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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 an 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

1 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

49 catchments led to €11600 million losses in Germany (Kron 2004). It is expected that flood risk
50 will continue to rise in response to a combination of a changing climate (e.g. Kundzewicz et al.
51 2005) and an increase in vulnerability, e.g. due to increasing flood plain occupancy, and changes
52 in the terrestrial system, e.g. land cover changes, and river regulation. One important factor in the
53 rise in flood losses is increased residential and economic development in flood prone areas. In
54 industrialised countries, this trend is due to relatively low prices for land, good transport
55 infrastructure, and the proximity of urban development to areas at risk for flooding. For instance,
56 in Germany, communities with more than 5000 citizens are twice as likely to be located near a
57 river (Borchert 1992).
58 In many regions, climate change is also expected to increase flood losses. The 2002 flood in the
59 Elbe and Danube catchments led to a lively debate about climate change and river flooding in
60 Germany. For the river Elbe, a decrease in winter floods was found in an analysis of the long
61 discharge record at the Dresden gauge by Mudelsee et al. (2003; 2004), while summer floods
62 showed no trend at all. In a German-wide study, Petrow and Merz (2009) analyzed changes in
63 flood indicators for 145 catchments in Germany for the period 1951-2002. They detected
64 spatially and seasonally coherent trend patterns and suggested that the observed changes in flood
65 behaviour were climate-driven. Such data-based trend studies are complemented by simulation
66 studies based on (global and regional) climate models and hydrological models. For example, an
67 investigation in England and Wales expects a 20 fold increase in the real economic flood risk by
68 the year 2080, if present flood policies and practices are not improved significantly (Hall et al.
69 2005). However, simulation studies are still associated with high uncertainty (e.g. Dankers and
70 Feyen 2008) and lead to regionally differentiated results: They depend on the chosen climate
71 scenarios, the type of models used (e.g. GCM, downscaling method, hydrological model), the
72 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; 1997b; 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 mobilization 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 organizations 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.

121 According to the broader literature on flooding, focusing events have induced limited policy
122 learning, as even after the Great Flood of 1993 in the United States, an increased amount of land
123 in floodplains was developed and more and more people and infrastructure were placed in harm's
124 way (Pinter 2005). However, there are also success stories, for example, Fort Collins, Colorado,
125 where the changes in the city's preparedness infrastructure undertaken after the 1997 flood were
126 very effective during a flood in 1999 (Weaver et al. 2000). Learning from histories of flood risk
127 by local jurisdictions in Florida was revealed by a study investigating mitigation activities under
128 the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS) from
129 1999 to 2005 (Brody et al. 2009).
130 In Germany, many programs and initiatives were launched in the aftermath of the severe flood in
131 August 2002 in order to improve the German flood risk management (see e.g. DKKV 2003). For
132 instance, many federal states, regardless of whether they were affected by the 2002 flood, began
133 development of state-wide flood hazard maps (e.g., Rheinland-Pfalz 2004; Sachsen 2004; Bayern
134 2005; Baden-Württemberg 2005). In the federal state of Saxony, flood management concepts for
135 47 catchments were developed. The municipal authorities in Dresden developed a new flood
136 management concept and substantially improved their emergency management system (Kreibich
137 and Thieken 2009). Additionally, many initiatives were introduced to improve the flood warning
138 system (Thieken et al. 2005a; Kreibich et al. 2007).
139 All these activities directly or indirectly influence the flood preparedness of private households
140 and businesses, e.g. hazard maps should improve the risk awareness and support behavioural
141 precaution. An improved, more detailed early warning should enable more effective emergency
142 measures. Governmental authorities were not alone in reacting to this extreme flood event: e.g.
143 the insurance industry changed its risk assessment policy (Thieken et al. 2006).
144 So far, few studies have used the focusing event framework to analyze the response of the

commercial or private sector to disasters. However, extreme event studies point to our limited understanding regarding organizational issues, in particular the tradeoffs 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.

2 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 1000-year event and assume that the measured discharge of 4580 $m^3 s^{-1}$ 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 €8700 million, followed by Saxony-Anhalt (€1187 million) and Bavaria (€198 million) (data from SSK 2004; IKSE 2004; Bavarian Ministry of Finance personal communication). Altogether, about €11600 million damage was caused in Germany.

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 one 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

193 situation changed further downstream (Fig. 1). Since no levee breaches occurred in the upper and
194 middle reaches of the Elbe River and since the retention areas at the Havel confluence were not
195 activated, the flood situation downstream of the Havel confluence was comparable to, or even
196 worse, than 2002. In 2006, the flood discharge of 3600 $m^3 s^{-1}$ was the second highest in 100 years
197 at the Neu Darchau gauge and exceeded the 2002 flood discharge of 3400 $m^3 s^{-1}$ (BfG 2006).
198 Although no official figures are available, it is estimated that the total damage in 2006 was
199 considerably lower than in 2002.
200

201 **3 Data and methods**

202 Telephone interviews with private households and businesses were undertaken after the flood in
203 2002 and again after the flood in 2006 in the Elbe and Danube catchments in Germany (Kreibich
204 et al. 2007; Thieken et al. 2007; Kreibich and Thieken 2009). Lists of all affected streets were
205 compiled with the help of flood masks derived from radar satellite data (DLR, Center for Satellite
206 Based Crisis information, www.zki.caf.dlr.de), and official data (e.g. reports, press releases). On
207 this basis, building specific random samples of private households and businesses were
208 generated. Computer-aided telephone interviews were undertaken with the VOXCO software
209 package (www.voxco.com). The SOKO institute for social research and communication
210 (www.soko-institut.de) interviewed private households in April and May 2003 and businesses in
211 October 2003, May 2004 and October 2006. The Explorare institute for marketing research
212 (www.explorare.de) interviewed private households in November and December 2006. In all
213 polls, the individual with the best knowledge of the flood damage was interviewed. The surveys
214 after the 2002 flood resulted in 1697 completed interviews with private households and 415
215 completed interviews with businesses. The surveying in 2006 resulted in 461 interviews with
216 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 (geo-coding) 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).

