1%	95.7%
	n305	n391	n162	n655	n449	n327	n139	n109	n92
Informed about risk/yes	52.3%	60.7%	63.6%	51.8%	60.7%	71.9%	—	—	—
	n323	n366	n151	n629	n440	n317			

share of homeowners, who usually experience and report higher financial damage.

The perceived consequences of damage to buildings corresponded with reported financial damages. However, while the financial damage for the third flood were considerably lower than the first flood, the perceived consequences reach similar (sample 2 households) or even higher values (sample 1 households) with regard to the building damage (see Fig. 3).

There are different reasons for this nonlinear, U-shaped pattern. To exclude this U shape from being a result of flood characteristics, we tested whether and how the financial damage correlate with flood characteristics (i.e., water level and duration). While damage to the building correlated positively with both water depth and the duration of flooding (see Table A3), the results also indicated that respondents with more flood experience were affected by higher water levels, but still reported lower damage. This suggests that the observed pattern for financial damage with regard to flood experience cannot simply be explained by flood characteristics, but that other variables also influence the financial damage for companies and households—a point we return to in the discussions section in chapter 5.

In a second step, we analyzed the *ability of households to withstand damage to mobile objects (contents)*. The ability of households to withstand losses to mobile objects increased significantly between the first and the second flood experienced (see Fig. 4): when the 2013 flood was the first flood experienced, this again resulted in the highest values with regard to the loss of or damage to mobile objects—whether of financial or sentimental value. However, thereafter values remained on a similar (sample 2 households) or slightly lower level (sample 1 households) if the 2013 flood was experienced as the third flood.

In a third step, we analyzed *the ability of households to withstand negative psychological and health-related consequences*. The ability to withstand the negative psychological and health-related consequences was again different to the previously reported ability to withstand damage to immobile and mobile objects (see Fig. 3), as it seems to decline with flood experience. However, there are also profound differences between both samples. In sample 1 households, there was evidence that health-related and—descriptively—psychological consequences follow a nonlinear pattern (i.e., consequences are perceived as more severe in the case of a third flood) indicating an exponential relationship between multiple flood experiences and stress- and health-related consequences. However, in sample 2 households, it was the first flood that was associated with the highest values, followed by the third flood.

TABLE 5. Summary results of regression analysis—adaptation of households and companies. Note: * $p < 0.05$; ** $p < 0.01$.

Dependent variables	Age	Tenure	Building type	Sum flood	Sum flood^2
Sample 1 households					
Adaptation measures in general		+**		+**	
Constructional adaptation measures		+**		+**	
Insurance		+**		+**	
Sum of emergency measure	−*	+**		+**	
Sample 2 households					
Adaptation measures in general		+**		+*	
Constructional adaptation measures	−**	+**		+**	
Insurance		+**			
Emergency measure	−*	+**		+**	
Dependent variables	Size	Sector	Ownership	Spatial situation	Sum flood
Sample 3 households					
Adaptation measures in general		−**	+**		+**
Constructional adaptation measures					+*
Insurance			+*		
Emergency measure				−**	

In a fourth step, we analyzed *how households were able to recover*: the time it took for households to return to daily life and the relative change of the household situation compared to before the flood were positively correlated to the number of floods experienced, at least in sample 1 households. Among respondents who experienced 2013 as their third flood, 72% ($n = 161$) reported that it took them three months or longer to return to daily life, compared to 67.1% ($n = 325$) who experienced 2013 as their first and 52.7% ($n = 366$) as their second flood. Similarly, the share of respondents who perceived their household situation to be worse or considerably worse compared to their preflood situation was higher (43.9%, $n = 157$) for respondents that experienced 2013 as their third flood in comparison to the answers provided by respondents from households that had experienced less floods (first flood: 29.5%, $n = 312$; second flood: 29.5%, $n = 353$).

The results of sample 2 households indicate a somewhat different pattern regarding postimpact recovery. The results revealed that respondents who experienced floods for the third time needed significantly less time on average to completely restore their buildings compared to respondents who were affected for the first or second time. Results on recovery time with respect to household contents showed a similar, albeit nonsignificant

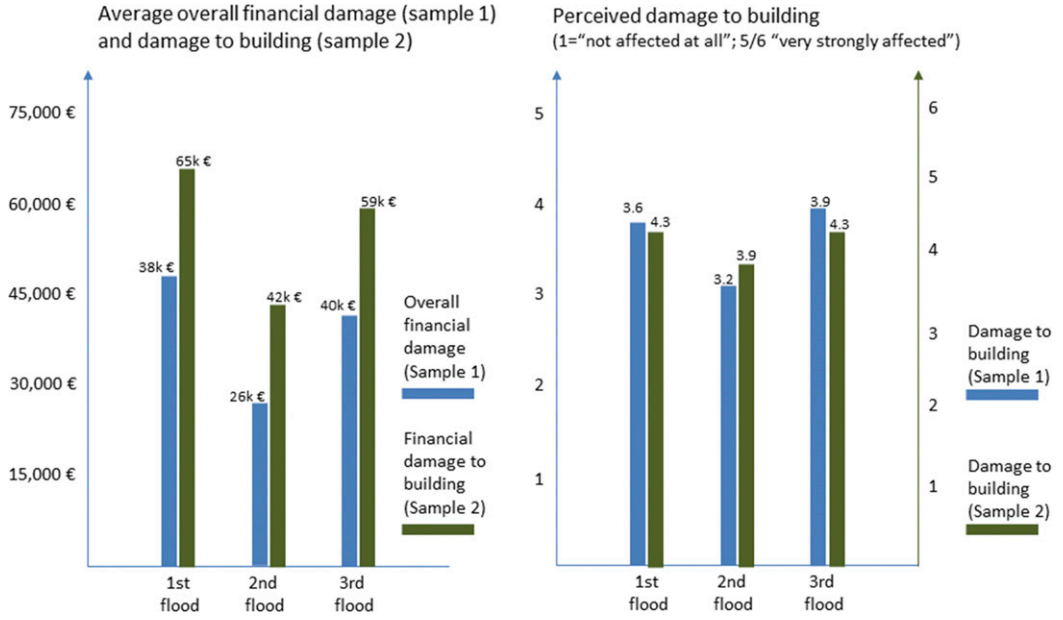

FIG. 3. Financial damages, their perception, and previous flood experience (2013 reference event).

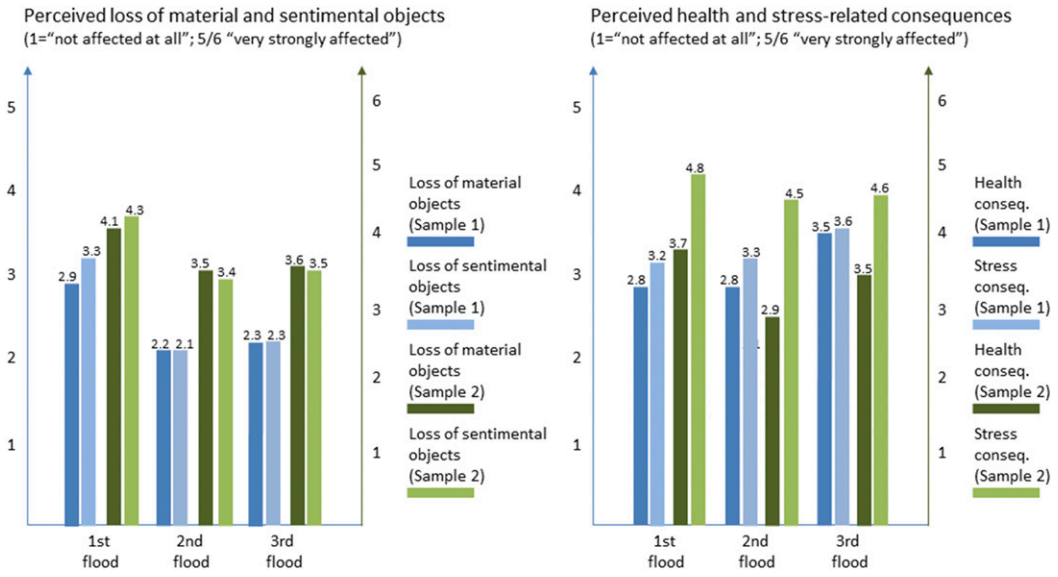

FIG. 4. Perceived average consequences and previous flood experience (2013 as reference flood).

trend. At this point, however, it must be taken into account that the corresponding question regarding respondents' recovery was slightly different between sample 1 households and 2 households (see Table 2). In contrast to sample 1 households, the question in sample 2 households primarily related to the recovery time of material values and was evaluated separately for damage to building and damage to household contents.

To further investigate household resilience, we submitted the different measures of resilience (financial damage, perceived consequences, time to recover) to multiple regression analysis, including the number of flood events experienced as well as the ownership status (owner vs tenant), the type of building (detached/terraced/multifamily house), age (as covariates), and constructional adaptation (yes/no) in the regression. To additionally test for nonlinear effects of flood experience we also included the squared number of flood events experienced (for a similar strategy, see Klein et al. 2011; Masson and Barth 2019).

