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ORIGINAL ARTICLE

# Recent changes in flood preparedness of private households and businesses in Germany

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**Abstract** Using the focusing event framework, a comprehensive analysis of private households' and businesses' preparedness was undertaken in the aftermath of the 2002 and 2006 flood events on the Elbe River in Germany. In August 2002, preparedness of households ($n = 235$) and businesses ($n = 103$) was low: 30% of the households and 54% of the businesses took no precautionary measures before the flood event. Many undertaken emergency measures were ineffective, since only 26% of all households knew how to react when the flood warning came, and only 9% of businesses had an emergency plan in place. Due to this extreme flood, double-loop learning occurred in many households and businesses, so that many did implement precautionary measures. The distribution of adopted precautionary measures for households fits well to Preisendörfer's low-cost hypothesis, but does not apply for businesses. Only 10% of the households ($n = 112$), but still 29% of the businesses ($n = 41$) were unprepared before the flood in 2006. Significant improvement in flood preparedness activities is still necessary. Particularly for businesses, regulatory programs and programs encouraging proactive behaviour should be implemented. The focusing event framework proofed to be a useful tool for a differentiated analysis of the responses to and learning due to a disaster also in the commercial and private sector.

**Keywords** Emergency measures · Flood management · Focusing event · Learning · Precautionary measures

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## Introduction

Physical, societal, and monetary damages from natural disasters have dramatically increased during the last few decades and floods have generated the largest economic losses of all (Munich Re 1997, 2004). For instance, the extreme flood event in August 2002 in the Elbe and Danube catchments led to €11,600 million losses in Germany (Kron 2004). It is expected that flood risk will continue to rise in response to a combination of a changing climate (e.g. Kundzewicz et al. 2005) and an increase in vulnerability, e.g. due to increasing flood plain occupancy, and changes in the terrestrial system, e.g. land cover changes, and river regulation. One important factor in the rise in flood losses is increased residential and economic development in flood-prone areas. In industrialised countries, this trend is due to relatively low prices for land, good transport infrastructure, and the proximity of urban development to areas at risk for flooding. For instance, in Germany, communities with more than 5,000 citizens are twice as likely to be located near a river (Borchert 1992).

In many regions, climate change is also expected to increase flood losses. The 2002 flood in the Elbe and Danube catchments led to a lively debate about climate change and river flooding in Germany. For the river Elbe, a decrease in winter floods was found in an analysis of the long discharge record at the Dresden gauge by Mudelsee et al. (2003, 2004), while summer floods showed no trend at all. In a German-wide study, Petrow and Merz (2009) analysed changes in flood indicators for 145 catchments in Germany for the period 1951–2002. They detected spatially and seasonally coherent trend patterns and suggested that the observed changes in flood behaviour were climate-driven. Such data-based trend studies are complemented by simulation studies based on (global and regional) climate models and hydrological models. For example, an investigation in England and Wales expects a 20-fold increase in the real economic flood risk by the year 2080, if present flood policies and practices are not improved significantly (Hall et al. 2005). However, simulation studies are still associated with high uncertainty (e.g. Dankers and Feyen 2008) and lead to regionally differentiated results. They depend on the chosen climate scenarios, the type of models used (e.g. GCM, downscaling method, hydrological model), the studied catchments and the chosen flood indicator (e.g. mean annual flood, 100-year flood; Boorman and Sefton 1997). By now, no clear picture about the impact of climate change on extreme flood events arises. However, from the variety of data-based trend studies and scenario-based simulation studies, it has to be concluded that the flood hazard is currently changing and that future changes have to be expected.

In view of these changes, decreasing the impact of floods can only be achieved with significantly improved risk management. Risk management is defined as a systematic process to implement policies, strategies, and coping capacities of the society and communities to lessen the impacts of natural hazards and related disasters. It comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards (ISDR 2004). Thus, not only public efforts—such as technical protection measures and an increase in natural retention—are to be taken into account; the mitigation potential of private households and businesses via flood precautionary measures and response to early warning must also be examined and encouraged (Hayes 2004; Wynn 2004). Private precautionary measures want to mitigate damage e.g. due to flood proofing of buildings and preparative measures like collecting information about flood protection or signing flood insurance.

This study investigates the flood preparedness of private households and businesses along the Elbe River in 2002, after a long period of relatively low flood discharges, and in 2006, just a few years after a severe flood event. In particular, this study was inspired by the focusing event framework, i.e. examining how the commercial and private sector responded to and learned from the major flood disaster in 2002. The focusing event framework was developed to explain policy change over time and for the most part has been applied to institutional policy making. In this study, we have applied the framework to responses of the commercial and private sector. The approach is based on Kingdon's (1995) broader study of agenda change and his illustrations of how crises, as focusing events, are powerful initiators of agenda change. Birkland (1997a, b, 1998, 2004) expanded upon Kingdon's framework with a more empirical approach to focusing events. By studying multiple national-level focusing events over time (e.g. oil spills, nuclear power plant accidents), Birkland focused on media attention to the event and subsequent political reactions and the mobilisation of interest groups and pro-change actors.

A "focusing event" is an event, such as a crisis or disaster, natural or man-made, that shifts attention away from the status quo. Birkland (1997a) defines a potential focusing event as "a rare, harmful, sudden event that becomes known to the mass public and policy elites virtually simultaneously". The major characteristic of a focusing event, according to Kingdon (1995), is that it provides a push in calling attention to a problem. While a problem may be hovering just under the radar of decision-makers, without a push from a crisis or disaster, the problem may never rise on the decision agenda and warrant policy responses.