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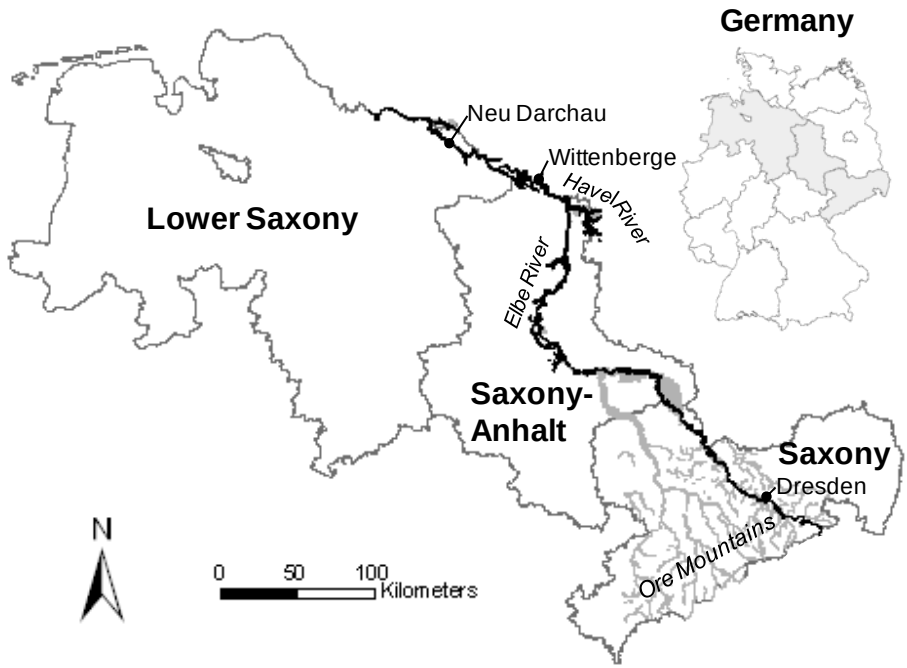

242

243 Fig. 1. Research area in the three federal states Lower Saxony, Saxony-Anhalt and Saxony in
244 Germany. Flooded area in 2002 (grey area) and 2006 (black area)[1].

245

246 **4 Results and discussion**

247 **4.1 Flood experience and risk awareness**

248 The private households and businesses surveyed had hardly any flood experience before August
249 2002, which is consistent with the results for the city of Dresden and for the entire Elbe
250 catchment (Kreibich et al. 2005a; 2005b; Kreibich and Thieken 2009). Only 6% of the
251 households had flood experience and only 0.4% had a flood loss of >1000 € before August 2002
252 (Table 1). Their last experienced flood before August 2002 was on average 23 years ago.

[1] Data sources of Fig. 1: 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

253 Eighteen percent of the businesses had flood experience, which was on average 45 years ago.
254 However, the situation was significantly different in 2006: in this sub-dataset, 90% of the
255 households and 89% of the businesses had recent flood experiences (Table 1). Flood experience
256 is a significant factor for learning steps to undertake precautionary measures and thus for flood
257 loss mitigation (Kreibich et al. 2005a; 2005b; Grothmann and Reusswig 2006; Siegrist and
258 Gutscher 2006; 2008; Thieken et al. 2007). It has also been shown before that relatively recent
259 flood experience supports effective emergency measures (Burn 1999; Yeo 2002), and that
260 damage is effectively reduced where people have frequently and recently experienced flooding
261 (Smith 1981; Wind et al. 1999).
262 Besides flood experience, the knowledge that one lives in a flood prone area seems to influence
263 decisions on the implementation of precautionary measures (Kreibich et al. 2005b). In the
264 samples under study, flood risk awareness was low in August 2002: Only 33% of the households
265 and 30% of the businesses who had no prior flood experience knew that their building was
266 located in a flood prone area. In contrast, in 2006 most of the private households and businesses
267 without previous flood experience knew that their building was located in a flood prone area
268 (64% and 75%, respectively). It can only be speculated that this increase in risk awareness may
269 also be due to the improved availability of flood hazard maps e.g. in the federal state of Saxony
270 (Sachsen 2004).
271 The percentage of households and businesses who perceived a recurrence of flooding to be very
272 likely increased significantly from 14% in 2002 to 69% in 2006 and from 28% in 2002 to 75% in
273 2006, respectively (Table 1). This might be due to the exceptionally extreme event in 2002,
274 which was perceived as a singular event, in contrast to the 2006 flood. Kreibich et al. (2005b)
275 noted that estimates about the probability of being affected by a flood again in the future did not
276 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 which influences the learning process of private households to undertake precautionary measures 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.

Table 1: State of flood risk awareness in 2002 and 2006 (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; n.r. = not retrieved).

	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 >1000 € [%]	0.4*	64*	n.r.	n.r.
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*	n.r.	n.r.

