Evaluation of flash flood awareness and risk perception as a foundation for flood risk adaptation

Juan Miguel Rosillo Comino[1*], Celso García[1], Florence Gignac[2], Meritxell Abril Cuevas[2], Lorenzo Proia[2], Joan Lloret[3], Maina Gautier[3], Manuel Sapiano[4], Aaron Cutajar[4], Marzio Melis[4], Marco Graziani[4], Angela Ingenio[4], Valeri Penchev[5], Shirin Shukrieva[5], Raffaele Giordano[6], Stefania Santoro[6], Virginia Rosa Coletta[6], Xavier Llort[7], Jordi Roca[7], Christos Makris[8], Yannis Androulidakis[8], Angelos Kokkinos[8], Zisis Mallios[8], Theofanis Karambas[8], Pablo Rodríguez-Lozano[9,1]

1 GLOWATER Research Group, Universitat de les Illes Balears, Spain
2 BETA Technological Centre (UVic-UCC), Spain
3 Euroregion Pyrenees Mediterranean
4 Energy and Water Agency, Malta
5 Black Sea – Danube Association for Research and Development, Bulgaria
6 Water Research Institute – National Research Council, Bari, Italy
7 Hydrometeorological Innovative Solutions, Spain
8 Aristotle University of Thessaloniki, Greece
9 Departamento de Ecología, Universidad Autónoma de Madrid, Spain
*contact: juan-miguel.rosillo@uib.cat

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Introduction

Flash floods are characterized by a rapid and significant increase in water level or discharge in specific areas, often in response to torrential rains that occur over a short period. According to the Centre for Research on the Epidemiology of Disasters (CRED, 2016), this type of flooding can develop within minutes to hours, making it one of the most challenging hazards to predict and manage. Its sudden nature can cause devastation in minutes, resulting in human losses, damage to infrastructure, and considerable economic costs. In quantitative terms, the IPCC (2021) indicates that the frequency of flash floods has increased by approximately 30% in the last two decades globally. This increase is especially notable in regions prone to severe storms. Furthermore, according to a report by CRED (2018), it is estimated that in the Mediterranean region, flash floods have risen by 50% since 2000, underscoring the urgent need for adequate risk management strategies.

The IPCC establishes that risk is the result of the interaction between four interrelated components: hazard, vulnerability, exposure, and response (IPCC, 2021). This framework underlines that to effectively address risk, it is necessary to consider not only the probability and nature of the hazard but also how social and natural systems are exposed to that hazard and how they respond to it. In this vein, understanding how individuals and communities understand and react to flash floods is key to reducing people's vulnerability and exposure to flash floods. Research has shown that risk perception varies significantly depending on factors such as prior experience, trust in authorities and media, educational level, and socioeconomic environment (Slovic, 2000; Zhang; 2010; Lujala et al., 2015). Besides, the search for adaptation solutions must include the participation of the population, promoting a community-centered approach that considers their knowledge and needs, which is essential to increase the effectiveness of the measures adopted and to foster social acceptance.

The goal of this study is to assess the social awareness and risk perception revolving around flash floods in seven study cases located along the Mediterranean. This assessment will serve to evaluate the

adaptation capacity of people living and/or working in areas with high flood risk and be the basis to design and implement participatory education actions to increase their adaptation capacity.

Methodology

A face-to-face survey was designed and implemented in seven pilot sites characterized by high vulnerability to flash floods: Anthemountas river catchment (Greece), city of Bari (Italy), Birkirkara – Msida (Malta), Gurri Catchment (Catalunya, Spain), Kamchia-Varna (Bulgaria), Torrent de na Bàrbara (Mallorca, Spain), Torrent Gros (Mallorca, Spain). The survey was approved by the Ethical Committee of Research of the Universitat de les Illes Balears on July 9th, 2024 (Expedient 42CER24).

