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FLASH FLOOD AWARENESS AND RISK PERCEPTION EVALUATION AS A BASIS TO DESIGN ADAPTATION SOLUTIONS IN THE 4 DIFFERENT TOPOGRAPHICAL AREAS

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Deliverable 1.3

Project acronym	LocAll4Flood
Project title	Flash flood risk prevention & resilience in Mediterranean area through an Integrated Multi-stakeholder Governance Model, gathering prevention, adaptation and mitigation solutions
Project mission	Protecting, restoring and valorising the natural environment and heritage
Project priority	Greener MED
Specific objective	RSO2.4: Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system based approaches
Type of project	Test
Project duration	01/01/24 – 30/09/26 (33 months)

Deliverable title	Flash flood awareness and risk perception evaluation as a basis to design adaptation solutions in the 4 topographical areas
Deliverable number	D.1.3.1
Deliverable type	Public
Work package number	WP1
Work package title	DESIGNING LOCALL4FLOOD integrated multi-stakeholder governance model - IMGM
Activity name	Adaptation: Define the components of an integrated governance model and assess the social awareness and risk perception revolving around flash flood events
Activity number	Activity 1.3
Partner in charge (author)	UIB-GLOWATER (Pablo Rodríguez Lozano, Juan Miguel Rosillo Comino, Celso García García)
Partners involved	All

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1. INTRODUCTION

1.1. Flash floods

Within the broader framework of natural hazards, floods rank among the most common and lethal. They are present in various forms, including river and coastal flooding, each with its own characteristics and risks. According to Gaume et al. (2016), floods constitute the primary natural risk worldwide, accounting for more deaths and damage compared to other natural disasters, such as earthquakes or cyclones. This phenomenon has been the subject of numerous studies, making it evident that in many regions the increase in flash floods' frequency is concerning.

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.

Factors such as uncontrolled urbanization contribute to making these floods more severe. Soil impermeabilization, caused by infrastructure development, prevents water absorption and increases the volume of water that quickly flows into nearby drains and bodies of water (Cortès et al., 2017). In the Mediterranean context, where torrential rainfall is more common, this risk is even more significant. Gaume et al. (2016) emphasize that flash floods are particularly frequent in this region, highlighting the urgent need to implement appropriate risk management strategies.

1.2. Risk concept

Modern society faces a wide and diverse range of risks, including both natural and anthropogenic hazards. Each of these risks presents unique challenges that require effective management, making the concept of risk a central topic for policies in areas such as health, environment, technology, finance, and security (Eiser et al., 2012).

In the field of natural sciences, the term "**risk**" refers to the probability distribution of adverse effects, implying a quantitative assessment of the likelihood of catastrophic events occurring and their consequences (Wachinger, 2010). On the other hand, from a social sciences perspective, the term risk refers to the subjective perception of danger or threat associated with a particular situation, rather than an accurate statistical evaluation. In this context, risk is clearly differentiated from the concept of **hazard**. Scheer (2014) defines hazard as the intrinsic capacity of an event to cause adverse effects, which may not materialize if assets are not exposed or if they develop resilience to such hazards. Natural hazards are processes or phenomena that can have negative impacts on society (Gill and Malamud, 2017) and encompass a wide range of events, including earthquakes, cyclones, and droughts.

Vulnerability, in this context, is defined as the predisposition of a system to suffer damage when exposed to a hazard, and it can be classified into two categories: one focused on the potential damage that natural events can cause, and another that considers the internal state of the system before facing a hazard (Brooks, 2003). Twigg (2015) suggests that vulnerability arises from multiple economic, social, cultural, institutional, and political factors that create the environments in which people live and work. This dichotomy between physical and social vulnerability is crucial for understanding its impact in different contexts (Parsons et al., 2016). Thus, the risk associated with a hazard depends on both the probability of occurrence and the social vulnerability of the exposed system (Brooks, 2003). This reveals that both biophysical vulnerability and risk have their roots in the same determinants: hazard and social vulnerability.

Moreover, **exposure** plays a crucial role in the relationship between risk and vulnerability. It refers to the amount and type of assets that are at risk from a specific hazard, implying that greater exposure may increase the level of risk. On the other hand, **responses** are the actions and strategies adopted to mitigate the impact of adverse events. These responses are fundamental to reducing both vulnerability and exposure, and to increasing the resilience of communities to adverse events. Responses can range from prevention and mitigation policies to emergency and recovery plans.

The IPCC establishes that risk is the result of the interaction between four interrelated components: hazard, vulnerability, exposure and response (Figure 1). This framework suggests 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. Therefore, a comprehensive risk assessment must include an analysis of these four elements, allowing for the development of effective strategies that reduce vulnerability and exposure while strengthening resilience to future hazards.

