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A comparative analysis of property level flood mitigation behaviour in the regions of England

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Introduction

- The Environment Agency is responsible for flood management in the seven regions England.
- In between 1997 and 2005 the Environment Agency conducted surveys with households and businesses among the population at risk of flooding.
- During these surveys the people were asked about their experience with floods and the measures they had taken to prepare for future flooding.
- This provides a consistent data set both in time and space for the analysis of the differences in flood mitigation behaviour in England.

Is there a difference in the relationship between flood experience and preparedness for the regions of England and why do these differences exist?

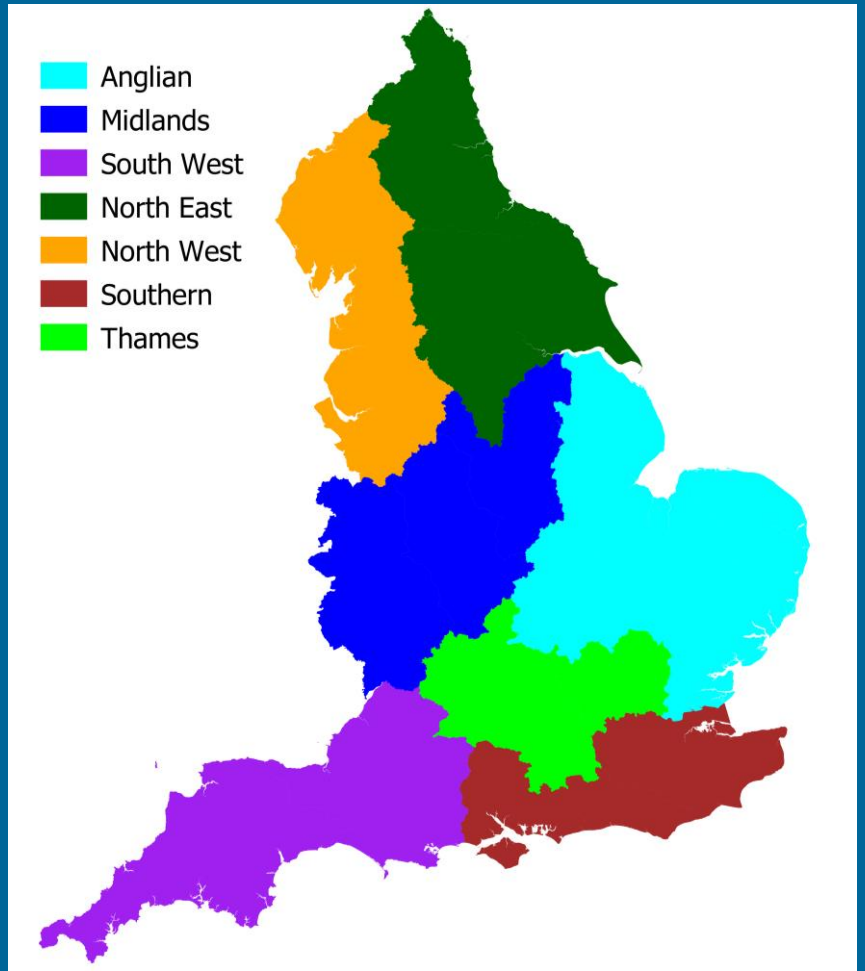

Figure 1. The seven regions of England as previously used by the Environment Agency. Barendrecht et al. (2020)

Methods

The differences in the relationship between flood experience (E) and preparedness (P) between the regions of England are investigated by applying a Bayesian hierarchical beta regression. The model is described with the following equations:

$$P_{i,j} \sim beta\left(\mu_{i,j}\sigma, (1-\mu_{i,j})\sigma\right)$$

$$\mu_{i,j} = \frac{e^{\tilde{\mu}_{i,j}}}{1+e^{\tilde{\mu}_{i,j}}}$$

$$\tilde{\mu}_{i,j} = \alpha_i + \beta_i E_{i,j}$$

$$\alpha_i = \alpha + \tau_\alpha \tilde{\alpha}_i$$

$$\beta_i = \beta + \tau_\beta \tilde{\beta}_i$$

Where $P_{i,j}$ is the average level of preparedness of region i in year j and $E_{i,j}$ is the average level of experience of region i in year j. The parameter $\mu_{i,j}$ is the mean level of preparedness in region i in year j, while σ is inversely related to the dispersion around the mean. We use $E_{i,j}$ to calculate $\tilde{\mu}_{i,j}$, which is then transformed to the interval between zero and one using an inverse logit to obtain $\mu_{i,j}$. The parameters α_i and β_i are region dependent, but they depend on the parameters α and τ_α and β and τ_β, respectively, which are assumed constant for England. $\tilde{\alpha}_i$ and $\tilde{\beta}_i$ account for the differences between regions.

