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Trust in flood protection: Spillovers from prior experience with non-flood hazards

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Abstract

There is already evidence that experiencing a natural hazard shapes how people subsequently evaluate public protection and risk management. Using three surveys among 2,272 Dutch homeowners, we indeed find that owners confronted with flood-related property damage are 18.2 percentage points (p.p.) less likely to trust flood protection. But, we also find that experience spills over across hazard domains. Damage due to rainfall is associated with a 4.2 p.p. lower trust in flood protection. We also find indications that experiencing earthquake-related damage affects trust in flood protection. This evidence for spillovers highlights the importance of broad-based, multi-hazard risk communication and governance strategies.

JEL codes: Q54, Q56, D14
Keywords: natural hazards, trust, prior experience, flood protection

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1 Introduction

How can households build resilience in the face of natural hazards? A central factor shaping household responses is trust in public risk management and protection systems. In contexts where protection against natural hazards is largely provided by public authorities, households rely not only on their own resources but also on the effectiveness and reliability of that protection. Such trust reflects beliefs about the competence and performance of public actors tasked with managing risk and delivering protection. It has been shown to shape protective behavior and preparedness through both cognitive and affective channels (Terpstra, 2011; Wachinger et al., 2013; Voogd et al., 2021).

Prior experience with natural hazards is widely documented as an important determinant of attitudes and behavior related to risk and protection for those same hazards. Survey-based studies on flood risk commonly find that direct experience influences how individuals evaluate risks and protective arrangements. Reviewing the flood risk literature, Bubeck et al. (2012) report that most studies find a positive relationship between experience and protective behavior. Frondel et al. (2017) show that Germans affected by the 2013 floods exhibit higher flood risk perceptions. Mol et al. (2020) find that Dutch respondents with flood damage experience perceive a higher likelihood of flooding. Köhler and Han (2024) document that repeated flood experience is associated with stronger responses to flood risk. However, the relationship between flood experience and protective attitudes or capacities is not uniform across contexts or outcomes. For example, Bubeck et al. (2018) find little support for a positive relationship between flood experience and perceived coping capacity in Germany and France, while Barendrecht et al. (2021) show that preparedness increases with flood experience in only four out of seven English regions.

Beyond preparedness and risk perception, complementary evidence indicates that adverse hazard experiences can also affect trust in public authorities and protection arrangements, with implications for risk governance and compliance (Ahmad and Younas, 2021). Related work further shows that trust in existing public flood protection measures plays an independent role in shaping households' responses to flood risk and risk communication, underscoring trust as a distinct and policy-relevant outcome rather than a proxy for risk perception (Attems et al., 2020).

In all this, the literature mainly takes a hazard-specific perspective. Existing studies primarily examine how experience with a given hazard affects perceptions, trust, or behavior related to that same hazard. To the best of our knowledge, less is known about whether adverse experiences with one type of natural hazard affect confidence in public protection systems designed to manage other hazards, even when those systems are institutionally or technologically distinct. Put differently, while hazard experience is known to shape trust in authorities and perceptions of protective arrangements, it remains unclear whether such belief updating generalizes across hazard domains rather than remaining confined to the hazard that caused the experience.

From a conceptual perspective, this focus on confidence in protection systems aligns with decision-making frameworks that emphasize the role of institutions, authorities, and risk communication in shaping household responses to hazards. In the Protective Action Decision Model (PADM), perceptions of stakeholders and source credibility are central inputs into how households evaluate protective actions and protective systems (Lindell and Perry, 2012). Adverse experiences with natural hazards can, therefore, lead to updated beliefs about institutional reliability. Importantly, such belief updating need not remain confined to the hazard that caused the experience, but may generalize across hazard domains, possibly leading to cross-hazard spillovers in trust.

The specific setting is, naturally, important for the relevance of cross-hazard spillovers. This paper focuses on the Netherlands, a small open economy where historically much attention has been devoted to flood risk and protection. More than 25% of the country is below sea level and close to 60% is at risk from flooding. A major flood in 1953 claimed 1,800 lives. Since then, much has been invested in physical flood protection infrastructure—including dikes protecting against both sea and river flooding, storm surge barriers, and spillover areas—making the Netherlands the best protected delta around the world.[1]

In this paper, we focus on the public's trust in physical flood protection infrastructure. Specifically, we measure respondents' perceived effectiveness of the protection offered by Dutch dikes. While dikes are a prominent and visible element of the Dutch flood defense system, flood protection also encompasses complementary measures such as storm surge barriers, spillover areas, and spatial planning. Our survey question explicitly asks about dikes, so the trust measure we use should be interpreted as capturing confidence in this central component of physical flood protection rather than the system in its entirety. This focus on physical infrastructure is distinct from trust in other policy responses such as government compensation or insurance arrangements for flood-related damages.

