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# How do people behave during flash floods and why? Lessons for the prediction of the human vulnerability dynamics in short-fuse weather events

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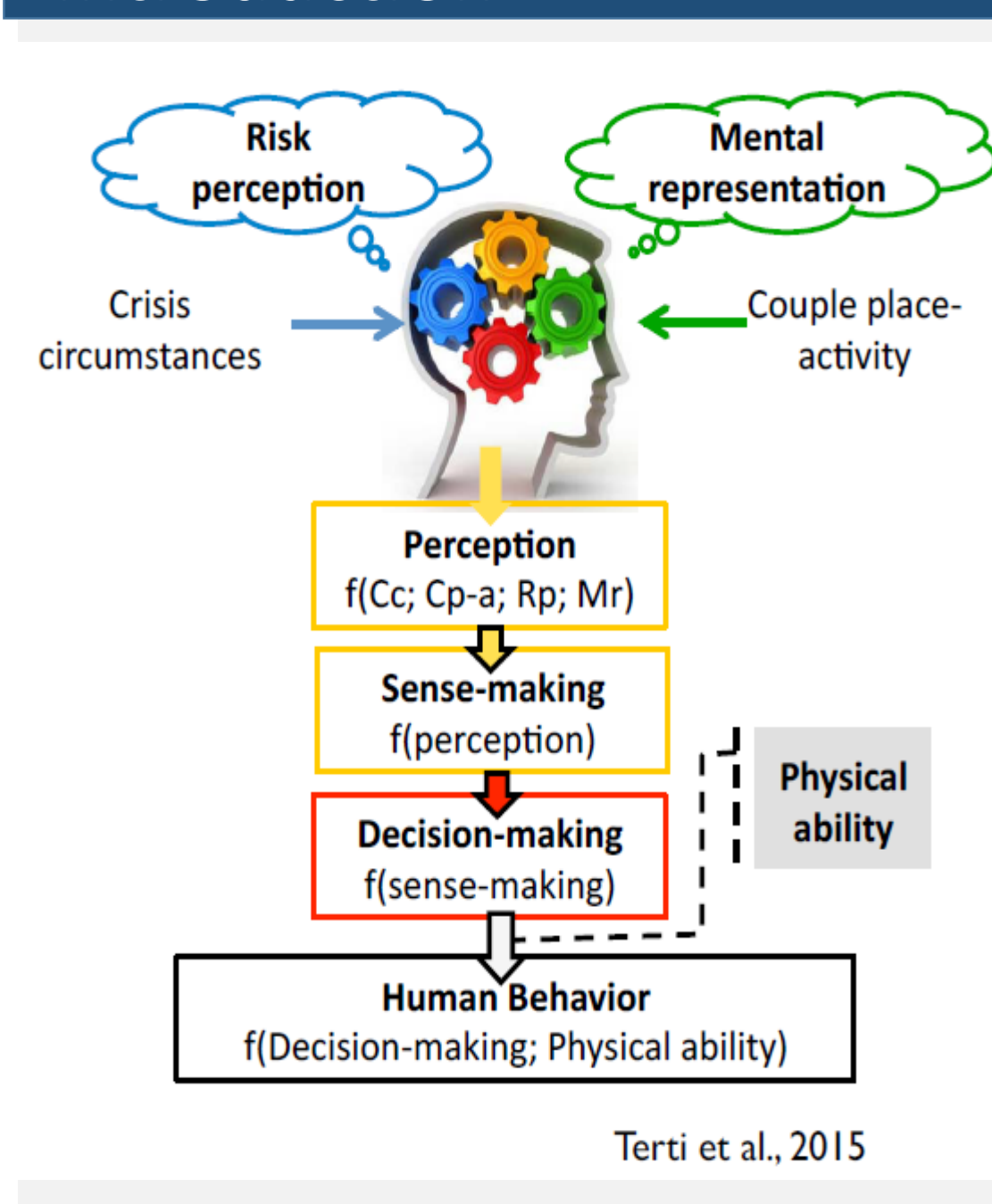
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## Introduction



- The characteristics of the hazard, the warning information characteristics, the situational and personal characteristics of the receiver and the socio-cultural context are strong determinants of the public behavioural response.
- In fast-moving events like flash-floods, the amount of time available to detect the threat and respond to it is so limited that protective actions often consist in dealing with contingent situations triggered by the irruption of dangerous circumstances in the middle of daily life activities and routines (Ruin et al., 2008, 2009; Terzi et al., 2015).