In this way we are assuming that the regions behave differently but are related to each other. Instead of using only information from region i to estimate the parameters that determine its behaviour, this allows us to also use the data that is available for the other regions as well.

Results

There is a difference in the relationship between flood experience and preparedness for the regions of England.

In the Thames, Midlands and North West regions the preparedness increases less with increasing experience.

In the South West, Southern and Anglian regions increases in preparedness with increasing experience are higher compared to other regions.

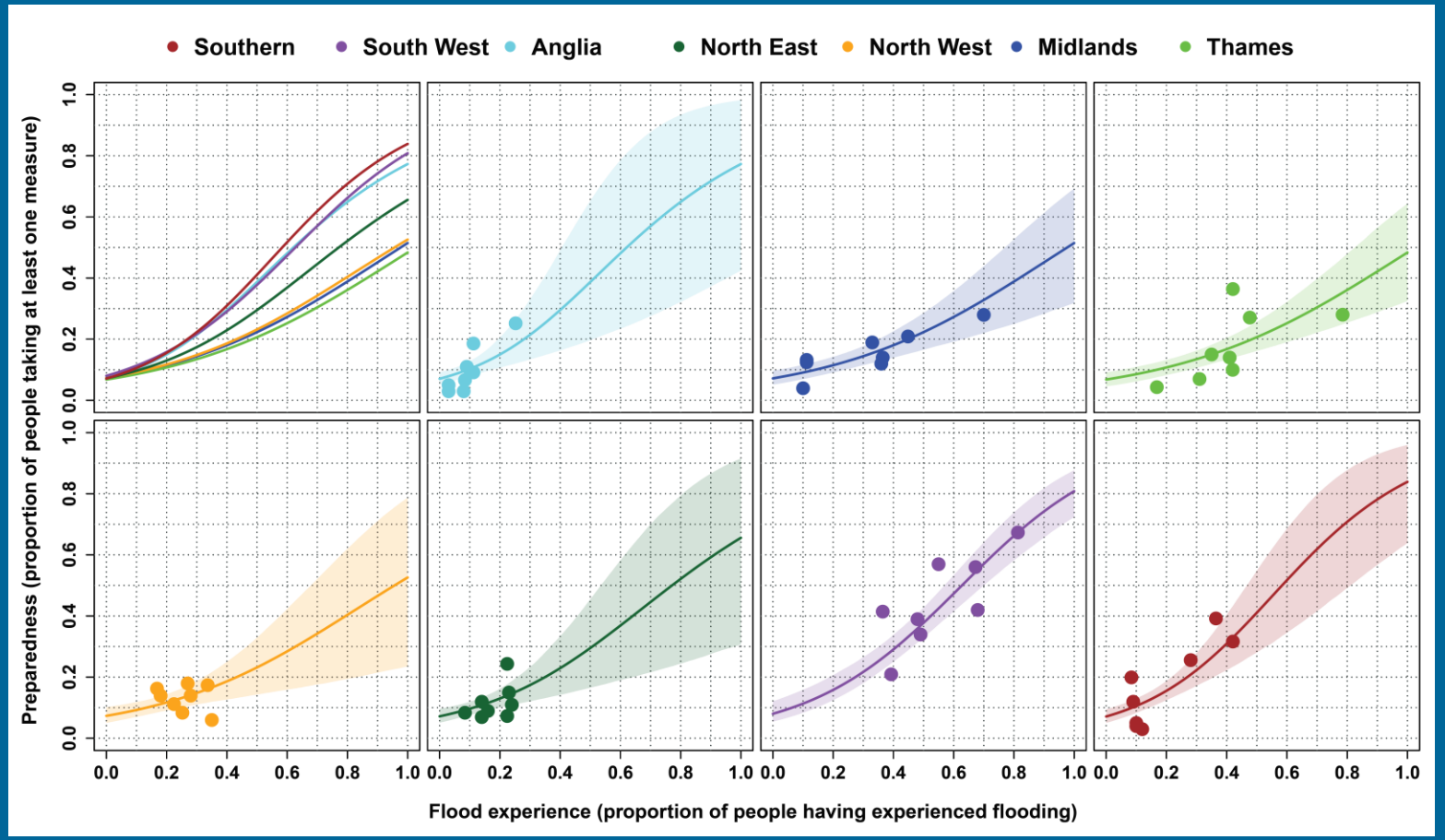

Figure 2. Results of the hierarchical beta regression. The top left panel shows the mean relationship between experience and preparedness for each of the seven regions. The other panels show the data (dots) and mean relationship with 90% credible interval for the different regions. Barendrecht et al. (2020)

Data consists of in between 4 and 8 surveys per region and sample sizes vary from 70 to 300 households/businesses.

Results

The impact of flooding seems to positively influence the preparedness, whereas the presence of structural defences and the fact that residents do not feel responsible for flood risk mitigation appear to have a negative influence.

