

Scotland's Rural College

## The impact of flood action groups on the uptake of flood management measures

Dittrich, R; Wreford, A; Butler, A; Moran, D

*Published in:*  
Climatic Change

*DOI:*  
[10.1007/s10584-016-1752-8](https://doi.org/10.1007/s10584-016-1752-8)

First published: 03/08/2016

*Document Version*  
Peer reviewed version

[Link to publication](#)

*Citation for pulished version (APA):*  
Dittrich, R., Wreford, A., Butler, A., & Moran, D. (2016). The impact of flood action groups on the uptake of flood management measures. *Climatic Change*, 138(3). <https://doi.org/10.1007/s10584-016-1752-8>

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# 1 The impact of flood action groups on the uptake of flood 2 management measures

3

4 Ruth Dittrich\*

5 SRUC, Land Economy, Environment and Society Research Group, Peter Wilson Building, West Mains  
6 Road, Edinburgh, EH9 3JG United Kingdom. Phone: tel +44 (0)131 535 4301

7 Email: Ruth.dittrich@sruc.ac.uk

8

9 Anita Wreford

10 SRUC, Land Economy, Environment and Society Research Group, Peter Wilson Building, West Mains  
11 Road, Edinburgh, EH9 3JG, United Kingdom

12 Email: anita.wreford@sruc.ac.uk;

13 Adam Butler

14 BioSS, James Clerk Maxwell Bldg, King's Buildings, Mayfield Rd, Edinburgh EH9 3JZ, United  
15 Kingdom

16 Email: adam.buttler@bioss.ac.uk;

17

18 Dominic Moran

19 SRUC, Land Economy, Environment and Society Research Group, Peter Wilson Building, West Mains  
20 Road, Edinburgh, EH9 3JG, United Kingdom

21 Email: dominic.moran@sruc.ac.uk

22

23 \* Corresponding author

## 24 Abstract

25 Household flood management measures can significantly reduce the risk from flooding.  
26 Understanding the factors that influence the uptake of measures has important implications for the  
27 design of measures to induce people to take charge of risk mitigation. We investigate the impact of  
28 flood action groups in communities in Scotland on the uptake of four measures: insurance, flood  
29 warnings, sandbags and floodgates applying regression analysis using a cross-sectional survey  
30 (n=124). The groups were formed in response to the threat from flooding in those communities, and  
31 offer information and training on household flood management measures. We use the theoretical  
32 framework of Protection Motivation Theory, and compare uptake of the measures before and after  
33 the foundation of the flood action groups, as well as in the near future. The models show positive  
34 adoption effects for flood warnings, floodgates and to an extent for insurance, and a positive  
35 correlation with increased confidence of implementing and belief in the effectiveness of the measures.  
36 The effect is significant if specific information on the measures was provided, indicating the  
37 importance of tailored content. We conclude that appropriately designed flood action groups can be a  
38 cost-effective way of increasing the uptake of household flood management measures.

## 39 1. Introduction

40 In Europe, storms and flooding are the most costly weather-related disasters, accounting for 77 %  
41 (€282bn in 2005 value) of economic losses due to extreme weather events between 1980 and 2006  
42 (CEA, 2007). Beyond the economic losses, the recovery stage for flood victims often has important  
43 repercussions on family, health and work situations. Climate change may increase the frequency of  
44 high impact events locally in the future (IPCC, 2012) and this may be exacerbated by development of  
45 housing in flood-prone areas (Bouwer et al., 2010) as well as impermeable surfaces such as streets and  
46 parking lots that increase runoff (Brattebo and Booth, 2003). Taking the described factors together,  
47 implementing adaptation measures against flooding should be considered in vulnerable areas. This  
48 may require public flood protection - for example through integrated flood management strategies on  
49 a national and international level (European Union, 2007, Scottish Government, 2009) - but also  
50 adaptation measures implemented by households and firms where flood risk cannot be eliminated  
51 due to budget limitations. Private flood protection measures can reduce flood damage significantly  
52 (ICPR, 2002, Kreibich et al., 2005), depending on the local conditions and the flood severity (Kreibich  
53 et al., 2015).

54 Yet practical experience suggests that households do not necessarily implement adaptation measures  
55 in order to increase their resilience to flooding (Kunreuther, 1996, Peek and Mileti, 2002, Bichard and  
56 Kazmierczak, 2012). Research addressing household decision-making on flood prevention provides  
57 limited insights into the communication of flood risk (Dawson et al., 2011, Meyer et al., 2012, Kellens  
58 et al., 2013). There are an increasing number of studies highlighting the role of psychological factors  
59 in private adaptation to flooding in addition to risk perception and socio-economic variables. One  
60 approach, known as Protection Motivation Theory (PMT), attempts to reflect the main cognitive  
61 processes leading to the motivation to take protective action.

62 PMT suggests that individuals' decisions to take action is influenced not only by their evaluation of  
63 the physical risk, but also by their beliefs regarding the cost and effectiveness of the measure, as well  
64 as their confidence in implementing it. Several studies have found PMT a suitable framework for  
65 exploring flood adaptation behaviour (Grothmann and Reusswig, 2006, Zaalberg et al., 2009, Bubeck  
66 et al., 2012b, Bubeck et al., 2013, Le Dang et al., 2014).