4.2 Precautionary measures undertaken

310 Precautionary measures can be divided in three groups according to the costs involved and the
311 planning and maintenance efforts (Fig. 2 and 3). Low-cost measures cost little and are easy to
312 perform. Medium-cost measures are more costly but no substantial changes to buildings or
313 equipment are necessary. In contrast, high-cost measures depend on reconstruction of buildings
314 or equipment. According to Preisendörfer (1999), this classification of measures as low-cost,
315 medium-cost or high-cost may be used to explain different types of environmental protection
316 actions. Preisdörfers low-cost hypothesis says that the frequency of positive environmental
317 behaviour correlates negatively with its costs (effort, difficulty). Environmental attitudes are less
318 important for environmental behaviour than its costs. Adapted to flood preparedness the low-cost
319 hypothesis says that people are willing to improve their flood preparedness depending on the
320 costs of the measures. For instance, Florida's localities pursue a form of least-cost learning from
321 flood risk, since they disproportionately select mitigation measures that are less expensive and
322 more politically viable (Brody et al. 2009).
323 Before the 2002 flood, most interviewed private households relied on flood insurance for
324 compensation of flood losses (Fig. 2), a measure that is considered medium-cost. Similar results
325 were found in surveys of larger parts of the Elbe catchment and its tributaries (Kreibich et al.
326 2005b, Thieken et al., 2007). This may have a historical basis, as in the former German
327 Democratic Republic flood insurance was generally included in the household insurance and
328 many residents of Eastern Germany still have comparable contracts (Thieken et al. 2006).
329 Typical low-cost measures are the next most prevalent precautionary measures: 30% of the
330 interviewees mentioned that they gathered information about precautionary measures to protect
331 their house or flat, 24% joined neighbourhood flood networks and 12% adapted their building
332 use, which means that they prevented losses by situating low-value uses in flood prone stories or
333 areas. Thieken et al. (2007) found that this preference for low-cost measures also existed among

334 private households in the Danube catchment. Medium-cost measures, besides flood insurance, are
335 flood adapted interior fitting and shielding with water barriers, which were performed by 10%
336 and 5% of the private households, respectively. High-cost measures were seldom implemented
337 (Fig. 2).
338 Overall, 30% of the households surveyed had undertaken no precautionary measures prior to the
339 2002 flood, while less than 1% of the households reported seven or more implemented
340 precautionary measures (Tab. 2). By 2006 the percentage of households that had implemented no
341 precautionary measures fell to below 10%, with many households implementing two or more
342 precautionary measures (Tab. 2). In detail, in 2006 more than twice as many private households
343 had gathered information on possible precautionary measures, twice as many households had
344 joined neighbourhood flood networks, and more than three times as many private households had
345 adapted the use of their building, compared to before the 2002 flood (Fig. 2). These low-cost
346 measures together with the medium-cost measure of an adapted interior fitting, clearly dominate
347 the overall precautionary behaviours. However, compared with 2002, also the percentage of
348 households who utilized building measures to protect their homes increased until 2006 (Fig. 2).
349 These results show that flood experience and learning processes initiated by a focusing event can
350 induce some householders to use high-cost precautionary measures. The comparison of a sample
351 of private households in the Elbe area with little flood experience and households in the Danube
352 area having more flood experience revealed the same findings: respondents in the sample with
353 greater flood experience reported a higher rate of sealed cellars and greater avoidance of oil
354 heatings (Thieken et al. 2007).
355 The percentage of private households covered by flood insurance decreased slightly from 49% in
356 2002 to 43% in 2006. This may be due to the increased efforts insurance companies put into risk
357 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.