At the same time, Dutch households face a multi-hazard environment. The Royal Netherlands Meteorological Institute (KNMI, 2025) has recently described how nine types of extreme weather events could disrupt the country and result in damages to infrastructure and real estate. The events included heavy rainfall, heat, storms, and wildfires. In addition to extreme weather, the northern province of Groningen is at risk from earthquakes, which are related to the decades-long exploitation of gas fields. Since a few

[1] See also `https://themasites.pbl.nl/o/flood-risks/`. URL last accessed on 22 January 2026.

years, owners of damaged properties can claim government compensation. Between 2018 and 2024, EUR 1.7bn in compensation has been granted.[2] This combination of salient non-flood hazards and well-known, institutionally provided flood protection makes the Netherlands a useful setting to test whether adverse experiences in one hazard domain correlate with trust in protective systems in another.

The contribution of this paper is to show that hazard experience does spill over across domains. We find that adversity related to various hazards affects trust in flood protection, rather than remaining confined to the hazard that caused the damage. Using three survey waves among 2,272 Dutch homeowners, we document that prior flood experience substantially reduces trust in Dutch flood protection systems: homeowners whose properties were damaged by flooding are 18.2 percentage points (p.p.) less likely to express trust in flood protection. Such a finding is in line with the literature (Bubeck et al., 2012). Importantly, we also find evidence of cross-hazard spillovers. Homeowners with prior rainfall-related damage are 4.2 p.p. less likely to trust flood protection. There are also indications (though the significance level varies across specifications) that homeowners who experienced earthquake-related damage are less likely to trust flood protection. Here, the estimated marginal effect is around 6 p.p.

These findings have implications for risk governance and communication. As climate change increases the frequency and severity of multiple natural hazards, households are likely to face repeated and compounding losses (Auffhammer, 2018). Our results suggest that such experiences can undermine confidence in public protection systems beyond the hazard that caused the damage. This points to a need for broad-based, multi-hazard risk communication and governance strategies that recognise how perfor-

[2] See `https://www.dashboardgroningen.nl/schadeafhandeling`. URL last accessed on 22 January 2026.

mance or failure in one domain may shape trust in others, rather than addressing protection one hazard at a time.

2 Methodology

This paper uses three survey waves collected among Dutch households. The first wave was fielded in spring 2021, followed by two additional waves in 2023 and 2024. The survey was administered to members of the Centerpanel. This a long-running household panel operated by Centerdata, a research institute affiliated with Tilburg University. All panel members aged 16 or older were invited to participate. The Centerpanel is designed to be representative of the Dutch population, with post-stratification weights applied by Centerdata; our analysis conditions on realized participation and focuses on homeowners only. The resulting dataset forms an unbalanced panel.

Two related papers also use information from these survey waves. Jansen (2024) employs the first two waves to study whether owners of at-risk properties are more likely to invest in energy efficiency, while De Leeuw and Jansen (2025) examine whether at-risk owners display greater financial resilience. Different to those two papers, the present paper focuses on how prior experience with natural hazards relates to trust in flood protection systems, including potential spillovers from non-flood hazards.

Amongst other things, the survey asked respondents whether their place of living had previously been damaged by four types of natural hazards: floods, wind, precipitation (rainfall), and earthquakes. These questions capture self-reported damage experience at the property level. Trust in flood protection was measured using a separate question in which respondents indicated, on a five-point Likert scale ranging from 1 (“a very small degree”) to 5 (“a very large degree”), how much protection they believe is offered by Dutch dikes. As noted in the introduction, this item captures trust in dikes as the central and most visible component of physical flood protection infrastructure. The exact wording of the survey questions is provided in the appendix.