67 This study uses insights from PMT to explore the factors influencing the uptake of a range of  
68 household flood adaptation measures among 124 private households in Scotland. We add to the  
69 existing research by investigating the effect of flood action groups on uptake. These autonomous  
70 groups were founded in 2012 in small communities across Scotland with the aim of finding local

71 solutions to flood risk, and provide information and training on a number of flood-related issues. The  
72 flood action groups are self-relying and run by community members. We specifically explore whether  
73 the groups have a direct impact on uptake and on people's perceptions of the effectiveness of  
74 measures and their confidence in implementing them - which according to PMT play an important  
75 role in determining flood adaptation behaviour. Thus, if the existence of flood action groups is shown  
76 to influence adaptation behaviour, this may indicate an effective, low-cost and relatively simple way  
77 to promote private flood adaptation.

78 The remainder of the article is structured as follows. Section 2 reviews the theoretical framework and  
79 relevant literature. Section 3 describes the data and the statistical model. The results are presented in  
80 Section 4 followed by a discussion of the practical implications for encouraging households to  
81 implement private flood management measures.

## 82 **2. Protection motivation theory and literature review**

83 PMT (Rogers, 1975, Rogers, 1983) was originally developed for protective behaviour to health threats  
84 and has been successfully extended to other threats including natural hazards such as flooding.

85 The model distinguishes two cognitive steps to describe the decision process when individuals  
86 evaluate a threat and possible coping measures: 'threat appraisal' and 'coping appraisal'. The former  
87 includes perceived risk and fear and describes how threatened the individual feels by a specific  
88 danger. Coping appraisal focuses on possible responses to address the risk and can be divided into  
89 three components. (Rogers and Prentice-Dunn, 1997). First, 'response-efficacy' expresses how  
90 effectively the individual perceives the measure to reduce risk. 'Self-efficacy' describes whether the  
91 individual feels capable and confident to carry out the measure. Finally, 'response cost' refers to both  
92 the financial as well as the emotional cost of implementing the measure. Taken together, coping  
93 appraisal and threat appraisal influence the protection motivation of an individual, which is  
94 considered as the variable to induce, sustain and direct the activity of the individual to protect  
95 themselves (Maddux and Rogers, 1983). The responses can be both protective and non-protective.

96 Protective responses are those that reduce the threat and will be enacted if high risk perceptions  
97 coincide with a strong coping appraisal. The answers respondents give may be non-protective if high  
98 risk perceptions go together with low coping appraisals (Rippetoe and Rogers, 1987). Non-protective  
99 answers include wishful thinking, avoidance and denial.

100 Several empirical studies support the applicability of PMT to flooding: Grothmann and Reusswig

101 (2006) applied PMT to flood adaptation behaviour of private households in Germany showing a good  
102 fit in contrast to socio-economic variables. Bubeck et al. (2013) showed that coping appraisal is an  
103 important variable in terms of precautionary behaviour among flood-prone households along the  
104 river Rhine. In particular, response efficacy and self-efficacy contribute to the models of flood-  
105 adaptation behaviour. Similar results were found in other studies (Botzen et al., 2009, Terpstra et al.,  
106 2009, Botzen and van den Bergh, 2012) confirming the importance of the coping appraisal for  
107 adaptation intentions. Zaalberg et al. (2009) carried out a comparative study between flood victims  
108 and non-victims in the Netherlands, showing that exposure positively affects protective motivation  
109 for future flooding. In addition to the PMT variables, a number of other factors may influence uptake.  
110 These include flood experience (Grothmann and Patt, 2005, Kreibich et al., 2005, Siegrist and  
111 Gutscher, 2006) as well as social networks such as neighbours or friends having implemented  
112 measures (Bubeck et al., 2013), or public provision of flood risk adaptation measures inducing moral  
113 hazard (Le Dang et al., 2014).

114 A number of studies conclude that communication for flooding and adaptation should focus on  
115 explaining the potential measures as well as on information on how to implement them (Bubeck et al.,  
116 2013, Maidl and Buchecker, 2014, Clayton et al., 2015). While several studies have found that  
117 increased knowledge and information correlate positively with precautionary behaviour (Thieken et  
118 al., 2006, Miceli et al., 2008), numerous studies found no evidence of a direct effect of information  
119 sources and flood adaptation behaviour when risk perception was controlled for (Zaleskiewicz et al.,  
120 2002, Grothmann and Reusswig, 2006, Botzen et al., 2009).

121 Behavioural decision research suggests that people may take action if they feel empowered to take  
122 charge rather than being treated as helpless citizens (Bush and Folger, 1994, Page and Czuba, 1999).  
123 Detailed, precise and personally relevant information might lead to more effective adaptation to flood  
124 risk (Klein, 1998) such as proposing concrete easily implemented action which can alleviate the  
125 problem (Moser, 2010).

126 Tentative evidence has been found for earthquake preparedness through targeted information  
127 campaigns (Lindell and Perry, 2000). Further, communication research recognises that messenger  
128 choice is critical in the communications process (Moser, 2010) and people are more likely to accept  
129 suggestions conveyed by people with similar views (Malka et al., 2009) such as peers as suggested by  
130 social learning theory (Bandura, 1977).

131 We hypothesise that the activity of flood action groups works precisely through the mechanisms  
132 described above and can thus impact the motivation for implementing adaptation measures. The

133 flood action groups provide information on a number of flood-related issues, including information  
134 and training on the use of flood adaptation measures, but also work as interest groups to lobby for  
135 flood protection schemes on the council level. They turn flooding into a locally relevant issue creating  
136 responsibility and ownership. In addition, flood action groups are locally grounded and people may  
137 thus be more likely to trust the recommended actions. Group members may influence neighbours and  
138 friends in the community who have been shown to be influential in PMT studies (Bubeck et al., 2013).

139 The hypothesised mechanisms within the PMT framework are presented in figure 1. The flood action  
140 groups may both affect the protection motivation directly but there may also be a mediating effect.  
141 The groups could positively impact self- and response-efficacy which in turn impact positively  
142 protection motivation.