The hazard literature tells us much about immediate and emergency responses, but little about the long-term policy changes that occur over time, farther away from the initial event itself. According to Birkland (1997a), the immediate needs of the community overshadow any longer term attention to the problem: "soon after the disaster, interest on the hazard subsides, and disaster policy returns to its prior status as the province of technical experts charged with promoting mitigation and preparing to provide disaster relief". One of the most important aspects of focusing events in regard to policy change is the role of policy learning, and the question of whether or not an individual or institution learns from one event to another (Birkland 2006). For our study, we adopt the learning model of Argyris and Schön (1978, 1996). They argue that in organisations, three types of learning should be distinguished: single-loop learning in which implementation errors are addressed within a given set of goals, double-loop learning in which the existing goals are scrutinised, and deuteron learning in which the learning process is revised.

According to the broader literature on flooding, focusing events have induced limited policy learning, as even after the Great Flood of 1993 in the United States, an increased amount of land in floodplains was developed and more and more people and infrastructure were placed in harm's way (Pinter 2005). However, there are also success stories, for example, Fort Collins, Colorado, where the changes in the city's preparedness infrastructure undertaken after the 1997 flood were very effective during a flood in 1999 (Weaver et al. 2000). Learning from histories of flood risk by local jurisdictions in Florida was revealed by a study investigating mitigation activities under the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS) from 1999 to 2005 (Brody et al. 2009).

In Germany, many programs and initiatives were launched in the aftermath of the severe flood in August 2002 in order to improve the German flood risk management (see e.g. DKKV 2003). For instance, many federal states, regardless of whether they were affected by the 2002 flood, began development of state-wide flood hazard maps (e.g., Rheinland-Pfalz 2004; Sachsen 2004; Bayern 2005; Baden-Württemberg 2005). In the federal state of Saxony, flood management concepts for 47 catchments were developed. The municipal authorities in Dresden developed a new flood management concept and substantially improved their emergency management system (Kreibich and Thieken 2009). Additionally, many initiatives were introduced to improve the flood warning system (Thieken et al. 2005a; Kreibich et al. 2007).

All these activities directly or indirectly influence the flood preparedness of private households and businesses, e.g. hazard maps should improve the risk awareness and support behavioural precaution. An improved, more detailed early warning should enable more effective emergency measures. Governmental authorities were not alone in reacting to this extreme flood event: e.g. the insurance industry changed its risk assessment policy (Thieken et al. 2006).

So far, few studies have used the focusing event framework to analyse the response of the commercial or private sector to disasters. However, extreme event studies point to our limited understanding regarding organisational issues, in particular the trade-off businesses have to make in terms of resource allocation and decision-making (McDaniels et al. 2008; Barker and Haimes 2009). The focusing event framework should be an appropriate framework with which to improve our understanding of the impact of disasters, such as floods, and the respective (and variable) policy changes exhibited by private households and businesses.

The primary objective of this paper is to investigate recent changes in flood preparedness among private households and businesses in Germany from a focusing event perspective. The study focuses on the situation during and following the 2002 Elbe River flood and the subsequent changes, manifested during the 2006 flood. This study is an extension of the work presented in Thieken et al. (2007), Kreibich et al. (2007) and Kreibich and Thieken (2009). In addition, by applying a focusing event framework to this situation, we expand this literature into two new policy and decision domains: the private household decision-maker and the business/corporate decision-maker.

## Flood events descriptions

In August 2002, the low-pressure system "Ilse", a Genoa Cyclone Type Vb weather system, brought prolonged, heavy rainfall resulting in devastating floods in Germany, Austria, the Czech Republic and Slovakia, particularly in the Elbe and the Danube basins (Ulbrich et al. 2003; Engel 2004). The Elbe River rose to a level of 9.40 m at the Dresden gauge (BfG 2002). The return period of this event was first estimated to be around 150 years (e.g., Umweltatlas 2002; IKSE 2004). However, new analyses, which take into account historical changes of the riverbed, assess the 2002 flood as a 1,000-year event and assume that the measured discharge of 4,580 $m^3$ $s^{-1}$ is the highest value at Dresden that occurred since (Pohl 2007).

Downstream of Dresden, the flood in 2002 caused 14 levee breaches along the Elbe River in Saxony and seven in Saxony-Anhalt, resulting in vast inundated areas (Fig. 1). The flood wave was somewhat dampened by the usage of the Quitzöbel Weir that led to an activation of huge retention areas at the confluence of the Havel and Elbe rivers. Therefore, the return period of the flood discharge dropped considerably at the gauges at Wittenberge and Neu Darchau to 70 and 35 years, respectively (IKSE 2004). The retention areas at the Havel River were used for the first time in 2002. Since the land within the retention polders was under agricultural cultivation, large quantities of corn plants were submerged, resulting in oxygen depletion in the water and a great number of fish deaths (Buchta 2003).

Twenty-one people were killed in Germany during this extreme flood event and substantial parts of the infrastructure were destroyed. The most seriously affected German federal state was Saxony, where the total flood damage amounted to €8,700 million, followed by Saxony-Anhalt (€1,187 million) and Bavaria (€198 million; data from SSK 2004; IKSE 2004; Bavarian Ministry of Finance personal communication). Altogether, about €11,600 million damage was caused in Germany.