This communication focuses on the core section of the survey, which was a battery of 20 Likert-scale questions (Q10-Q29) covering the following topics: i) perception of the hazard, ii) vulnerability, exposure, and response, iii) broad causes and solutions, and iv) actions focused on the river. Descriptive and frequency analyses were performed on survey responses. Questions Q23-Q29 of the Birkirkara – Msida (BI) pilot site were excluded from the shared analyses because they were modified to better fit the specific context of the pilot site.

Results

A total of 2822 survey responses were obtained in the seven pilot sites. Results show a varying degree of agreement with the different statements and a variation among pilot cases (Figure 1).

Perception of the hazard

- **Awareness of flood risk** (Q10). Generally, respondents did not feel well-informed about flood risk across most pilot sites, with mean agreement values ranging from 1.9 to 2.4 in five of them. However, respondents from the Kamchia-Varna site reported high flood risk awareness, with a mean value of 4.03.
- **Hazard likelihood** (Q12). Perceptions of flood likelihood varied across pilot sites, but none of the pilot sites showed a high perception of a flood occurring soon. Mean values ranged from 2.22 in Kamchia-Varna to 3.53 in Birkirkara – Msida. Notably, Kamchia-Varna, the site where respondents felt the most informed about flood risk, had the lowest perceived likelihood of a flood occurring soon.
- **Hazard concern** (Q13). In most pilot sites, there was higher agreement on concern about flood risk than on flood likelihood, i.e., respondents expressed worry about flood risk even if they did not believe a flood would occur soon. Concerns about flood risk ranged from 2.72 in the city of Bari to 4.17 in Torrent de na Bàrbara. Indeed, respondents of the two pilot sites on Mallorca Island expressed the most concern about flood risk.

Vulnerability, exposure, and response

- **Perception of personal vulnerability** (Q14). Responses varied on whether respondents felt they would be personally affected by a flood, resulting in intermediate to high mean values (3.13 to 3.69), indicating that more respondents agreed about their own vulnerability than disagreed.
- **Communication and trust in public authorities** (Q15, Q16). Respondents expressed low levels of trust in the public administration's ability to manage flood protection and low confidence in the effectiveness of public authorities in informing and preparing people for flood risks. Mean values for these statements ranged from 2.25 to 3.11.
- **Knowledge of flood response actions** (Q11). Across most pilot sites, respondents generally lacked knowledge about appropriate actions during a flood emergency, with mean values ranging from 2.01 to 2.60 in five sites. In contrast, respondents from Kamchia-Varna showed a high level of agreement regarding their knowledge of flood response actions, with a mean value of 4.15.

- **Flood response regarding vehicle use** (Q19). Opinions varied regarding the recommendation to move parked cars to safer areas during a flood. Respondents in five pilot sites (city of Bari, Gurri catchment, Kamchia-Varna, Torrent de na Bàrbara, and Torrent Gros) strongly disagreed with this action (mean values of 2.13 to 2.39), while respondents in Birkirkara-Msida and Anthemountas pilot sites generally agreed (mean values of 3.8 and 3.67, respectively).

Broad causes and solutions

- **Urban planning** (Q18). Overall, respondents largely agreed that urban planning is a main cause of flood impacts on human societies (mean value: 3.64 to 4.64).
- **Drainage system and green spaces** (Q20, Q21, Q22). There was a strong consensus on the importance of improving drainage systems, expanding green spaces, and restoring forests and natural vegetation in nearby areas to reduce flood risk. Mean agreement values for these statements ranged from 3.52 to 4.72, with the highest agreement for the three of them observed at the two pilot sites on Mallorca Island.
- **Education** (Q17). Respondents generally supported educating the public on reducing flood vulnerability as an essential measure to mitigate flood impacts. Five pilot sites showed very high levels of agreement (mean values between 4.58 and 4.70). However, respondents from the Bari and Birkirkara-Msida sites showed somewhat lower agreement on the importance of education (mean values of 3.72 and 3.83, respectively).