143

144 **Figure 1** 'Conceptual framework for data analysis' should go here

145 The response variables within our analyses are household flood management measures. They include  
146 traditional measures, such as insurance and sandbags, but also more innovative and modern  
147 measures such as flood warnings and floodgates that have been specifically promoted or discussed by  
148 flood action groups.

149 Flood insurance reduces the financial consequences of a flood once it occurs and is identified in other  
150 studies as an adaptation measure (Grothmann and Reusswig, 2006, Bubeck et al., 2012b). Sandbags  
151 can slow down the penetration of water through buildings by acting as a barrier. Floodgates for  
152 households are installed in the case of flooding to hold back floodwater and generally provide very  
153 effective protection from flooding (SFF, 2014). Flood warnings allow residents time to move valuable  
154 items to higher floors and to secure their properties with further measures.

155 In total 30 explanatory variables were gathered from the respondents based on the framework in  
156 figure 1, including their threat and coping appraisal, non-protective and protective responses, as well  
157 as socio-economic characteristics. Questions regarding financial aid by public authorities were  
158 included, which may provide a negative incentive to implement measures. Further, individuals may  
159 be influenced by neighbours and friends' adoption of measures (Ajzen, 1991). Severity of experience  
160 of flooding in the near and distant past was also included as this has been observed to have positive  
161 effects on self-protective behaviour of natural hazards (Bubeck et al., 2012a). Finally, flood action  
162 group variables were included. Specifically, whether the respondents were aware of a flood action  
163 group in their community ('flood action group'), whether they were directly involved with the group

164 ('involvement') as well as whether specific information was provided by the groups and whether the  
165 information was useful (see table 1 for the different types of information and table A1 in the electronic  
166 supplementary material for a complete list of explanatory variables).

### 167 3. Materials and Methods

168 Cross-sectional data from 124 private households across Scotland that have either experienced  
169 flooding or are at risk of flooding was gathered through a questionnaire-based survey and analysed  
170 with ordinal regression.

171 The questionnaire is based on the frameworks of Grothman and Patt (2005) and Bubeck et al. (2013). It  
172 was refined with a pilot study of 18 flood risk households, and based on discussions with local flood  
173 groups and the Scottish Flood Forum (SFF) (an NGO that deals both with flood prevention and post-  
174 flood assistance). The results from the pilot study were used to further develop the questionnaire  
175 structure. The survey was distributed online and in paper format to 600 residents in 34 communities  
176 across Scotland where flooding has occurred in the past and thus flood action groups were formed  
177 since 2012. The survey was also distributed at a flood exhibition in Scotland to include respondents  
178 from communities without a flood action group and yielded a response rate of just over 20 %.

179 Table 1 shows a range of sample characteristics. All participants had experienced some flooding in the  
180 past and about 75% classified their flood experience as very severe. 85% of respondents have already  
181 implemented some form of flooding adaptation measure and 49% of participants confirmed they  
182 were actively involved in the community flood action groups. In the communities surveyed, the flood  
183 action groups provide information on the flood risk strategy of the local council (44%), flood  
184 warnings (66%), information on private flood management measures (56%) and, finally, information  
185 on how to use certain flood management measures (44%). The sample characteristics are not perfectly  
186 representative of the Scottish population. For example, average age in the study are higher than in the  
187 overall population. The percentage of people over 65 is above the Scottish average (39 per cent in the  
188 sample versus 17 per cent in the Scottish population (National Statistics, 2014). However, over-  
189 representation of some population subgroups does not appear to affect estimates of means and  
190 proportions and is unlikely to affect correlation and regression analyses (Huang et al., 2012, Terpstra  
191 and Lindell, 2013).

192 **Table 1 'Sample characteristics (n=124) should go here**

### 193 3.1. Statistical model

194 The response variables were measured on a five-point Likert-scale and we thus estimate the effect of  
195 the potential determining factors on the different adaptation measures by using an ordered-logit  
196 model (Christensen, 2015). We provide a polychloric correlation matrix in the electronic  
197 supplementary material (table A3) for all dependent and independent variables which shows that the  
198 correlation between predictor variables included in the models is moderate (around 0.4). As the  
199 dataset is small and about 11 per cent of the data per variable are missing due to non-responses, we  
200 used multiple imputation to compute the missing values stochastically in a way that accounts for  
201 uncertainty using the MICE package in R (Honaker et al., 2015) in order to improve the efficiency of  
202 estimation. We obtained five imputed datasets for our model selection. Despite the imputation, the  
203 observations to response variables ratio remains low, so backward selection is infeasible. For each of  
204 the response variables we therefore proceeded as follows: we entered each explanatory variable one  
205 at a time into an ordinal regression to determine which of the explanatory variables are significant at  
206 the 5% level. We created the model that contains all of these variables, and then performed backwards  
207 selection on this model using the Wald-test eliminating the least significant variables at each step,  
208 until all of the variables that remain within the model are significant at the 5 per cent level.

209 The estimated regression coefficients are on the scale of the cumulative log odds; we present the  
210 exponential of these coefficients, which correspond to the cumulative odds, because these have a  
211 natural interpretation. For instance, we compare people who use flood warnings to an average extent  
212 (3 on the Likert scale) or less with people who use flood warnings more.

### 213 3.2. Analytic methods

214 We ran three regressions per measure: 1. implementation of the household flood adaptation measures  
215 prior to the foundation of the flood action groups as the response variable, 2. implementation after the  
216 foundation of the flood action groups, 3. motivation for future implementation of measures. The latter  
217 two regressions included variables testing for the influence of the flood action groups to compare  
218 communities with and without flood action groups. For communities where flood action groups are  
219 in place, we tested for the influence of specific information provided by the groups.