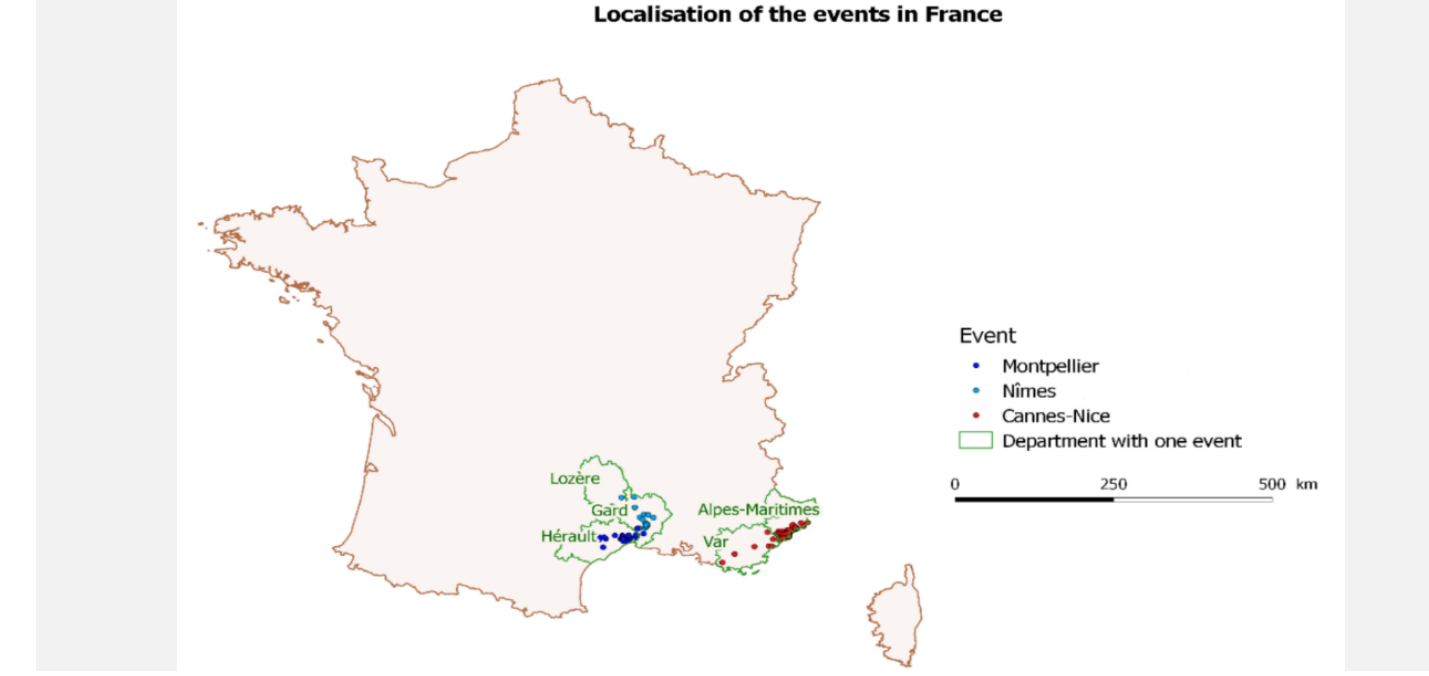
- Understanding how people actually detect potentially dangerous circumstances and manage to timely adapt their routine to cope with the speed of the hazard evolution remains a challenge.
- Based on insights from post event interviews, online surveys were used to quantitatively document behavioural responses associated with 3 catastrophic flash flood events that happened in southern France in 2014 and 2015.
- A multivariate statistical analysis among different variables that define the social structure, and different subcategories that characterize people's behavior was carried out in order to investigate the linkage between these two concepts.

## Methodology

### 1. Data Collection

Victims of two flash floods in 2014 and 2015 were selected in this study: one near Montpellier (Hérault department) on 30th September 2014 and another one near Nîmes (Gard department) on 10th October 2015. Online questionnaire surveys were used to collect the data about flash floods and social behaviors. 250 people answered the online questionnaire. The rainfall data associated to questionnaire responses were obtained from reanalysis data that combine radar and rain gauges observations data. The rainfall data was calculated at the location where the respondents were at the time of the event.

	Montpellier-Nice-2014	Cannes-Nice-2015
Event	Montpellier-Nice-2014	Cannes-Nice-2015
Place	Hérault department (Montpellier)	Gard department (Nîmes)
Date	Monday 29/9 15-18h Weekday, afternoon and evening	Friday 10/10 1h-10h Weekday, night and morning
Max cumulated rain 1h (mm)	129	92
Max cumulated rain 24h (mm)	352	426
Météo-France warning	Red	Red
Impact	No death	No death
Number of valid answers	100	180
Link broadcast	Meteorological websites	Professional networks + Meteorological websites
Main characteristics of the sample	Age 20-30 years (average: 33) Mostly men	Age 30-45 years (average: 40), Couple, children high socio-professional groups, public sector



### 2. Social Variables

Estimation of detected damage levels for each respondent by adding all the declared types which have been weighted according to their seriousness:

*Score of damages type*  
 $= \text{River flood} + \text{Road flood} \times 2 + \text{Electricity cuts} \times 3 + \text{Building flood} \times 4 + \text{School closures} \times 5 + \text{rescues} \times 6 + \text{Corporal damages} \times 7$

Estimation of general seriousness by taking the weighted most serious type.

*Max of damages types*  
 $= \max(\text{River flood}, \text{Road flood} \times 2, \text{Electricity cuts} \times 3, \text{Building flood} \times 4, \text{School closures} \times 5, \text{rescues} \times 6, \text{Corporal damages} \times 7)$

*Score of trip changes* = Extend + Adapt  $\times 2$  + Cancel  $\times 6$   
*Max of trip changes* =  $\max(\text{Extend}, \text{Adapt} \times 2, \text{Cancel} \times 6)$

Estimation of activity change levels:

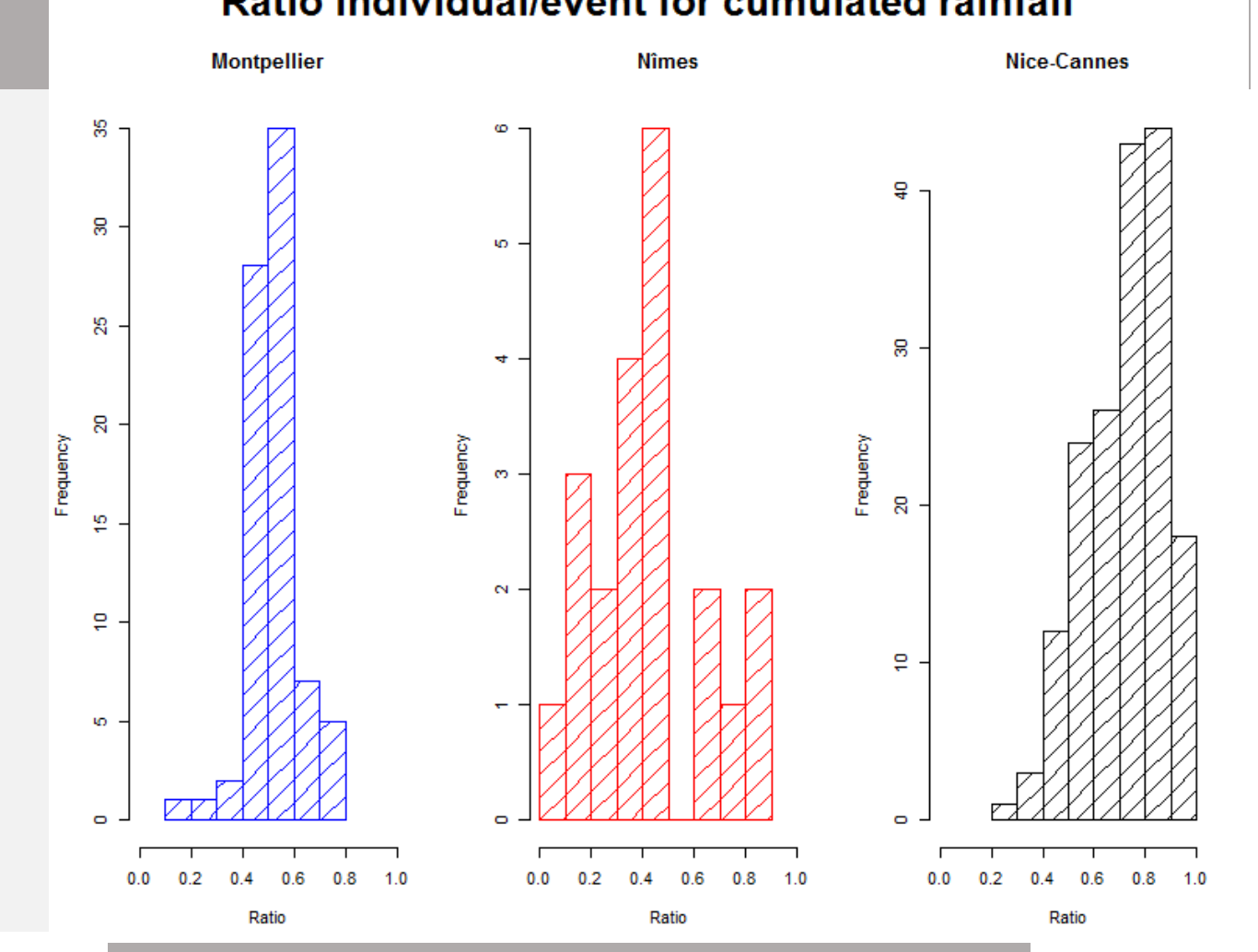
*Score of activity changes*  
 $= \text{Inquiry} + \text{Organize} \times 2 + \text{Protect goods} \times 6 + \text{Protect myself} \times 8 + \text{Rescue others} \times 8$

*Maximum of activity changes*  
 $= \max(\text{Inquiry}, \text{Organize} \times 2, \text{Protect goods} \times 6, \text{Protect myself} \times 8, \text{Rescue others} \times 8)$