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

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

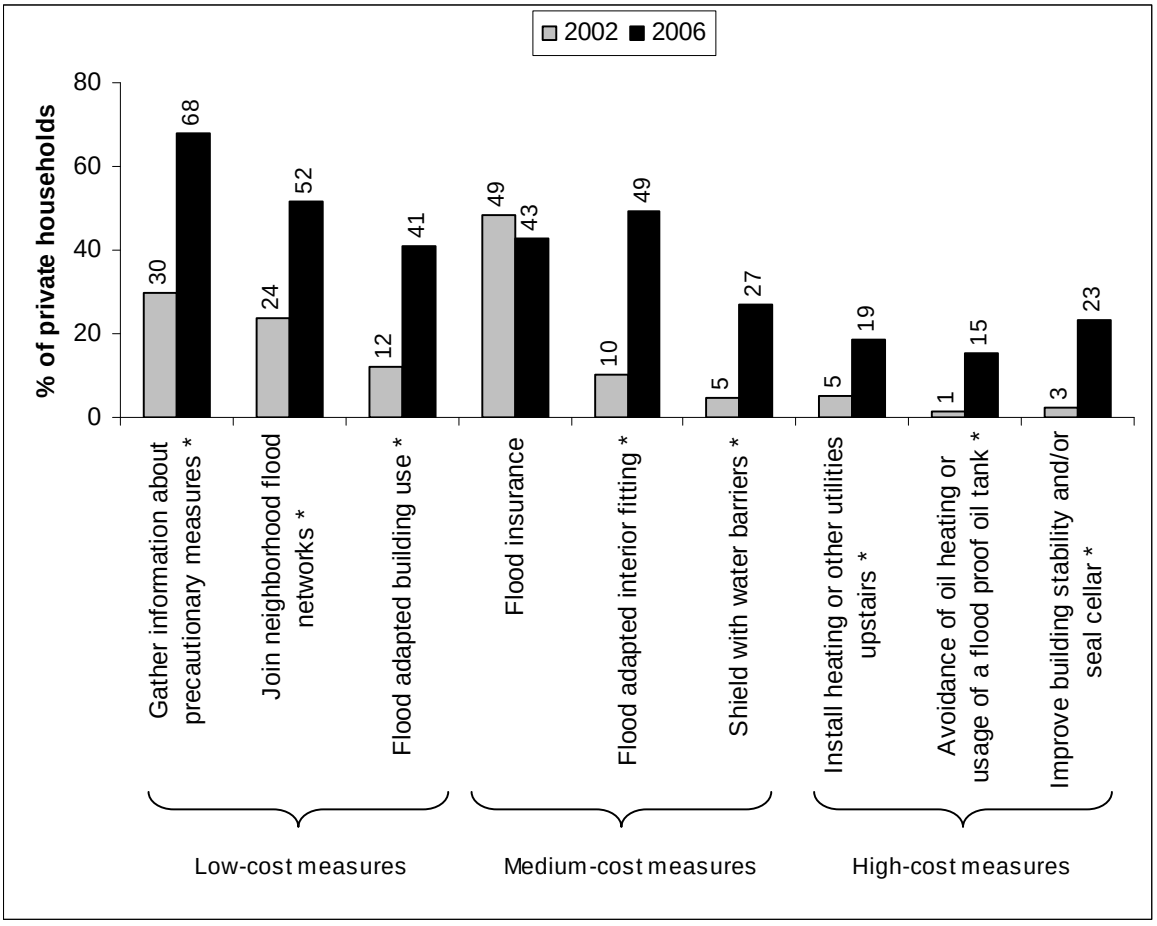

Figure 2. Percentage of private households who had undertaken different types of precautionary measures, before the floods in 2002 and 2006, respectively (investigated private households 2002 n = 235, 2006 n = 112; measures marked with a * show a significant difference ($p<0.05$) between 2002 and 2006,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

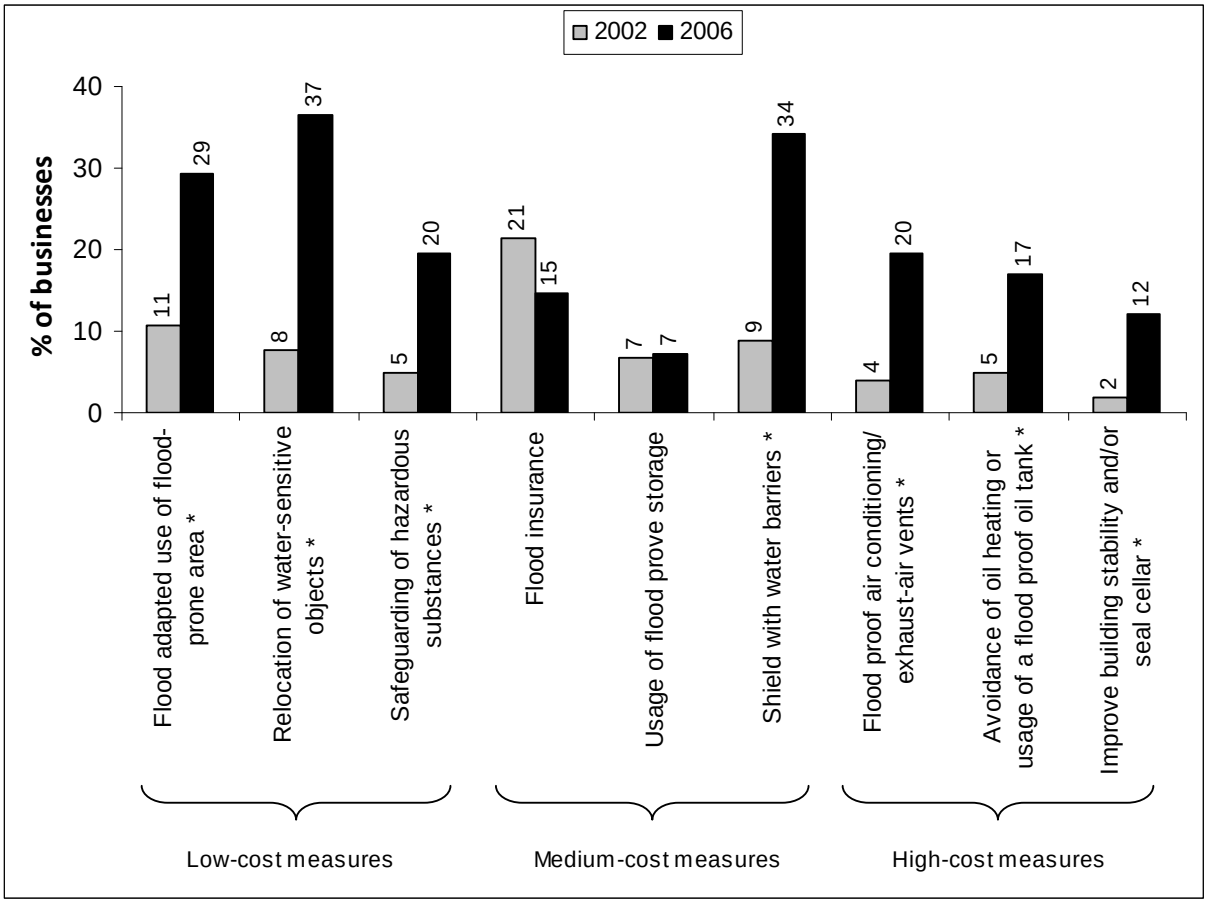

Figure 3. Percentage of businesses who had undertaken different types of precautionary measures, before the floods in 2002 and 2006, respectively (investigated businesses 2002 n = 103, 2006 n = 41; measures marked with a * show a significant difference ($p<0.05$) between 2002 and 2006, multiple answers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

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 percent 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 (Tab. 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 (Tab. 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 to 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.

419

420 **4.3 Emergency measures undertaken**

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

429 In contrast to the 2002 flood, more households and businesses were knowledgeable about what
430 actions to take when they received warning of impending flooding in 2006 (Table 3). The
431 percentage of businesses with an emergency plan in place increased significantly from 9% in
432 2002 to 24% in 2006. The percentage of businesses that had undertaken emergency exercises
433 before remained on an insignificant low level of 2-5%, i.e. only two businesses for both flood
434 events (Table 3).

435

436 Table 3 Early warning and knowledge about or preparation for emergency measures (investigated
437 private households 2002 n = 235, 2006 n = 112; investigated businesses 2002 n = 103, 2006 n =
438 41; * significant difference ($p<0.05$) between 2002 and 2006; n.r. = not retrieved).

