Keynote Speech

Willingness to Pay to Avoid Black Swan Events Related to Flood Risks

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Presentation Outline

1. Introduction
2. Research Background
3. Methodology
4. Results
   - Descriptive Analysis
   - Regression Analysis
5. Limitations
6. Discussion
7. Conclusion

1. Introduction – Research Motivation, Aim & Scope (1/2)

- Case Study: **Ahrtal Flood, July 2021** (Rhineland-Palatinate and NRW, Germany)
  - Severe flooding in Western Germany
  - Vicht river overflowed: homes, roads, communication lines destroyed
  - Stolberg hit hard: €353 million in infrastructure damage
    (nearby Eschweiler was saved)

- Disaster Was **Scientifically Predictable**
  - Early warnings by DWD and EFAS
  - Risk maps and models available
  - Yet, residents were unprepared → disconnect between foresight and experience

- **Research Motivation**
  - How much are people willing to pay to reduce disaster risk?
  - **Does direct flood experience increase WTP?**

Pictures: City of Stolberg / printed in VDI Nachrichten

Research Questions:

1. Which **financing mechanisms** for flood risk mitigation (e.g., taxes, insurance premia, voluntary contributions) are **most favored** by residents and what **reasons** underpin their willingness or refusal to pay?
2. Do individuals who **directly experienced** the 2021 Stolberg flood have a **higher WTP** compared to those without direct flood experience?
3. Which **measures** are people willing to adopt at a personal level (insurance, emergency kits, building modifications, etc.) specifically to mitigate the impact of extreme weather events and what factors influence these decisions?
4. **How does willingness to pay differ** across demographic and socioeconomic groups, including region, income and education level?

2. Research Background (1/5) – Black (and Green) Swans

Are Climate Disasters Still Black Swan Events?

- **Black Swan Definition (Taleb 2010):** Extremely rare, severe consequences, unpredictable in hindsight

- Climate change increasing frequency and intensity of such events
- Advance warnings were posted (DWD, EFAS) but largely ignored
- **Climate change** is making such events more foreseeable
- **Prevention failures** stemmed from institutions, communication, and preparedness
- Useful for highlighting **governance gaps / failure** and systemic risks

→ The **Stolberg flood** can be framed as a "Black Swan event" from the perspective of the unprepared population

- **"Green Swans"**: rare, to some extent predictable (risks are known)
  - BIS* (2020): disruptive (natural, political) risks beyond models' predictive capabilities, often cascading, longer-term impact, requires cooperation
  - Elkington (2020): title of a book on **sustainable capitalism**

BIS … Bank for International Settlements

2. Research Background (2/5) – Related Literature on WTP & Flood Risk

International Case Studies (NL, Germany, France, Bangladesh, US):

- **The Netherlands – Botzen et al. (2009, 2012)**
  - Surveyed 1,000+ households in flood-prone Dutch regions
  - WTP higher after flood experience
  - WTP further higher when:
    - Insurance includes **mitigation incentives**
    - Backed by **government guarantees**
    - Low-income households = lower WTP despite risk

- **Bangladesh – Brouwer et al. (2009)**
  - Low-income households still showed WTP→ Up to 2.6% of monthly income
  - Driven by:
    - Recent flood experience
    - Perceived risk

2. Research Background (3/5) – Related Literature on WTP & Flood Risk

- **China – Liu (2023)**
  - WTP higher with:
    - **Flood experience**
    - **Trust in government**
    - **Climate change concern**
  - Strong support for adoption of **collective measures**

- **Germany – Entorf & Jensen (2020):**
  - Nationwide study on WTP for flood protection
  - Key findings:
    - WTP ↑ with **experience + institutional trust**
    - Many refused to pay without trust or ability
    - Strong support for **state-led protection**, not private responsibility
  - Preferred payment methods: **taxes & compulsory insurance**