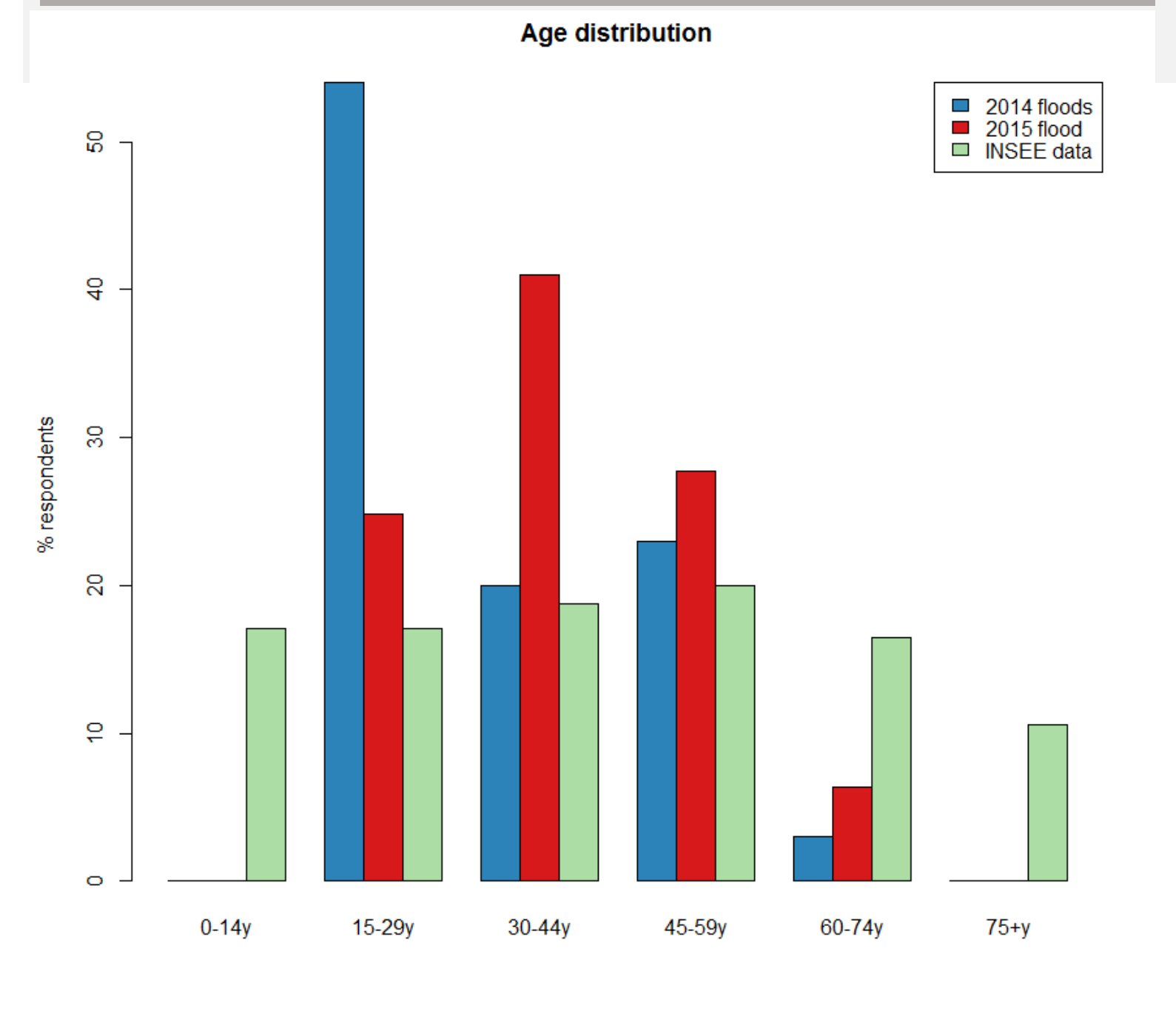
## Results

### 1. Comparison between 2014 and 2015 events

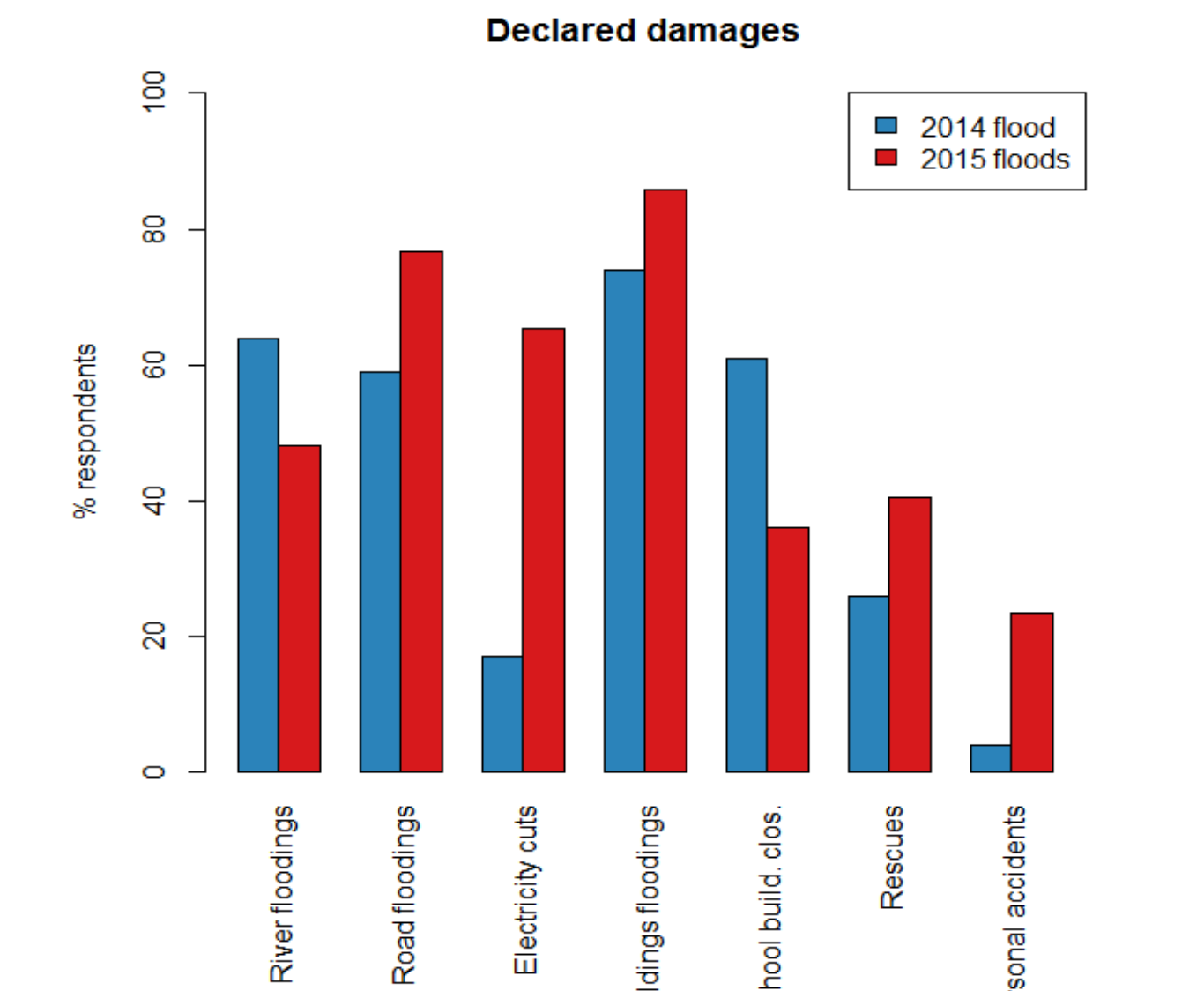
Ratio between individual (respondent) cumulated rainfall and maximum cumulated rainfall of the event was used to evaluate the difference of rainfall severity experienced by each respondent depending on their location at the time of the event. Respondents related to the Nice-Cannes event are the ones who were exposed to the most severe rainfall circumstances followed by the Montpellier respondents.