	Private households		Businesses	
	2002	2006	2002	2006
Percentage of households/businesses that	12	13	24	12

received no warning [%]				
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*	n.r.	n.r.
Percentage of businesses with an emergency plan in place [%]	n.r.	n.r.	9*	24*
Percentage of businesses that had undertaken emergency exercises before [%]	n.r.	n.r.	2	5

439

440 The main aim of emergency measures is the safeguarding of contents, equipment, goods,
441 products or stock, which might be achieved by moving them to flood-safe areas like higher
442 stories or by using water barriers which prevent the water from entering the building. The
443 percentage of private households and businesses who undertook emergency measures, the
444 average number of people involved and the resulting mitigation costs for businesses showed no
445 significant difference between the 2002 flood and the 2006 flood (Table 4). The average time
446 households and businesses spent on implementing emergency measures was significantly higher
447 in 2006 than in 2002 (Table 4). This might be largely due to the fact that a significantly higher
448 percentage of households was better informed about what to do when they received advance
449 warning of the flood in 2006; in addition, in 2006 a significantly higher percentage of businesses
450 had emergency plans in place (Table 3). The types of emergency measures undertaken in 2002
451 and 2006 were similar (Figure 4).
452 Since types of emergency measures (Figure 4) and people involved as well as costs (Table 4)
453 were similar during both events, it is particularly interesting that the effectiveness of emergency

454 measures significantly increased from 2002 to 2006. The percentage of private households
455 effectively protecting household contents and preventing water from entering buildings increased
456 considerably, from 51% in 2002 to 92% in 2006, and from 16% in 2002 to 59% in 2006,
457 respectively (Table 4). The percentage of businesses effectively protecting their equipment,
458 goods, products and stock also increased significantly (Table 4). Thieken et al. (2007) found that
459 in the flood of 2002 the better informed people were, the more success they had with emergency
460 measures. Businesses faced with a flooding situation undertook emergency measures more
461 effectively when an emergency plan was in place (Kreibich et al. 2007). In addition, warnings,
462 particularly those issued by authorities, and relatively long lead times, were also factors for an
463 effective implementation of emergency measures by businesses (Kreibich et al. 2007). However,
464 the effectiveness of emergency measures is hampered by high flood impacts, e.g. by high water
465 levels (Thieken et al. 2007). Therefore, it is unclear whether the significant increases in the
466 effectiveness of emergency measures seen in 2006 are due to improved coping capacities of
467 households and businesses or to lower flood impacts in 2006, but both factors may play a part.
468 Effective emergency measures are able to mitigate flood losses significantly in both, private
469 households (see Thieken et al. 2005b) and businesses. For instance, Kreibich et al. (2007) showed
470 that businesses that successfully protected their goods, products or stock achieved a significant
471 damage reduction by 52% on average and that successfully saving equipment led to an average
472 decrease of damage to equipment by 28%. The ICPR (2002) presumes a 50-75% cutback of
473 damage due to the implementation of emergency measures in industry and trade.
474
475 Table 4 Effort for and effectiveness of emergency measures undertaken by private households
476 (2002 n = 235, 2006 n = 112) and businesses (2002 n = 103, 2006 n = 41), (* significant
477 difference ($p<0.05$) between 2002 and 2006; n.r. = not retrieved).

	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 [1000 €]	n.r.	n.r.	5	9
Percentage of households that effectively saved their contents [%]	51*	92*	n.r.	n.r.
Percentage of households that effectively prevented water entering the building [%]	16*	59*	n.r.	n.r.
Percentage of businesses that effectively saved their equipment [%]	n.r.	n.r.	36*	76*
Percentage of businesses that effectively saved their goods/products/stock [%]	n.r.	n.r.	41*	77*

478

479

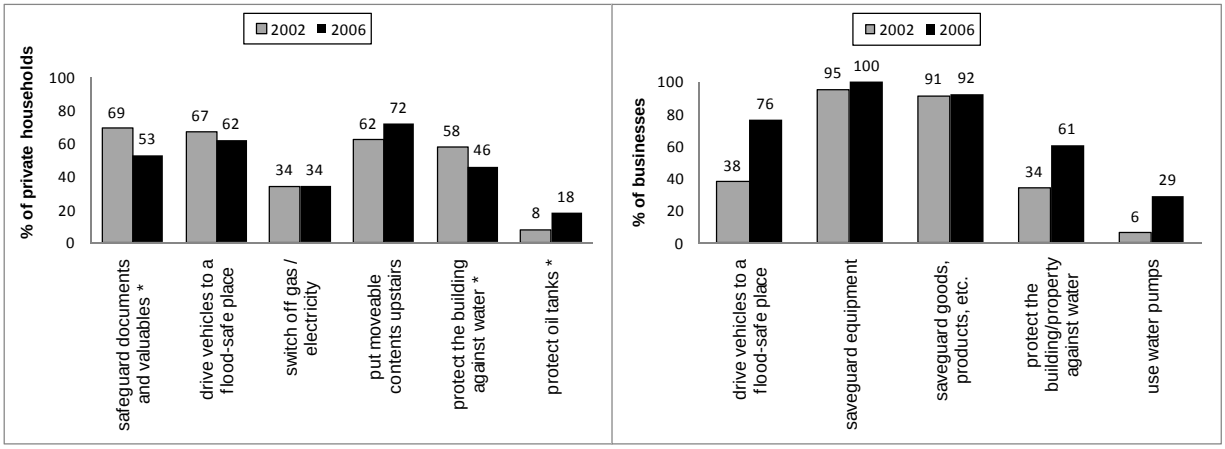

Figure 4 Percentage of private households (left) and businesses (right) implementing different types of emergency measures during the flood in 2002 and 2006, respectively (investigated private households 2002 n = 235, 2006 n = 112; investigated businesses 2002 n = 103, 2006 n = 41; measures marked with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