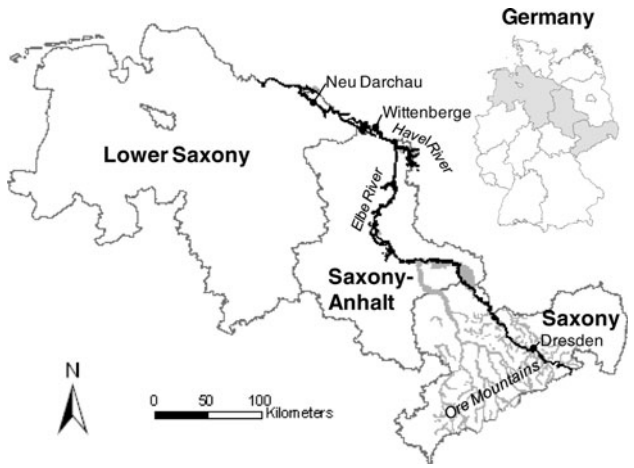


**Fig. 1** Research area in the three federal states Lower Saxony, Saxony-Anhalt and Saxony in Germany. Flooded area in 2002 (*grey area*) and 2006 (*black area*). Data sources of figure: VG250, Hochwasserlinien des Elbe-Hochwassers 2002, copyright BKG, Frankfurt am Main, 2004; Überschwemmungsgebiet der Mulde in Sachsen-Anhalt, UFZ Leipzig, 2003; Überschwemmte Flächen Hochwasser in Sachsen August 2002, Sächsisches Landesamt für Umwelt und Geologie, Staatliche Umweltfachämter Chemnitz, Leipzig, Plauen und Radebeul, Landestalsperrenverwaltung Sachsen, Stadtverwaltungen Landeshauptstadt Dresden/Umweltamt, Chemnitz/Umweltamt, Zwickau/Umweltamt und Olbernhau; Elbe-Flut 2006, ZKI 2006 http://www.zki.caf.dlr.de/applications/2006/germany/elbe_flood_2006_de.html

At the Elbe River, the flood in 2002 was followed by another event in April 2006. Snowfall was exceptionally heavy during the winter of 2005/2006. In March 2006, in the upper Elbe catchment in the Czech Republic, the amount of water stored as snow was about 2.4 billion $m^3$ (Umweltamt Dresden 2006). At the end of March, temperatures rose rapidly to 5–15°C leading to a complete snowmelt within 1 week also in the upper parts of the middle hills (BfG 2006). Due to several westerly cyclones, snowmelt was accompanied by heavy rainfall. At the Dresden gauge, the water level of the Elbe River rose to a maximum of 7.49 m (Umweltamt Dresden 2006). The flood discharge in 2006 was the second highest discharge since 1940 at the Dresden gauge, although its return period was only about 15 years (Kreibich and Thieken 2009). However, the situation changed further downstream (Fig. 1). Since no levee breaches occurred in the upper and middle reaches of the Elbe River and since the retention areas at the Havel confluence were not activated, the flood situation downstream of the Havel confluence was comparable to or even worse than 2002. In 2006, the flood discharge of 3,600 $m^3 s^{-1}$ was the second highest in 100 years at the Neu Darchau gauge and exceeded the 2002 flood discharge of 3,400 $m^3 s^{-1}$ (BfG 2006). Although no official figures are available, it is estimated that the total damage in 2006 was considerably lower than in 2002.

## Data and methods

Telephone interviews with private households and businesses were undertaken after the flood in 2002 and again after the flood in 2006 in the Elbe and Danube catchments in Germany (Kreibich et al. 2007; Thieken et al. 2007; Kreibich and Thieken 2009). Lists of all affected streets were compiled with the help of flood masks derived from radar satellite data (DLR, Center for Satellite Based Crisis information, www.zki.caf.dlr.de), and official data (e.g. reports, press releases). On this basis, building specific random samples of private households and businesses were generated. Computer-aided telephone interviews were undertaken with the VOXCO software package (www.voxco.com). The SOKO institute for social research and communication (www.soko-institut.de) interviewed private households in April and May 2003 and businesses in October 2003, May 2004 and October 2006. The Explorare institute for marketing research (www.explorare.de) interviewed private households in November and December 2006. In all polls, the individual with the best knowledge of the flood damage was interviewed. The surveys after the 2002 flood resulted in 1697 completed interviews with private households and 415 completed interviews with businesses. The surveying in 2006 resulted in 461 interviews with private households and 227 interviews with businesses.

All questionnaires addressed the following topics: emergency and precautionary measures, flood experience, flood parameters (e.g. contamination, water level), socio-economic parameters or business characteristics, and flood damage. For instance, private households and businesses were asked about the kinds of precautionary and emergency measures they had undertaken before the flood event. Additionally, they were asked to assess the effectiveness of the emergency measures undertaken on a rank scale from 1 to 6, where 1 described the best case, i.e. "measure was very effective" and 6 described the worst case, i.e. "measure was very ineffective". Further details about the surveys and the data processing after the 2002 flood are published by Kreibich et al. (2005b, 2007) and Thieken et al. (2005b, 2006, 2007).

For this comparative study, we selected only private households and businesses located in the same areas for both flood events, to avoid a bias due to different flood characteristics and damaging processes. For instance, all private households and businesses in the Ore Mountains were excluded, since this area experienced flash floods (i.e. high flow velocities, short lead times) and was affected only in 2002 (Fig. 1). Thus, all households and businesses that were affected during the 2002 flood or during the 2006 flood and that were located within the flood mask of the 2006 flood derived from radar satellite

data (www.zki.caf.dlr.de/applications/2006/germany/136_en.html) plus a 200-m buffer (Fig. 1) were selected for our analysis. The buffer around the flood mask was added because quite a number of households and businesses affected by the 2006 flood were located just outside the flood mask due to location uncertainties (geocoding) and blurring of the satellite data. This selection resulted in 235 private households and 103 businesses affected by the 2002 flood and 112 households and 41 businesses affected by the 2006 flood. Significant differences of flood preparedness between the two floods were tested for nominal scaled data by a chi-square test and for ordinal scaled data by the Mann–Whitney *U*-test (Norušis 2002).