### 2. Social profile

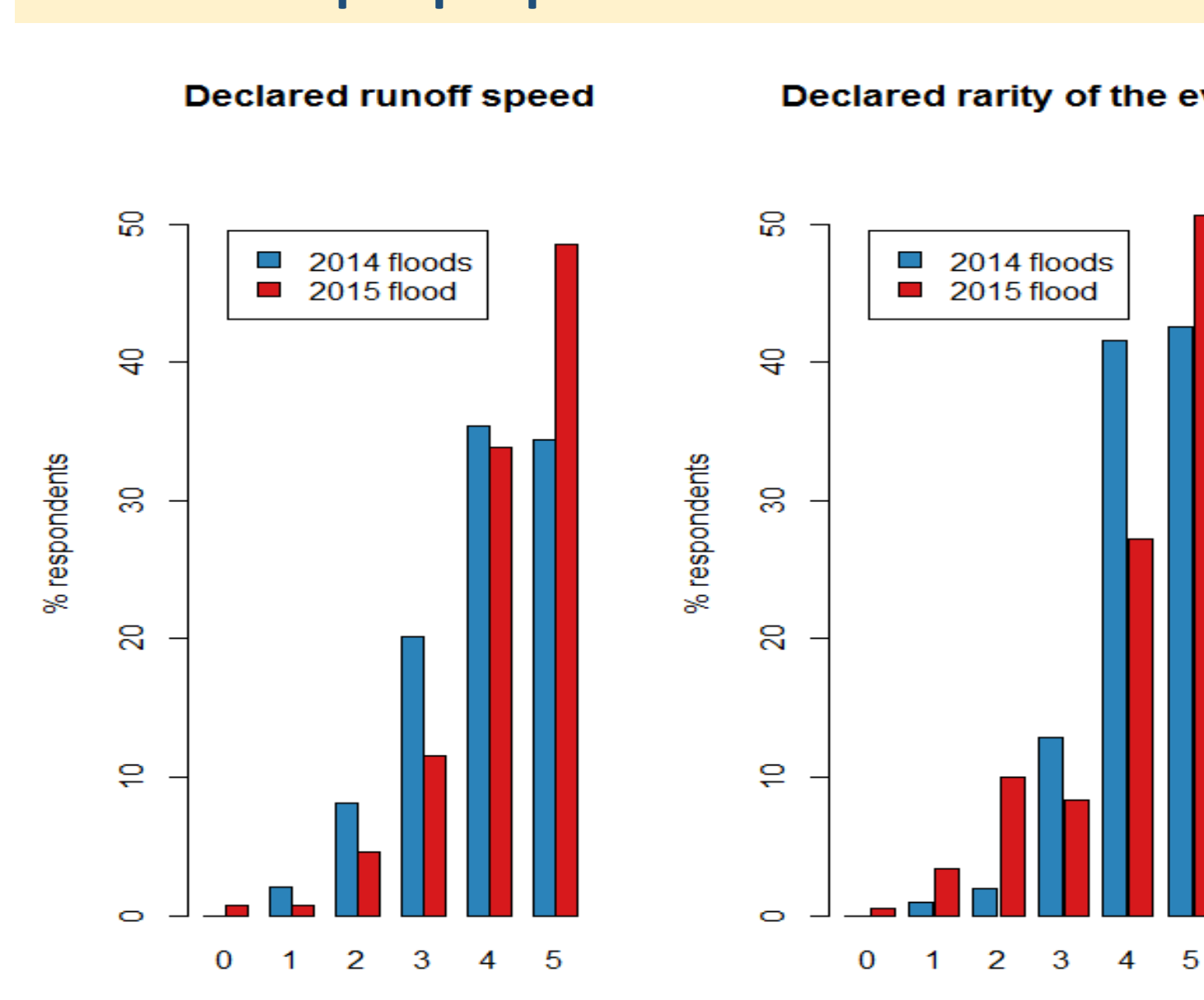


### 3. Damages

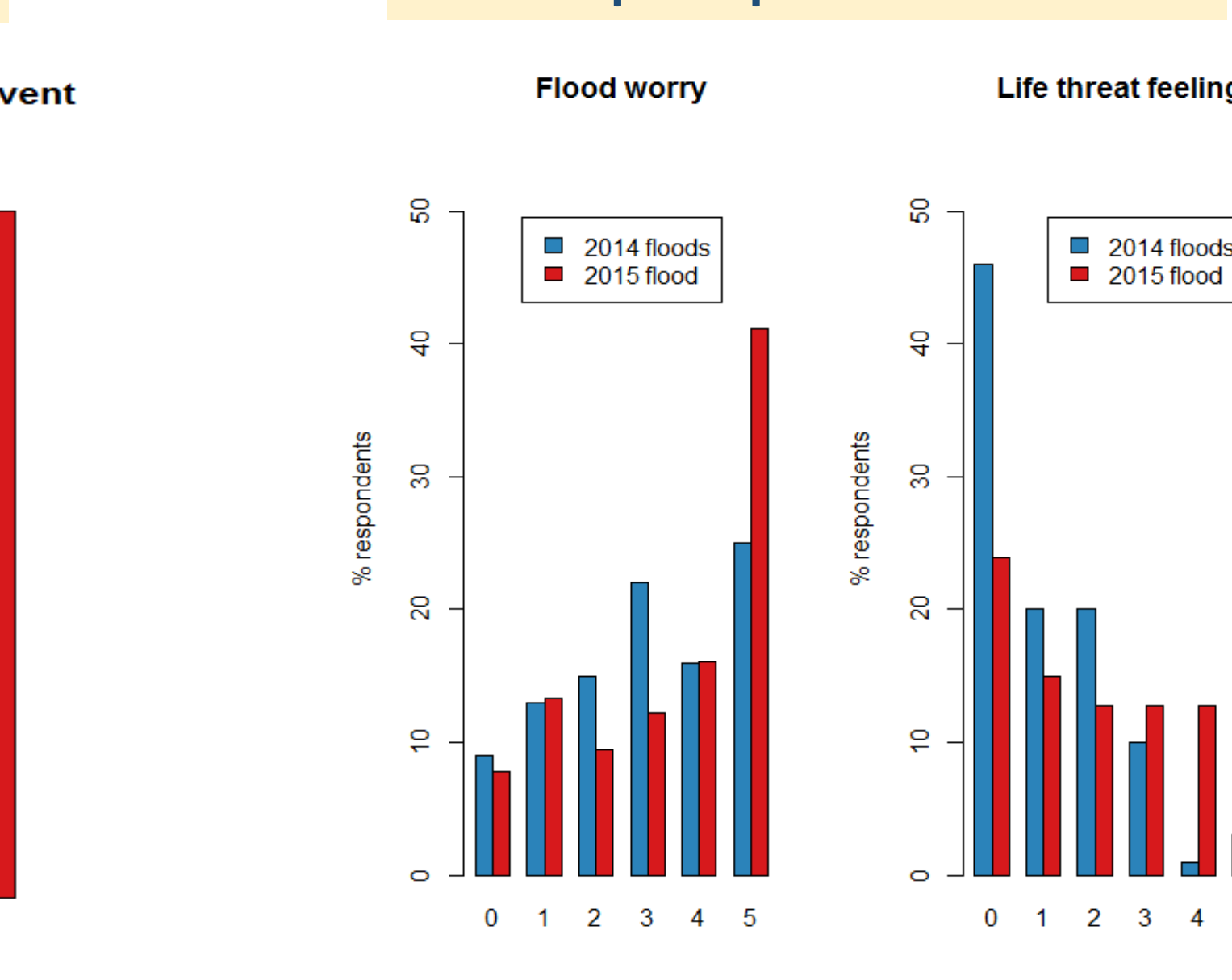