For the main analysis, we estimate regressions relating trust in flood protection to prior hazard experience using the pooled panel data. To facilitate interpretation and ease comparison with related work (Jansen (2024); De Leeuw and Jansen (2025)), the baseline specification uses a binary dependent variable indicating whether respondents express trust in flood protection, constructed from the five-point scale. The dummy is equal to one for responses 4 ("a large degree") or 5 ("a very large degree") and zero otherwise. Respondents selecting the 'don't know' category (234 observations, or 4.6% of the estimation sample) are coded as low trust in the baseline specification; alternative treatments of these responses are examined in the robustness analysis. The analysis is based on an unbalanced panel with up to $T = 3$ observations per respondent and a total of $n = 2{,}272$ homeowners. Table A1 reports descriptive statistics on wave participation and the panel structure. The table shows that over half of respondents (1,148, or 50.5%) are observed in all three survey waves.

We exploit the panel structure of the data by including survey-wave fixed effects and by clustering standard errors at the household level. This accounts for both repeated observations of the same respondents over time and for within-household correlation arising from the presence of multiple respondents within some households. As in Jansen (2024) and De Leeuw and Jansen (2025), the baseline analysis further excludes 86 observations from homeowners residing in unprotected flood-prone areas. We examine the sensitivity to this restriction in the robustness section. The general estimating equation is:

$$Trust_{it} = \mu + \beta_1 \boldsymbol{Experience}_{it} + \boldsymbol{x}'_{it}\boldsymbol{\beta} + \omega_t + \epsilon_{it}, \tag{1}$$

where i indexes respondents and t indexes survey waves. The dependent variable $Trust_{it}$ is a binary indicator of trust in flood protection. The vector $\boldsymbol{Experience}_{it}$ consists of dummy variables capturing prior damage experience from floods, wind, precipitation, and earthquakes. The control vector $\boldsymbol{x}_{it}$ includes socio-economic characteristics such as age, gender, income, and education, as well as an indicator for whether the respondent lives in a designated flood-risk zone. The term ω_t captures survey-wave fixed effects. Standard errors are clustered at the household level.

The baseline specification does not include respondent fixed effects. The degree of within-person variation in the experience variables differs across hazard types: reported flood and earthquake experience are near-constant within individuals (98.1% and 95.2% of multi-wave respondents report the same value across all waves, respectively), while rainfall and wind experience exhibit more variation (71.4% and 67.1% unchanged, respectively). The latter reflects the self-reported and perception-based nature of the experience measures. For flood and earthquake experience, fixed-effects specifications would absorb most of the relevant variation and preclude identification. For rainfall and wind, however, there is sufficient within-person variation to support respondent fixed effects, and we explore such specifications in the robustness section. Location-based exposure is also largely stable: among respondents observed in multiple waves, the flood-risk classification remains unchanged in 94.1% of cases (Appendix Table A1, panel B).

3 Results

Table 1 reports the baseline regression results. The table presents selected coefficient estimates and standard errors (in brackets, clustered at the household level) from panel regressions in which trust in flood protection is the dependent variable. The estimates are based on 5,139 observations from 2,272 Dutch homeowners who participated in up to three survey waves between 2021 and 2024.

Turning to the results, the first key finding is that prior flood experience is strongly associated with lower trust in flood protection. Homeowners whose properties were previously damaged by a flood event are 18.2 p.p. less likely to express trust in the Dutch flood protection system. This result is consistent with earlier evidence (Bubeck et al., 2012) showing that direct hazard experience can weaken confidence in public protection and risk management arrangements.

A second and, to the best of our knowledge, novel finding concerns cross-hazard spillovers. We find that damage experience from non-flood hazards is also associated with lower trust in flood protection. In particular, homeowners with prior rainfall-related damage are 4.2 p.p. less likely to trust flood protection. This negative association is statistically significant and robust across alternative specifications. It is worth noting that rainfall and flooding can be related in practice: extreme precipitation can contribute to flood events, and individuals who have experienced rainfall damage may perceive a higher probability of future extreme weather, including floods. The rainfall spillover may therefore partly reflect an overlap between hazard domains or a general updating of risk perceptions, rather than a purely cross-domain effect. We also find indications that earthquake-related damages matter, though there is more variation here across specifications (see also Section 4). In the baseline model, experiencing earthquake damage is associated with a 6 p.p. lower level of trust. However, the earthquake coefficient could partly reflect a generally lower level of institutional trust among residents of earthquake-affected areas, rather than—or in addition to—a pure cross-hazard spillover. Taken together, these results indicate that adverse experiences with other natural hazards can generalize beyond the hazard domain in which they occurred. Experience with non-flood hazards affects trust in flood protection systems, even though these systems are designed to manage different risks.