## Results and discussion

### Flood experience and risk awareness

The private households and businesses surveyed had hardly any flood experience before August 2002, which is consistent with the results for the city of Dresden and for the entire Elbe catchment (Kreibich et al. 2005a, b; Kreibich and Thieken 2009). Only 6% of the households had flood experience, and only 0.4% had a flood loss of >1,000 € before August 2002 (Table 1). Their last experienced flood before August 2002 was on average 23 years ago. Eighteen per cent of the businesses had flood experience, which was on average 45 years ago. However, the situation was significantly different in 2006: in this sub-dataset, 90% of the households and 89% of the businesses had recent flood experiences (Table 1). Flood experience is a significant factor for learning steps to undertake precautionary measures and thus for flood loss mitigation (Kreibich et al. 2005a, b; Grothmann and Reusswig 2006; Siegrist and Gutscher 2006, 2008; Thieken et al. 2007). It has also been shown before that relatively recent flood experience supports effective emergency measures (Burn 1999; Yeo 2002) and that damage is effectively reduced where people have frequently and recently experienced flooding (Smith 1981; Wind et al. 1999).

Besides flood experience, the knowledge that one lives in a flood-prone area seems to influence decisions on the implementation of precautionary measures (Kreibich et al. 2005b). In the samples under study, flood risk awareness was low in August 2002. Only 33% of the households and 30% of the businesses who had no prior flood experience knew that their building was located in a flood-prone area. In contrast, in 2006, most of the private households and businesses without previous flood experience knew that their building was located in a flood-prone area (64 and 75%, respectively). It can only be speculated that this increase in risk awareness may also be due to the improved availability of flood hazard maps e.g. in the federal state of Saxony (Sachsen 2004).

The percentage of households and businesses who perceived a recurrence of flooding to be very likely increased significantly from 14% in 2002 to 69% in 2006 and from 28% in 2002 to 75% in 2006, respectively (Table 1). This might be due to the exceptionally extreme event in 2002, which was perceived as a singular event, in contrast to the 2006 flood. Kreibich et al. (2005b) noted that estimates about the probability of being affected by a flood again in the future did not differ significantly among those households that had implemented building precautionary measures before the 2002 flood, after the 2002 flood, or which did not intend to undertake measures. Grothmann and Reusswig (2006) found that the fear of being affected by a flood in the future was not related to taking precautionary action. However, they demonstrated that there is a correlation between that fear and threat assessment, with the fear indirectly influencing the appraisal of the severity of flood risk (Grothmann and Reusswig 2006).

Another aspect that influences the learning process of private households to undertake precautionary measures

**Table 1** State of flood risk awareness in 2002 and 2006

| | Private households | | Businesses | |
|---|---|---|---|---|
| | 2002 | 2006 | 2002 | 2006 |
| Percentage of households/businesses with flood experience [%] | 6* | 90* | 18* | 89* |
| Percentage of households with a previous flood loss of >1,000 € [%] | 0.4* | 64* | NR | NR |
| Average time since last experienced flood [years] | 23 | 4 | 45* | 3* |
| Percentage of households/businesses without flood experience knowingly located in a flood-prone area [%] | 33* | 64* | 30 | 75 |
| Percentage of households/businesses that perceive it is very likely to be flooded again [%] | 14* | 69* | 28* | 75* |
| Percentage of households convinced of the effectiveness of private precautionary measures [%] | 38* | 53* | NR | NR |

Investigated private households 2002 $n = 235$, 2006 $n = 112$; investigated businesses 2002 $n = 103$, 2006 $n = 41$

*NR* not retrieved

* Significant difference ($p < 0.05$) between 2002 and 2006

was significantly different between 2002 and 2006: the fraction of investigated households who are convinced of the effectiveness of private precautionary measures increased from 38 to 53% (Table 1).

Without flooding risk awareness diminishes. The ICPR (2002) states: "If nothing points towards a flood risk, flood awareness is reduced to a minimum within 7 years after a flood event. On the long run only great disasters—like that of 1953 in the Netherlands—are remembered." In an empirical study by Wagner (2004), the half-life of memory of bigger local damaging events was 14 years in three communities of the Bavarian Alps. However, there is only little empirical data about fading of awareness, and it is unknown how long households and businesses will remember the floods in 2002 and 2006 and stay prepared. To support the sustainability of the learning processes, it is recommended to make use of past flood experience. For example, historical flood marks should be installed or extended after an event, flood commemoration days should be implemented, regular information gatherings at which the public is informed about private precautionary measures should be undertaken (Petrow et al. 2006; Hagemeier-Klose and Wagner 2009). Emergency plans should be updated and exercises undertaken regularly. Flood risk mapping as well as the implementation of flood management in guidelines and legislation supports the consideration of the flood risk in decision-making. Measures with long-lasting effects like private building precautionary measures or structural measures are advantageous, especially if the technique is robust and still able to function in decades (Kreibich and Thieken 2009). However, it is a challenge to keep preparedness at a high level also without recurrent flood experiences.

## Precautionary measures undertaken

Precautionary measures can be divided into three groups according to the costs involved and the planning and maintenance efforts (Figs. 2, 3). Low-cost measures cost little and are easy to perform. Medium-cost measures are more costly but no substantial changes to buildings or equipment are necessary. In contrast, high-cost measures depend on reconstruction of buildings or equipment. According to Preisendörfer (1999), this classification of measures as low-cost, medium-cost or high-cost may be used to explain different types of environmental protection actions. Preisdörfer's low-cost hypothesis says that the frequency of positive environmental behaviour correlates negatively with its costs (effort, difficulty). Environmental attitudes are less important for environmental behaviour than its costs. Adapted to flood preparedness, the low-cost hypothesis says that people are willing to improve their flood preparedness depending on the costs of the measures. For instance, Florida's localities pursue a form of least cost learning from flood risk, since they disproportionately select mitigation measures that are less expensive and more politically viable (Brody et al. 2009).