2. Research Background (4/5) – Related Literature on WTP & Flood Risk

- **Germany – Thieken (2023):**
  - Study on **Ahrtal flood 2021**
  - Flood perceived as sudden and overwhelming
  - Despite early warnings
  - Key findings:
    - Weaknesses in **risk communication**
    - **Low preparedness** locally
    - Emotional & financial stress shaped public attitudes toward future protection

2. Research Background (5/5) – WTP & Flood Risk

Key Take-Aways from Related Literature:

- WTP rises with **experience** and **trust**, but also **climate belief** and **income**
- Preference for **tax-based or mandatory insurance models**
- **Emotional and communication factors** crucial after disaster
- Even **low-income groups** may contribute when risk is **personally understood**

Research Gap:

- Few studies on **localized WTP** after real disasters in Germany
- **Post-Ahrtal data** remains limited despite scale of impact
- Lack of research on:
  - How **direct experience** shapes WTP
  - Role of **institutional trust** at the town level
  - **Preference for payment models** post-flood

3. Methodology (1/2)

- Survey with a **structured questionnaire**, following principles of the **contingent valuation method, CVM** (frequently used in environmental and disaster economics)
- Aimed at **eliciting monetary valuations for non-market goods**
- **Presenting** hypothetical, yet realistic scenarios and structured payment mechanisms to individuals
- **Survey Design:**
  - Set of proposed flood mitigation measures **scenarios**
  - Individuals were asked whether and how much they would be **willing to pay**)
  - Framed to emphasize **shared societal benefits** (w/o exaggerating risks, aimed at avoiding / mitigating *hypothetical bias*)
- Contextualization: **July 2021 Flooding in Stolberg, NRW**
  - Early warnings (alerts) not received or severity of flood event underestimated
    → technically predictable but unexpected
  - **Behavioral gap** in individual preparedness (→ central to understanding CVM results)
    → ~30% of respondents reported to have taken no protective action

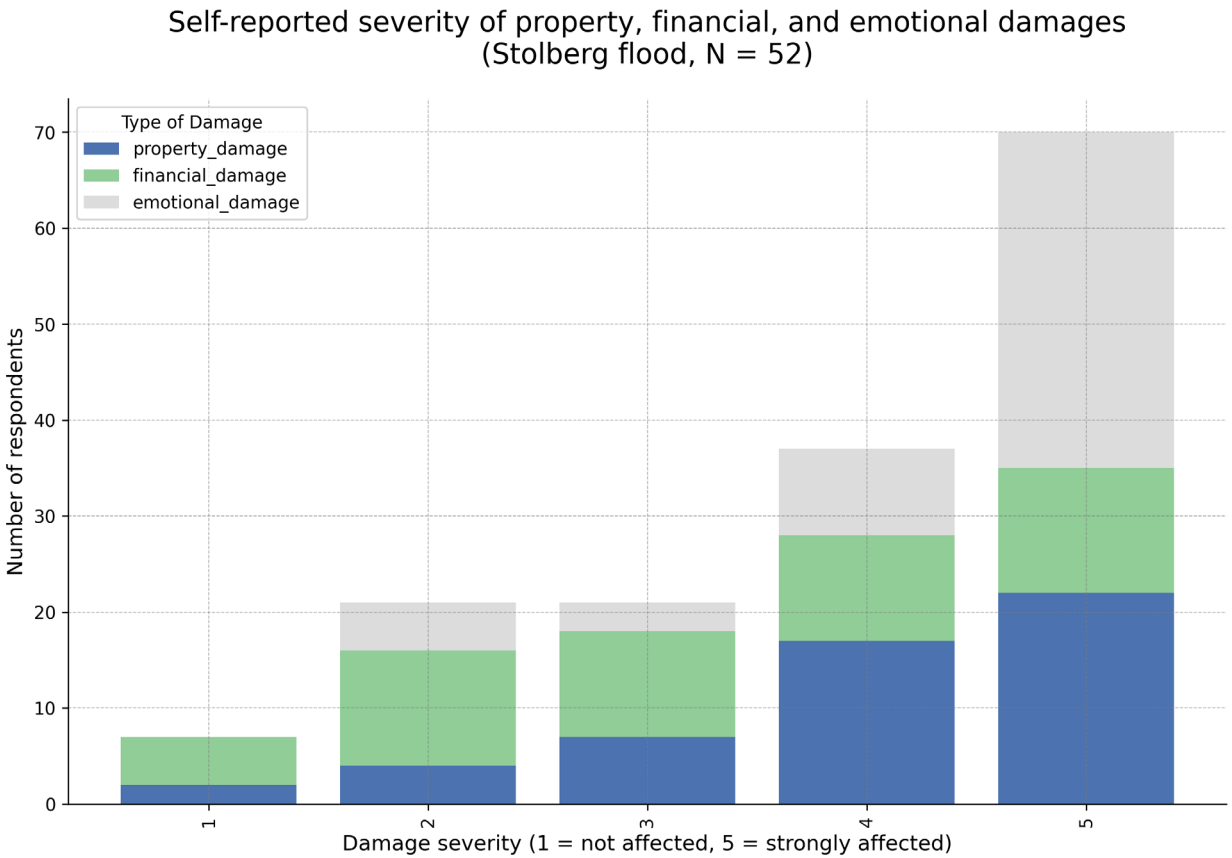
3. Methodology (2/2)