Turning to other covariates, we find some significant coefficients. Respondents with a university degree exhibit significantly higher trust in flood protection, and men report higher levels of trust than women. These demographic patterns are broadly consistent with earlier findings in the flood risk literature, where education and gender have been shown to relate to risk perceptions and protective attitudes (Bubeck et al., 2012; Wachinger et al., 2013). There is no clear effect on trust of owning a property that lies in a designated flood-risk zone.

Table 1: Regression results

	(1)
	Trust in flood protection
Prior damages to property due to	
- Flood	-0.182**
	[0.076]
- Wind	0.013
	[0.012]
- Rainfall	-0.042***
	[0.014]
- Earthquake	-0.060*
	[0.034]
Owner characteristics	
Has university degree	0.053***
	[0.017]
Male	0.082***
	[0.012]
Income	
- low	0.013
	[0.017]
- high	0.027*
	[0.015]
Age	
- over 65	-0.028
	[0.018]
Owns at-risk property	0.011
	[0.014]

Notes: Selected coefficients and standard errors (in brackets, clustered at the household level) from panel regressions with survey-wave fixed effects. Estimates are based on 5,139 observations from 2,272 Dutch homeowners participating in up to three survey waves between 2021 and 2024. The dependent variable is a binary indicator equal to one if respondents report high trust in flood protection (categories 4 or 5 on a five-point scale), and zero otherwise. 'Owns at-risk property' indicates whether a respondent owns a property located in an area of the Netherlands designated as flood-prone. Regressions also include controls for additional age categories (16–34, 50–64), a socio-economic status indicator, an income-missing dummy, and survey-wave fixed effects; the full set of control variables is listed in Table A2. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure 1 illustrates the main findings using fitted values derived from the regression results in Table 1. The figure displays predicted probabilities and 90% confidence intervals for five groups. The reference group consists of homeowners living in a flood-risk zone who report no prior damage from natural hazards. For this group, predicted trust in flood protection is high, with close to 90% expressing trust. The remaining four groups also consist of homeowners living in flood-risk zones, differentiated by damage experience from floods, wind, rainfall, and earthquakes. Consistent with the regression results, flood damage is associated with the largest reduction in predicted trust, albeit with wider confidence intervals due to the smaller number of respondents with flood experience. The figure also shows lower predicted trust among respondents with prior rainfall damage, and a more modest reduction among those with prior earthquake damage, illustrating the presence of cross-hazard spillovers in trust. For experience with earthquake damage, confidence intervals are also wider due to a smaller number of respondents with such experience in the sample (see also Appendix Table A2).

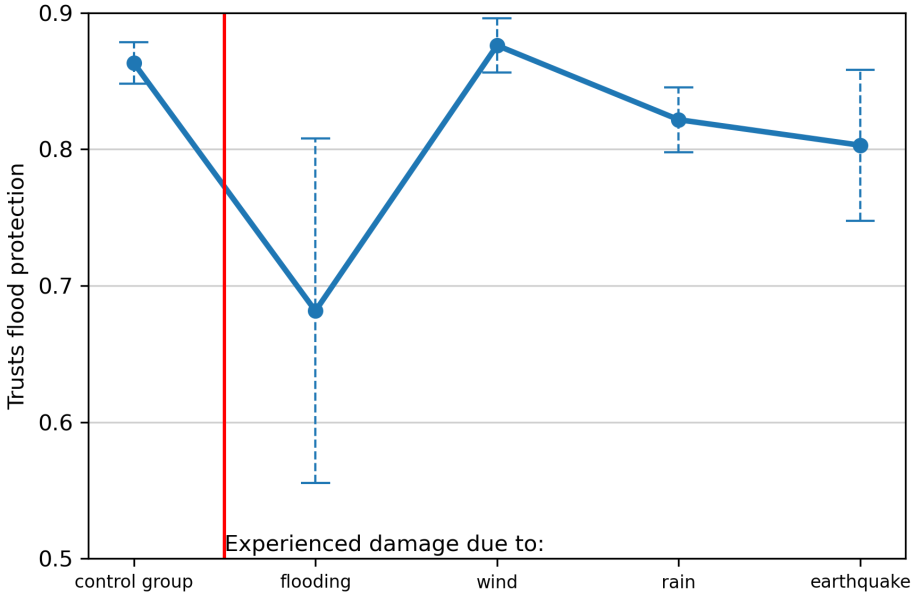

Figure 1: The role of flood and non-flood hazards for trust

Notes: Based on the baseline panel regression model, the figure shows predicted probabilities for different combinations of explanatory variables. The dependent variable is a binary indicator equal to one if the respondent expresses high trust in flood protection (categories 4 or 5 on a five-point scale), and zero otherwise. The control group consists of respondents who live in a flood-risk zone and report no prior property damage from extreme events. Dashed vertical lines indicate 90% confidence intervals.