5 Conclusions

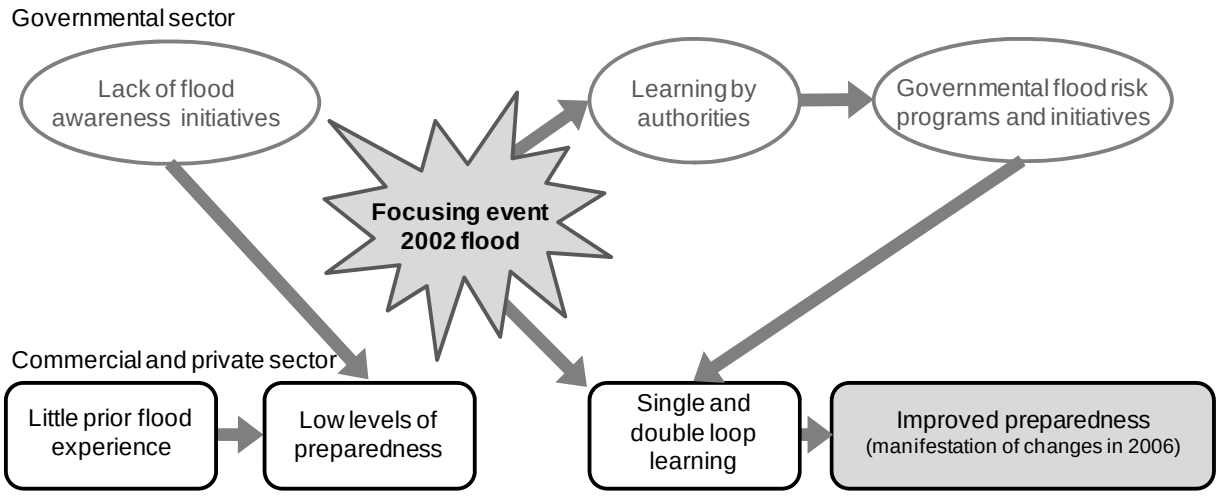

Figure 5 Sketch of the changes due to the 2002 flood as focusing event

The focusing event perspective enables a differentiated analysis of the aspects of learning due to

492 a disaster. Figure 5 visualises recent changes in flood preparedness among private households
493 and businesses due to the 2002 flood in Germany from a focusing event perspective. Private
494 households, businesses as well as authorities were hardly aware of the flood risk in the Elbe
495 catchment before 2002, due to a lack of flood experience (Kreibich et al. 2005b; Kreibich et al.
496 2007; Kreibich and Thieken 2009). Thus, preparedness was on a low level. Authorities learned
497 due to the extreme flood in 2002, and many governmental flood risk programs and initiatives
498 were launched (DKKV 2003; Kreibich and Thieken 2009). Learning due to the focussing event in
499 the commercial and private sector was additionally supported by these governmental initiatives.
500 Thus, preparedness improved significantly: A high percentage of the private households adopted
501 precautionary measures after the extreme flood in 2002 and were prepared for emergency actions
502 before the flood in 2006. Often double loop learning occurred because people accepted that flood
503 protection was not only an official, but also a private duty. Also many businesses acted after the
504 extreme flood. However, 29% of the businesses still had not taken any precautionary measures to
505 reduce damage before the flood in 2006. Perhaps the diversity of responsibilities in businesses
506 and the institutional structure create hurdles to achieve deuteron learning. Other, more immediate
507 problems dominate the management agenda of businesses after any disastrous event, such as
508 restoring the means of production and managing the economic consequences of the situation.
509 This speaks to the focusing event theory that suggests that policy makers lose sight of the
510 necessity for long term planning as they move farther away from the event itself. After immediate
511 short term initiatives have been undertaken, the long term implications are not as critical to the
512 organization. We also find, especially in larger businesses, that there is a difference between the
513 workers, who learned during the disaster how to reduce damage, and the management, who
514 focuses on the financial impact. The question here is: is there a deuteron learning system within
515 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 section 4.3. For example, moving vehicles to a flood-safe place, a relatively low-cost measure, was utilized 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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References

Argyris C, Schön DA (1978) Organizational learning. A theory of action perspective. Addison-Wesley, Reading, Mass

Argyris C, Schön DA (1996) Organizational learning II. Theory, method, and practice. Addison-Wesley, Reading, Mass

Baden-Württemberg (2005) Hochwassergefahrenkarte Baden-Württemberg. Umweltministerium Baden-Württemberg, Stuttgart (http://www.hochwasser.baden-wuerttemberg.de)

Barker K, Haimes YY (2009) Assessing uncertainty in extreme events: Applications to risk-based decision making in interdependent infrastructure sectors. Reliability Engineering & System Safety 94(4): 819-829

Bayern (2005) Informationsdienst Überschwemmungsgefährdete Gebiete in Bayern. Bayerisches Landesamt für Wasserwirtschaft, München (http://www.geodaten.bayern.de/bayernviewer-aqua/)

562 Becker A, Grünewald U (2003) Flood Risk in Central Europe. Science 300(5623): 1099. DOI:
563 10.1126/science.1083624

564 BfG (Bundesanstalt für Gewässerkunde) (2002) Das Augusthochwasser 2002 im Elbegebiet.
565 BfG, Koblenz, Germany

566 BfG (Bundesanstalt für Gewässerkunde) (2006) Das Hochwasser der Elbe im Frühjahr 2006.
567 BfG-1514, Koblenz, Germany

568 Birkland TA (1997a) After Disaster: Agenda Setting, Public Policy and Focusing Events.
569 Washington D.C., Georgetown University Press

570 Birkland TA (1997b) Factors Inhibiting a National Hurricane Policy. Coastal Management 25(4):
571 387-403

572 Birkland TA (1998) Focusing Events, Mobilization, and Agenda Setting. Journal of Public Policy
573 18(3): 53-74

574 Birkland TA (2004) 'The World Changed Today': Agenda Setting and Policy Change in the Wake
575 of September 11 Terrorist Attacks. Review of Policy Research 21(2): 179-200