For sample 1 households, results of the regression analyses generally supported the findings described above (see Table 6; for more detailed information see Table A5), that is, the relationship between the number

TABLE 6. Summary results of regression analysis—adaptation of households. Note: * $p < 0.05$; ** $p < 0.01$.

Dependent variables	Age	Tenure	Building type	Sum flood	Sum flood^2	Construction adaptation
Sample 1 households						
Financial damage (Fd)				−**	+**	
Perceived overall consequences				−**	+**	
Perceived damage to building		+**		−**	+**	
Perceived loss of material objects				−**	+**	
Perceived loss of sentimental objects	+*	+**		−**	+**	−*
Perceived health consequences			−**	−**	+**	
Perceived stress consequences			−*			
Duration to recover		+**		−**	+**	
Dependent variables	Age	Tenure	Building type	Sum flood	Sum flood^2	Construction adaptation
Sample 2 households						
Fd to building	+*		+**			
Fd to household content		+**	−**			−**
Perceived damage to building		+*	−**			
Perceived loss to household content			−**	−**		
Perceived loss of sentimental objects				−**		−**
Perceived health consequences			−**			
Perceived stress consequences			−**			
Perceived personal strain	+**		−**			

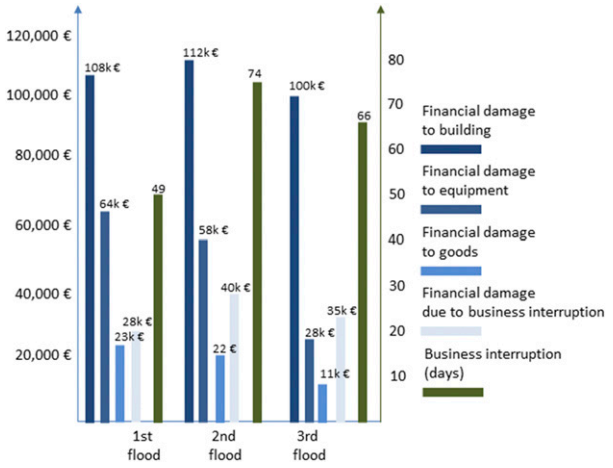

FIG. 5. Consequences for companies (financial damage and business interruption).

of floods experienced and the resilience measures (exception: psychological consequences) are nonlinear, corroborating the patterns displayed in Figs. 3 and 4. For instance, our findings indicated a quadratic (U shaped) relationship between the number of floods experienced on the one hand and the financial damage to households and consequences to the building on the other. The regression analysis conducted for sample 2 households revealed that there is a negative relationship between constructional adaptation and reported financial damage to household contents, indicating that more adapted households also reported lower damage. A similar pattern could be observed in sample 1 households with regard to the loss of sentimental objects and adaptation.

d. *Companies: Multiple flood experiences and resilience*

Among the companies interviewed, the distributional pattern for financial damage with regard to buildings was different to households (see Fig. 5): companies that experienced the 2013 flood as their second flood event reported the highest damage on average. Financial damage due to business interruptions also resulted in the highest values, if 2013 was experienced as the second flood. However, both financial damage to the building and due to business interruption decreased with the third flood event. This seems to point toward a weak trend that asset damage decrease with increasing experience. This trend becomes more robust with respect to financial damage to mobile equipment and goods. Both correlated negatively with the number of floods experienced as damage decreased linearly with each flood event. This seems to point to a learning effect after each flood event resulting in lower damage.

TABLE 7. Summary results of regression analysis—adaptation of companies. Note: * $p < 0.05$; ** $p < 0.01$.

Dependent variables	Size	Tenure	Sector	Spatial situation	Sum flood
			Sample 3 companies		
Fd do building	+**				
Fd to equipment	+**		−**		
Fd to goods and stocks	+*		−**	−*	
Fd due to business interruption	+**				
Business interruption in days					

Business interruption was shortest for those companies who experienced the 2013 flood as their first flood. The longest business interruptions were suffered by companies experiencing the 2013 flood as their second flood, whereby the difference between the first and the second flood were significant and the difference between the second and third were not. Similar to private households, it was also the case that companies with more flood experience were affected by higher water levels. Thus, the potentially positive effects of more experience are counteracted by the negative effects of higher hazard magnitudes.

For this sample, regression analysis revealed no significant relationship between experience and resilience (see Table 7). It was mainly the companies' size that had an effect on their resilience.

5. Discussion

The three different surveys revealed that there is a strong positive correlation between flood experience and adaptation among all samples: households and companies that had experienced repeated flooding prior to 2013 were more likely to invest in adaptation actions and were also more capable of mitigating damage during the 2013 flood (also by taking emergency actions) compared to respondents with less or no previous flood experience. Our findings thus confirm previous research on flood experience and adaptation, both for affected households and companies.

Based on our empirical data and the analyses we conducted, it is difficult to judge whether increased adaptation also leads to greater resilience of households and companies. Our findings rather underline that resilience is influenced by many characteristics.

Prior flood experience shapes the resilience of households and companies. Generally speaking, between households' first and second experienced flood, an increase in resilience can be detected. When 2013 was experienced as the second, the ability to withstand

financial damage was higher, as well as the ability to withstand damage to immobile and mobile objects. Furthermore, the ability to withstand negative psychological and health-related consequences increased or remained on a similar level. We attribute the difference between the first and the second flood to a learning effect that results in an increased capacity to act upon and to cope with the consequences of flooding.

When households experienced the 2013 flood as their third flood, their ability to withstand damage to immobile objects decreased compared to the second flood. Experiencing a third flood seemed to act as a tipping point; a preliminary finding that needs further exploration in future research. There are different reasons for this nonlinear, U-shaped pattern. While damage to the building correlated positively with both water depth and duration of flooding (see Table A3), the results also indicated that respondents with more flood experience were affected by higher water levels, although they still reported lower damage. This suggests that the observed pattern for financial damage with regard to flood experience cannot simply be explained by flood characteristics. Even if somewhat speculative, the reported higher damage for the third flood might also be a result of learning effects among respondents of how to account for financial damage. This could therefore represent a reporting bias due to a more realistic assessment of the financial damage compared to households with less flood experience.

When households experienced the 2013 flood as their third flood, their ability to withstand negative psychological and health-related consequences also decreased. While sample 2 households show a similar U-shape pattern as the financial damage, the findings of sample 1 households reveal an exponential relationship. There is evidence that households' capacity to cope with a flood event emotionally and healthwise is undermined, if respondents have experienced their third flood. It also took households longer to recover and their situation was worse or considerably worse compared to before the flood (sample 1 households). In our interpretation this supports the assumption that experiencing three floods within a relatively short time span can be understood as a chronically distressing situation that results in a deterioration of human well-being and thus undermines the resilience of households (see also research on learned helplessness for similar results; Seligman and Peterson 2001).

If households experienced their third flood, their ability to withstand damage to mobile objects increased. Such objects can be moved without great effort and residents report lower losses with each flood event experienced. Another finding of sample 2 households points in a similar direction, revealing that respondents who experienced the 2013 flood as their third flood, required significantly less time on average to restore their buildings compared to respondents who were affected for the first or second time. With each flood event experienced, households develop certain flood-related capacities that help them to reduce damage and restore buildings and interiors quicker than for previous floods. However, the result might also indicate that households simply had less mobile objects that were exposed to the risk of flooding. This, however, is difficult to capture in a survey.

Companies' ability to withstand direct financial losses increases when they experience multiple flood events, particularly with regard to mobile goods and equipment. However, the negative consequences of business interruption increase with flood experience. This indicates that companies are able to reduce damage to their material assets, but they have difficulties to recover from the flood event and to return to the same state of business that they were in before the flood occurred.

With regard to losses of valuable objects, findings for companies were quite similar to the households' results. Furthermore, companies seem to build up experience-based capacities with each flood event, reducing the vulnerability of mobile equipment and goods. Again, bivariate correlation analysis with respect to sample 3 companies also supports this relationship as companies with multiple flood experiences have significantly taken adaptation and emergency actions more often. However, such companies also experienced higher damage, which might have been even higher without adaptation, pointing again to the contingent relationship between adaptation and resilience. Whether this finding also holds for medium-size or large companies still needs to be tested.

Implications for future research

Based on our findings, we first suggest that there is a need to establish more systematic and evidence-based, resilience-related baselines against which the various interventions of local, regional, and national initiatives or the implementation of private (i.e., at the property level) or public adaptation measures can be evaluated (Weichselgartner and Kelman 2015). In many countries private actors are asked to take on greater responsibility in flood risk management and more generally in terms of climate adaptation, by reducing their individual risks through their own adaptation actions (Begg et al. 2015). It is usually assumed that such actions have positive effects (Begg et al. 2017). While our findings support such effects, particularly with regard to mobile objects (e.g., furniture, cars, and sentimental objects), such simple relationships are harder to detect with regard to building damage, but also with regard to perceived psychological and

TABLE A1. Correlations (Corr) sample 1 households. Note: * $p < 0.05$; ** $p < 0.01$. Significant correlations are in bold.