4 Robustness

This section examines whether the baseline results are sensitive to alternative inference procedures, sample restrictions, and modeling choices.

First, we examine whether the results depend on the inclusion of respondents with earthquake damage experience. Given the specific geographical scope of earthquake exposure in the Netherlands, we re-estimate the baseline model after excluding all respondents who report prior earthquake-related property damage. The estimated effects of flood and rainfall experience remain negative and statistically significant. This indicates that the spillover from rainfall experience into trust in flood protection is not driven by including observations with earthquake experience.

We then explore heterogeneity with respect to flood-risk salience by augmenting the baseline specification with an interaction between the flood-zone indicator and an indicator for having experienced any non-flood hazard (wind, rainfall, or earthquake). The motivation for this interaction is that households residing in flood-risk zones are likely to have more salient flood risk awareness and more established beliefs about flood protection, which may attenuate the extent to which adverse experiences with other hazards translate into reduced trust in flood defenses. Specifically, we estimate

$$\begin{aligned} Trust_{it} &= \alpha + \beta_F FloodExp_{it} + \beta_{NF} NonFloodExp_{it} + \beta_A AtRisk_{it} \\ &\quad + \beta_I \left(AtRisk_{it} \times NonFloodExp_{it}\right) + \mathbf{X}_{it}'\boldsymbol{\gamma} + \delta_t + \varepsilon_{it}, \end{aligned} \tag{2}$$

where $Trust_{it}$ denotes trust in flood protection, $FloodExp_{it}$ is an indicator for prior flood damage, $NonFloodExp_{it}$ is an indicator equal to one if the respondent reports prior damage due to wind, rainfall, or earthquakes, $AtRisk_{it}$ indicates residence in a flood-risk zone, $\mathbf{X}_{it}$ denotes the demographic controls, and δ_t are survey-wave fixed effects. Standard errors are clustered at the household level.

The interaction term is positive and statistically significant, while the main effect of non-flood experience is negative. So, non-flood hazard experience is negatively associated with trust in flood protection among owners outside flood-risk zones, but this negative association is markedly smaller for owners whose properties are located in flood-risk zones.

We also assess robustness to functional form, sample definition, and outcome coding. Re-estimating the baseline model using logit and probit specifications for the binary trust indicator yields the same qualitative pattern of results: flood and rainfall experience are negatively associated with trust in flood protection, while wind experience is not. The estimated earthquake effect is negative in the logit and probit specifications, but is less robust than the flood and rainfall effects. We also estimate ordered logit models that exploit the full ordinal structure of the 1–5 trust scale rather than collapsing it to a binary indicator. In the baseline-consistent specification, where 'don't know' responses are recoded as the lowest trust category, the rainfall experience effect is negative and highly significant ($p < 0.001$), confirming the cross-hazard spillover. The flood experience coefficient is also negative but does not reach statistical significance in the ordered specification, reflecting the wider confidence intervals associated with the small number of flood-experienced respondents (50 observations). The earthquake coefficient is negative but insignificant. Re-estimating the ordered logit after excluding 'don't know' responses yields very similar results for rainfall, while the earthquake coefficient becomes small and positive, consistent with the sensitivity to 'don't know' treatment observed in the linear models.

We also examine whether results are sensitive to how 'don't know' responses are handled in the trust item. The baseline binary trust indicator codes respondents as having high trust if they select categories 4 or 5 on the five-point scale, and as having low trust otherwise. As an alternative, we reconstruct the binary trust indicator from the original five-point item while excluding 'don't know' responses, and re-estimate the baseline models. The estimated effects of flood and rainfall experience remain negative and statistically significant, while the earthquake coefficient becomes smaller and statistically insignificant in the linear probability model. This indicates that the rainfall spillover is robust to outcome coding choices, whereas evidence for earthquake spillovers is more sensitive to how low trust and item non-response are treated.