Before the 2002 flood, most interviewed private households relied on flood insurance for compensation of flood losses (Fig. 2), a measure that is considered medium-cost. Similar results were found in surveys of larger parts of

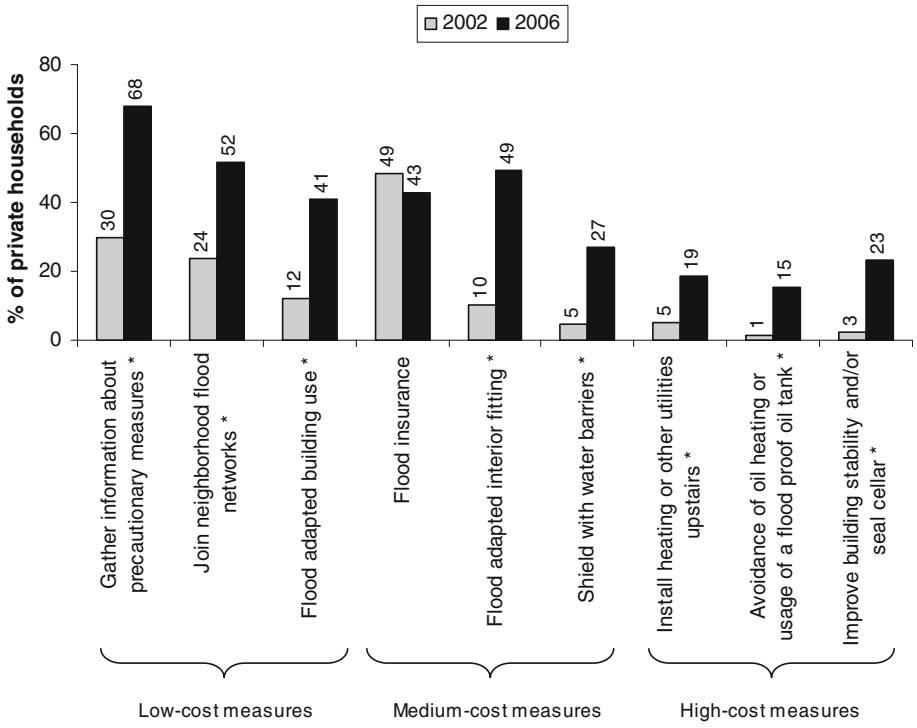


**Fig. 2** Percentage of private households who had undertaken different types of precautionary measures, before the floods in 2002 and 2006, respectively (investigated private households 2002 $n = 235$, 2006 $n = 112$; measures marked with a * show a significant difference ($p < 0.05$) between 2002 and 2006, multiple answers were possible)

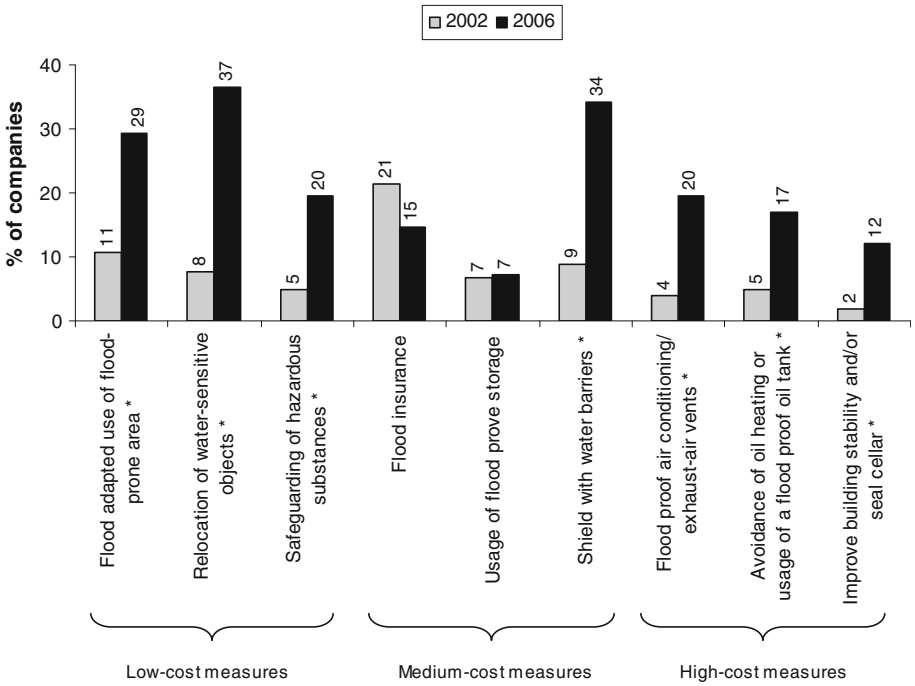


**Fig. 3** Percentage of businesses who had undertaken different types of precautionary measures, before the floods in 2002 and 2006, respectively (investigated businesses 2002 $n = 103$, 2006 $n = 41$; measures marked with a * show a significant difference ($p < 0.05$) between 2002 and 2006, multiple answers were possible)

the Elbe catchment and its tributaries (Kreibich et al. 2005b; Thieken et al. 2007). This may have a historical basis, as in the former German Democratic Republic, flood insurance was generally included in the household insurance and many residents of Eastern Germany still have comparable contracts (Thieken et al. 2006).

Typical low-cost measures are the next most prevalent precautionary measures: 30% of the interviewees mentioned that they gathered information about precautionary measures to protect their house or flat, 24% joined neighbourhood flood networks and 12% adapted their building use, which means that they prevented losses by situating low-value uses in flood-prone stories or areas. Thieken et al. (2007) found that this preference for low-cost measures also existed among private households in the Danube catchment. Medium-cost measures, besides flood insurance, are flood-adapted interior fitting and shielding with water barriers, which were performed by 10 and 5% of the private households, respectively. High-cost measures were seldom implemented (Fig. 2).