576 Birkland TA (2006) Lessons of disaster: policy change after catastrophic events. Washington
577 D.C., Georgetown University Press

578 Boorman DB, Sefton CEM (1997) Recognising the uncertainty in the quantification of the effects
579 of climate change on hydrological response. Climatic Change 35(4): 415-434

580 Borchert J (1992) Flusskorridore als überregionale Verbundstrukturen. Natur und Landschaft
581 67(9): 413-418

582 Brody SD, Zahran S, Highfield WE, Bernhardt SP, Vedlitz A (2009) Policy Learning for Flood
583 Mitigation: A Longitudinal Assessment of the Community Rating System in Florida. Risk
584 Analysis 29(6): 912-929

585 Buchta R (2003) Hochwasserschutz und Landnutzung in der Unternen Havelniederung –
586 Schlussfolgerungen aus dem Elbe-Hochwasser vom August 2002. Naturschutz und
587 Landschaftspflege in Brandenburg 3

588 Burn DH (1999) Perception of flood risk: A case study of the Red River flood of 1997. Water
589 Resour Res 35: 3451– 3458

590 Dankers R, Feyen L (2008) Climate change impact on flood hazard in Europe: An assessment
591 based on high-resolution climate simulations. JGR 113, D19105

592 DKKV (Deutsches Komitee für Katastrophenvorsorge) (2003) Hochwasservorsorge in
593 Deutschland - Lernen aus der Katastrophe 2002 im Elbegebiet. Schriftenreihe des DKKV
594 29, Lessons Learned, DKKV, Bonn, Germany

595 Engel H (2004) The flood event 2002 in the Elbe river basin: causes of the flood, its course,
596 statistical assessment and flood damages. Houille Blanche 6: 33-36

597 Grothmann T, Reusswig F (2006) People at risk of flooding: Why some residents take
598 precautionary action while others do not. Natural Hazards 38(1-2): 101-120

599 Grünewald U (2006) Extreme hydro(meteoro)logical Events in the Elbe Basin. (in German)
600 Österr Wasser- und Abfallwirtschaft 58(3-4): 27-34

601 Hagemeier-Klose M, Wagner K (2009) Evaluation of flood hazard maps in print and web
602 mapping services as information tools in flood risk communication. NHESS 9(2): 563-574

603 Hall JW, Sayers PB, Dawson RJ (2005) National-scale Assessment of Current and Future Flood
604 Risk in England and Wales. Natural Hazards 36: 147-164

605 Hayes BD (2004) Interdisciplinary planning of non-structural flood hazard mitigation. J Water
606 Resour Plann Manage 130: 15-25

607 ICPR (International Commission for the Protection of the Rhine) (2002) Non structural flood
608 plain management - measures and their effectiveness. ICPR, Koblenz, Germany

609 IKSE (International Commission for the Protection of the Elbe) (2004) Dokumentation des
610 Hochwassers vom August 2002 im Einzugsgebiet der Elbe. Report Magdeburg, IKSE,
611 Magdeburg, Germany

612 ISDR (International Strategy for Disaster Reduction) (2004) Terminology: Basic terms of disaster
613 risk reduction. www.unisdr.org/eng/library/lib-terminology-eng home.htm (last accessed
614 2nd July 2009)

615 ISO (International Organization for Standardization) (2008) ISO 9000 and ISO 14000.
616 (http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000.htm)

617 Kingdon JW (1995) Agendas, Alternatives, and Public Policies, 2nd ed. New York, Harper
618 Collins College

619 Kreibich H, Thieken AH (2009) Coping with floods in the city of Dresden, Germany. Natural
620 Hazards, 51(3): 423-436

621 Kreibich H, Petrow T, Thieken AH, Müller M, Merz B (2005a) Consequences of the extreme
622 flood event of August 2002 in the city of Dresden (Germany). In: Savic DA, Marino MA,
623 Savenije HHG, Bertoni JC (eds.): Sustainable Water Management Solutions for Large
624 Cities, IAHS red book publ. 293: 164-173

625 Kreibich H, Thieken AH, Petrow T, Müller M, Merz B (2005b) Flood loss reduction of private
626 households due to building precautionary measures - Lessons Learned from the Elbe flood
627 in August 2002. NHESS 5: 117-126

628 Kreibich H, Thieken AH, Müller M, Merz B (2005c) Precautionary measures reduce flood losses
629 of households and companies - Insights from the 2002 flood in Saxony, Germany, in van
630 Alphen J, Beek E, Taal M (eds.) Floods, From Defence to Management pp. 851–859,
631 Taylor and Francis, Philadelphia, Pa

632 Kreibich H, Müller M, Thieken AH, Merz B (2007) Flood precaution of companies and their
633 ability to cope with the flood in August 2002 in Saxony, Germany, Water Resour Res, 43,
634 W03408, doi:10.1029/2005WR004691

635 Kron W (2004) Zunehmende Überschwemmungsschäden: Eine Gefahr für die
636 Versicherungswirtschaft? ATV-DVWK: Bundestagung 15.-16.09.2004 in Würzburg,
637 DCM, Meckenheim, 47-63

638 Kundzewicz ZW, Ulbrich U, Brücher T, Graczyk D, Krüger A, Leckebusch GC, Menzel L,
639 Pinskwar I, Radziejewski M, Szwed M (2005) Summer floods in Central Europe – Climate
640 Change Track? Natural Hazards 36: 165-189

641 McDaniels T, Chang S, Cole D, Mikawoz J, Longstaff H (2008) Fostering resilience to extreme
642 events within infrastructure systems: Characterizing decision contexts for mitigation and
643 adaptation. Glob Environ Change - Human Policy Dimens 18(2): 310-318

644 Mudelsee M, Börngen M, Tetzlaff G, Grünewald U (2003) No upward trends in the occurrence
645 of extreme floods in central Europe. Nature 425: 166-169

646 Mudelsee M, Börngen M, Tetzlaff G, Grünewald U (2004) Extreme floods in Central Europe
647 over the past 500 years: Role of cyclone pathway „Zugstrasse Vb“. J Geophys Res 109:
648 D23101.