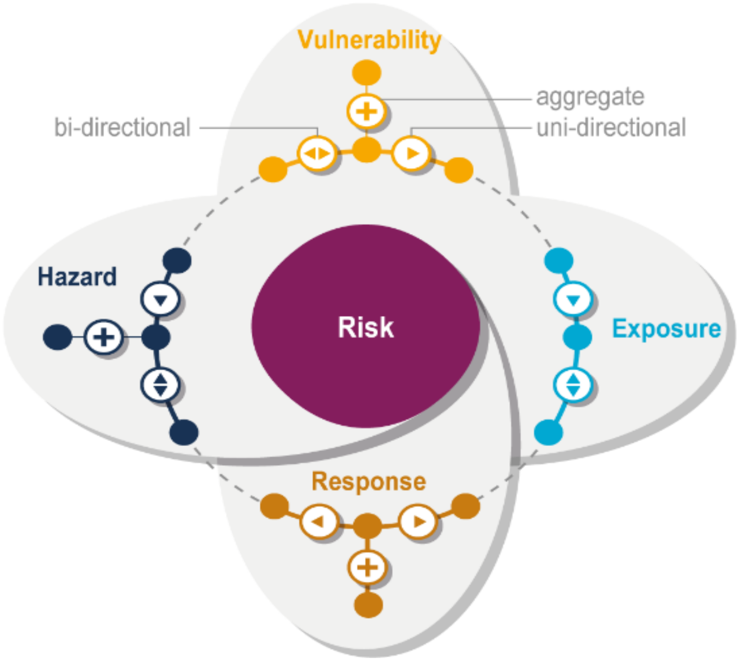

Figure 1. Diagram showing the interaction between Hazard, Vulnerability, Exposure, and Response in determining Risk, with both bi-directional and aggregate uni-directional relationships. *Source: IPCC Sixth Assessment Report, Working Group II, Chapter 1*

1.3. Risk perception and adaptation

Risk perception has been studied from various perspectives, focusing particularly on how individuals and communities understand and react to natural hazards. This perception varies significantly depending on factors such as prior experience, trust in authorities and media, educational level, and socioeconomic environment. According to Slovic (2000), risk perception is profoundly influenced by subjective and psychological factors, explaining why some communities respond more effectively to certain hazards than others, even when facing similar risks.

Zhang (2010) notes that while proximity to danger is correlated with the level of risk perception, other factors, such as institutional trust and the source of information about the hazard, are equally important. In communities with limited disaster experience, risk perception may be even more distorted (Lujala et al., 2015). The lack of direct experience can lead to underestimating risks or misjudging the adequacy of responses, as individuals may rely more on media reports or institutional communications, which can vary in accuracy and reliability. The role of communication is crucial in shaping risk perception. Effective communication strategies can enhance public awareness and preparedness, while poor communication can lead to confusion and apathy.

In this context, adaptation refers to the process by which individuals, communities, and systems adjust their practices, processes, and structures to better cope with the effects of natural disasters. Implementing adaptation measures is essential to reduce the impacts of disasters, as not all catastrophic events can be prevented (Rudzewicz and Matczak, 2012; Jongman, 2018). In recent years, adaptations have focused on the use of technologies and the design of climate-resilient infrastructures; however, Nature-Based Solutions (NBS) are also gaining prominence (Colls et al., 2009). These NBS are considered part of mitigation strategies, as they help reduce the adverse effects of climate change and manage flood risks through ecosystem restoration and sustainable use of natural resources (Jongman, 2018).

The search for adaptation solutions must include the participation of the population, promoting a community-centered approach that considers their knowledge and needs. This is essential to increase the effectiveness of the measures adopted and to foster social acceptance. However, the relationship between adaptation, prevention, and mitigation is complex. For example, the existence of early warning systems (EWS) allows for preventive responses to flooding, but some communities may oppose certain mitigation measures, such as the implementation of NBS, due to concerns about land use alteration or the aesthetics of their environment (Ferreira et al., 2020).

The interaction between risk perception and the acceptance of adaptation measures underscores the importance of public participation in planning processes. Involving communities in discussions about adaptation strategies can enhance understanding, build trust, and ultimately lead to better outcomes in disaster risk reduction.