In the North West and Thames regions, there is a higher percentage of the population that lives close to structural defences. Possibly leading to lower increases in preparedness.

In the Anglian region, flooding seems to have had a higher impact. Possibly leading to higher increases in preparedness.

In the North East and Midlands regions, a higher percentage of respondents seems to think that the government should do more. Possibly leading to lower increases in preparedness.

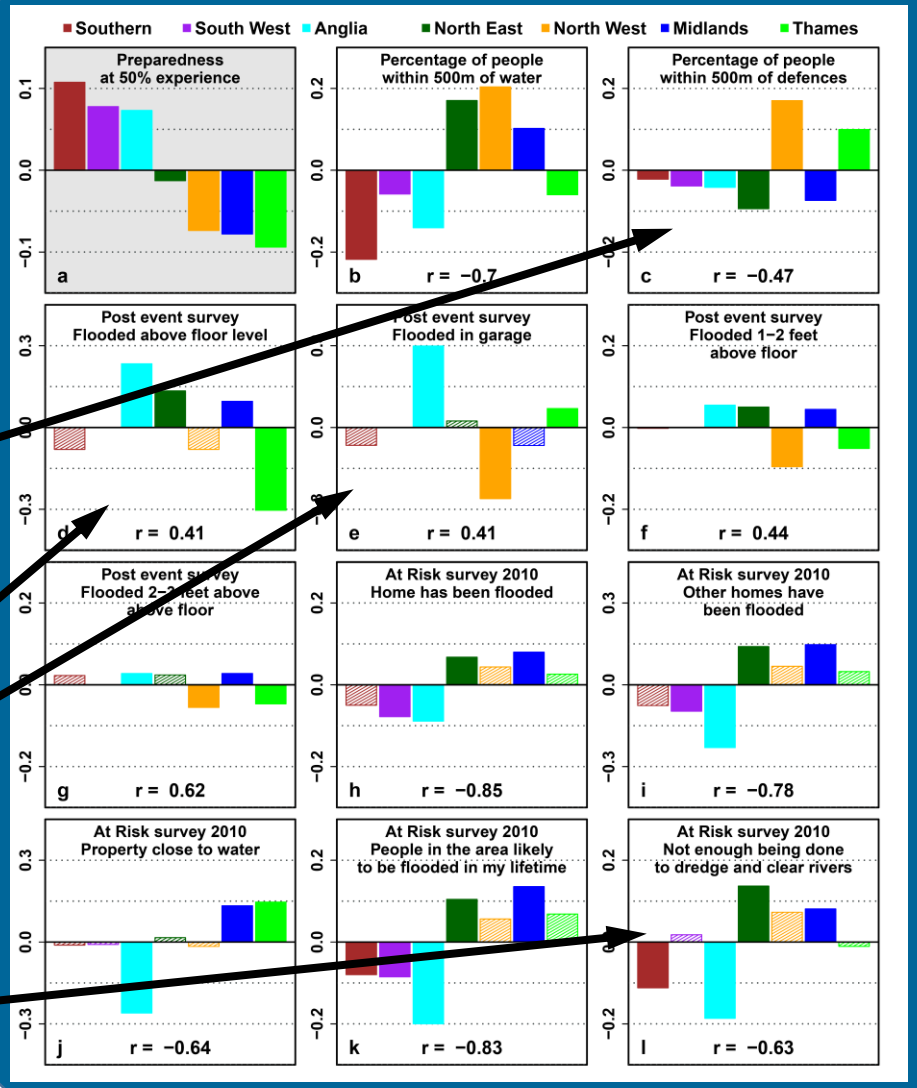

Figure 3. Differences in selected explanatory variables for the regions of England. Panel a gives for each region the level of preparedness for a level of experience of 50% of the population as calculated with the regression model. The other panels show for each region the difference from the mean of all regions. Bars with values that are significant at a level of 5% are plotted with a solid fill. r values give the correlation between the variable and the 50% preparedness level. Barendrecht et al. (2020)

Significant difference between regions was tested with a two proportions z-test (see Barendrecht et al. 2020).

Conclusion

- Applying a hierarchical model allows for including information about the other regions in the estimation of the individual regions, thereby making thorough use of all the information available and reducing uncertainty.
- There are differences between the regions in the relationship between experience and preparedness.
- An analysis of possible explanatory factors shows that there is a combination of factors that influence the increase in preparedness and these may differ per region.

Implications for Socio-hydrology

- Hierarchical models are useful in the analysis of multiple similar systems, where data is scarce, which is often the case in a socio-hydrological context.
- Using hierarchical model may reduce the uncertainty in the analysis.
- Multiple surveys at different time points are needed.
- Consistent surveys in multiple locations are needed.
- By contrasting and comparing case studies using data that has been collected in a consistent way, we can learn from the differences and similarities and better inform flood risk management strategies.