	Spearman		Adaptation and emergency actions					Resilience									Sociodemographic			
			v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13	v14	v15	v16	v17	v18
	v1: Number of floods experienced	Corr		0.200**	0.188**	0.176**	0.130**	−0.089**	−0.077	−0.036	0.132**	0.090*	0.026	−0.185**	−0.278**	−0.009	0.103**	0.157**	0.003	0.077*
		N		873	873	815	858	840	601	880	670	722	737	510	488	852	822	889	859	894
Adaptation and emergency actions	V2: Adaptation actions	Corr	**0.197****		0.452**	0.201**	0.149**	−0.252**	−0.046	0.019	0.193**	0.076*	0.080*	−0.046	−0.064	0.070*	0.072*	0.069*	0.219**	−0.092**
		N	873		873	795	833	819	586	854	653	704	721	501	478	830	803	860	831	865
	V3: Constructional adaptation actions	Corr	**0.180****	**0.452****		0.166**	0.084*	−0.157**	0.008	0.077*	0.144**	0.079*	0.135**	−0.028	−0.078	0.045	0.117**	0.047	0.302**	−0.193**
		N	873	873		795	833	819	586	854	653	704	721	501	478	830	803	860	831	865
	V4: Insurance	Corr	**0.189****	**0.201****	**0.166****		0.091*	−0.147**	0.201**	−0.028	0.130**	0.130**	0.059	−0.111*	−0.097*	0.068	−0.001	0.159**	0.349**	−0.223**
		N	815	795	795		782	763	548	802	610	655	669	465	446	775	745	804	776	808
	V5: Emergency actions during 2013 flood	Corr	**0.133****	**0.149****	**0.084***	**0.091***		−0.123**	−0.085*	−0.046	0.016	−0.014	−0.023	−0.155**	−0.186**	−0.052	−0.070*	0.000	0.095**	−0.027
		N	858	833	833	782		803	580	841	642	693	706	489	467	814	786	847	817	851
	V6: Informed about flood risk	Corr	**0.139****	0.052	**0.105****	0.064			−0.062	−0.033	−0.095*	−0.049	−0.103**	−0.008	−0.019	−0.080*	−0.117**	−0.124**	−0.187**	0.049
		N	840	819	819	763	803		567	821	629	677	691	485	467	799	776	828	803	832
Resilience	V7: Financial damages	Corr	**−0.084***	,051	**0.148****	**0.200****	0.044	0.016		0.376**	0.209**	0.210**	0.396**	0.261**	0.272**	0.357**	0.248**	−0.021	0.294**	−0.229**
		N	601	586	586	548	580	567		594	502	516	556	408	395	585	569	592	571	594
	V8: Degree of overall perceived Impact	Corr	−0.049	**0.078***	**0.105****	0.051	0.039	−0.038	**0.618****		0.472**	0.419**	0.668**	0.468**	0.453**	0.547**	0.303**	0.046	0.204**	−0.139**
		N	880	854	854	802	841	821	594		657	708	725	502	481	835	806	867	837	872
	V9: Perceived physical and health effects	Corr	**0.122****	**0.193****	**0.145****	**0.129****	−0.017	−0.032	**0.398****	**0.542****		0.685**	0.458**	0.402**	0.378**	0.399**	0.334**	0.081*	0.254**	−0.201**
		N	670	653	653	610	642	629	502	657		632	623	474	457	657	634	661	638	663
	V10: Perceived mental effects	Corr	**0.082***	0.071	0.073	**0.125****	0.013	−0.013	**0.391****	**0.493****	**0.687****		0.433**	0.420**	0.419**	0.362**	0.338**	0.046	0.243**	−0.209**
		N	722	704	704	655	693	677	516	708	632		651	487	467	707	684	713	692	717
	V11: Perceived damage to the house/flats/outbuildings	Corr	0.010	0.073	**0.123****	0.070	0.030	−0.009	**0.633****	**0.716****	**0.453****	**0.436****		0.514**	0.513**	0.598**	0.370**	0.080*	0.276**	−0.118**
		N	737	721	721	669	706	691	556	725	623	651		495	472	723	699	725	699	729
	V12: Perceived loss of valuables materials (car, jewelry, etc.)	Corr	**−0.201****	−0.046	−0.018	**−0.107***	**0.153****	−0.025	**0.352****	**0.569****	**0.401****	**0.423****	**0.531****		0.699**	0.434**	0.340**	0.065	0.109*	−0.096*
		N	510	501	501	465	489	485	408	502	474	487	495		446	501	488	504	488	507
	V13: Perceived loss of sentimental objects (photos, souvenirs, etc.)	Corr	**−0.291****	−0.060	−0.070	−0.084	**0.175****	−0.065	**0.382****	**0.529****	**0.380****	**0.419****	**0.537****	**0.702****		0.445**	0.322**	0.083	0.169**	−0.159**
		N	488	478	478	446	467	467	395	481	457	467	472	446		480	466	483	465	483
	V14: Duration to recover	Corr	0.018	**0.079***	0.036	0.062	0.019	−0.032	**0.573****	**0.588****	**0.427****	**0.396****	**0.603****	**0.451****	**0.427****		0.402**	0.080*	0.228**	−0.120**
		N	852	830	830	775	814	799	585	835	657	707	723	501	480		805	839	812	844
	V15: Change of household situation after flood	Corr	**−0.091****	**−0.071***	**−0.102****	,008	−,067	−,062	**−0.265****	**−.0350****	**−0.325****	**−0.327****	**−0.373****	**−0.351****	**−0.324****	**−0.467****		0.076*	0.140**	−0.023
		N	822	803	803	745	786	776	569	806	634	684	699	488	466	805		810	783	814
Sociodemographic	V16: Age of respondent	Corr	**0.160****	0.065	0.054	**0.148****	−0.002	−0.058	−0.026	0.024	0.071	0.030	**.091***	0.053	0.080	**.070***	**−.080***		0.166**	−0.054
		N	889	860	860	804	847	828	592	867	661	713	725	504	483	839	810		852	885
	V17:Tenure	Corr	−0.003	**0.219****	**0.302****	**0.349****	**−0.095****	0.013	**0.531****	**0.266****	**0.253****	**0.236****	**0.273****	**0.119****	**0.174****	**0.224****	**−0.129****	**0.160****		−0.513**
		N	859	831	831	776	817	803	571	837	638	692	699	488	465	812	783	852		857
	V18: House type	Corr	**0.083***	**−0.084***	**−0.183****	**−0.221****	0.028	**0.076***	**−0.348****	**−0.229****	**−0.202****	**−0.206****	**−0.128****	**−0.102***	**−0.164****	**−0.104****	0.015	−0.046	**−0.505****	
		N	894	865	865	808	851	832	594	872	663	717	729	507	483	844	814	885	857	

TABLE A2. Correlations (Corr) sample 2 households. Note: * $p < 0.05$; ** $p < 0.01$. Significant correlations are in bold.