- Survey divided into **five thematic sections**, to capture
  - variables relevant to **flood risk exposure, perception, and payment preferences**
  - a wide range of **behavioral and socio-economic drivers:**
    - Age, gender, household composition, education, income
    - Property situation, flood insurance coverage
    - Postal code (→ spatial analysis)
    - Prior flood experience (esp. 2021 Stolberg flood event)
    - Were they or someone close affected by a flood (direct, indirect experiences)?
  - Perception, institutional trust, adaptive behavior
  - WTP section: preferred funding mechanism, and reason for refusal (if applicable)
- **Data collection** from 7 May-10June 2025, conduct of a pilot survey
- **Plain, concise language** to accommodate older respondents (+ use of online and paper version)
- 200 people approached (Stolberg and Eschweiler, 100 each), 120 responded (*N* = 103)
- No representative sample (“purposive sample and design”)
- **Econometric analysis:** based on linear and logistic OLS regression

4.1 Descriptive Analysis – Understanding the Sample

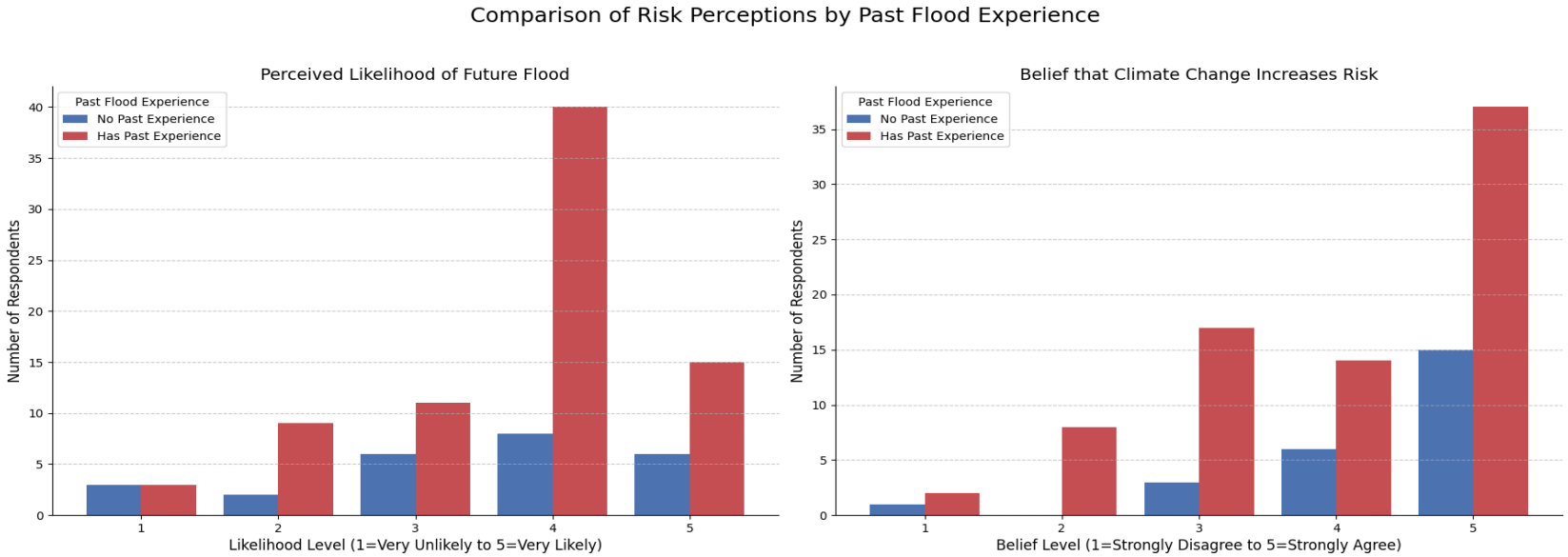
Variable	Value	Mean / % / Median	Std. Dev. / N	Min -- Max
Willingness to Pay (WTP)				
wtp_mid (€)	Midpoint of stated WTP	43.92	44.40	0 -- 125
wtp_positive	Willing to pay > 0€	73.8%	76.00	0 -- 1
Age				
age	Age in years	52.2	14.90	23 -- 87
Gender (N=103)				
Female		52.4%	54.90	---
Male		46.6%	48.00	---
Diverse		1.0%	1.00	---
Education				
education (median)	Education level (1–9)	6	---	1 -- 9
Income				
income_cat (median)	Household income (1–6)	4	---	1 -- 6
Flood Experience				
experienced_stolberg	Affected by 2021 flood	50.5%	52.09	0 -- 1
Housing				
homeownership	Owns their home	63.1%	65.00	0 -- 1