Overall, 30% of the households surveyed had undertaken no precautionary measures prior to the 2002 flood, while less than 1% of the households reported seven or more implemented precautionary measures (Table 2). By 2006, the percentage of households that had implemented no precautionary measures fell to below 10%, with many households implementing two or more precautionary measures (Table 2). In detail, in 2006, more than twice as many private households had gathered information on possible precautionary measures, twice as many households had joined neighbourhood flood networks, and more than three times as many private households had adapted the use of their building, compared to before the 2002 flood (Fig. 2). These low-cost measures together with the

**Table 2** Percentage of private households and businesses who had undertaken precautionary measures before the 2002 flood and before the 2006 flood

| Number of precautionary measures undertaken | Private households [%] | | Businesses [%] | |
|---|---|---|---|---|
| | 2002 | 2006 | 2002 | 2006 |
| 0 | 29.79* | 9.82* | 54.37* | 29.27* |
| 1–2 | 54.89* | 26.79* | 37.86 | 34.15 |
| 3–4 | 12.34* | 31.25* | 7.77* | 29.27* |
| 5–6 | 2.55* | 25.89* | 0.00* | 4.88* |
| 7 and more | 0.43* | 6.25* | 0.00 | 2.44 |

Investigated private households 2002 $n = 235$, 2006 $n = 112$; investigated businesses 2002 $n = 103$, 2006 $n = 41$

* Significant difference ($p < 0.05$) between 2002 and 2006

medium-cost measure of an adapted interior fitting, clearly dominate the overall precautionary behaviours. However, compared with 2002, also the percentage of households who utilised building measures to protect their homes increased until 2006 (Fig. 2). These results show that flood experience and learning processes initiated by a focusing event can induce some householders to use high-cost precautionary measures. The comparison of a sample of private households in the Elbe area with little flood experience and households in the Danube area having more flood experience revealed the same findings: respondents in the sample with greater flood experience reported a higher rate of sealed cellars and greater avoidance of oil heatings (Thieken et al. 2007).

The percentage of private households covered by flood insurance decreased slightly from 49% in 2002 to 43% in 2006. This may be due to the increased efforts insurance companies put into risk assessments after the 2002 flood, making it more difficult for private households to get insurance (Thieken et al. 2006), or due to the cancellation of contracts by insurance holders because of rising premiums. After the 2002 event, the distribution of adopted precautionary measure shows a good fit with Preisendörfer's (1999) low-cost hypothesis. People tend to adopt more low-cost measures than medium or high-cost measures. However, the tendency to adopt precautionary measures following a focusing event is not necessarily long-term learned behaviour, when the risk subsides; the impetus to change behaviour diminishes (Birkland 1997a). For instance, if high-cost actions, such as precautionary measures strengthening individual buildings, are not undertaken at the time of reconstruction, it is unlikely that such high-cost measures will be implemented at all. In this study, the situation prior to the 2002 flood is somewhat contradictory to Preisendörfer's thesis, since insurance—a medium-cost action—is the most prevalent precautionary measure. However, this can be explained by the historical reasons mentioned earlier, i.e. the insurance regulations in the former German Democratic Republic.

As was the case with private households, flood insurance was the most important precautionary measure used by businesses in 2002 (Fig. 3). Adaptive use of flood-prone areas at the business's premises was practiced by 11% of businesses surveyed. Eight per cent of businesses reported a relocation of water-sensitive objects, and 5% reported safeguarding of hazardous substances. The use of flood resistant storage, e.g. by anchoring the storage facilities, was undertaken by 7%, and the use of water barriers to shield assets was reported by 9% of the surveyed businesses. High-cost measures were mentioned by less than 5%.

In general, businesses implemented fewer precautionary measures than private households (Table 2). Before the 2002 flood event, 54% of the interviewed businesses had not undertaken any precautionary measure, even though equipment losses could have been lowered considerably using preventive measures (ICPR 2002; Kreibich et al. 2005c). While the number of businesses implementing no precautionary measures decreased, 29% of the businesses interviewed in 2006 still had not undertaken any precautionary measures at all, despite the flooding experienced in 2002 (Table 2).

From 2002 to 2006, businesses increased their applications of all precautionary measures with the exception of purchasing flood insurance (Fig. 3). Low-cost measures accounted for the highest increase. For medium-cost measures, there was a significant increase in shielding with water barriers, while the use of flood-proof storage increased by less than 1%. The use of flood insurance decreased by 6%, perhaps due to rising premiums or general difficulties to contracting for insurance coverage after 2002 (Thieken et al. 2006). In addition, the percentage of businesses applying high-cost precautionary measures increased by a factor of 3–6.

Preisendörfer's (1999) low-cost hypothesis is not applicable for businesses in this study. This is in line with a previous study in Saxony, which found that the majority of businesses preferred costly building precautionary measures over less expensive behavioural measures (Kreibich et al. 2007). This may be accounted for by the possibility that in the commercial world, other factors are considered in determining what kind of precautionary measures to undertake. For example, Kreibich et al. (2005c) stated that high-cost measures like the flood proofing of air conditioning and tanks may be supported by high standards when buying and installing air conditioning systems or by regulations like the statutory order on hazardous incidents.

### Emergency measures undertaken

In general, the flood early warning system in the research area along the Elbe River worked well in both 2002 and 2006. The percentage of private households and businesses who had received no warning ranged from 12 to 24% (Table 3). For those who had advanced warning lead times were very long, i.e. over 40 h on average. Early warning is an important precondition for implementing emergency measures. Studies after the 2002 flood revealed that the main reason why private households and businesses did not perform emergency measures was a lack of time, with many respondents stating that earlier warnings would have allowed the implementation of more emergency measures (Thieken et al. 2007; Kreibich et al. 2007).