				Adaptation actions					Resilience									Sociodemographic				Flood char.	
	Spearman		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21
	V1: Sum of experienced floods	Corr																					
		N																					
Adaptation and emergency actions	V2: Adaptation actions	Corr	**0.093****																				
		N	1421																				
	V3: Constructional adaptation actions	Corr	**0.189****	**0.417****																			
		N	1414	1414																			
	V4: Insurance	Corr	**0.071****	**0.358****	**0.283****																		
		N	1383	1383	1380																		
	V5: Emergency actions during 2013 flood	Corr	**0.118****	**0.096****	**0.140****	**0.089****																	
		N	1431	1419	1412	1382																	
	V6: Informed about flood risk	Corr	**0.160****	**0.369****	**0.369****	**0.235****	**0.079****																
		N	1386	1386	1382	1366	1386																
Resilience	V7: Building damage	Corr	−0.016	0.014	−0.029	0.041	0.057	0.033															
		N	848	844	840	828	847	827															
	V8: Damage to household contents	Corr	**−0.070***	0.023	−0.010	**0.101****	0.097**	−0.016	**0.573****														
		N	846	840	834	826	846	822	547														
	V9: Perceived personal strain due to 2013 flood	Corr	0.051	0.008	0.051	**0.091****	**0.073***	0.026	**0.313****	**0.271****													
		N	1214	1206	1201	1178	1213	1178	764	741													
	V10: Perceived building damage	Corr	−0.047	0.015	0.021	0.018	0.027	0.007	**0.458****	**0.350****	**0.389****												
		N	1282	1276	1270	1242	1281	1248	835	759	1112												
	V11: Perceived damage to household contents	Corr	**−0.150****	−0.010	**−0.064***	0.030	−0.008	−0.032	**0.348****	**0.510****	**0.320****	**0.618****											
		N	1147	1139	1132	1111	1145	1114	680	827	997	1046											
	V12: Perceived health effects	Corr	−0.064	−0.072	0.021	−0.006	0.004	0.045	**0.207****	**0.129***	**0.336****	**0.422****	**0.453****										
		N	603	598	595	584	603	584	382	364	601	572	510										
	V13: Perceived stress and other psychological stress	Corr	**−0.058***	−0.023	−0.038	0.049	**0.063***	−0.024	**0.225****	**0.200****	**0.417****	**0.358****	**0.375****	**0.474****									
		N	1193	1186	1181	1158	1192	1158	753	732	1189	1091	983	578									
	V14: Perceived stress other financial losses	Corr	**−0.137****	−0.059	**−0.107****	0.011	−0.023	−0.030	**0.233****	**0.277****	**0.281****	**0.450****	**0.551****	**0.532****	**0.354****								
		N	847	840	836	818	847	824	553	554	777	816	773	464	762								
	V15: Perceived loss of sentimental objects	Corr	**−0.196****	**−0.072***	**−0.155****	−0.046	−0.012	**−0.081***	**0.284****	**0.350****	**0.323****	**0.418****	**0.565****	**0.570****	**0.384****	**0.521****							
		N	757	752	748	732	757	735	461	541	691	704	717	426	682	582							
Sociodemographic	V16: Age	Corr	**0.100****	**−0.074****	**−0.081****	−0.005	−0.044	**−0.102****	**−0.089***	**−0.101****	**0.102****	−0.010	−0.001	0.033	0.006	−0.033	0.005						
		N	1328	1318	1314	1285	1326	1285	807	796	1134	1194	1064	545	1113	771	682						
	V17: Gender	Corr	**−0.057***	−0.005	0.001	0.020	−0.008	−0.030	0.057	0.041	**0.126****	**0.102****	0.055	0.064	**0.131****	**0.090****	0.062	0.002					
		N	1433	1421	1414	1383	1431	1386	848	846	1214	1282	1147	603	1193	847	757	1328					
	V18: Tenure	Corr	−0.003	**0.141****	**0.210****	**0.177****	**0.130****	**0.085****	−0.033	**0.355****	**0.105****	**0.122****	**0.122****	−0.051	0.043	**0.087***	0.037	−0.004	**−0.060***				
		N	1433	1421	1414	1383	1431	1386	848	846	1214	1282	1147	603	1193	847	757	1328	**1433**				
	V19: Building type	Corr	0.020	**−0.082****	**−0.102****	**−0.103****	**−0.090****	**−0.061***	**0.095****	**−0.267****	**−0.125****	**−,117****	**−0.137****	−0.055	**−0.104****	**−0.189****	**−,077***	0.038	0.009	**−0.491****			
		N	1428	1416	1409	1379	1426	1382	846	845	1210	1277	1142	599	1189	843	754	1324	1428	1428			
Flood characteristics	V20: Water level	Corr	**0.110****	0.018	0.023	0.019	**0.086****	**0.055***	**0.570****	**0.436****	**0.223****	**0.306****	**0.235****	**0.138****	**0.161****	**0.142****	**0.153****	−0.046	−0.024	−0.026	0.037		
		N	1339	1328	1321	1297	1338	1297	812	809	1139	1203	1079	567	1119	794	713	1248	1339	1339	1335		
	V21: Flood duration	Corr	−0.025	0.010	0.000	0.037	0.042	0.012	0.056	0.053	**0.083****	0.032	**0.081****	0.056	**0.064***	**0.140****	**0.151****	**0.071***	**0.105****	0.023	**−0.123****	**−0.080****	
		N	1330	1318	1311	1288	1328	1289	798	800	1126	1197	1069	558	1106	788	706	1238	1330	1330	1325	1264	

TABLE A3. Correlations (Corr) sample 3 companies. Note: * $p < 0.05$; ** $p < 0.01$. Significant correlations are in bold.

			Adaptation actions						Resilience									Sociodemographic				Flood char.	
	Spearman		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21
	V1: Sum of experienced floods	Corr																					
		N																					
Adaptation and emergency actions	V2: Adaptation actions	Corr	**0.093****																				
		N	1421																				
	V3: Constructional adaptation actions	Corr	**0.189****	**0.417****																			
		N	1414	1414																			
	V4: Insurance	Corr	**0.071****	**0.358****	**0.283****																		
		N	1383	1383	1380																		
	V5: Emergency actions during 2013 flood	Corr	**0.118****	**0.096****	**0.140****	**0.089****																	
		N	1431	1419	1412	1382																	
	V6: Informed about flood risk	Corr	**0.160****	**0.369****	**0.369****	**0.235****	**0.079****																
		N	1386	1386	1382	1366	1386																
Resilience	V7: Building damage	Corr	−0.016	0.014	−0.029	0.041	0.057	0.033															
		N	848	844	840	828	847	827															
	V8: Damage to household contents	Corr	**−0.070***	0.023	−0.010	**0.101****	**0.097****	−0.016	**0.573****														
		N	846	840	834	826	846	822	547														
	V9: Perceived personal strain due to 2013 flood	Corr	0.051	0.008	0.051	**0.091****	**0.073***	0.026	**0.313****	**0.271****													
		N	1214	1206	1201	1178	1213	1178	764	741													
	V10: Perceived building damage	Corr	−0.047	0.015	0.021	0.018	0.027	0.007	**0.458****	**0.350****	**0.389****												
		N	1282	1276	1270	1242	1281	1248	835	759	1112												
	V11: Perceived damage to household contents	Corr	**−0.150****	−0.010	**−0.064***	0.030	−0.008	−0.032	**0.348****	**0.510****	**0.320****	**0.618****											
		N	1147	1139	1132	1111	1145	1114	680	827	997	1046											
	V12: Perceived health effects	Corr	−0.064	−0.072	0.021	−0.006	0.004	0.045	**0.207****	**0.129***	**0.336****	**0.422****	**0.453****										
		N	603	598	595	584	603	584	382	364	601	572	510										
	V13: Perceived stress and other psychological stress	Corr	**−0.058***	−0.023	−0.038	0.049	**0.063***	−0.024	**0.225****	**0.200****	**0.417****	**0.358****	**0.375****	**0.474****									
		N	1193	1186	1181	1158	1192	1158	753	732	1189	1091	983	578									
	V14: Perceived stress other financial losses	Corr	**−0.137****	−0.059	**−0.107****	0.011	−0.023	−0.030	**0.233****	**0.277****	**0.281****	**0.450****	**0.551****	**0.532****	**0.354****								
		N	847	840	836	818	847	824	553	554	777	816	773	464	762								
	V15: Perceived loss of sentimental objects	Corr	**−0.196****	**−0.072***	**−0.155****	−0.046	−0.012	**−0.081***	**0.284****	**0.350****	**0.323****	**0.418****	**0.565****	**0.570****	**0.384****	**0.521****							
		N	757	752	748	732	757	735	461	541	691	704	717	426	682	582							
Sociodemographic	V16: Age	Corr	**0.100****	**−0.074****	**−0.081****	−0.005	−0.044	**−0.102****	**−0.089***	**−0.101****	**0.102****	−0.010	−0.001	0.033	0.006	−0.033	0.005						
		N	1328	1318	1314	1285	1326	1285	807	796	1134	1194	1064	545	1113	771	682						
	V17: Gender	Corr	**−0.057***	−0.005	0.001	0.020	−0.008	−0.030	0.057	0.041	**0.126****	**0.102****	0.055	0.064	**0.131****	**0.090****	0.062	0.002					
		N	1433	1421	1414	1383	1431	1386	848	846	1214	1282	1147	603	1193	847	757	1328					
	V18: Tenure	Corr	−0.003	**0.141****	**0.210****	**0.177****	**0.130****	**0.085****	−0.033	**0.355****	**0.105****	**0.122****	**0.122****	−0.051	0.043	**0.087***	0.037	−0.004	**−0.060***				
		N	1433	1421	1414	1383	1431	1386	848	846	1214	1282	1147	603	1193	847	757	1328	1433				
	V19: Building type	Corr	0.020	**−0.082****	**−0.102****	**−0.103****	**−0.090****	**−0.061***	**0.095****	**−0.267****	**−0.125****	**−0.117****	**−0.137****	−0.055	**−0.104****	**−0.189****	**−0.077***	0.038	0.009	**−0.491****			
		N	1428	1416	1409	1379	1426	1382	846	845	1210	1277	1142	599	1189	843	754	1324	1428	1428			
Flood characteristics	V20: Water level	Corr	**0.110****	0.018	0.023	0.019	**0.086****	**0.055***	**0.570****	**0.436****	**0.223****	**0.306****	**0.235****	**0.138****	**0.161****	**0.142****	**0.153****	−0.046	−0.024	−0.026	0.037		
		N	1339	1328	1321	1297	1338	1297	812	809	1139	1203	1079	567	1119	794	713	1248	1339	1339	1335		
	V21: Flood duration	Corr	−0.025	0.010	0.000	0.037	0.042	0.012	0.056	0.053	**0.083****	0.032	**0.081****	0.056	**0.064***	**0.140****	**0.151****	**0.071***	**0.105****	0.023	**−0.123****	**−0.080****	
		N	1330	1318	1311	1288	1328	1289	798	800	1126	1197	1069	558	1106	788	706	1238	1330	1330	1325	1264	