4.1 Descriptive Results – Impact of Flood Experience



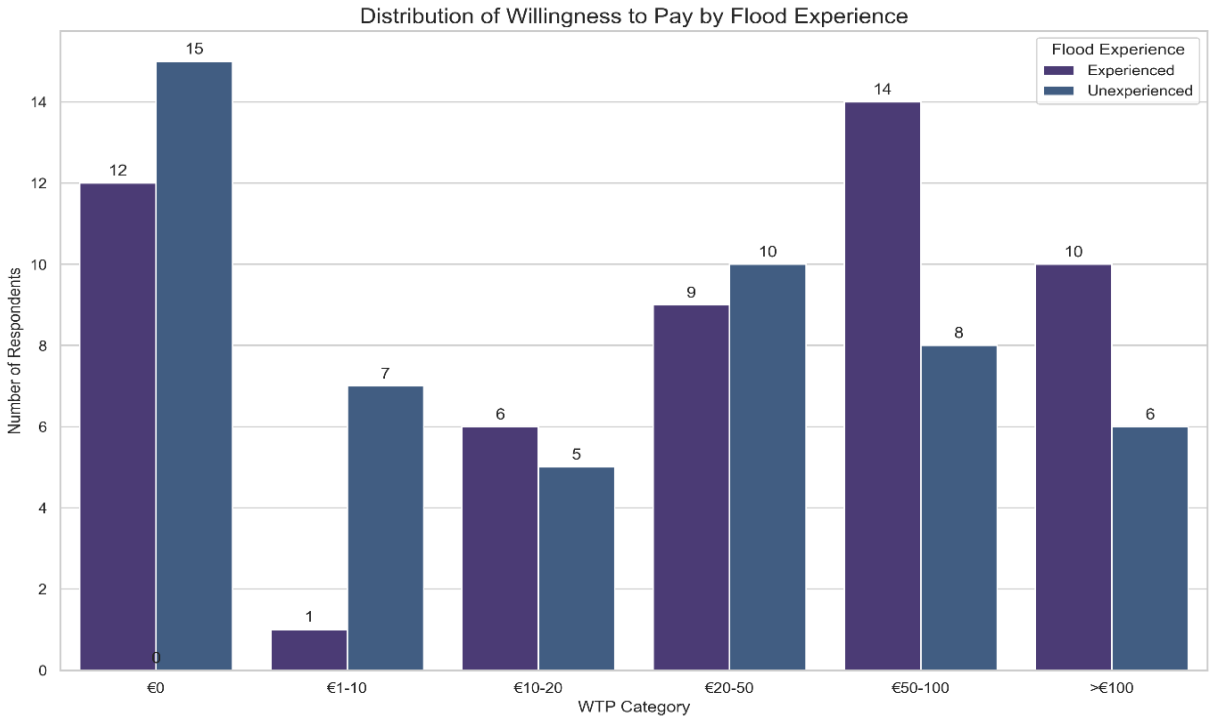
- **Emotional Distress:** Most severe and frequently reported impact
  - 35 individuals rated highest severity
  - Highlights significant psychological trauma beyond economic costs