In contrast to the 2002 flood, more households and businesses were knowledgeable about what actions to take when they received warning of impending flooding in 2006

**Table 3** Early warning and knowledge about or preparation for emergency measures

| | Private households | | Businesses | |
|---|---|---|---|---|
| | 2002 | 2006 | 2002 | 2006 |
| Percentage of households/businesses that received no warning [%] | 12 | 13 | 24 | 12 |
| Average lead time of households/businesses that received a warning [h] | 43 | 47 | 45* | 60* |
| Percentage of households that knew what to do, when they received the warning [%] | 26* | 73* | NR | NR |
| Percentage of businesses with an emergency plan in place [%] | NR | NR | 9* | 24* |
| Percentage of businesses that had undertaken emergency exercises before [%] | NR | NR | 2 | 5 |

Investigated private households 2002 $n = 235$, 2006 $n = 112$; investigated businesses 2002 $n = 103$, 2006 $n = 41$

*NR* not retrieved

* Significant difference ($p < 0.05$) between 2002 and 2006

(Table 3). The percentage of businesses with an emergency plan in place increased significantly from 9% in 2002 to 24% in 2006. The percentage of businesses that had undertaken emergency exercises before remained on an insignificant low level of 2–5%, i.e. only two businesses for both flood events (Table 3).

The main aim of emergency measures is the safeguarding of contents, equipment, goods, products or stock, which might be achieved by moving them to flood-safe areas like higher stories or by using water barriers which prevent the water from entering the building. The percentage of private households and businesses who undertook emergency measures, the average number of people involved, and the resulting mitigation costs for businesses showed no significant difference between the 2002 flood and the 2006 flood (Table 4). The average time households and businesses spent on implementing emergency measures was significantly higher in 2006 than in 2002 (Table 4). This might be largely due to the fact that a significantly higher percentage of households was better informed about what to do when they received advance warning of the flood in 2006; in addition, in 2006, a significantly higher percentage of businesses had emergency plans in place (Table 3). The types of emergency measures undertaken in 2002 and 2006 were similar (Fig. 4).

Since types of emergency measures (Fig. 4) and people involved as well as costs (Table 4) were similar during both events, it is particularly interesting that the effectiveness of emergency measures significantly increased from 2002 to 2006. The percentage of private households effectively protecting household contents and preventing water from entering buildings increased considerably, from 51% in 2002 to 92% in 2006, and from 16% in 2002 to 59% in 2006, respectively (Table 4). The percentage of businesses effectively protecting their equipment, goods, products, and stock also increased significantly (Table 4). Thieken et al. (2007) found that in the flood of 2002, the better informed people were, the more success they had with emergency measures. Businesses faced with a flooding situation undertook emergency measures more effectively when an emergency plan was in place (Kreibich et al. 2007). In addition, warnings, particularly those issued by authorities, and relatively long lead times were also

**Table 4** Effort for and effectiveness of emergency measures undertaken by private households and businesses

| | Private households | | Businesses | |
|---|---|---|---|---|
| | 2002 | 2006 | 2002 | 2006 |
| Percentage of households/businesses undertaking emergency measures [%] | 90 | 95 | 79 | 93 |
| Average number of people involved in emergency measures | 5 | 6 | 18 | 13 |
| Average time spent on emergency measures [h] | 17* | 34* | 23* | 34* |
| Average cost of emergency measures [1,000 €] | NR | NR | 5 | 9 |
| Percentage of households that effectively saved their contents [%] | 51* | 92* | NR | NR |
| Percentage of households that effectively prevented water entering the building [%] | 16* | 59* | NR | NR |
| Percentage of businesses that effectively saved their equipment [%] | NR | NR | 36* | 76* |
| Percentage of businesses that effectively saved their goods/products/stock [%] | NR | NR | 41* | 77* |

Investigated private households 2002 $n = 235$, 2006 $n = 112$; investigated businesses 2002 $n = 103$, 2006 $n = 41$

*NR* not retrieved

* Significant difference ($p < 0.05$) between 2002 and 2006

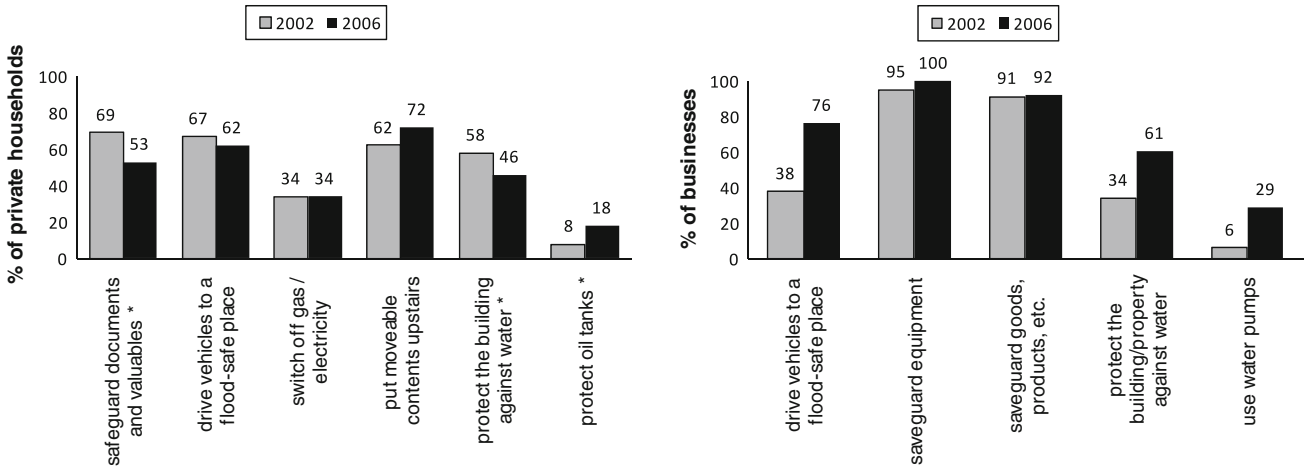


**Fig. 4** Percentage of private households (*left*) and businesses (*right*) implementing different types of emergency measures during the flood in 2002 and 2006, respectively (investigated private households 2002 $n = 235$, 2006 $n = 112$; investigated businesses 2002 $n = 103$, 2006 $n = 41$; measures marked with a * show a significant difference ($p < 0.05$) between 2002 and 2006, multiple answers were possible)

factors for an effective implementation of emergency measures by businesses (Kreibich et al. 2007). However, the effectiveness of emergency measures is hampered by high flood impacts, e.g. by high water levels (Thieken et al. 2007). Therefore, it is unclear whether the significant increases in the effectiveness of emergency measures seen in 2006 are due to improved coping capacities of households and businesses or to lower flood impacts in 2006, but both factors may play a part.