TABLE A4. Linear and logistic regressions of adaptive and emergency actions sample 1 households. DV: dependent variable. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	Wald	Cox and Snell R^2	Nagelkerkes R^2
1	DV: Adaptation actions			0.068	0.115
	Age	−0.001	0.029		
	Tenure	0.916**	22.931		
	Building—single	0.030	0.013		
	Building—semidetached	0.258	0.593		
	Building—apartment	−0.051	0.038		
	Sum of flood experience	0.601**	30.151		
2	DV: Constructional adaptation actions			0.141	0.233
	Age	−0.003	0.150		
	Tenure	2.214**	31.955		
	Building—single	0.226	0.545		
	Building—semidetached	0.439	1.135		
	Building—apartment	−0.309	0.807		
	Sum of flood experience	0.744**	27.695		
3	DV: Insurance			0.158	0.211
	Age	0.006	1.419		
	Tenure	1.138**	30.968		
	Building—single	0.020	0.005		
	Building—semidetached	−0.657	3.533		
	Building—apartment	−0.659	5.744		
	Sum of flood experience	0.514**	19.552		
Model		B	T	R^2	Adjusted R^2
4	DV: Sum of emergency measures during 2013 flood			0.128	0.122
	Age	−0.023**	−5.947		
	Tenure	0.828**	5.691		
	Building—single	−0.404	−2.100		
	Building—semidetached	−0.435	−1.719		
	Building—apartment	−0.324	−1.672		
	Sum of flood experience	0.583**	7.203		

health-related consequences. Therefore, the establishment of evidence-based resilience baselines is needed in order to understand whether the redistribution of responsibility to the individual level would have the desired effects (i.e., an increase in individual resilience) or whether the capacity of individuals is limited to increase their resilience.

Second, our findings suggest that greater efforts should be undertaken to better understand the relationship between adaptation and resilience. Previous research has often focused on the factors that shape people's motivation to invest in property-level adaptation measures. The implementation of adaptation measures is usually equated to an increase in households' or companies' resilience. Our findings at least question this simple, linear relationship (correlation) and hint at a positive, but by far more complicated and nonlinear relation. The reasons for this are manifold. Property-level adaptation measures often have a design level that might be overtopped by a flood and to be effective they need to be properly in place before premises are flooded; if homeowners (or employees) are not available or not capable of installing the measure in time, then the measure cannot fulfill its full potential. In addition, the effects of adaptation measures to reduce nonmonetary consequences are probably not as significant as one would expect. However, in order to better understand these effects more research is required to assess the relation between adaptation/emergency actions and resilience in a more systematic manner.

Third, more research is needed on the framing effects and how they shape respondents' answers in survey-based research. We attribute some of the differences in our findings, particularly with regard to health-related and psychological consequences, but also with respect to the greater perceived severity of the third flood event, to the way we addressed households' flood experience in the survey. While sample 2 households focused on the 2013 flood and addressed prior flood experience just as a lumped variable, sample 1 households focused on all floods experienced since 2002. Respondents were asked to report detailed about the consequences of each flood event they experience chronologically. This means that

TABLE A5. Regressions of adaptive and emergency actions sample 2 households. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	T	R^2	Adjusted R^2
1	DV: Adaptation actions			0.027	0.024
	Tenure	0.053**	4.411		
	Age	−0.001*	−2.509		
	Building	0.001	0.096		
	Sum flood experience	0.012*	2.001		
2	DV: Constructional adaptation actions			0.087	0.084
	Tenure	0.142**	7.232		
	Age	−0.004**	−3.884		
	Building	0.009	0.517		
	Sum flood experience	0.067**	6.750		
3	DV: Insurance			0.034	0.031
	Tenure	0.111**	5.264		
	Age	0.000	0.037		
	Building	−0.012	−0.622		
	Sum flood experience	0.011	1.043		
4	DV: Emergency actions during 2013 flood			0.036	0.033
	Tenure	0.041**	4.062		
	Age	−0.001*	−1.981		
	Building	−0.012	−1.273		
	Sum flood experience	0.018**	3.649		

if the 2013 flood was experienced as the third flood event by households, then they had to answer several questions about previous floods before turning their attention to the 2013 flood. In this sense, sample 1 households primed the cumulative flood experience of households. Although our results hint at possible priming effects, more experimental research is needed to better understand how the framing/cognitive processing of

TABLE A6. Linear and logistic regressions of adaptive and emergency actions sample 3 companies. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	T	R^2	Adjusted R^2
1	DV: Adaptation actions			0.126	0.111
	Sum of flood experience	0.221**	2.906		
	Size	0.013	0.323		
	Sector	−0.221*	−2.147		
	Spatial situation	−0.091	−0.747		
	Ownership	0.803**	3.378		
2	DV: Constructional adaptation actions			0.063	0.048
	Sum of flood experience	0.057*	1.845		
	Size	0.004	0.229		
	Sector	−0.065	−1.546		
	Spatial situation	−0.077	−1.537		
	Ownership	0.137	1.401		
3	DV: Number of emergency measures			0.080	0.056
	Sum of flood experience	−0.164	−1.945		
	Size	0.031	0.682		
	Sector	−0.102	−0.831		
	Spatial situation	−0.424**	0.3.040		
	Ownership	−0.352	−1.359		
Model			Wald Z	Cox and Snell R^2	Nagelkerkes R^2
4	DV: Insurance			0.029	0.041
	Sum of flood experience	−0.006	−0.071		
	Size	−0.004	−0.074		
	Sector	−0.112	−0.901		
	Spatial situation	−0.063	−0.427		
	Ownership	0.603*	2.104		

TABLE A7. Regressions of resilience sample 1 households. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	T	R^2	Adjusted R^2
1	DV: Financial damage			0.34	0.33
	Age	−0.002	−0.790		
	Tenure	0.815	9.774		
	Building—single	0.174	1.654		
	Building—semidetached	0.127	0.984		
	Building—apartment	−0.243	−2.262		
	Sum of flood experience	−1.117**	−4.227		
	Sum of flood experience^2	0.264**	3.874		
	Constructional adaptation actions	−0.028	−0.339		
2	DV: Perceived overall consequences			0.14	0.13
	Age	0.001	0.348		
	Tenure	0.573	4.078		
	Building—single	0.064	0.343		
	Building—semidetached	0.648	2.709		
	Building—apartment	−0.326	−1.752		
	Sum of flood experience	−2.029**	−4.521		
	Sum of flood experience^2	0.524**	4.553		
	Constructional adaptation actions	−0.017	−0.114		
3	DV: Perceived damage to house/flat			0.11	0.10
	Age	0.005	1.273		
	Tenure	0.728**	5.318		
	Building—single	−0.119	−0.668		
	Building—semidetached	0.090	0.404		
	Building—apartment	−0.124	−0.694		
	Sum of flood experience	−1.747**	−4.033		
	Sum of flood experience^2	0.458**	4.116		
	Constructional adaptation actions	0.152	1.069		
4	DV: Perceived health-related consequences			0.11	0.10
	Age	0.004	0.904		
	Tenure	0.441	2.873		
	Building—single	0.156	0.801		
	Building—semidetached	−0.158	−0.643		
	Building—apartment	−0.424*	−2.150		
	Sum of flood experience	−1.022*	−2.131		
	Sum of flood experience^2	0.032**	2.686		
	Constructional adaptation actions	0.032	0.205		
5	DV: Perceived stress-related consequences			0.09	0.07
	Age	0.001	0.162		
	Tenure**	0.471	3.286		
	Building—single	0.078	0.418		
	Building—semidetached	−0.108	−0.446		
	Building—apartment	−0.450*	−2.401		
	Sum of flood experience	−0.303	−0.674		
	Sum of flood experience^2	0.121	1.051		
	Constructional adaptation actions	−0.172	−1.137		
6	DV: Perceived loss of material objects			0.07	0.06
	Age	0.008	1.722		
	Tenure	0.283	1.619		
	Building—single	0.074	0.331		
	Building—semidetached	0.259	0.956		
	Building—apartment	−0.020	−0.087		
	Sum of flood experience	−2.074**	−3.687		
	Sum of flood experience^2	0.461**	3.151		
	Constructional adaptation actions	−0.138	−0.767		
7	DV: Perceived loss of sentimental objects			0.16	0.15
	Age	0.012*	2.378		
	Tenure	0.437*	2.194		
	Building—single	0.364	1.484		
	Building—semidetached	0.440	1.454		
	Building—apartment	0.034	0.134		
	Sum of flood experience	−3.081**	−4.863		
	Sum of flood experience^2	0.658**	3.963		
	Constructional adaptation actions	−0.489*	−2.369		
8	DV: Duration to recover			0.08	0.07
	Age	0.004	1.234		
	Tenure	0.687**	4.848		
	Building—single	−0.176	−0.925		
	Building—semidetached	0.066	0.273		
	Building—apartment	−0.235	−1.244		
	Sum of flood experience	−1.684**	−3.785		
	Sum of flood experience^2	0.459**	4.021		
	Constructional adaptation actions	−0.276	−1.832		