4.1 Descriptive Results – Impact of Flood Experience



- **Risk Perception:** Past flood experience **dramatically increases perceived likelihood of future floods**
- Experienced group: greater perceived risk of future floods
- Unexperienced group: moderate concern
- **Climate Change Belief:** Strong across both groups
- Experience *reinforces* belief that climate change increases risk

4.1 Descriptive Results – WTP Distribution & Perceived Responsibility



- **WTP Distribution:** Significant divergence based on flood experience
- Refusal to pay (WTP = 0) most common for unexperienced, less for experienced respondents
- Experienced group shows stronger willingness for higher contributions (€50-100 and > €100 categories)

4.1 Descriptive Results – WTP Distribution & Perceived Responsibility

- **Reasons for Refusal (WTP=0):**

Reason for Refusal	Percentage (%)
Government should pay	77.8
Cannot afford it	33.3
Have already taken mitigation	7.4
Do not believe it is necessary	3.7

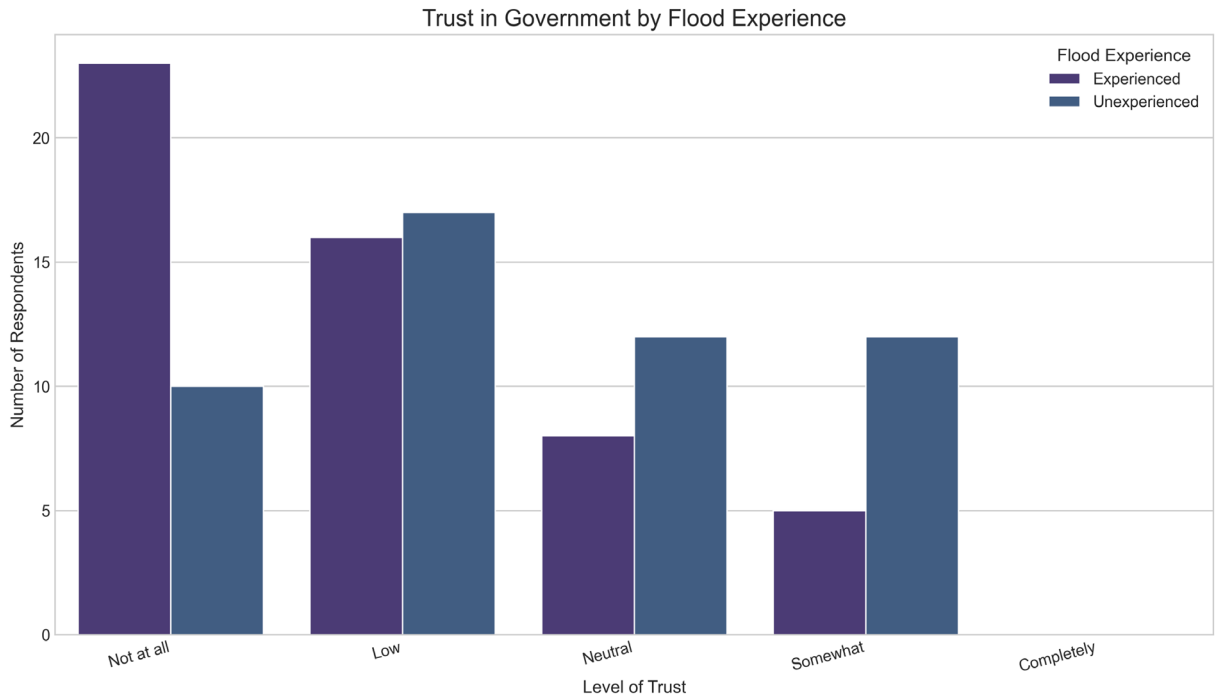
- **Perceived Responsibility for Flood Protection**