Actions focused on the river

- **River natural value** (Q23). While mean responses generally aligned with agreement on the natural value of the river (mean values > 3), variability across pilot sites was considerable. Agreement values ranged from 4.75 in Kamchia-Varna to 3.29 in the Bari pilot case.
- **River re-naturalization** (Q25). Overall, respondents concurred that rivers should be re-naturalized to enhance their current state (mean values ranged from 3.58 to 4.08).
- **Simultaneous flood mitigation and river conservation measures** (Q29). Respondents broadly agreed that flood risk mitigation efforts should concurrently improve river conservation. Agreement was notably high in the two Mallorca pilot sites (mean values of 4.81 and 4.82). However, respondents from the Bari pilot site demonstrated lower agreement (mean value of 3.67), suggesting possible support for flood mitigation measures that may not enhance, or could even detract from, river conservation. This response aligns with Q23, as Bari respondents showed the lowest agreement on the river's natural value.
- **Vegetation clearing (river "cleaning")** (Q27). Views on the importance of vegetation clearing to reduce flood risk varied significantly among sites (mean values ranged from 2.32 to 4.71). Respondents in Kamchia-Varna and Anthemountas were strongly in favor of this measure (mean values of 4.71 and 4.6, respectively), while those in Gurri catchment, Torrent de na Bàrbara, and Torrent Gros showed more moderate agreement (mean values: 3.73 to 3.84). In contrast, respondents in Bari generally disagreed (mean value: 2.32). These results contrast with findings in Q23, Q25, and Q29 for both Mallorca pilot sites, indicating a possible misperception of the ecological drawbacks and lack of flood mitigation benefits of vegetation clearing.
- **Channel modification** (Q28). Similar to vegetation clearing, respondents from the Bari site generally disagreed with channel modification interventions (mean value of 2.32), while other sites showed moderate agreement (mean values ranged from 3.2 to 3.78).
- **Dam construction** (Q24). Opinions on dam construction varied across pilot sites. Respondents from Bari city, Gurri catchment, and Kamchia-Varna demonstrated the least support (mean values ranged from 2.52 to 2.6), whereas respondents from the Anthemountas site showed the highest support (mean value of 3.78).
- **River burying** (Q26). In all sites except Kamchia-Varna, respondents predominantly rejected river burying as a flood risk reduction strategy (mean values: 1.55–1.85). In contrast, Kamchia-Varna respondents exhibited less clear disagreement (mean value of 2.63), while 50% of Kamchia-Varna respondents opposed this measure, 31% expressed agreement or strong agreement. Notably, fewer than 15% of respondents from other sites supported this measure. These results for the Kamchia-Varna pilot site are in strong contradiction with responses to questions regarding the river's natural value and the need for re-naturalization (Q23, Q25, and Q29).