In addition, we assess whether the baseline restriction to protected at-risk areas affects the results. The baseline sample excludes the 53 homeowners (86 observations) residing in unprotected flood-prone areas. Re-estimating the model while including this group and controlling for flood-zone status using indicators for protected and unprotected at-risk areas yields highly similar estimates for flood and rainfall experience. The earthquake coefficient is also negative and marginally significant in this specification.

We further examine whether the results are robust to controlling for individual heterogeneity and trust persistence. First, we estimate respondent fixed effects specifications, which identify the experience coefficients solely from within-person changes across survey waves. Trust itself exhibits substantial persistence: among respondents observed in consecutive waves, 90.0% of those with high trust and 52.5% of those with low trust remain in the same category. In the respondent fixed effects model, the rainfall experience coefficient remains negative (-0.034, $p = 0.050$), indicating that the rainfall spillover is not driven by time-invariant individual characteristics. A correlated random effects specification (Mundlak approach), which controls for individual-level means of time-varying covariates while retaining time-invariant controls, yields a similar estimate (-0.035, $p = 0.043$). As expected, the flood and earthquake experience coefficients cannot be reliably identified in the fixed effects framework due to limited within-person variation (only 32 and 82 individuals change their reported flood and earthquake experience, respectively). The earthquake coefficient becomes small and positive under fixed effects, suggesting that the negative pooled association largely reflects time-invariant characteristics of earthquake-region residents rather than a within-person effect. Second, we assess whether trust persistence could bias the baseline estimates by including lagged trust as a regressor. This specification, estimated on respondents observed in consecutive waves ($n = 2{,}772$), yields a significant coefficient on lagged trust (0.399, $p < 0.001$), confirming persistence. Importantly, the rainfall experience coefficient remains negative and statistically significant (-0.034, $p = 0.040$) after conditioning on prior trust, while the flood coefficient is also negative and marginally significant (-0.114, $p = 0.057$). We note that the lagged dependent variable specification is subject to Nickell bias in short panels, primarily affecting the coefficient on lagged trust itself rather than the other regressors.

Overall, the robustness checks indicate that the main empirical conclusions are not driven by inference procedures, sample composition, outcome coding, time-invariant individual heterogeneity, or trust persistence. In particular, the evidence for cross-hazard spillovers from rainfall-related damages into trust in flood protection remains stable across specifications.

Table 2: Robustness checks: sign and significance of experience effects

	Flood	Wind	Rainfall	Earthquake
Baseline LPM (cluster: household)	$-^{**}$	0	$-^{***}$	$-^{*}$
LPM excl. earthquake experience	$-^{**}$	0	$-^{**}$	n.a.
Logit (binary trust)	$-^{***}$	0	$-^{***}$	$-^{**}$
Probit (binary trust)	$-^{***}$	0	$-^{***}$	$-^{*}$
LPM, DK excl. (binary from 1–5)	$-^{**}$	0	$-^{***}$	0
LPM incl. unprotected at-risk areas	$-^{**}$	0	$-^{***}$	$-^{*}$
Ordered logit (DK as low trust)	0	0	$-^{***}$	0
Ordered logit (DK excl.)	0	0	$-^{***}$	0
Respondent FE	0	0	$-^{*}$	0
Correlated random effects (Mundlak)	0	0	$-^{**}$	0
LPM with lagged trust	$-^{*}$	0	$-^{**}$	0

Notes: Entries report the sign and statistical significance of the coefficient on each experience variable within the corresponding robustness specification. − indicates a negative association; 0 indicates no statistically significant effect; n.a. indicates not estimated. All specifications include the full set of demographic controls and year fixed effects. Baseline specifications condition on the flood-zone indicator; the specification including unprotected at-risk areas controls for flood-zone status using indicators for protected and unprotected areas. Ordered logit specifications use the original 1–5 trust scale as the dependent variable; the 'DK as low trust' variant recodes 'don't know' responses as category 1, while the 'DK excl.' variant drops them. The respondent FE specification identifies effects from within-person changes only; the correlated random effects specification augments the pooled model with individual means of time-varying covariates. The LPM with lagged trust includes the previous wave's trust indicator as a regressor (estimated on consecutive-wave pairs, $n = 2{,}772$). Standard errors are clustered at the household level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5 Discussion and limitations

Consistent with earlier work (Bubeck et al., 2012), we find that a person's flood experience is strongly associated with reduced trust in flood protection. A novel finding related to cross-hazard spillovers from non-flood hazards. In particular, homeowners with prior rainfall-related damage are 4.2 percentage points less likely to trust flood protection, a result that remains stable across several robustness tests. Evidence for spillovers from earthquake damage is present, though more sensitive to modeling choices and the treatment of item non-response. These findings indicate that adverse experiences with natural hazards can generalize beyond the hazard that caused the damage and affect confidence in public protection systems, even when those systems are designed to manage different risks.