Responsible Party	Percentage (%)
City/Municipality	92.2
State Government	74.8
Federal Government	54.4
Homeowners	48.5
Each Individual	17.5
Insurance Companies	4.9

- **Preferred Financing Mechanisms**

Financing Mechanism	Percentage (%)
Taxes	62.1
Insurance Premiums	28.2
Utility Bills	19.4
None of the above	19.4
Voluntary Donations	16.5

4.1 Descriptive Results – Trust in Institutions & Preparatory Measures



- **Trust in Public Authorities:** Profound lack of confidence among **experienced group**.
  - Most frequent response for experienced: "Not at all" trust.
  - Unexperienced group: more varied, peaking at "Low" and "Somewhat" trust.

4.1 Descriptive Results – Trust in Institutions & Preparatory Measures

- **Personal Flood Mitigation Measures**

Personal Measure Adopted	Percentage (%)
Home Structurally Adapted	54.4
No Measures Taken	29.1
Emergency Kit Prepared	24.3
Insurance Purchased	22.3

- **Comparison of Personal Measure Adoption Rates Across Subgroups**

Personal Measure	Homeowners (%)	Renters (%)	Experienced (%)	Unexperienced (%)
Emergency Kit Prepared	27.7	18.4	30.8	17.6
Home Structurally Adapted	69.2	28.9	55.8	52.9
Insurance Purchased	33.8	2.6	25	19.6
No Measures Taken	16.9	50	23.1	35.3

4.2 Regression Analysis – Data and Model Setup

- **Goal:** Identify key factor that influence how much people are willing to pay
- **Method:** Ordinary Least Squares (OLS) regression with log-transformed WTP
- **Key Dependent Variable:** Log transformed WTP (WTP_mid+1)
  - Addresses skewed data and includes zero WTP values
- **Independent Variables:**
  - Experience: experience_stolberg (dummy for 2021 flood)
  - Perception: climate_change_belief
  - Trust: trust_government
  - Demographics: age_centered, homeownership, income_cat
- **Robustness:** HC1 robust standard errors used due to small size and potential heteroskedasticity

4.2 Regression Results – Drivers of WTP Amount

- **Overall Fit:** Model explains ~30.2% of WTP variation
- **Income:**
  - Highly significant positive effect
  - Strongest predictor of WTP
  - Each income category increase leads to ~66,2% higher WTP. Financial capacity is a key determinant.

Variable	Coefficient	p-value
experienced_stolberg	0.603*	0.074
climate_change_belief	0.526***	0.002
trust_government	0.222	0.147
age_centered	0.015	0.152
homeownership	0.336	0.374
income_cat	0.508***	0
Notes: * p<0.1, ** p<0.05, *** p<0.01. Robust standard errors (HC1) were used.		