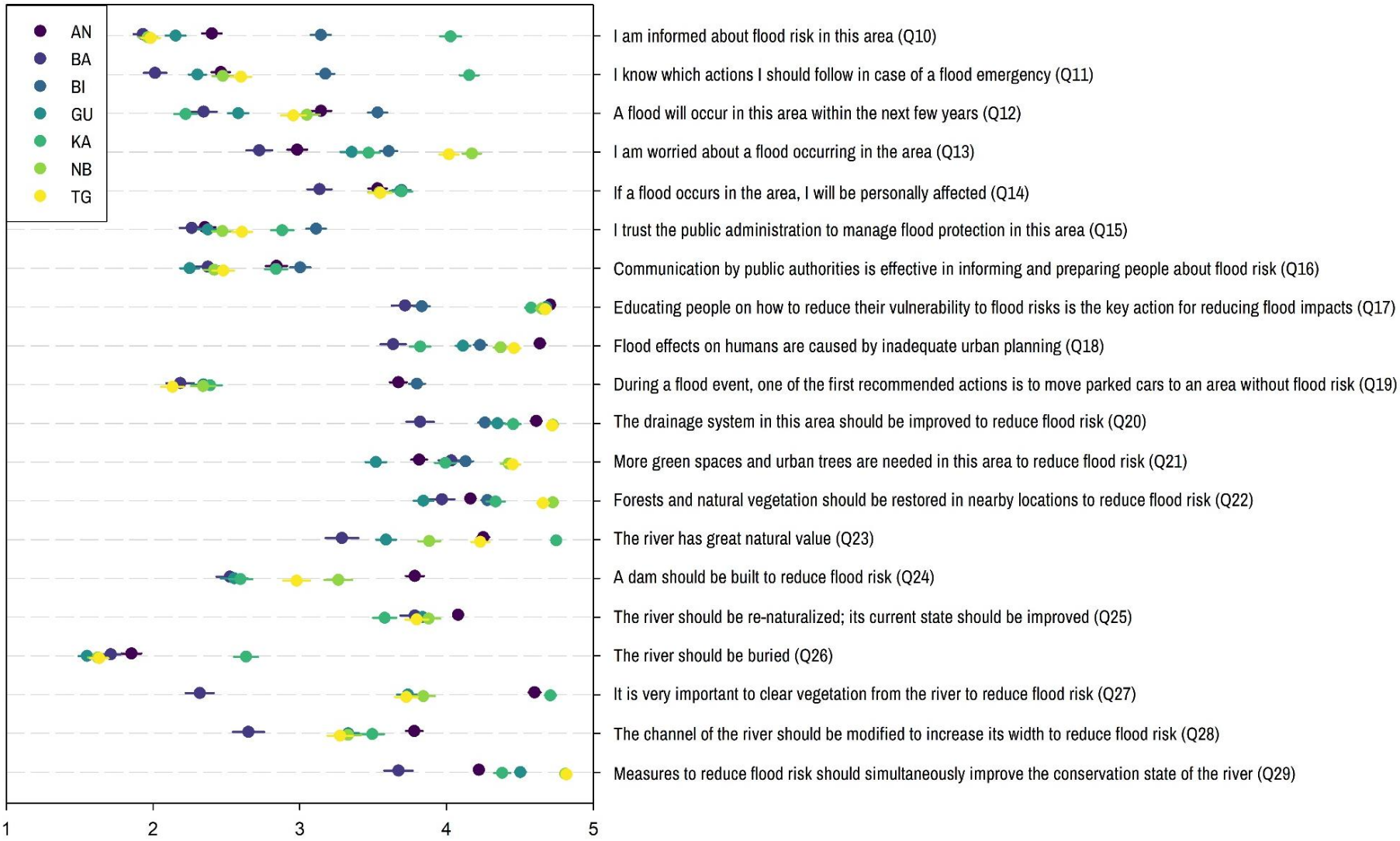

Figure 1. Agreement level (mean ± SE) to each of the 20 statements by pilot site. 5-point Likert-scale: 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree. AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).

Conclusions

Results suggest potential public support for natural and educational flood mitigation strategies, while structural interventions (such as damming or burying the river) are more contentious but varied among pilot sites. Responses revealed a lack of trust in public administration to manage flood risk effectively and highlighted the need for improved information and communication between public authorities and the general public. Based on the results, we propose a list of topics as a starting point for developing educational actions and tools to improve people and community adaptation to flash flood risk in the various pilot sites (Table 1).

Table 1. Proposed topics to feed into educational actions and tools. Based on the results, topics were marked as recommended (X) or highly recommended (XX) for each pilot case. AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).

Topics	AN	BA	BI	GU	KA	NB	TG
Information on the hazard	X	XX	X	X		XX	XX
Public administration role (IMGM)	XX	XX	XX	XX	XX	XX	XX
People's response in a flood event	XX	XX	XX	XX	XX	XX	XX
Vehicle use during flood event	XX	X	XX	X	X	X	X
Green spaces importance							
River natural value	X	XX		X	X	X	X
Vegetation clearing	XX	X		X	XX	XX	XX
Channel modification	XX	X		XX	XX	XX	XX
Dam construction	XX	X		X	X	XX	XX
River burying					XX		

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