We also document meaningful heterogeneity in these spillover effects. The negative association between non-flood hazard experience and trust in flood protection is concentrated among homeowners located outside designated flood-risk zones, while it is markedly attenuated for homeowners residing in flood-prone areas. This pattern suggests that the way households interpret and attribute adverse hazard experiences depends on the salience of flood risk and existing exposure to flood governance arrangements. For households in flood-risk zones, beliefs about flood protection may be more strongly anchored in long-standing risk awareness and institutional arrangements, limiting the extent to which experiences with other hazards translate into reduced trust in flood defenses.

An important conceptual consideration is that our trust measure is narrow in scope: it captures confidence in a specific protection system (dikes) rather than broad trust in government or institutions in general. Whether adverse hazard experiences affect narrow trust in specific protective infrastructure, broad institutional trust, or both, is a question our data cannot fully disentangle. Future work could investigate whether the spillovers we document operate through a general erosion of institutional trust or through more targeted updating of beliefs about physical protection capacity.

Turning to limitations, there are a few points upon which future research could improve. First, our analysis relies on two survey questions only. Follow-up research could use additional questions, more granular response scales, or alternative wording. Second, the sub-samples of respondents with prior experience are sometimes small, which means confidence intervals become larger. Using our findings as guidance, future work could try and collect larger samples to allow for more precise measurement. Third, while we document cross-hazard spillovers, the precise psychological mechanism—whether generalized institutional distrust, heightened risk salience, or broader updating of beliefs about government competence—remains an open question that could be studied through more targeted survey instruments. Lastly, the set of hazards could be expanded. This paper focuses on 4 distinct hazards that capture top-of-mind risks for the Netherlands (KNMI, 2025). In other jurisdictions, different hazards or a larger set of shocks could be relevant.

6 Conclusions and policy implications

This paper studies how prior experience with a range of natural hazards relates to trust in flood protection systems. While much of the existing literature examines prior experience in a hazard-specific manner, this paper broadens the focus by documenting spillovers across hazards. Using three survey waves collected between 2021 and 2024 among 2,272 Dutch homeowners, we show that prior damage experience (both for floods and non-flood events) is systematically associated with lower trust in flood protection.

Our findings have important implications for climate risk governance.

In light of the expected increased frequency and severity of various natural hazards, households are more likely to experience repeated and potentially compounding losses, leading to higher cumulative economic damages (Auffhammer, 2018). From a governance perspective, our results suggest that perceived failures in one hazard domain may weaken trust in other public protection systems, reflecting system-wide belief updating about institutional reliability and public protection performance rather than narrowly hazard-specific evaluations. Risk communication strategies that focus exclusively on individual hazards may, therefore, be defined too narrowly. Instead, a broad-based, multi-hazard approach that explicitly addresses overall protection capacity, institutional performance, and credibility across risk domains may be better suited to maintain public trust in years to come.

Disclosure statement

The authors have no competing interests to declare that are relevant to the content of this article.

Data availability statement

Research data are proprietary, and hence cannot be shared.

References

Ahmad, N. and Younas, M. Z. (2021). A blessing in disguise?: Assessing the impact of 2010–2011 floods on trust in Pakistan. *Environmental Science and Pollution Research*, 28(20):25419–25431.

Attems, M.-S., Thaler, T., Snel, K. A., Davids, P., Hartmann, T., and Fuchs, S. (2020). The influence of tailored risk communication on individual adaptive behaviour. *International Journal of Disaster Risk Reduction*, 49:101618.

Auffhammer, M. (2018). Quantifying economic damages from climate change. *Journal of Economic Perspectives*, 32(4):33–52.

Barendrecht, M. H., McCarthy, S., and Viglione, A. (2021). A comparative analysis of the relationship between flood experience and private flood mitigation behaviour in the regions of England. *Journal of Flood Risk Management*, 14(2):e12700.

Bubeck, P., Botzen, W. J. W., and Aerts, J. C. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis*, 32(9):1481–1495.