- **Climate Change Belief:**
  - Highly significant positive effect
  - Risk perception influences valuation
  - Stronger belief in climate change increasing extreme weather leads to higher WTP

- **Flood Experience:**
  - Weakly significant positive effect
  - Direct exposure tends to increase WTP
  - Those with experience have ~82.8% higher WTP

4.2 Regression Results – Decision to Pay

- **Overall Fit:** Model is statistically significant (p=0.002), Pseudo R-squared ~0.189
- **Income:**
  - Statistically significant positive effect (→ RQ #4)
  - Income influences the likelihood of making a payment
- **Climate Change Belief:**
  - Statistically significant positive effect
  - Stronger belief increases the probability of WTP
- **Trust in government:**
  - Weakly significant positive effect
  - Institutional trust may play a role in the decision to pay
- **Flood experience:**
  - Positive but not statistically significant effect (→ RQ #2)

Variable	Coefficient	p-value
Intercept	-5.093***	0.001
experienced_stolberg	0.819	0.154
climate_change_belief	0.588**	0.022
trust_government	0.552*	0.063
age_centered	0.011	0.502
homeownership	0.695	0.276
income_cat	0.482**	0.02

Notes: * p<0.1, ** p<0.05, *** p<0.01. Coefficients represent log-odds. Robust standard errors (HC1) were used.

5. Limitations

- **Non-random sample** from Stolberg and Eschweiler → limits generalizability
- **Self-selection and attrition bias** may influence who responded
- **CVM limitations**: hypothetical and strategic bias (free rider effect)
- **Self-reported data** affected by memory, emotion, and social desirability
- **Midpoints used** for WTP categories → possible loss of detail
- **Small sample size (*n* = 103)** reduces statistical power and depth
- **Findings on Ahrtal flood** may not apply to other natural disasters

6. Discussion (1/3)

Flood Experience:

- People affected by the 2021 flood had a WTP 83% higher than those not affected
- Flood experience led to stronger risk perception
- Experience led to significantly higher perception of future flood risk
- Confirms earlier research: direct disaster experience increases awareness and financial engagement

Preferred Protective Measures:

- Preferred solutions were **structural adaptations or emergency kits**
- 69% of **houseowners** made structural adaptations; 50% of **renters** took no action
- Confirms that **housing situation and control** shape adaptation behavior more than **experience** alone

6. Discussion (2/3)

Income, Affordability, and Financing Preferences:

- WTP rose 66% per income level: **top earners** would pay 7x more than **lowest income group**
- Low WTP not caused by **affordability** → 78% cited government responsibility
- Most preferred **tax-based solutions** (62%), followed by **insurance premia** (28%)
- Strong rejection of **voluntary donations** shows preference for **mandatory, collective systems**

Institutional Trust vs. Responsibility Expectations:

- **Trust in government** was low, especially among those affected
- Common **complaints**: slow response, lack of transparency, poor communication
- Still, majority expect flood protection to be handled **by the state** (federal, state, municipal)
- Only 5% saw **insurance companies** as responsible
- People may distrust institutions, but still **prefer public solutions**

6. Discussion (3/3)

Climate Change Belief and Education:

- Belief in climate change raised WTP by **70% on average**, even when income and experience were controlled
- Shows strong link between **climate belief, risk awareness**, and **financial willingness**
- **Education level** surprisingly had **no significant effect**
- Likely due to **frustration with institutional response** during 2021 flood
- Suggests that **experience and trust** are more important than formal **knowledge**

7. Conclusions

1. Flood experience, income, and climate belief strongly increase willingness to pay
2. Zero WTP often based on political belief in state responsibility, not lack of money
3. Trust in institutions is low, but expectations for public protection remain high
4. Insured natural hazard losses reached €2.6 bn in 2024, well above average
5. CDU-SPD coalition (May 2025) proposed mandatory, state-backed insurance with opt-out
6. Public support is high, but concerns remain around pricing and access in high-risk areas
7. WTP alone is not enough — future policies must ensure trust, affordability, and transparency