Numerous studies analyzed risk perception using various methodologies, such as surveys, interviews, and focus groups. These tools provide both quantitative and qualitative data on how communities perceive and respond to environmental risks, which is crucial for developing effective adaptation strategies. Research by Das et al. (2020) and Jong Seok Lee and Hyun Il Choi (2020) illustrates how these methodologies are applied in specific contexts, often framed within the IPCC framework, which considers the components of hazard, vulnerability, exposure and response. This comprehensive approach not only helps understand individual and collective perceptions of risk but also identifies factors influencing the adaptive capacity of communities. By applying this framework, researchers can offer more precise recommendations for policy formulation and risk management strategies, ensuring they align with local realities and needs and promote effective adaptation to future natural disasters.

1.4. Action goal

The goal of this action is to assess the social awareness and risk perception revolving around flash floods in the pilot sites of the LocAll4Flood project. 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. To achieve this goal, a face-to-face survey was designed and implemented in seven pilot sites characterized by high vulnerability to flash floods: Gurri Catchment (Catalunya, Spain), Torrent Gros (Mallorca, Spain), Torrent de na Bàrbara (Mallorca, Spain), Kamchia-Varna (Bulgaria), Birkirkara – Msida (Malta), city of Bari (Italy), Anthemountas river catchment (Greece).

2. Methodology - survey

A face-to-face survey was designed to assess the social awareness and risk perception revolving around flash floods in each pilot site (Annex 1). A survey draft was prepared by the activity lead partner (UIB-GLOWATER). After preparing the draft, a co-design activity to which all project partners were invited was carried out using the platform Miro (May 2024) (Figure 2). Then, the draft was improved to include those aspects emerged during the co-design activity. The improved draft was presented in the First Validation Workshop of the project (June 2024), to receive feedback from the Advisory Board of the LocAll4Flood project, and then shared with all partners during several revision rounds until a final version of the survey was reached.

The final survey was approved by the Ethical Committee of Research of the *Universitat de les Illes Balears* on July 9th, 2024 (Expedient 42CER24). The survey (Annex 1) had 7 different sections:

- Section 1: informed consent
- Section 2: context (if the interviewee lived and/or worked on the area)
- Section 3: focused on the relationship between the interviewee and the river.
- Section 4: questions regarding the knowledge and previous experiences of the interviewee.

- Section 5: two open questions, one focused on the behavior of the interviewee in case of a flood event and the other on their opinion about potential solutions to reduce flood risk.
- Section 6: a battery of 20 Likert-scale questions covering the four components of risk: hazard, vulnerability, exposure and response, as well as potential solutions.
- Section 7: socio-demographic questions.