Effective emergency measures are able to mitigate flood losses significantly in both, private households (see Thieken et al. 2005b) and businesses. For instance, Kreibich et al. (2007) showed that businesses that successfully protected their goods, products, or stock achieved a significant damage reduction by 52% on average and that successfully saving equipment led to an average decrease in damage to equipment by 28%. The ICPR (2002) presumes a 50–75% cutback of damage due to the implementation of emergency measures in industry and trade.

## Conclusions

The focusing event perspective enables a differentiated analysis of the aspects of learning due to a disaster. Figure 5 visualises recent changes in flood preparedness among private households and businesses due to the 2002 flood in Germany from a focusing event perspective. Private households, businesses as well as authorities were hardly aware of the flood risk in the Elbe catchment before 2002, due to a lack of flood experience (Kreibich et al. 2005b, 2007; Kreibich and Thieken 2009). Thus, preparedness was on a low level. Authorities learned due to the extreme flood in 2002, and many governmental flood risk programs and initiatives were launched (DKKV 2003; Kreibich and Thieken 2009). Learning due to the focussing event in the commercial and private sector was additionally supported by these governmental initiatives. Thus, preparedness improved significantly: A high percentage of the private households adopted precautionary measures after

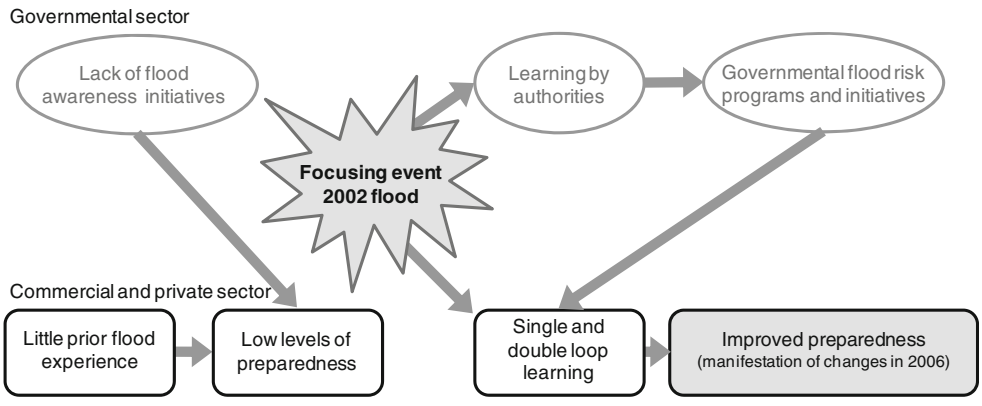


**Fig. 5** Sketch of the changes due to the 2002 flood as focusing event

the extreme flood in 2002 and were prepared for emergency actions before the flood in 2006. Often double-loop learning occurred because people accepted that flood protection was not only an official, but also a private duty. Also, many businesses acted after the extreme flood. However, 29% of the businesses still had not taken any precautionary measures to reduce damage before the flood in 2006. Perhaps the diversity of responsibilities in businesses and the institutional structure create hurdles to achieve deuteron learning. Other more immediate problems dominate the management agenda of businesses after any disastrous event, such as restoring the means of production and managing the economic consequences of the situation. This speaks to the focusing event theory that suggests that policy makers lose sight of the necessity for long-term planning as they move farther away from the event itself. After immediate short-term initiatives have been undertaken, the long-term implications are not as critical to the organisation. We also find, especially in larger businesses, that there is a difference between the workers, who learned during the disaster how to reduce damage, and the management, who focuses on the financial impact. The question here is 'Is there a deuteron learning system within the organisation which enables the exchange of information between the different hierarchical levels?'

A second reason why businesses may choose not to execute precautionary measures is the level of uncertainty regarding which actions are most cost-effective and will provide significant damage reduction. Businesses as well as private households have to decide which goods or processes are highly vulnerable to flooding and if there are means available to protect them. This task is much more complicated for businesses due to different loss types (direct and indirect losses) and the interdependence between different processes. Thus, every business has to develop its own plan and identify the most suitable precautionary and emergency measures. The high potential for such plans is illustrated in Sect. 4.3. For example, moving vehicles to a flood-safe place, a relatively low-cost measure, was utilised twice as often during the 2006 flood than in 2002 (Fig. 4).

From a public perspective, the relatively low level of preparedness found in the businesses is a serious problem. Businesses may suffer losses from flooding which lead to economic and job losses, in addition to the possible environmental risk if a business handles toxic or hazardous substances. There are two possible ways for the government to address this problem:

1. Regulatory programs—In Bavaria, for example, the water law (Bayerisches Wassergesetz (BayWG)) allows district offices to prohibit the location of oil tanks which are not flood-proof within the 100-year flood zone.
2. Encouragement of deuteron learning within businesses—Businesses should be encouraged to introduce management systems which address not only work safety but also protection against natural hazards. The ISO 9000 (quality management) or ISO 14000 (environmental management) standards (ISO 2008) could serve as models for such an encouragement. Neither are technological standards but rather promote effective risk management systems. Within such a system, a deuteron learning process should be initiated, in order to reduce the vulnerability of businesses over the long term.

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