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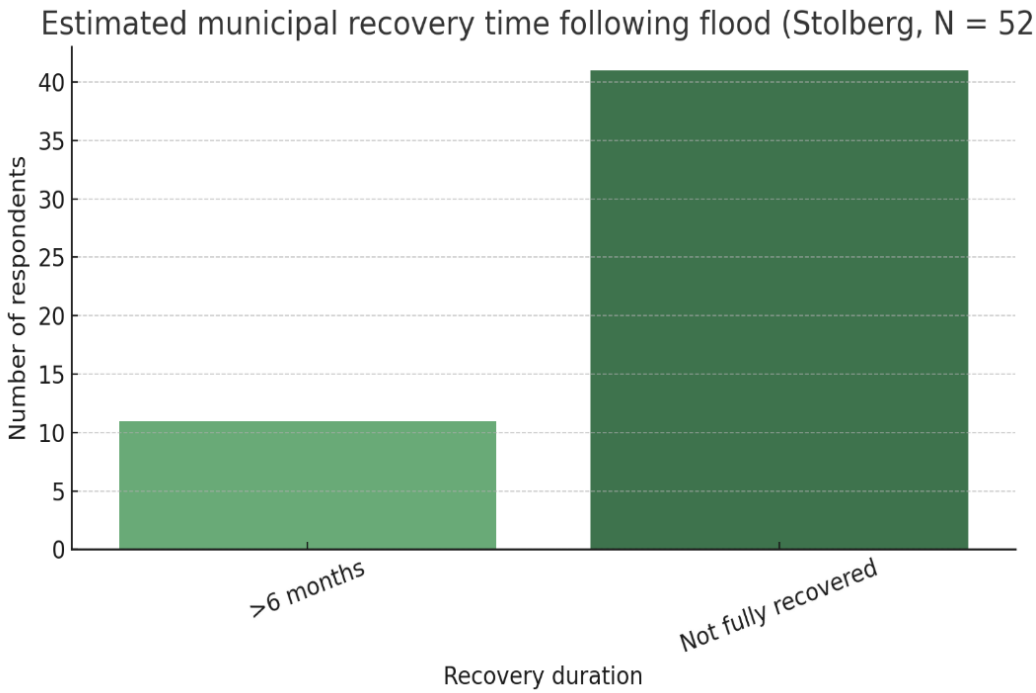
4.1 Descriptive Results – Impact of Flood Experience



- **Recovery:** Over 40% of affected communities **"Not fully recovered"** almost 4 years after the event
  - Signals persistent physical, social, and economic disruptions

4.1 Descriptive Results – Personal Mitigation Measure Adoption

Table 4.2: Overall adoption of personal flood mitigation measures (multiple responses allowed).

Personal Measure Adopted	Count	Percentage of All Respondents (%)
Home Structurally Adapted	56	54.4
No Measures Taken	30	29.1
Emergency Kit Prepared	25	24.3
Insurance Purchased	23	22.3

Table 4.3: Comparison of personal measure adoption rates across subgroups.

Personal Measure	Homeowners (%)	Renters (%)	Experienced (%)	Unexperienced (%)
Emergency Kit Prepared	27.7	18.4	30.8	17.6
Home Structurally Adapted	69.2	28.9	55.8	52.9
Insurance Purchased	33.8	2.6	25.0	19.6
No Measures Taken	16.9	50.0	23.1	35.3

4.1 Descriptive Results – Split Sample Analysis

Goal: Check whether main drivers of WTP are consistent across experienced and unexperienced

Table 4.11: Comparison of OLS regression results for experienced and unexperienced respondents

Variable	Experienced (β)	Unexperienced (β)	Std. Error (Exp / Unexp)
climate_change_belief	0.571**	0.547**	0.273 / 0.225
trust_government	0.015	0.373	0.205 / 0.233
age_centered	0.014	0.014	0.013 / 0.017
homeownership	0.242	0.347	0.561 / 0.517
income_cat	0.572***	0.505***	0.178 / 0.168

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. HC1 robust standard errors.

4.2 Regression Results – Robustness Check

Split Sample Analysis

- Aim: Ensure that drivers of WTP are consistent across experienced and unexperienced
- **Income:**
  - Significant predictor for both experienced (beta=0.572 , p=0.001) and unexperienced group (beta=0.505, p=0,003)
- **Climate Change Belief:**
  - Significant predictor for both experienced (beta= 0.571, p=0.037) and unexperienced group (beta=0.547, p= 0.015)

→ These two factors are consistent drivers of WTP, regardless of personal 2021 flood experience,

Trust in government, homeownership, and age are not statistically significant in either group