TABLE A8. Regressions of resilience sample 2 households. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	T	R^2	Adjusted R^2
1	DV: Log. financial damage to building			0.019	0.012
	Sum of flood experience	0.023	0.197		
	Sum of flood experience^2	−0.015	−0.552		
	Age	−0.009*	−2.114		
	Tenure	0.015	0.073		
	Building type	0.216**	2.814		
	Constructional adaptation action	−0.162	−1.305		
2	DV: Log. Financial damage to household content			0.180	0.174
	Sum of flood experience	−0.078	−0.707		
	Sum of flood experience^2	0.016	0.624		
	Age	−0.011**	−2.819		
	Tenure	0.655**	8.287		
	Building type	−0.252**	−3.369		
	Constructional adaptation action	−0.346**	−3.046		
3	DV: Perceived personal strain due to 2013 flood			0.039	0.034
	Sum of flood experience	0.200	1.815		
	Sum of flood experience^2	−0.037	−1.494		
	Age	0.015**	3.912		
	Tenure	0.137	1.648		
	Building type	−0.220**	−3.022		
	Constructional adaptation action	0.136	1.200		
4	DV: Perceived damage to building			0.022	0.017
	Sum of flood experience	−0.072	−0.751		
	Sum of flood experience^2	0.011	0.493		
	Age	0.001	0.179		
	Tenure	0.184*	2.375		
	Building type	−0.171**	−2.660		
	Constructional adaptation action	0.024	0.236		
5	DV: Perceived damage to household contents			0.046	0.041
	Sum of flood experience	−0.323**	−2.912		
	Sum of flood experience^2	0.043	1.681		
	Age	0.002	0.586		
	Tenure	0.151	1.869		
	Building type	−0.224**	−2.968		
	Constructional adaptation action	−0.290*	−2.510		
6	DV: Perceived health-related consequences			0.025	0.014
	Sum of flood experience	−0.251	−1.398		
	Sum of flood experience^2	0.042	1.091		
	Age	0.009	1.472		
	Tenure	−0.412**	−2.972		
	Building type	−0.273*	−2.319		
	Constructional adaptation action	0.172	0.922		
7	DV: Perceived stress-related consequences			0.017	0.011
	Sum of flood experience	−0.132	−1.308		
	Sum of flood experience^2	0.022	0.956		
	Age	0.000	0.039		
	Tenure	0.014	0.185		
	Building type	−0.213**	−3.163		
	Constructional adaptation action	−0.139	−1.319		
8	DV: Loss of sentimental objects			0.058	0.050
	Sum of flood experience	−0.473**	−2.961		
	Sum of flood experience^2	0.069	1.918		
	Age	0.005	0.934		
	Tenure	−0.005	−0.046		
	Building type	−0.183	−1.687		
	Constructional adaptation action	−0.620**	−3.773		

TABLE A9. Regressions of resilience sample 3 companies. Note: * $p < 0.05$; ** $p < 0.01$.

Model		B	T	R^2	Adjusted R^2
1	DV: Financial damage to building			0.099	0.057
	Sum of flood experience	−0.014	−0.039		
	Sum of flood experience^2	−0.001	−0.027		
	Size	0.181**	3.371		
	Sector	−0.067	−0.487		
	Spatial situation	−0.155	−1.025		
	Ownership	−0.299	−1.007		
	General adaptation action	0.015	0.221		
2	DV: Financial damage to equipment			0.137	0.099
	Sum of flood experience	−0.182	−0.528		
	Sum of flood experience^2	−0.000	−0.013		
	Size	0.157**	3.532		
	Sector	−0.283*	−2.361		
	Spatial situation	0.095	0.672		
	Ownership	0.313	1.121		
	General adaptation action	0.039	0.604		
3	DV: Financial damage to goods and stocks			0.195	0.146
	Sum of flood experience	0.135	0.380		
	Sum of flood experience^2	−0.040	−0.757		
	Size	0.117*	2.378		
	Sector	−0.288*	−2.209		
	Spatial situation	−0.388*	−2.550		
	Ownership	−0.443	−1.455		
	General adaptation action	0.096	1.478		
4	DV: Financial damages due to business interruption			0.183	0.152
	Sum of flood experience	0.270	0.956		
	Sum of flood experience^2	−0.028	−0.654		
	Size	0.208**	5.400		
	Sector	−0.100	−1.003		
	Spatial situation	−0.122	−1.057		
	Ownership	−0.406	−1.782		
	General adaptation action	0.031	0.594		
5	DV: Business interruption in days			0.058	0.022
	Sum of flood experience	19.026	1.050		
	Sum of flood experience^2	−1.597	−0.582		
	Size	−2.365	−0.960		
	Sector	−6.167	−0.971		
	Spatial situation	10.387	1.401		
	Ownership	−6.738	−0.460		
	General adaptation action	3.390	1.015		

previous flood events (in surveys) translates into appraisals of these events. For example, experimental designs that manipulate respondents' processing of flood-related information (i.e., the time given to think about previous flood events or the number of questions asked about previous events) may provide an opportunity to investigate such framing effects more systematically.

Finally, more comparative research is needed. Comparing case studies in order to generate *converging evidence* or *discrepancies* across the three samples was only possible as we shared some of the theoretical constructs. We are convinced that more systematic comparisons across case studies is necessary, which requires researchers to agree upon, share, and apply some basic theoretical constructs and their operationalization across different case studies. Future research, however, might also use moderator analysis (as a part of meta-analysis) to investigate possible boundary conditions of (our) research findings.

6. Summary and conclusions

The key question addressed in this paper was whether the resilience of households and companies increases or decreases as a consequence of multiple flood experiences and how this is influenced by respondents' emergency and adaptation actions. Our analysis shows robust

evidence for a positive relationship between flood experience and the adoption of adaptation and emergency measures across all three samples. The relationship between flood experience and resilience is not as straightforward: The effect of multiple flood experiences depends upon the aspects of resilience that one is focusing on (i.e., financial losses, the subjective perception of such losses or perceived psychological and health-related impacts) as well as on the number of floods experienced. While our findings suggest that the resilience of households increases from the first to the second flood, the third flood event seems to be a tipping point: households' ability to withstand damage to immobile objects decreases as does their ability to withstand negative psychological and health-related consequences. Our findings furthermore suggest in this respect that multiple flood experiences are a burden for affected households. Similarly, companies' resilience in terms of their ability to withstand direct financial losses increases when they have experienced multiple flood events, particularly with regard to mobile goods and equipment. However, companies also have some difficulties recovering from the flood event and reassuming their preflood state of business if they have experienced multiple flood events. However, there are clear differences between samples that cannot easily be explained by the data.

We therefore conclude that while it is relevant and politically desirable to establish evidence-based resilience baselines for households and companies, it seems equally relevant to be more consistent when defining and operationalizing resilience in quantitative studies and to have a better methodological understanding of the effects from how flood experience is framed in surveys as well as how sampling and screening procedures affect respondents' answers. As the results of this study indicate, following diverse sets of sampling and framing approaches can be very positive, particularly if results point to similar patterns, even when they have relied on different sampling and framing strategies. However, differences in the results of empirical research also need to be better understood and assessed as to whether they can be explained by the underlying methodology. If this challenge is ignored, there is the risk of both overestimation and misrepresentation of the effectiveness of property-level adaptation on the resilience of households and companies.

APPENDIX

Correlation Tables and Results of the Regression Analysis

The appendix shows the results of the correlation as well as of the regression analysis (Tables A1–A9).

REFERENCES

Adger, W. N., 2000: Social and ecological resilience: Are they related? *Prog. Hum. Geogr.*, **24**, 347–364, https://doi.org/10.1191/030913200701540465.

Ahern, M., R. S. Kovats, P. Wilkinson, R. Few, and F. Matthies, 2005: Global health impacts of floods: Epidemiologic evidence. *Epidemiol. Rev.*, **27**, 36–46, https://doi.org/10.1093/epirev/mxi004.

Alderman, K., L. R. Turner, and S. Tong, 2012: Floods and human health: A systematic review. *Environ. Int.*, **47**, 37–47, https://doi.org/10.1016/j.envint.2012.06.003.

Alexander, D. E., 2013: Resilience and disaster risk reduction: An etymological journey. *Nat. Hazards Earth Syst. Sci.*, **13**, 2707–2716, https://doi.org/10.5194/nhess-13-2707-2013.

Begg, C., G. Walker, and C. Kuhlicke, 2015: Localism and flood risk management in England: The creation of new inequalities? *Environ. Plann.*, **33C**, 685–702, https://doi.org/10.1068/c12216.

——, M. Ueberham, T. Masson, and C. Kuhlicke, 2017: Interactions between citizen responsibilization, flood experience and household resilience: Insights from the 2013 flood in Germany. *Int. J. Water Resour. Dev.*, **33**, 591–608, https://doi.org/10.1080/07900627.2016.1200961.

Berkes, F., 2007: Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. *Nat. Hazards*, **41**, 283–295, https://doi.org/10.1007/s11069-006-9036-7.

Bonanno, G. A., C. R. Brewin, K. Kaniasty, and A. M. L. Greca, 2010: Weighing the costs of disaster: Consequences, risks, and resilience in individuals, families, and communities. *Psychol. Sci. Public Interest*, **11**, 1–49, https://doi.org/10.1177/1529100610387086.

Brand, F. S., and K. Jax, 2007: Focusing the meaning(s) of resilience: Resilience as a descriptive concept and a boundary object. *Ecol. Soc.*, **12**, 23, https://doi.org/10.5751/ES-02029-120123.