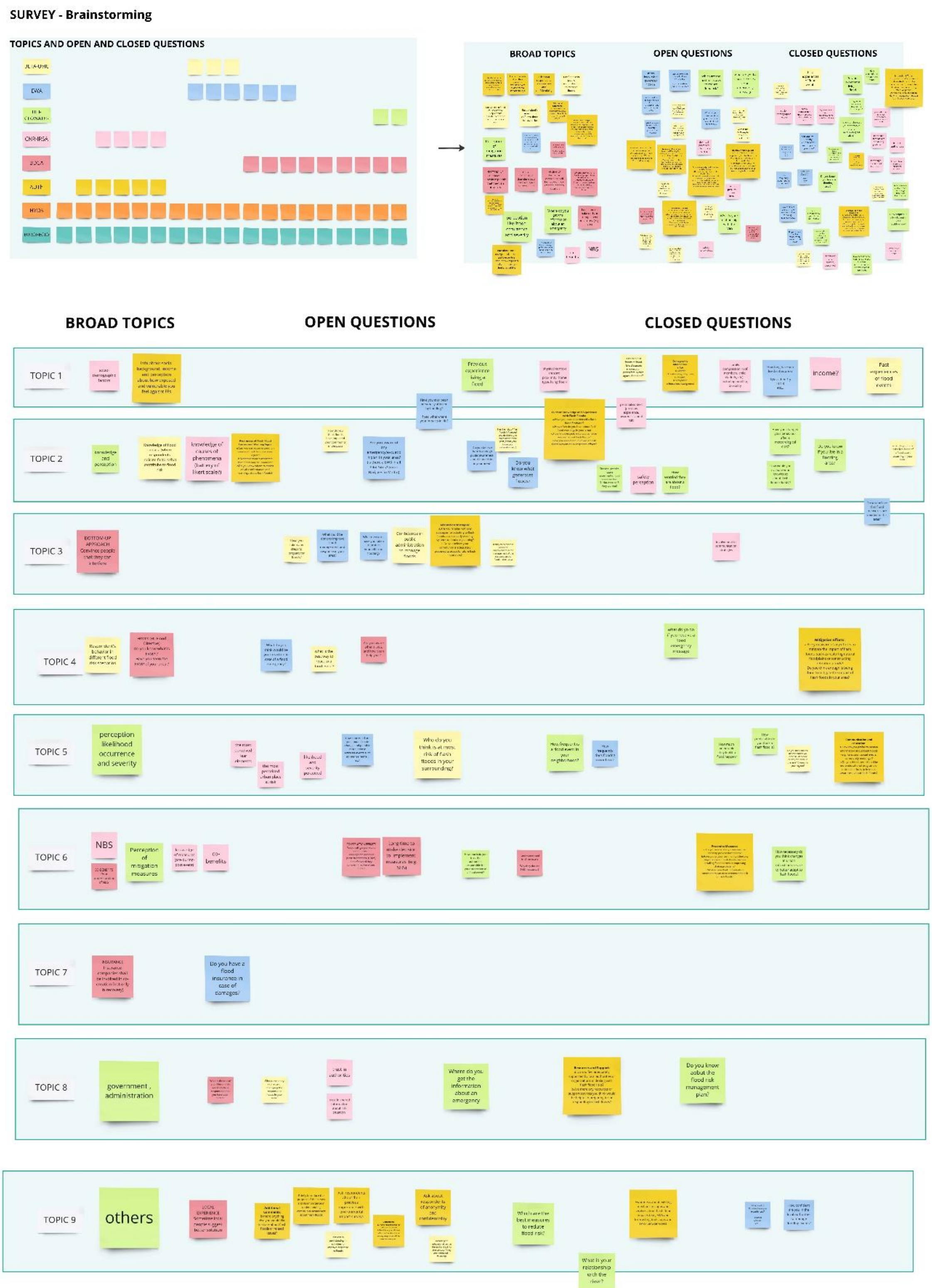

Figure 2. Co-design activity carried out using Miro platform.

The survey was carried out in each of the seven pilot sites, translated into the local language, taking place from July 24th to November 4th. A minimum sample size of 385 responses per each pilot site was established to achieve accuracy (confidence level 95%; margin error 5%). The seven pilot sites were:

- 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)

We performed frequency analyses on survey responses. Responses to open questions Q8 and Q9 were screened to design a code. Thirteen categories were defined for Q8 and twelve for Q9, besides the DK/DA category. Then, each response was assigned to one or several of these code categories. Besides, polarization was calculated for the 20 statements (Likert scale questions; Q10-Q29 in Annex 1). Polarization ranges from 0 to 1: if all observations are in the same category, polarization is 0; with half the observations in one category, and half the observations in a different (non-neighbouring) category, polarization is 1. All analysis were run in R 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results and discussion

A total of 2822 survey' responses were obtained in the seven pilot sites (Table 1). Each pilot site presented a different sociodemographic profile. It is worth it to highlight that 62.3% of survey respondents of the Birkirkara – Msida pilot case (BI) experienced a flood in the area, while this percentage was much lower in the rest of the pilot cases (from 31.9% for Kamchia-Varna (KA) to 5.1% for the city of Bari (BA)).

Survey respondents generally reported feeling a strong connection to nature (Human-Nature Connection; Q2). In most cases (except Birkirkara-Msida), over 50% of respondents felt either somewhat or strongly connected to nature, while fewer than 20% felt somewhat or strongly disconnected (see Figure 3). However, the connection with rivers (Human-River Connection; Q3) was notably lower than the overall Human-Nature Connection. In five pilot areas (Anthemountas (AN), Bari (BA), Gurri catchment (GU), Torrent de na Bàrbara (NB), and Torrent Gros (TG)) fewer than 40% of respondents reported feeling somewhat or strongly connected to the river, and in four of them over 50% reported feeling somewhat or strongly disconnected to the river. These results show that while many people feel connected to nature, they feel much less connected to the rivers in their watersheds where they live or work. Respondents in the Kamchia-Varna pilot area (KA) reported the strongest connections to both nature and the river, while respondents in Bari (BA) reported the lowest connection levels to rivers.

This lower Human-River Connection in most pilot areas could lead to a reduced interest in river conservation. It may also affect how much people observe the river, understand the river system, and recognize flood risks—potentially limiting their adaptability. This disconnection from the river may further reduce community support for sustainable solutions to manage flood risks, like Nature-Based Solutions (NBS). To address this, educational initiatives and programs that help people connect with their rivers are recommended, along with efforts to develop river areas that encourage this connection.