220 We also ran a mediation analysis based on the standard approach of Baron and Kenny (1986) to  
221 explore whether the flood action groups variables ( $X$ ) may be correlated with either of the two  
222 components of the coping appraisal ( $Y$ ) which in turn may be correlated with the uptake of the  
223 different measures ( $Z$ ). To test for partial and complete mediation, we verify whether there are  
224 significant relationships in regression equations between  $X$  and  $Y$  (with  $Y$  being the outcome) and  $X$



225 and Z (with Z being the outcome). Additionally, we tested whether adding X in the regression  
226 equation of Z on Y statistically significantly improves the model by using Wald tests to show partial  
227 mediation. If we find no added significance, this suggests complete mediation, i.e. the mediator  
228 'absorbs' the effect of the flood action variables. We also tested for mediation of flood experience  
229 through threat and coping appraisal as hypothesised in figure 1. We provide McKelvey Zavoina R<sup>2</sup> as  
230 goodness-of-fit measure.

231 The cross-sectional nature of data implies that the relationships should be interpreted as correlation  
232 rather than causation.

## 233 **4. Results and discussion**

234 Section 4.1 interprets the regression models for the four types of flood adaptation measures as well as  
235 the variables influencing response-efficacy and self-efficacy. Section 4.2 provides a short discussion.

### 236 **4.1. Results**

237 Table 2 presents the results of the regression equations. Across the four measures, more explanatory  
238 variables fitted to data from respondents were identified for the more recent uptake of flood risk  
239 management measures as well as for intentions in the near future. This makes sense for two reasons.  
240 First, people may not remember the exact extent of their use of, for instance, sandbags prior to 2012,  
241 and it may have varied over the time period. Second, the dataset is cross-sectional apart from the  
242 response variables. The respondents' perception may have changed over time but also their socio-  
243 economic status, so we find a better fit regarding their current opinions/status, which is reflected in  
244 current uptake and intentions for future uptake in the present.

245

246 Table 2 'Results of the ordered logit models: variables associated with the pre-2012, post-2012 and  
247 intended uptake of flood warnings (A1-A5), sandbags (B1-B5), floodgates (C1-C5) and insurance (D1-  
248 D5), for all communities and for communities with a flood action group' should go here.

#### 249 **4.1.1 Coping appraisal**

250 Self-efficacy is significant within at least one of the analyses for each measure. Response efficacy is  
251 significant for the use of insurance (D3 and D5) and flood warnings (A5). This confirms findings of  
252 other studies (Grothmann and Patt, 2005, Zaalberg et al., 2009, Bubeck et al., 2013) showing that the  
253 belief in the effectiveness of a measure and the level of confidence to implement the measure play a  
254 central role in the uptake of household flood management measures. The third variable of coping  
255 appraisal, response cost appears to be mostly non-significant. An exception is the cost for flood

256 warnings with a negative coefficient for intended uptake (A5) indicating a lower use with higher cost.  
257 This is a surprising result for a low cost measure such as flood warnings. It might reflect the cost of  
258 accessing flood warnings, mostly provided through text messages or the internet, which could be  
259 more challenging for the predominantly older respondents of the survey. Receiving financial support  
260 is not significant in the regressions. The lack of significance of response cost and financial support  
261 highlight that cost is mostly not decisive when it comes to encouraging the uptake of less expensive  
262 adaptation measures confirming the findings of Terpstra and Lindell (2013) and Lindell et al. (2013).  
263 While it is surprising that cost does not have a negative effect on insurance, conversations with the  
264 flood action groups indicated that all households are keen to obtain flood insurance (if provided by  
265 the insurance company) despite the high cost.

#### 266 ***4. 1.2 Threat appraisal***

267 Risk perception, a component of threat appraisal, is significant for a number of the analyses. Some  
268 studies have found a minor contribution of risk perception (Bubeck et al., 2013, Koerth et al., 2013)  
269 while others observe a strong link between increased risk perception and increased uptake of  
270 measures (Miceli et al., 2008, Bichard and Kazmierczak, 2012, Osberghaus, 2015). Due to the different  
271 formulation of risk it is challenging to compare the results across studies. We find significance for risk  
272 in particular for floodgates (C3-C5) and sandbags (B2-B5). This high and significant risk perception  
273 for these two measures may be related to the fact that they represent physical actions to avoid homes  
274 being flooded; where respondents' decisions to implement these emergency measures reveal their  
275 perception that the risk is real and high. The results indicate that high risk perception may lead to  
276 increased flood preparedness but appears to depend on the measure. We do not find significance for  
277 fear as the second component of threat appraisal.

#### 278 ***4.1.3 Social environment, previous flood experience, socio-economic variables, non-*** 279 ***protective answers***

280 We note the significance of neighbours in the use of insurance (D1), flood warnings (A2), floodgates  
281 (C2 and C4), as in other studies confirming the importance of the influence of peer behaviour (Bubeck  
282 et al., 2012a, Bubeck et al., 2013). For the use of floodgates post-2012 (C2), we find significance for the  
283 variable 'implementation with neighbour'. This likely reflects that non- or semi-detached houses  
284 require joint measures such as floodgates to protect the homes. Therefore, a respondent who has  
285 implemented a measure together with their neighbour is more likely to have set up a more sizeable  
286 floodgate.