Bubeck, P., W. J. W. Botzen, and J. C. J. H. Aerts, 2012a: A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Anal.*, **32**, 1481–1495, https://doi.org/10.1111/j.1539-6924.2011.01783.x.

——, ——, H. Kreibich, and J. C. J. H. Aerts, 2012b: Long-term development and effectiveness of private flood mitigation measures: An analysis for the German part of the river Rhine. *Nat. Hazards Earth Syst. Sci.*, **12**, 3507–3518, https://doi.org/10.5194/nhess-12-3507-2012.

——, A. Otto, and J. Weichselgartner, 2017: Societal impacts of flood hazards. *Oxford Research Encyclopedia on Natural Hazards Science*, Oxford University Press, https://doi.org/10.1093/acrefore/9780199389407.013.281.

Chinh, D. T., P. Bubeck, N. V. Dung, and H. Kreibich, 2016: The 2011 flood event in the Mekong Delta: Preparedness, response, damage and recovery of private households and small businesses. *Disasters*, **40**, 753–778, https://doi.org/10.1111/disa.12171.

Cote, M., and A. J. Nightingale, 2012: Resilience thinking meets social theory. *Prog. Hum. Geogr.*, **36**, 475–489, https://doi.org/10.1177/0309132511425708.

Cutter, S. L., L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, and J. Webb, 2008: A place-based model for understanding community resilience to natural disasters. *Global Environ. Change*, **18**, 598–606, https://doi.org/10.1016/j.gloenvcha.2008.07.013.

DKKV, 2003: Hochwasservorsorge in Deutschland—Lernen aus der Katastrophe 2002 im Elbegebiet (Flood prevention in Germany—Learning from the 2002 catastrophe in the Elbe area). Deutsches Komitee für Katastrophenvorsorge e.V., 152 pp.

——, 2015: Das Hochwasser im Juni 2013: Bewährungsprobe für das Hochwasserrisikomanagement in Deutschland (The flood in June 2013: A test for flood risk management in Germany). DKKV Series 53, 207 pp.

Fekete, A., G. Hufschmidt, and S. Kruse, 2014: Benefits and challenges of resilience and vulnerability for disaster risk management. *Int. J. Disaster Risk Sci.*, **5**, 3–20, https://doi.org/10.1007/s13753-014-0008-3.

Felgentreff, C., 2003: Post-disaster situations as ''window of opportunity''? Post-flood perceptions and changes in the German Odra River region after the 1997 flood. *Erde*, **134**, 163–180.

Fernandez, A., J. Black, M. Jones, L. Wilson, L. Salvador-Carulla, T. Astell-Burt, and D. Black, 2015: Flooding and mental health: A systematic mapping review. *PLOS ONE*, **10**, e0119929, https://doi.org/10.1371/journal.pone.0119929.

Fisher, L., 2015: Disaster responses: More than 70 ways to show resilience. *Nature*, **518**, 35–35, https://doi.org/10.1038/518035a.

Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C. S. Holling, and B. Walker, 2002: Resilience and sustainable development: Building adaptive capacity in a world of transformations. *Ambio*, **31**, 437–440, https://doi.org/10.1579/0044-7447-31.5.437.

Gallopín, G. C., 2006: Linkages between vulnerability, resilience, and adaptive capacity. *Global Environ. Change*, **16**, 293–303, https://doi.org/10.1016/j.gloenvcha.2006.02.004.

Gotham, K. F., R. Campanella, K. Lauve-Moon, and B. Powers, 2018: Hazard experience, geophysical vulnerability, and flood risk perceptions in a postdisaster city, the case of New Orleans. *Risk Anal.*, **38**, 345–356, https://doi.org/10.1111/risa.12830.

Greenberg, M. R., and M. D. Weiner, 2014: Keeping surveys valid, reliable, and useful: A tutorial. *Risk Anal.*, **34**, 1362–1375, https://doi.org/10.1111/risa.12250.

Grimm, V., and C. Wissel, 1997: Babel, or the ecological stability discussions: An inventory and analysis of terminology and a guide for avoiding confusion. *Oecologia*, **109**, 323–334, https://doi.org/10.1007/s004420050090.

Grothmann, T., and F. Reusswig, 2006: People at risk of flooding: Why some residents take precautionary action while others do not. *Nat. Hazards*, **38**, 101–120, https://doi.org/10.1007/s11069-005-8604-6.

Hirabayashi, Y., R. Mahendran, S. Koirala, L. Konoshima, D. Yamazaki, S. Watanabe, H. Kim, and S. Kanae, 2013: Global flood risk under climate change. *Nat. Climate Change*, **3**, 816–821, https://doi.org/10.1038/nclimate1911.

Holling, C. S., 1973: Resilience and stability of ecological systems. *Annu. Rev. Ecol. Syst.*, **4**, 1–23, https://doi.org/10.1146/annurev.es.04.110173.000245.

Hudson, P., W. J. W. Botzen, J. K. Poussin, and J. C. J. H. Aerts, 2019: The impacts of flooding and flood preparedness on subjective well-being: A monetisation of the tangible and intangible impacts. *J Happiness Stud.*, **20**, 665–682, https://doi.org/10.1007/s10902-017-9916-4.

Hutter, G., C. Kuhlicke, T. Glade, and C. Felgentreff, 2013: Natural hazards and resilience: Exploring institutional and organizational dimensions of social resilience. *Nat. Hazards*, **67**, 1–6, https://doi.org/10.1007/s11069-011-9901-x.

Jones, L., and T. Tanner, 2017: 'Subjective resilience': Using perceptions to quantify household resilience to climate extremes and disasters. *Reg. Environ. Change*, **17**, 229–243, https://doi.org/10.1007/s10113-016-0995-2.

Jongman, B., P. J. Ward, and J. C. J. H. Aerts, 2012: Global exposure to river and coastal flooding: Long term trends and changes. *Global Environ. Change*, **22**, 823–835, https://doi.org/10.1016/j.gloenvcha.2012.07.004.

Joseph, R., D. Proverbs, and J. Lamond, 2015: Assessing the value of intangible benefits of property level flood risk adaptation (PLFRA) measures. *Nat. Hazards*, **79**, 1275–1297, https://doi.org/10.1007/s11069-015-1905-5.

Kates, R. W., 1962: Hazard and choice perception in flood plain management. Department of Geography, University of Chicago Research Paper 78, 157 pp.

Kienzler, S., I. Pech, H. Kreibich, M. Müller, and A. H. Thieken, 2015: After the extreme flood in 2002: Changes in preparedness, response and recovery of flood-affected residents in Germany between 2005 and 2011. *Nat. Hazards Earth Syst. Sci.*, **15**, 505–526, https://doi.org/10.5194/nhess-15-505-2015.

Klein, O., L. Licata, and S. Pierucci, 2011: Does group identification facilitate or prevent collective guilt about past misdeeds? Resolving the paradox. *Br. J. Soc. Psychol.*, **50**, 563–572, https://doi.org/10.1111/j.2044-8309.2011.02028.x.

Kreibich, H., and A. H. Thieken, 2009: Coping with floods in the city of Dresden, Germany. *Nat. Hazards*, **51**, 423–436, https://doi.org/10.1007/s11069-007-9200-8.

——, ——, T. Petrow, M. Müller, and B. Merz, 2005: Flood loss reduction of private households due to building precautionary measures—Lessons learned from the Elbe flood in August 2002. *Nat. Hazards Earth Syst. Sci.*, **5**, 117–126, https://doi.org/10.5194/nhess-5-117-2005.

——, M. Müller, A. H. Thieken, and B. Merz, 2007: Flood precaution of companies and their ability to cope with the flood in August 2002 in Saxony, Germany. *Water Resour. Res.*, **43**, W03408, https://doi.org/10.1029/2005WR004691.

——, I. Seifert, A. H. Thieken, E. Lindquist, K. Wagner, and B. Merz, 2011: Recent changes in flood preparedness of private households and businesses in Germany. *Reg. Environ. Change*, **11**, 59–71, https://doi.org/10.1007/s10113-010-0119-3.

——, and Coauthors, 2014: Costing natural hazards. *Nat. Climate Change*, **4**, 303, https://doi.org/10.1038/nclimate2182.

——, P. Bubeck, M. Van Vliet, and H. De Moel, 2015: A review of damage-reducing measures to manage fluvial flood risks in a changing climate. *Mitig. Adapt. Strategies Global Change*, **20**, 967–989, https://doi.org/10.1007/s11027-014-9629-5.

——, and Coauthors, 2017: Adaptation to flood risk: Results of international paired flood event studies. *Earth's Future*, **5**, 953–965, https://doi.org/10.1002/2017EF000606.

Kuhlicke, C., 2010: The dynamics of vulnerability: Some preliminary thoughts about the occurrence of 'radical surprises' and a case study on the 2002 flood (Germany). *Nat. Hazards*, **55**, 671–688, https://doi.org/10.1007/s11069-010-9645-z.

——, 2013: Resilience: A capacity and a myth: Findings from an in-depth case study in disaster management research. *Nat. Hazards*, **67**, 61–76, https://doi.org/10.1007/s11069-010-9646-y.