Table 1. Socio-demographic characteristics of people interviewed in the seven pilot sites*. 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).*

		AN	BA	BI	GU	KA	NB	TG
N		383	234	403	400	401	500	501
Age (mean ± SD)		49.1 (17.5)	35.2 (9.7)	52.7 (19.0)	49.9 (19.2)	-	43.7 (17.6)	46.3 (18.5)
Gender (%)	Female	64.5	60.3	54.3	60.8	45.9	48.2	59.3
	Male	35.5	39.7	45.7	38.5	54.1	51.8	40.7
	Other	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Education	No formal education	0.8	0.0	1.2	2.3	0.0	0.6	3.0
	Primary education	12.5	0.0	12.9	11.5	9.0	10.6	11.2
	Secondary education	33.7	10.3	30.8	18.8	40.6	33.4	35.3
	Post high school	19.6	5.1	22.1	25.8	0.5	24.8	23.4
	Bachelor's degree	25.3	44.9	22.3	32.0	45.6	23.6	20.6
	Postgraduate (Master, PhD)	8.1	39.7	10.7	9.8	4.3	6.4	5.8
	NA	0.0	0.0	0.0	0.0	0.0	0.6	0.7
Live / Work in the area	Live	40.7	20.5	50.1	64.5	28.7	67.2	76.2
	Work	15.9	37.2	41.9	25.0	13.8	23.4	15.2
	Live and work	43.4	42.3	8.0	10.5	57.5	9.4	8.6
Time in the area	Less than 1 year	2.6	5.1	6.2	5.8	6.8	8.2	9.8
	1-5 years	12.3	21.8	17.1	21.0	3.8	18.4	14.0
	5-10 years	5.7	5.4	14.6	10.8	11.2	9.2	9.6
	Over 10 years	37.1	19.2	46.9	41.8	24.4	39.2	42.1
	Since I was born	42.3	38.5	15.1	20.8	53.9	24.4	23.8
	NA	0.0	0.0	0.0	0.0	0.0	0.6	0.7
Disability	Yes	3.4	0.0	11.2	6.3	15.2	6.8	6.2
	No	96.6	93.6	88.8	93.5	84.8	92.8	93.2
	NA	0.0	6.4	0.0	0.3	0.0	0.4	0.6
Experienced a flood	Yes, in the area	23.8	5.1	62.3	17.5	31.9	11.2	14.0
	Yes, in another area	11.0	9.0	9.2	20.2	14.2	22.2	17.2
	No	65.2	85.9	27.8	62.3	53.9	66.4	68.7