649 Munich Re (1997) Flooding and insurance. Munich Re Group, Munich

650 Munich Re (2004) TOPICSgeo - Natural catastrophes 2003. Munich Re Group, Munich

651 Norušis MJ (2002) SPSS 11.0 Guide to Data Analysis. Prentice Hall, Upper Saddle River, USA

652 Petrow T, Merz B (2009) Trends in flood magnitude, frequency and seasonality in Germany in
653 the period 1951–2002. J Hydrol 371: 129-141

654 Petrow T, Thieken AH, Kreibich H, Bahlburg CH, Merz B (2006) Land use planning as a
655 measure of flood risk management-Lessons Learned from the Elbe flood in August 2002 in
656 Germany. Environ Manage 38(5): 717–732

657 Pinter N (2005) One Step Forward, Two Steps Back on U.S. Floodplains. Science 308(5719):
658 207-208

659 Pohl R (2007) Auswertung von Wasserspiegellagenberechnungen mit historischen Datensätzen
660 für die Hochwasseranalyse. Wasserwirtschaft 5: 16-20

661 Preisendörfer P (1999) Umwelteinstellungen und Umweltverhalten in Deutschland. Opladen,
662 Leske & Budrich

663 Rheinland-Pfalz (2004) Grenzüberschreitender Atlas der Überschwemmungsgebiete im
664 Einzugsgebiet der Mosel. Struktur- und Genehmigungsdirektion Nord, Regionalstelle für
665 Wasserwirtschaft, Abfallwirtschaft, Bodenschutz Trier, (http://www.gefahrenatlas-
666 mosel.de)

667 Sachsen (2004) Gefahrenhinweiskarte Sachsen. Sächsisches Landesamt für Umwelt und
668 Geologie, Dresden (www.umwelt.sachsen.de/de/wu/umwelt/lfug/lfug-
669 internet/interaktive_karten_10950. html)

670 Siegrist M, Gutscher H (2006) Flooding Risks: A Comparison of Lay People's Perceptions and
671 Expert's Assessments in Switzerland. Risk Analysis 26(4): 971-979

672 Siegrist M, Gutscher H (2008) Natural hazards and Motivation for Mitigation Behavior: People
673 Cannot Predict the Affect Evoked by a Severe Flood. Risk Analysis 28(3): 771-778

674 Smith DI (1981) Actual and potential flood damage: a case study for urban Lismore, NSW,
675 Australia. Appl Geography 1: 31–39

676 SSK (Sächsische Staatskanzlei) (2004) Der Stand des Wiederaufbaus. Materialien zur Kabinetts-
677 Pressekonferenz (3 February 2004, Dresden)

678 Thieken AH, Grünewald U, Merz B, Petrow T, Schümberg S, Kreibich H, Streitz W, Kaltofen M
679 (2005a) Flood risk reduction in Germany after the Elbe 2002 flood: Aspects of hazard
680 mapping and early warning systems. In Proceedings of the International Conference
681 ‘‘Cartographic Cutting-Edge Technology for Natural Hazard Management,’’ Kartogr.
682 Bausteine, vol. 30, pp. 145– 156, Inst. für Kartogr., Dresden, Germany

683 Thieken AH, Müller M, Kreibich H, Merz B (2005b) Flood damage and influencing factors: New
684 insights from the August 2002 flood in Germany. Water Resour Res 41(12): W12430

685 Thieken AH, Petrow T, Kreibich H, Merz B (2006) Insurability and mitigation of flood losses in
686 private households in Germany. Risk Analysis 26(2): 383-395

687 Thieken AH, Kreibich H, Müller M, Merz B (2007) Coping with floods: Preparedness, response
688 and recovery of flood-affected residents in Germany in 2002. Hydrological Sciences
689 Journal 52(5): 1016-1037

690 Ulbrich U, Brücher T, Fink AH, Leckebusch GC, Krüger A, Pinto JG (2003) The central
691 European floods of August 2002: part 1 - Rainfall periods and flood development. Weather
692 58: 371–377

693 Umweltamt Dresden (2006) Bericht zum Frühjahrshochwasser 2006. Report of the Umweltamt
694 Dresden. Dresden, Germany

695 Umweltatlas (2002) Vorläufiges, fachlich ermitteltes Überschwemmungsgebiet der Elbe für ein
696 Hochwasser, das statistisch einmal in 100 Jahren auftritt, einschließlich des
697 Abflussbereiches. Sonderdruck Umweltatlas

698 Wagner K (2004) Naturgefahrenbewusstsein und -kommunikation am Beispiel von Sturzfluten
699 und Rutschungen in vier Gemeinden des bayerischen Alpenraums, Ph.D. thesis
700 (http://tumb1.biblio.tu-muenchen.de/publ/diss/ww/2004/wagner_k.html)

701 Weaver JF, Gruntfest E, Levy GM (2000) Two floods in Fort Collins, Colorado: Learning from a
702 Natural Disaster. Bulletin of the American Meteorological Society 81(10): 2359-2366

703 Wind HG, Nierop TM, de Blois CJ, de Kok JL (1999) Analysis of flood damages from the 1993
704 and 1995 Meuse floods. Water Res R 35(11): 3459–3465

705 Wynn P (2004) Potential common law liability for privately provided flood defences. Struct Surv
706 22: 110–113

707 Yeo SW (2002) Flooding in Australia: A review of events in 1998. Nat Hazards 25 : 177– 191