287 Flood experience has only been found to be significant for the post-2012 insurance regression (D4)  
288 with a negative coefficient. The negative coefficients of flood experience is counter-intuitive, but other  
289 studies have found similar results (Kreibich et al., 2011b, Bubeck et al., 2013) and have been linked to  
290 higher insurance premiums due to an increased of risk to flooding. The lack of significance of flood  
291 experience for other variables may be explained by a complete mediation of experience on uptake  
292 through threat and coping appraisal (Bubeck et al., 2013). Indeed, in our mediation analysis, we find  
293 mediation effects for flood experience variables for floodgates (analyses E1 and E1 in table 3) through  
294 both threat and coping appraisal and for sandbags for the former (analysis F1). For a complete list of  
295 the mediation results see table A4 in the electronic supplementary material.

296 In line with other studies (Grothmann and Reusswig, 2006, Zaalberg et al., 2009, Bubeck et al., 2013,  
297 Osberghaus, 2015), socio-economic variables explain relatively little of the data. Here, we only find  
298 that ownership positively influences the uptake of insurance (D2-D5) which is not surprising given  
299 the owners financial responsibility. Finally, we found no significance for non-protective responses  
300 once controlling for other variables.

301 **Table 3 should go here.**

302 **Table 3 Significant results of the mediation analysis for the mediation of flood experience variables and flood**  
303 **action group variables through coping and threat appraisal. The columns provide the p-values for the**  
304 **respective equations.**

#### 305 **4.1.4 Flood action groups**

306 We find a positive relationship where flood action group variables contribute significantly to the  
307 explanation of the data (A5, C4, C5, D5), indicating that such groups may positively influence the  
308 uptake of household flood management measures. We find significant links for variables which  
309 represent specific information provided by the flood action groups and uptake of measures.

310 We can speculate about the direction of the effect for insurance due to the cross-sectional data: the  
311 variable 'having obtained information on available measures' is significant for the intended uptake of  
312 insurance for communities with a flood group present. This may reflect that people who are at risk of  
313 flooding and have an expensive insurance premium, or even struggle to obtain insurance, are more  
314 likely to obtain further information through the flood action groups. This was confirmed by talking to  
315 the flood action groups. The members aim to find other solutions to flood risk beyond insurance and  
316 indeed we find significant correlations between insurance and the other measures of between 0.3 and  
317 0.7. These findings have been confirmed by other studies (Hudson et al., 2015, Lindell and Hwang,  
318 2008, Lindell et al., 2009). However, there may also be an exchange in the groups regarding the most

319 appropriate insurance cover, which was also confirmed by the groups themselves, which may result  
320 in a more comprehensive cover for members.

321 For floodgates, we find a positive effect of factor 3.6 for post-2012 uptake if respondents received  
322 information on how to implement specific measures. The flood action group members confirmed in  
323 personal conversation that the setting up of floodgates was discussed and demonstrated as part of the  
324 flood action group activities.

325 For flood warnings, we find an increased likelihood of intended uptake of factor 3.5 if information on  
326 flood warnings was provided by the flood action group. Similarly, if respondents have received  
327 information about the flood risk strategy of their council, they have a higher likelihood of using flood  
328 warnings in the future. We can speculate whether this is due to local authorities recommending the  
329 use of flood warnings or the insight of the respondents that structural flood risk schemes may take  
330 considerable time to materialise. We find no link for sandbags. This may reflect that sandbags are  
331 long-standing household flood adaptation measures and the flood action groups cannot increase  
332 uptake. Indeed, about 60 % of respondents already used sandbags in both samples before 2012.

333 We find significant mediating effects of self-efficacy and response efficacy with respect to floodgates  
334 and flood warnings (analyses E1 and G1 in table 3). For the uptake in the nearby future of floodgates,  
335 both partial and complete mediation are present if the obtained information from the group is  
336 perceived as useful, when information on available measures has been provided. The number of  
337 significant mediating relationships is more extensive for flood warnings and applies to both post-2012  
338 and intended uptake of flood warnings. The same variables as for floodgates are significant but in  
339 addition also whether information on flood warnings have been provided and information on how to  
340 implement measures.

341 There is also complete mediating effect of, 'existing schemes' for the use of flood warnings for the  
342 whole sample for post-2012 and intended uptake. Existing schemes refer to assistance (including that  
343 from flood action groups but also from the local council) with household flood management  
344 measures. While we cannot pin down the exact mechanism of 'existing schemes' on response and self-  
345 efficacy, we can deduce that specific help and information for flood risk at the household level appear  
346 to have a positive effect.

## 347 4.2 Discussion

348 The fitted models indicated a positive effect on uptake for insurance, floodgates and for flood  
349 warnings for flood action variables. It appears that having a flood action group in the community, or  
350 being involved in one, does not necessarily lead to an increased uptake of measures as the variable  
351 'flood action group' and 'involvement' did not prove significant. It is rather when the groups provide  
352 tailored information such as on flood warnings or how to implement measures that significant  
353 correlations were observed.

354 We also find partial and complete mediating effects through the correlation of the flood action groups  
355 variables with increased self-efficacy and response-efficacy which are in turn associated with uptake.  
356 We detect significant correlations for floodgates and flood warnings which were promoted among the  
357 groups, if specific information had been provided which is also subsumed in the significance of the  
358 variable whether the obtained information is perceived as useful. Thus, tailored information appear  
359 to positively impact the confidence in implementing these measures as well as the belief in their  
360 effectiveness. These coping appraisal variables are key for protection motivation as observed in our  
361 regressions and in other studies using PMT as theoretical framework.