NA	0.0	0.0	0.7	0.0	0.0	0.2	0.1

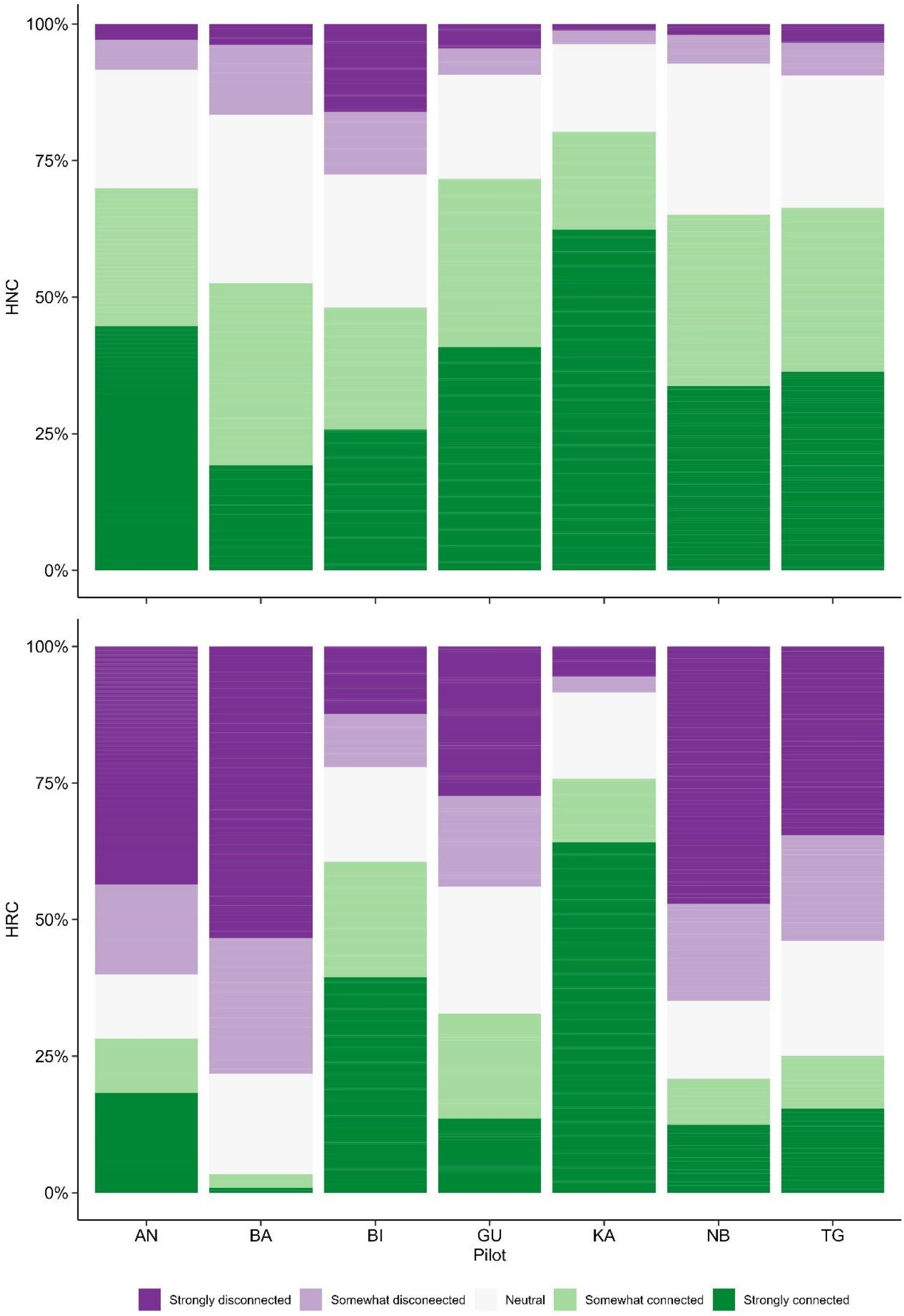

Figure 3. Self-reported level of connection with nature (HNC: Human-Nature Connection) and with the river of each pilot case (HRC: Human-River Connection) by survey respondents of each pilot case.

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).

Regarding flood risk awareness (Q6), over 70% of survey respondents from the Birkirkara–Msida (BI) and Kamchia-Varna (KA) pilot sites recognized that their area was at risk of flooding. These two pilot sites also had the highest proportion of people who had experienced a flood in the area (see Table 1). About half of the respondents from the Gurri catchment (GU) and Anthemountas (AN) pilot sites were also aware of the flood risk (53.5% and 45.5%, respectively). In contrast, flood risk awareness was lower in the two pilot sites on the island of Mallorca and was minimal in the city of Bari (see Figure 4). Low flood risk awareness may reduce people's ability to adapt, as they may be less aware of this potential risk and the importance of responding effectively in case of a flash flood.

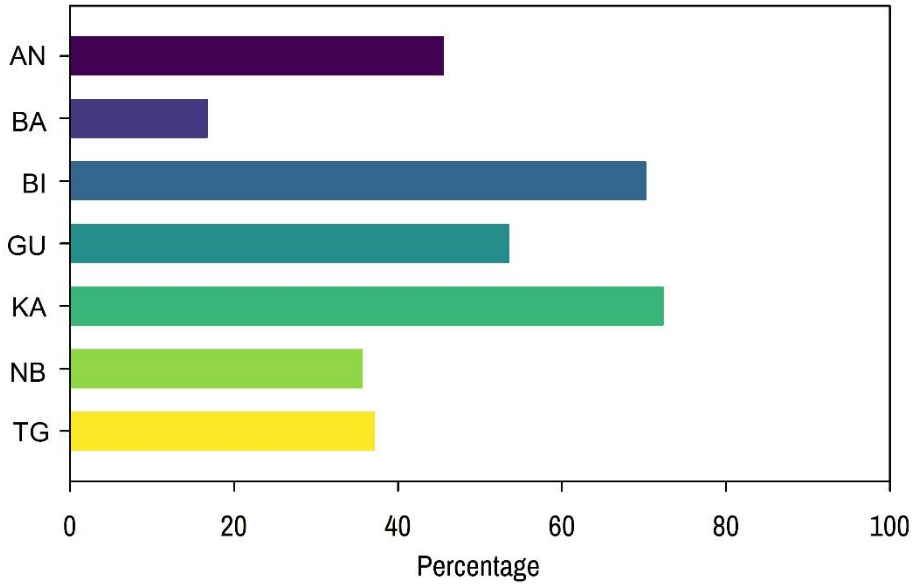

Figure 4. Percentage of survey respondents by pilot case that were aware that the area was a flood risk area. *AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).*