## 4. Perception of the hydro-meteorological events and their severity

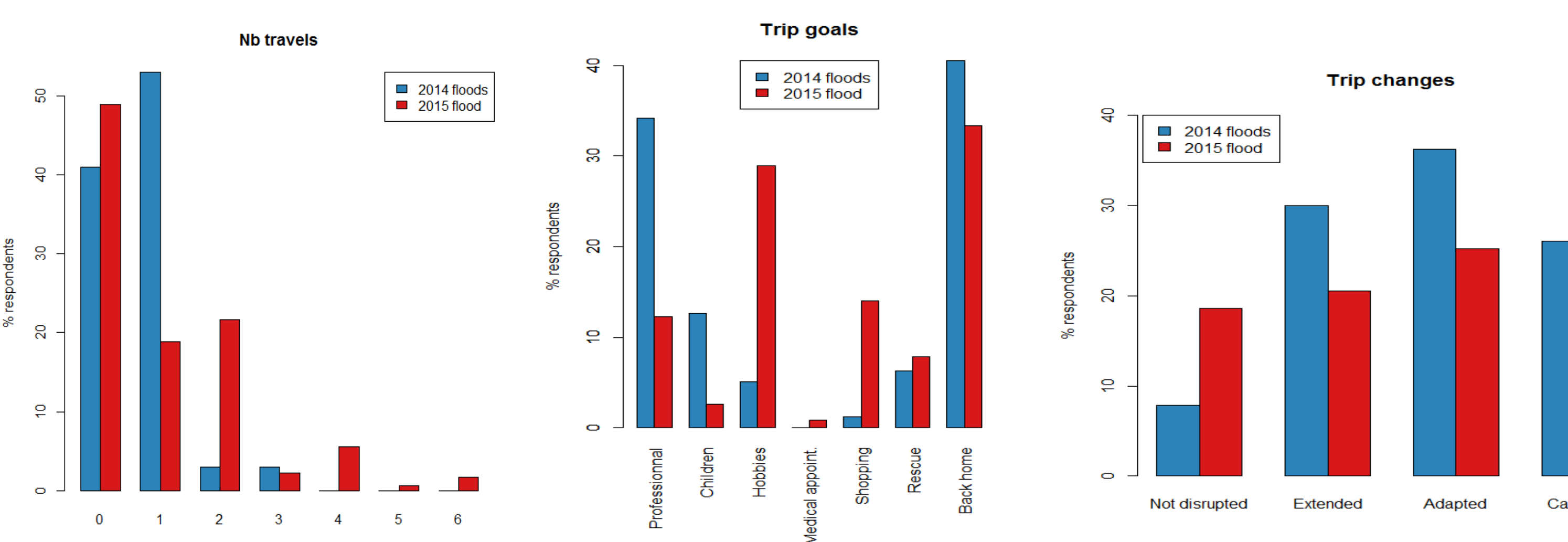
### 4.1 How do people perceive the floods?