362 The UK government encourages autonomous adaptation to climate change, with flooding being one  
363 of the major expected climate change impacts in the UK (DEFRA, 2013). If the flood action groups can  
364 be 'kickstarted' with the help and direction of the council and the SFF their subsequent running will  
365 be ensured by the community itself, relying on active and engaged community members. The support  
366 of groups in the study by their local councils was limited to providing sandbags. While we do not  
367 have estimates of the costs of running flood action groups, we know that household flood  
368 management measures often exhibit high benefit-cost ratios (Holub and Fuchs, 2008, Kreibich et al.,  
369 2011a), and would therefore expect its cost to be below that of a structural measure for the same  
370 benefit. Indeed, flood protection on the household level and supported by the community may prove  
371 to be the only viable solution for many small communities where larger structural flood defence  
372 measures will not pass a cost-benefit test due to a too small population.

373 A number of caveats need to be considered. First, the sample (n=124) is very small, which sets a limit  
374 to the complexity of the model and the robustness of the inference. This highlights the importance of  
375 conducting research on a larger scale to confirm the results of the study. Second, a different item to  
376 describe 'real' risk perception would have been feasible and delivered different results. This includes,  
377 amongst others, dread and unknown risk (Fischhoff et al., 1978), and combining these with well  
378 known disaster risks (Trumbo et al., in press) or people's expectations of the personal impacts caused

379 by a disaster (Huang et al., 2012, Mileti and Peek, 2000, Mileti and Sorensen, 1987). Third, the changes  
380 in uptake of certain measures may also partly be due to external reasons not captured in the study,  
381 such as easier access to flood warnings or the challenge of obtaining flood insurance for certain high  
382 risk properties.

## 383 **5. Conclusion**

384 This study examined the factors influencing the uptake of four household flood adaptation measures  
385 in small communities around Scotland using a cross-sectional survey (n=124) within an extended  
386 framework of PMT. The main focus was on testing whether local flood action groups, in which  
387 residents promote the deployment of flood management measures, have a positive effect on uptake.  
388 The fitted models indicated a positive effect for the use of insurance and of floodgates, if information  
389 on measures and implementation were provided; for flood warnings we detected a link if specific  
390 information on flood warnings were provided. Additionally, we found a mediating effect for flood  
391 warnings and floodgates: some flood action group variables appear to positively impact the coping  
392 appraisal variables which are key for protection motivation. We conclude that flood action groups  
393 may increase the uptake of precautionary measures in particular by providing specific information.  
394 Given limited resources of local authorities, the promotion of well-designed flood action groups  
395 might provide a cost-effective way of increasing household resilience to flooding in Scotland and  
396 elsewhere.

397

398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445

## References

- AJZEN, I. 1991. The Theory of Planned Behavior. *Organizational Behavior & Human Decision Processes*, 50, 179.
- BANDURA, A. 1977. *Social learning theory*, Englewood Cliffs ; London : Prentice-Hall, 1977.
- BARON, R. M. & KENNY, D. A. 1986. The Moderator- Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology*, 51, 1173-1182.
- BICHARD, E. & KAZMIERCZAK, A. 2012. Are homeowners willing to adapt to and mitigate the effects of climate change? *Climatic Change*, 633.
- BOTZEN, W. J. W., AERTS, J. C. J. H. & VAN DEN BERGH, J. C. J. M. 2009. Willingness of Homeowners to Mitigate Climate Risk through Insurance. *Ecological Economics*, 68, 2265-2277.
- BOTZEN, W. J. W. & VAN DEN BERGH, J. C. J. M. 2012. Monetary Valuation of Insurance against Flood Risk under Climate Change. *International Economic Review*, 53, 1005-1025.
- BOUWER, L. M., BUBECK, P. & AERTS, J. C. J. H. 2010. Changes in future flood risk due to climate and development in a Dutch polder area. *Global Environmental Change*, 20, 463-471.
- BRATTEBO, B. O. & BOOTH, D. B. 2003. Long- term stormwater quantity and quality performance of permeable pavement systems. *Water Research*, 37, 4369-4376.
- BUBECK, P., BOTZEN, W. J. W. & AERTS, J. C. J. H. 2012a. A Review of Risk Perceptions and Other Factors that Influence Flood Mitigation Behavior. *Risk Analysis: An International Journal*, 32, 1481-1495.
- BUBECK, P., BOTZEN, W. J. W., KREIBICH, H. & AERTS, J. C. J. H. 2012b. Long-term development and effectiveness of private flood mitigation measures: an analysis for the German part of the river Rhine. *Natural Hazards & Earth System Sciences*, 12, 3507-3518.
- BUBECK, P., BOTZEN, W. J. W., KREIBICH, H. & AERTS, J. C. J. H. 2013. Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. *Global Environmental Change*, 1327.
- BUSH, R. A. B. & FOLGER, J. P. 1994. *The promise of mediation: responding to conflict through empowerment and recognition*, San Francisco, CA, Jossey-Bass.
- CEA 2007. Reducing the Social and Economic Impact of Climate Change and Natural Catastrophes: Insurance Solutions and Public Private Partnerships. Insurers of Europe.
- CHRISTENSEN, R. H. B. 2015. Package 'Ordinal'.
- CLAYTON, S., DEVINE-WRIGHT, P., STERN, P. C., WHITMARSH, L., CARRICO, A., STEG, L., SWIM, J. & BONNES, M. 2015. Psychological research and global climate change. *Nature Climate Change*, 5, 640.
- DAWSON, R., PEPPE, R. & WANG, M. 2011. An agent-based model for risk-based flood incident management. *Natural Hazards*, 59, 167-189.
- DEFRA 2013. The National Adaptation Programme. Making the country more resilient to a changing climate. London: The Stationary office.
- EUROPEAN UNION 2007. Directive 2007/80/ec of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risk.