Bubeck, P., Wouter Botzen, W., Laudan, J., Aerts, J. C., and Thieken, A. H. (2018). Insights into flood-coping appraisals of protection motivation theory: Empirical evidence from Germany and France. *Risk Analysis*, 38(6):1239–1257.

De Leeuw, D. and Jansen, D.-J. (2025). Floods and homeowners' financial resilience: Survey-based evidence from the Netherlands. *DNB Working Paper No. 845*.

Frondel, M., Simora, M., and Sommer, S. (2017). Risk perception of climate change: Empirical evidence for Germany. *Ecological Economics*, 137:173–183.

Jansen, D.-J. (2024). Flood risk and climate change: A disconnect between homeowners' awareness and mitigating actions? *Climate Risk Management*, 44:100616.

KNMI (2025). Een extreem report. Technical report.

Köhler, L. and Han, S. (2024). The driving effect of experience: How perceived frequency of floods and feeling of loss of control are linked to household-level adaptation. *International Journal of Disaster Risk Reduction*, 112:104745.

Lindell, M. K. and Perry, R. W. (2012). The protective action decision model: Theoretical modifications and additional evidence. *Risk Analysis*, 32(4):616–632.

Mol, J. M., Botzen, W. W., Blasch, J. E., and de Moel, H. (2020). Insights into flood risk misperceptions of homeowners in the Dutch river delta. *Risk analysis*, 40(7):1450–1468.

Terpstra, T. (2011). Emotions, trust, and perceived risk: Affective and cognitive routes to flood preparedness behavior. *Risk Analysis*, 31(10):1658–1675.

Voogd, R., de Vries, J. R., and Beunen, R. (2021). Understanding public trust in water managers: Findings from the Netherlands. *Journal of Environmental Management*, 300:113749.

Wachinger, G., Renn, O., Begg, C., and Kuhlicke, C. (2013). The risk perception paradox—implications for governance and communication of natural hazards. *Risk Analysis*, 33(6):1049–1065.

Appendix

Survey questions

The wording of the two key questions from the survey was as follows:

Q: Have you ever experienced that the following events in the Netherlands caused damage to your residence?

- An earthquake
- Wind speeds
- Floods (sea/river)
- Extreme precipitation

Options: yes / no / I do not know / I prefer not to say

Q: How much protection do the Dutch dikes offer according to you?

1. a very small degree
2. a small degree
3. neither small nor large
4. a large degree
5. a very large degree
6. I do not know

Table A1: Sample composition and panel structure

Panel A: Survey waves

	2021	2023	2024
Observations	1,696	1,749	1,694
Share trusting flood protection	0.870	0.835	0.842
Share owning at-risk property	0.639	0.642	0.649

Panel B: Panel structure

Observed in 1 wave	553	(24.3%)
Observed in 2 waves	571	(25.1%)
Observed in 3 waves	1,148	(50.5%)
Share of respondents with unchanged flood-risk classification[a]	0.941	
Total respondents	2,272	

Notes: Panel A reports wave-by-wave participation and headline shares. Panel B reports the distribution of respondents across survey waves, illustrating the unbalanced panel structure. The sample consists of homeowners only.

[a] Calculated among respondents observed in at least two survey waves.

Table A2: Descriptive statistics

Variable	Mean	SD	N
Trust in flood protection (binary)	0.849	0.358	5,139
Trust in flood protection (1–5 scale; DK=6 in raw)	4.273	0.765	5,139
Owns at-risk property	0.643	0.479	5,139
Prior flood damage	0.010	0.098	5,139
Prior wind damage	0.351	0.477	5,139
Prior rainfall damage	0.227	0.419	5,139
Prior earthquake damage	0.061	0.240	5,139
Male	0.535	0.499	5,139
Age 16–34	0.049	0.215	5,139
Age 50–64	0.322	0.467	5,139
Age 65+	0.418	0.493	5,139
University degree	0.157	0.364	5,139
Socio-economic status (1–5)	3.728	1.015	5,139
Low income	0.261	0.439	5,139
High income	0.206	0.404	5,139
Income missing	0.317	0.465	5,139

Notes: The table reports means and standard deviations for the main variables used in the analysis, computed on the estimation sample. The binary trust indicator equals one if respondents report high trust (categories 4 or 5). 'Don't know' responses are coded as 6 in the raw trust item. The sample consists of homeowners only.