——, 2015: Vulnerability, ignorance and the experience of radical surprises. *Routledge International Handbook of Ignorance Studies*, M. Groß and L. McGoey, Eds., Routledge, 239–246.

——, 2019: Risk and resilience in the management and governance of natural hazards. *Oxford Research Encyclopedia on Natural Hazards Science*, Oxford University Press, https://doi.org/10.1093/acrefore/9780199389407.013.299.

——, A. Scolobig, S. Tapsell, A. Steinführer, and B. De Marchi, 2011: Contextualizing social vulnerability: Findings from case studies across Europe. *Nat. Hazards*, **58**, 789–810, https://doi.org/10.1007/s11069-011-9751-6.

Kundzewicz, Z. W., and Coauthors, 2014: Flood risk and climate change: Global and regional perspectives. *Hydrol. Sci. J.*, **59**, 1–28, https://doi.org/10.1080/02626667.2013.857411.

Lamond, J., C. Rose, N. Bhattacharya-Mis, and R. Joseph, 2018: Evidence review for property flood resilience phase 2 report. Flood Re and UWE Bristol, 60 pp., https://www.floodre.co.uk/wp-content/uploads/UWE-report_Evidence-review-for-PFR_Phase-2-report.pdf.

Lawrence, J., D. Quade, and J. Becker, 2014: Integrating the effects of flood experience on risk perception with responses to changing climate risk. *Nat. Hazards*, **74**, 1773–1794, https://doi.org/10.1007/s11069-014-1288-z.

Masson, T., and M. Barth, 2019: Solving the paradox—(Further) evidence for a quadratic relationship between in-group centrality and group-based guilt. *Br. J. Soc. Psychol.*, **58**, 917–937, https://doi.org/10.1111/bjso.12310.

Meyer, V., and Coauthors, 2013: Review article: Assessing the costs of natural hazards—State of the art and knowledge gaps. *Nat. Hazards Earth Syst. Sci.*, **13**, 1351–1373, https://doi.org/10.5194/nhess-13-1351-2013.

Miller, J. W., W. R. Stromeyer, and M. A. Schwieterman, 2013: Extensions of the Johnson-Neyman technique to linear models with curvilinear effects: Derivations and analytical tools. *Multivar. Behav. Res.*, **48**, 267–300, https://doi.org/10.1080/00273171.2013.763567.

Milly, P. C. D., J. Betancourt, M. Falkenmark, R. M. Hirsch, Z. W. Kundzewicz, D. P. Lettenmaier, and R. J. Stouffer, 2008: Stationarity is dead: Whither water management? *Science*, **319**, 573–574, https://doi.org/10.1126/science.1151915.

Ogunbode, C. A., Y. Liu, and N. Tausch, 2017: The moderating role of political affiliation in the link between flooding experience and preparedness to reduce energy use. *Climatic Change*, **145**, 445–458, https://doi.org/10.1007/s10584-017-2089-7.

Plapp, T., and U. Werner, 2006: Understanding risk perception from natural hazards. Examples from Germany. *RISK21—Coping with Risks due to Natural Hazards in the 21st Century*, W. J. Ammann, S. Dannenmann, and L. Vulliet, Eds., CRC Press, 101–108.

Poussin, J. K., W. J. Wouter Botzen, and J. C. J. H. Aerts, 2015: Effectiveness of flood damage mitigation measures: Empirical evidence from French flood disasters. *Global Environ. Change*, **31**, 74–84, https://doi.org/10.1016/j.gloenvcha.2014.12.007.

Reiter, J., B. Wenzel, C. Dittmer, D. F. Lorenz, and M. Voss, 2018: The 2013 flood in the community of Elbe-Havel-Land in the eyes of the population. Research Rep. of the Quantitative Survey, KFS Working Paper 08, 44 pp., https://refubium.fu-berlin.de/bitstream/handle/fub188/21920/Working_paper_Elbe_flood_English_final.pdf?sequence=1.

Schröter, K., M. Kunz, F. Elmer, B. Mühr, and B. Merz, 2015: What made the June 2013 flood in Germany an exceptional event? A hydro-meteorological evaluation. *Hydrol. Earth Syst. Sci.*, **19**, 309–327, https://doi.org/10.5194/hess-19-309-2015.

Seifert, I., W. J. W. Botzen, H. Kreibich, and J. C. J. H. Aerts, 2013: Influence of flood risk characteristics on flood insurance demand: A comparison between Germany and the Netherlands. *Nat. Hazards Earth Syst. Sci.*, **13**, 1691–1705, https://doi.org/10.5194/nhess-13-1691-2013.

Seligman, M., and C. Peterson, 2001: Learned helplessness. *International Encyclopedia of Social & Behavioral Sciences*, 1st ed. Science Direct, 8583–8586.

Sieg, T., K. Vogel, B. Merz, and H. Kreibich, 2017: Tree-based flood damage modeling of companies: Damage processes and model performance. *Water Resour. Res.*, **53**, 6050–6068, https://doi.org/10.1002/2017WR020784.

Siegrist, M., 2013: The necessity for longitudinal studies in risk perception research. *Risk Anal.*, **33**, 50–51, https://doi.org/10.1111/j.1539-6924.2012.01941.x.

——, 2014: Longitudinal studies on risk research. *Risk Anal.*, **34**, 1376–1377, https://doi.org/10.1111/risa.12249.

Spence, A., W. Poortinga, C. Butler, and N. F. Pidgeon, 2011: Perceptions of climate change and willingness to save energy related to flood experience. *Nat. Climate Change*, **1**, 46–49, https://doi.org/10.1038/nclimate1059.

Stein, D. J., S. Seedat, A. Iversen, and S. Wessely, 2007: Post-traumatic stress disorder: Medicine and politics. *Lancet*, **369**, 139–144, https://doi.org/10.1016/S0140-6736(07)60075-0.

Surminski, S., and A. H. Thieken, 2017: Promoting flood risk reduction: The role of insurance in Germany and England. *Earth's Future*, **5**, 979–1001, https://doi.org/10.1002/2017EF000587.

Tapsell, S. M., and S. M. Tunstall, 2008: "I wish I'd never heard of Banbury": The relationship between 'place' and the health impacts from flooding. *Health Place*, **14**, 133–154, https://doi.org/10.1016/j.healthplace.2007.05.006.

Thieken, A. H., H. Kreibich, M. Müller, and B. Merz, 2007: Coping with floods: Preparedness, response and recovery of flood-affected residents in Germany in 2002. *Hydrol. Sci. J.*, **52**, 1016–1037, https://doi.org/10.1623/hysj.52.5.1016.

——, S. Mariani, S. Longfield, and W. Vanneuville, 2014: Preface: Flood resilient communities—Managing the consequences of flooding. *Nat. Hazards Earth Syst. Sci.*, **14**, 33–39, https://doi.org/10.5194/nhess-14-33-2014.

——, T. Bessel, S. Kienzler, H. Kreibich, M. Müller, S. Pisi, and K. Schröter, 2016a: The flood of June 2013 in Germany: How much do we know about its impacts? *Nat. Hazards Earth Syst. Sci.*, **16**, 1519–1540, https://doi.org/10.5194/nhess-16-1519-2016.

——, and Coauthors, 2016b: Review of the flood risk management system in Germany after the major flood in 2013. *Ecol. Soc.*, **21**, 51, https://doi.org/10.5751/ES-08547-210251.

——, H. Kreibich, M. Müller, and J. Lamond, 2017: Data collection for a better understanding of what causes flood damage—Experiences with telephone surveys. *Flood Damage Survey and Assessment: New Insights from Research and Practice*, D. Molinari, S. Menoni, and F. Ballio, Eds., Wiley, 95–106.

van Valkengoed, A. M., and L. Steg, 2019: Meta-analyses of factors motivating climate change adaptation behaviour. *Nat. Climate Change*, **9**, 158–163, https://doi.org/10.1038/s41558-018-0371-y.

Wachinger, G., O. Renn, C. Begg, and C. Kuhlicke, 2013: The risk perception paradox: Implications for governance and communication of natural hazards. *Risk Anal.*, **33**, 1049–1065, https://doi.org/10.1111/j.1539-6924.2012.01942.x.

Walker, B. H., C. S. Holling, S. R. Carpenter, and A. Kinzig, 2004: Resilience, adaptability and transformability in social-ecological systems. *Ecol. Soc.*, **9**, 5, https://doi.org/10.5751/ES-00650-090205.

Walker-Springett, K., C. Butler, and W. N. Adger, 2017: Wellbeing in the aftermath of floods. *Health Place*, **43**, 66–74, https://doi.org/10.1016/j.healthplace.2016.11.005.

Weichselgartner, J., and I. Kelman, 2015: Geographies of resilience: Challenges and opportunities of a descriptive concept. *Prog. Hum. Geogr.*, **39**, 249–267, https://doi.org/10.1177/0309132513518834.

Zaalberg, R., C. Midden, A. Meijnders, and T. McCalley, 2009: Prevention, adaptation, and threat denial: Flooding experiences in the Netherlands. *Risk Anal.*, **29**, 1759–1778, https://doi.org/10.1111/j.1539-6924.2009.01316.x.