Most respondents were unfamiliar with most key concepts related to flood risk (Q7; Figure 5), especially with the European Union Flood Directive, Flood Risk Maps and Nature-Based Solutions. In general, respondents' literacy related to flood risk terminology was higher at Anthemountas (AN) and city of Bari (BA) pilot sites. In five pilot sites (Anthemountas, Bari, Gurri catchment, Torrent de na Bàrbara, and Torrent Gros), over 75% of respondents affirmed to know meteorological alerts. The same five pilot sites presented a high proportion of respondents familiar to emergency plans (88.5% for city of Bari and around 50% in the other 4 pilot sites). In contrast, a high proportion of respondents in Birkirkara – Msida (BI) and specially in Kamchia-Varna (KA) were unfamiliar to these two concepts. The proportion of respondents that known Early Warning Systems varied from 68.4% for Anthemountas (AN) and 39-48% for Bari, Birkirkara – Msida and Kamchia-Varna, to less than 25% for the three pilot sites in Spain (Gurri catchment, torrent de na Bàrbara, and torrent Gros).

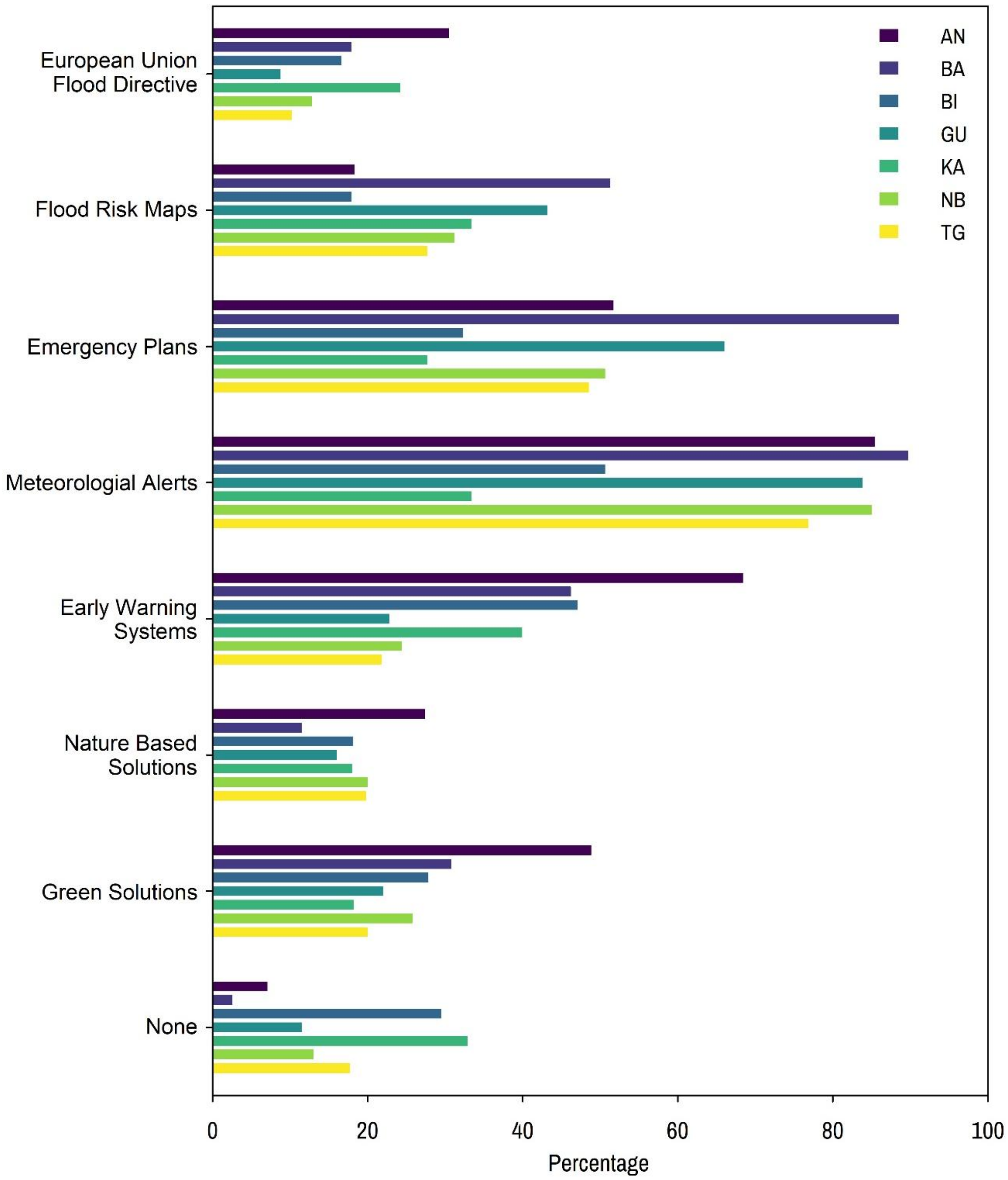

Figure 5. Percentage of survey respondents by pilot case that affirmed to be familiar with the following concepts: *European Union Floods Directive, Flood Risk Maps, Emergency Plans, Meteorological Alerts, Early Warning Systems, Nature Based Solutions, Green Solutions, or none of them. AN: Anthemountas (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).*