- 446 FISCHHOFF, B., SLOVIC, P., LICHTENSTEIN, S., READ, S. & COMBS, B. 1978. How safe is  
447 safe enough? A psychometric study of attitudes towards technological risks and  
448 benefits. *Policy Sci*, 9, 127-152.
- 449 GROTHMANN, T. & PATT, A. 2005. Adaptive capacity and human cognition: The process  
450 of individual adaptation to climate change. *Global Environmental Change*, 15,  
451 199-213.
- 452 GROTHMANN, T. & REUSSWIG, F. 2006. People at risk of flooding: Why some residents  
453 take precautionary action while others do not. *Natural Hazards*, 38, 101-120.
- 454 HOLUB, M. & FUCHS, S. 2008. Benefits of local structural protection to mitigate torrent-  
455 related hazards. In: BREBBIA, C. & BERIATOS, E. (eds.) *Risk Analysis VI*. WIT  
456 Press/WIT Transaction on Information and Communication Technologies.
- 457 HONAKER, J., KING, G. & BLACKWELL, M. 2015. Package Amelia. A program for missing  
458 data. <https://cran.r-project.org/web/packages/Amelia/Amelia.pdf>.
- 459 HUANG, S.-K., LINDELL, M. K., PRATER, C. S., WU, H.-C. & SIEBENECK, L. K. 2012.  
460 Household Evacuation Decision Making in Response to Hurricane Ike. *Nat.*  
461 *Hazards Rev.*, 13, 283-296.
- 462 HUDSON, P., BOTZEN, W. W., CZAJKOWSKI, J. & H., K. 2015. Adverse selection and moral  
463 hazard in natural disaster insurance markets: Empirical evidence from Germany  
464 and the United States. Available at <http://www.aria.org/>.
- 465 ICPR 2002. Non Structural Flood Plain Management: Measures and Their Effectiveness.  
466 Koblenz: International Commission for the Protection of the Rhine.
- 467 IPCC 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate*  
468 *Change Adaptation. A Special Report of Working Groups I and II of the*  
469 *Intergovernmental Panel on Climate Change.*, Cambridge, UK and New York, USA,  
470 Cambridge University Press.
- 471 KELLENS, W., TERPSTRA, T. & DE MAEYER, P. 2013. Perception and Communication of  
472 Flood Risks: A Systematic Review of Empirical Research. *Risk Analysis: An*  
473 *International Journal*, 33, 24-49.
- 474 KLEIN, R. J. T. 1998. Towards better understanding, assessment and funding of climate  
475 adaptation. *Change*, 44.
- 476 KOERTH, J., VAFEIDIS, A., HINKEL, J. & STERR, H. 2013. What motivates coastal  
477 households to adapt pro-actively to sea-level rise and increasing flood risk?  
478 *Regional Environmental Change*, 13, 897-909.
- 479 KREIBICH, H., BUBECK, P., VLIET, M. & MOEL, H. 2015. A review of damage- reducing  
480 measures to manage fluvial flood risks in a changing climate. *Mitig Adapt Strateg*  
481 *Glob Change*, 20, 967-989.
- 482 KREIBICH, H., CHRISTENBERGER, S. & SCHWARZE, R. 2011a. Economic motivation of  
483 households to undertake private precautionary measures against floods. *Natural*  
484 *Hazards and Earth System Sciences*, 11, 309-321.
- 485 KREIBICH, H., SEIFERT, I., THIEKEN, A. H., LINDQUIST, E., WAGNER, K. & MERZ, B.  
486 2011b. Recent changes in flood preparedness of private households and  
487 businesses in Germany. *Regional Environmental Change*, 11, 59-71.
- 488 KREIBICH, H., THIEKEN, A. H., PETROW, T., MULLER, M. & MERZ, B. 2005. Flood loss  
489 reduction of private households due to building precautionary measures -  
490 lessons learned from the Elbe flood in August 2002. *Natural Hazards and Earth*  
491 *System Sciences*, 5, 117-126.
- 492 KUNREUTHER, H. 1996. Mitigating Disaster Losses through Insurance. Kluwer  
493 Academic Publishers.