### 4.2 Risk perception

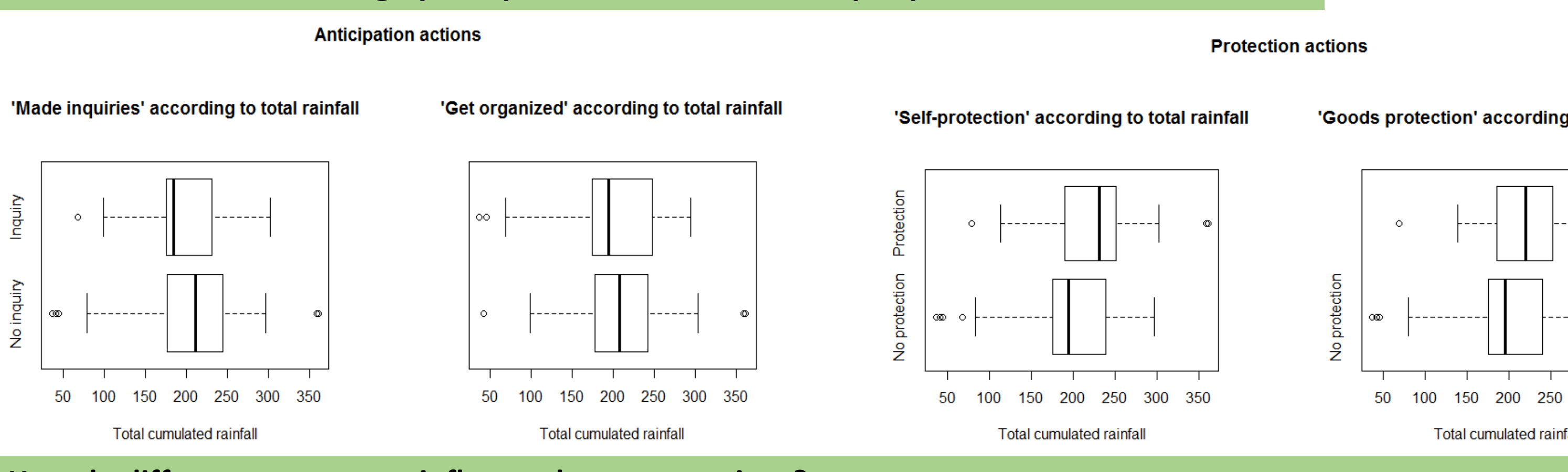


### 4.3 How do people change their travel plans and activities during flash floods?

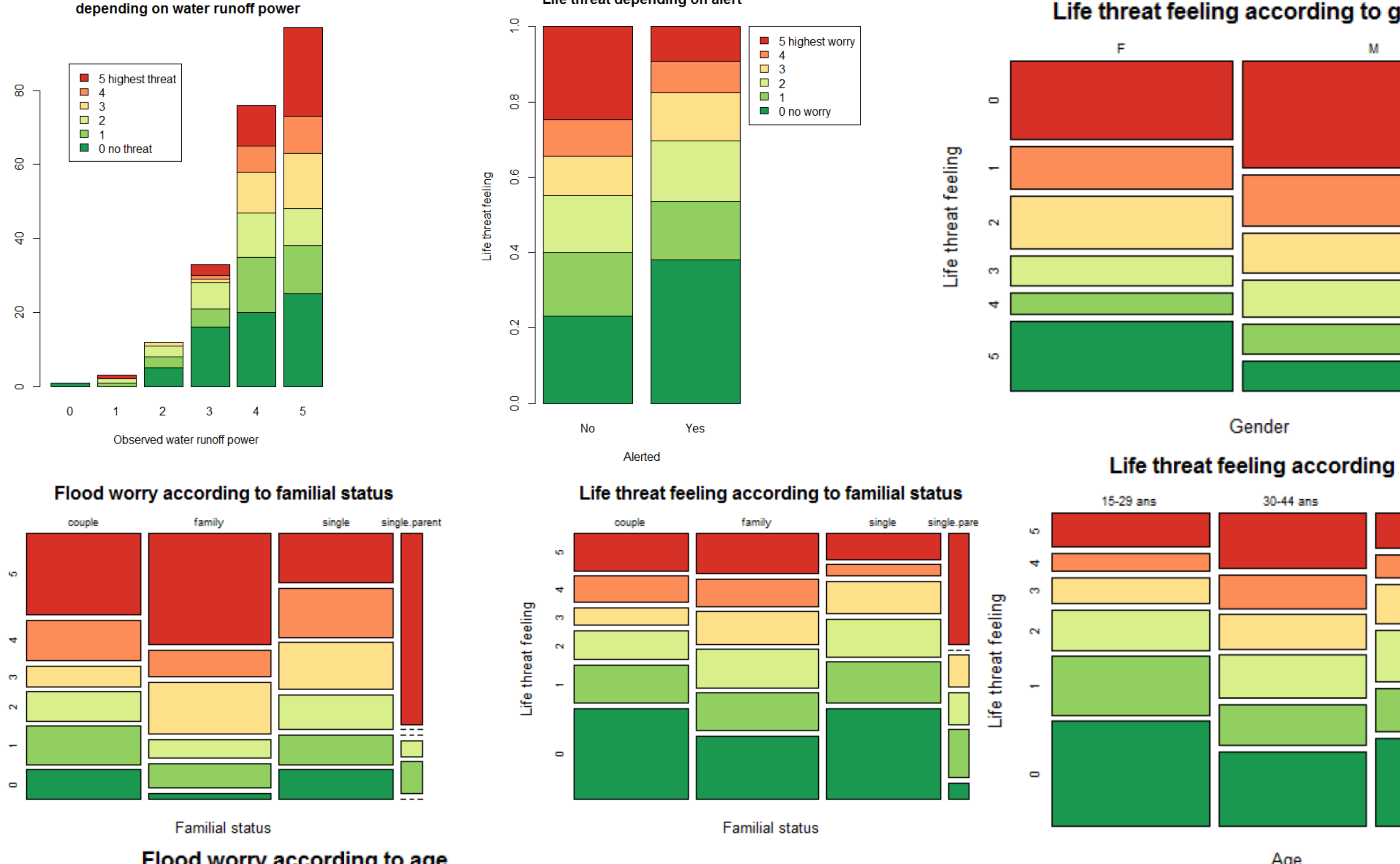


## Bivariate analysis of the 2015 event

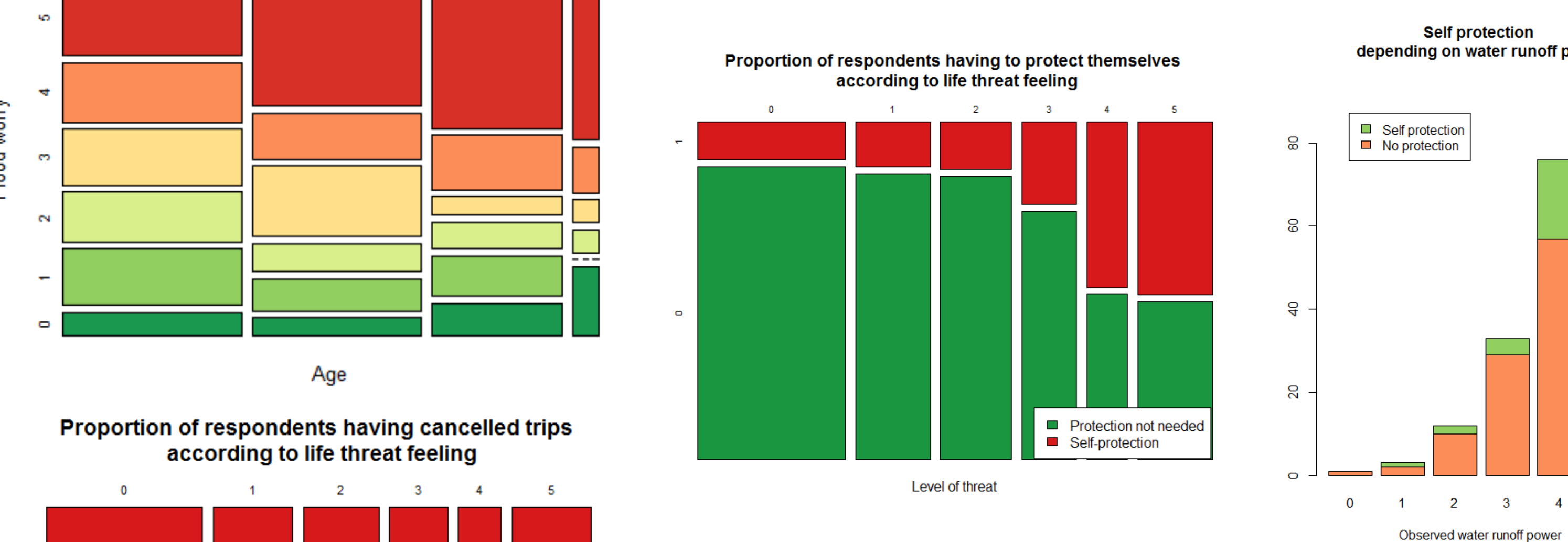
### 1. How does the rain change perceptions and behavior of people?



### 2. How do different parameters influence human emotions?



### 3. Protection actions and adaptation behaviors during flash flood



## Conclusion

- The coupled analysis of responses to the surveys with hydro-meteorological parameters allows to better understand the link between the event magnitude and self-protective behaviours in the context of short-fuse weather events as flash floods. Knowledge gained from such an integrated approach is necessary for drawing lessons for the development of coupled human-natural system modeling and the prediction of the human vulnerability dynamics in short-fuse weather events.
- Flash floods affect every social system differently according to its characteristics. People behave and adapt differently in a dangerous situation depending on how they perceive risk or what they are doing at that time. The time and space distribution of their daily routine influence the overall human behaviour during a flooding event.

**References**

- Ruin, I. et al., 2009. Human vulnerability to flash floods: Addressing physical exposure and behavioural questions. *Flood Risk Management: Research and Practice*, pp. 1005-1012.
- Ruin, I., Creutin, J.-D., Anquetin, S. & Lutoff, C., 2008. Human exposure to flash floods - Relation between flood parameters and human vulnerability during a storm of September 2002 in Southern France. *Journal of Hydrology*, Volume 361, pp. 199-213.
- Terzi, G., Ruin, I., Anquetin, S. & Gourley, J. J., 2015. Dynamic vulnerability factors for impact-based flash flood prediction. *Nat Hazards*.