- 494 LE DANG, H., LI, E., NUBERG, I. & BRUWER, J. 2014. Understanding farmers' adaptation  
495 intention to climate change: A structural equation modelling study in the Mekong  
496 Delta, Vietnam. *Environmental Science and Policy*, 11.
- 497 LINDELL, M. K., ARLIKATTI, S. & PRATER, C. S. 2009. Why People Do What They Do to  
498 Protect Against Earthquake Risk: Perceptions of Hazard Adjustment Attributes.  
499 *Risk Analysis*, 29, 1072-1088.
- 500 LINDELL, M. K. & HWANG, S. N. 2008. Households' Perceived Personal Risk and  
501 Responses in a Multihazard Environment. *Risk Analysis*, 28, 539-556.
- 502 LINDELL, M. K. & PERRY, R. W. 2000. Household Adjustment to Earthquake Hazard: A  
503 Review of Research. *Environment and Behavior*, 32, 461-501.
- 504 MADDUX, J. E. & ROGERS, R. W. 1983. Protection motivation and self-efficacy: A revised  
505 theory of fear appeals and attitude change. *Journal of Experimental Social  
506 Psychology*, 19, 469-479.
- 507 MAIDL, E. & BUCHECKER, M. 2014. Raising risk preparedness through flood risk  
508 communication. *Natural Hazards and Earth System Sciences Discussions*, 2, 167.
- 509 MALKA, A., KROSNICK, J. A. & LANGER, G. 2009. The Association of Knowledge with  
510 Concern About Global Warming: Trusted Information Sources Shape Public  
511 Thinking. *Risk Analysis*, 29, 633-647.
- 512 MEYER, V., KUHLLICKE, C., LUTHER, J., FUCHS, S., PRIEST, S., DORNER, W., SERRHINI, K.,  
513 PARDOE, J., MCCARTHY, S., SEIDEL, J., PALKA, G., UNNERSTALL, H., VIAVATTENE,  
514 C. & SCHEUER, S. 2012. Recommendations for the user-specific enhancement of  
515 flood maps. *Natural Hazards & Earth System Sciences*, 12, 1701-1716.
- 516 MICELI, R., SOTGIU, I. & SETTANNI, M. 2008. Disaster preparedness and perception of  
517 flood risk: A study in an alpine valley in Italy. *Journal of Environmental  
518 Psychology*, 28, 164-173.
- 519 MILETI, D. S. & PEEK, L. 2000. The social psychology of public response to warnings of a  
520 nuclear power plant accident. *Journal of Hazardous Materials*, 75, 181-194.
- 521 MILETI, D. S. & SORENSEN, J. H. 1987. Why people take precautions against natural  
522 disasters. In: WEINSTEIN, N. (ed.) *Taking care: Why people take precautions*. New  
523 York: Cambridge University Press.
- 524 MOSER, S. C. 2010. Communicating climate change: history, challenges, process and  
525 future directions. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 31-53.
- 526 NATIONAL STATISTICS 2014. Mid-2014 Population Estimates Scotland Population  
527 estimates by sex, age and administrative area. A National Statistics publication  
528 for Scotland. Edinburgh.
- 529 OSBERGHAUS, D. 2015. Analysis: The determinants of private flood mitigation measures  
530 in Germany — Evidence from a nationwide survey. *Ecological Economics*, 110,  
531 36-50.
- 532 PAGE, N. & CZUBA, C. E. 1999. Empowerment: What Is It? *Journal of Extension*, 37.
- 533 PEEK, L. A. & MILETI, D. S. 2002. The history and future of disaster research. In:  
534 BECHTEL, R. & CHURCHMAN, A. (eds.) *Handbook of environmental psychology*.  
535 New York: John Wiley.
- 536 RIPPEOE, P. A. & ROGERS, R. W. 1987. Effects of Components of Protection-Motivation  
537 Theory on Adaptive and Maladaptive Coping With a Health Threat. *Journal of  
538 Personality & Social Psychology*, 52, 596.
- 539 ROGERS, R. W. 1975. A Protection Motivation Theory of fear appeals and attitude  
540 change. *Journal of Psychology*, 91, 93.

- 541 ROGERS, R. W. 1983. Cognitive and physiological processes in fear appeals and attitude  
542 change: A revised theory of protection motivation. *In: CACIOPPO, B. L. & PETTY,*  
543 *L. L. (eds.) Social Psychophysiology: A sourcebook.* London, UK: Guilford.
- 544 ROGERS, R. W. & PRENTICE-DUNN, S. 1997. Protection motivation theory. *In:*  
545 *GOCHMAN, D. S. (ed.) Handbook of Health Behavior Research I: Personal and Social*  
546 *Determinants.* New York: Plenum Press.
- 547 SCOTTISH GOVERNMENT 2009. Flood Risk Management Act (Scotland) 2009.  
548 [http://www.legislation.gov.uk/asp/2009/6/pdfs/asp\\_20090006\\_en.pdf](http://www.legislation.gov.uk/asp/2009/6/pdfs/asp_20090006_en.pdf).
- 549 SIEGRIST, M. & GUTSCHER, H. 2006. Flooding Risks: A Comparison of Lay People's  
550 Perceptions and Expert's Assessments in Switzerland. *Risk Analysis: An*  
551 *International Journal, 26, 971-979.*
- 552 TERPSTRA, T. & LINDELL, M. K. 2013. Citizens' Perceptions of Flood Hazard  
553 Adjustments: An Application of the Protective Action Decision Model.  
554 *Environment and Behavior, 45, 993-1018.*
- 555 TERPSTRA, T., LINDELL, M. K. & GUTTELING, J. M. 2009. Does Communicating (Flood)  
556 Risk Affect (Flood) Risk Perceptions? Results of a Quasi-Experimental Study. *Risk*  
557 *Analysis: An International Journal, 29, 1141-1155.*
- 558 THIEKEN, A. H., PETROW, T., KREIBICH, H. & MERZ, B. 2006. Insurability and Mitigation  
559 of Flood Losses in Private Households in Germany. *Risk Analysis: An International*  
560 *Journal, 26, 383-395.*
- 561 TRUMBO, C. W., PEEK, L., MEYER, M. A., MARLATT, H. L., GRUNTFEST, E., MCNOLDY, B.  
562 D. & SCHUBERT, W. H. in press. A cognitive - affective scale for hurricane risk  
563 perception. *Risk Analysis.*
- 564 ZAALBERG, R., MIDDEN, C., MEIJNDERS, A. & MCCALLEY, T. 2009. Prevention,  
565 Adaptation, and Threat Denial: Flooding Experiences in the Netherlands. *Risk*  
566 *Analysis: An International Journal, 29, 1759-1778.*
- 567 ZALESKIEWICZ, T., PISKORZ, Z. & BORKOWSKA, A. 2002. Fear or money? Decisions on  
568 insuring oneself against flooding. *Risk, Decision and Policy, 7, 221-233.*

569  
570