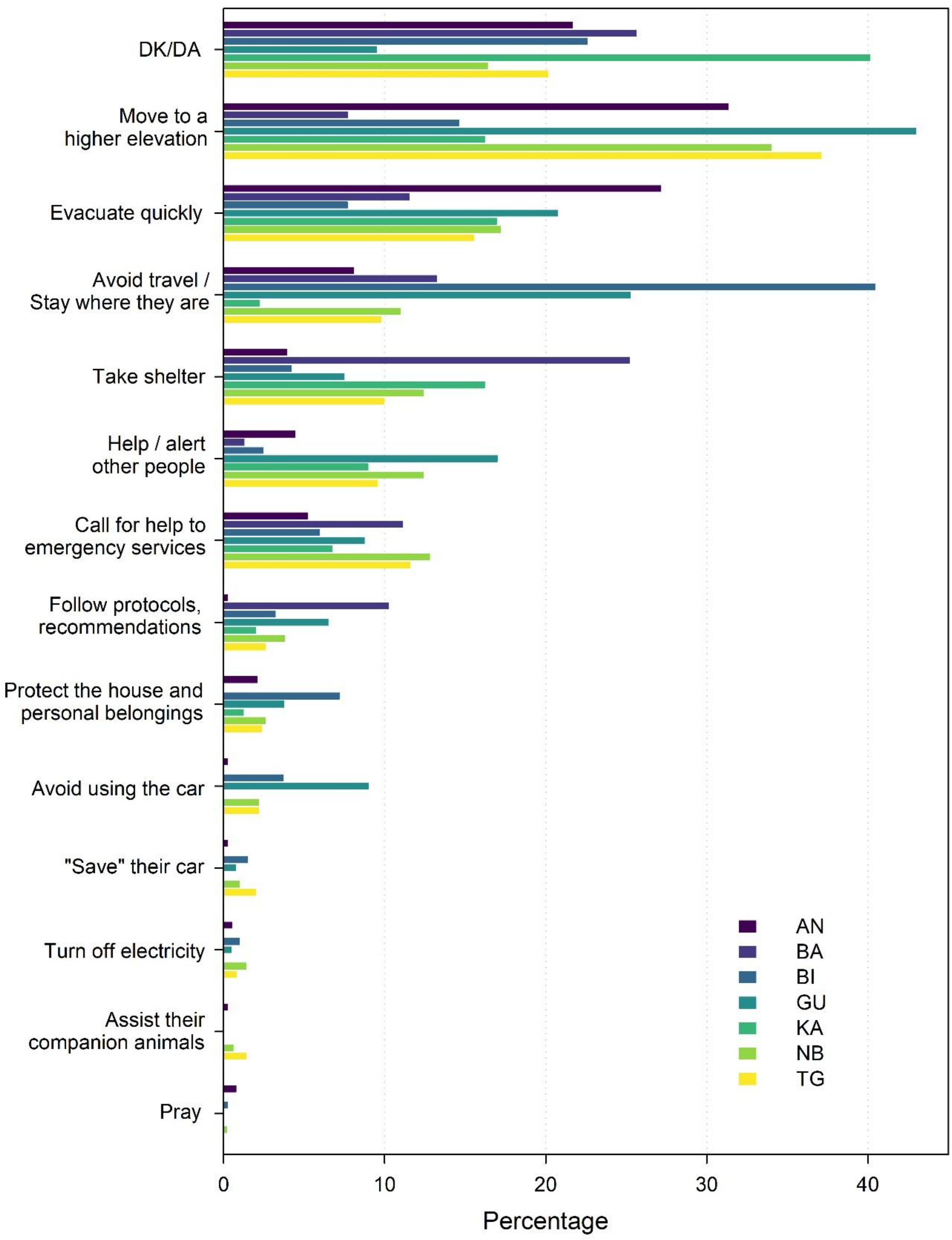

Figure 6. Percentage of survey respondents by pilot case regarding what actions they think they should follow if a flood occurs in their area (Q8). *AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).*

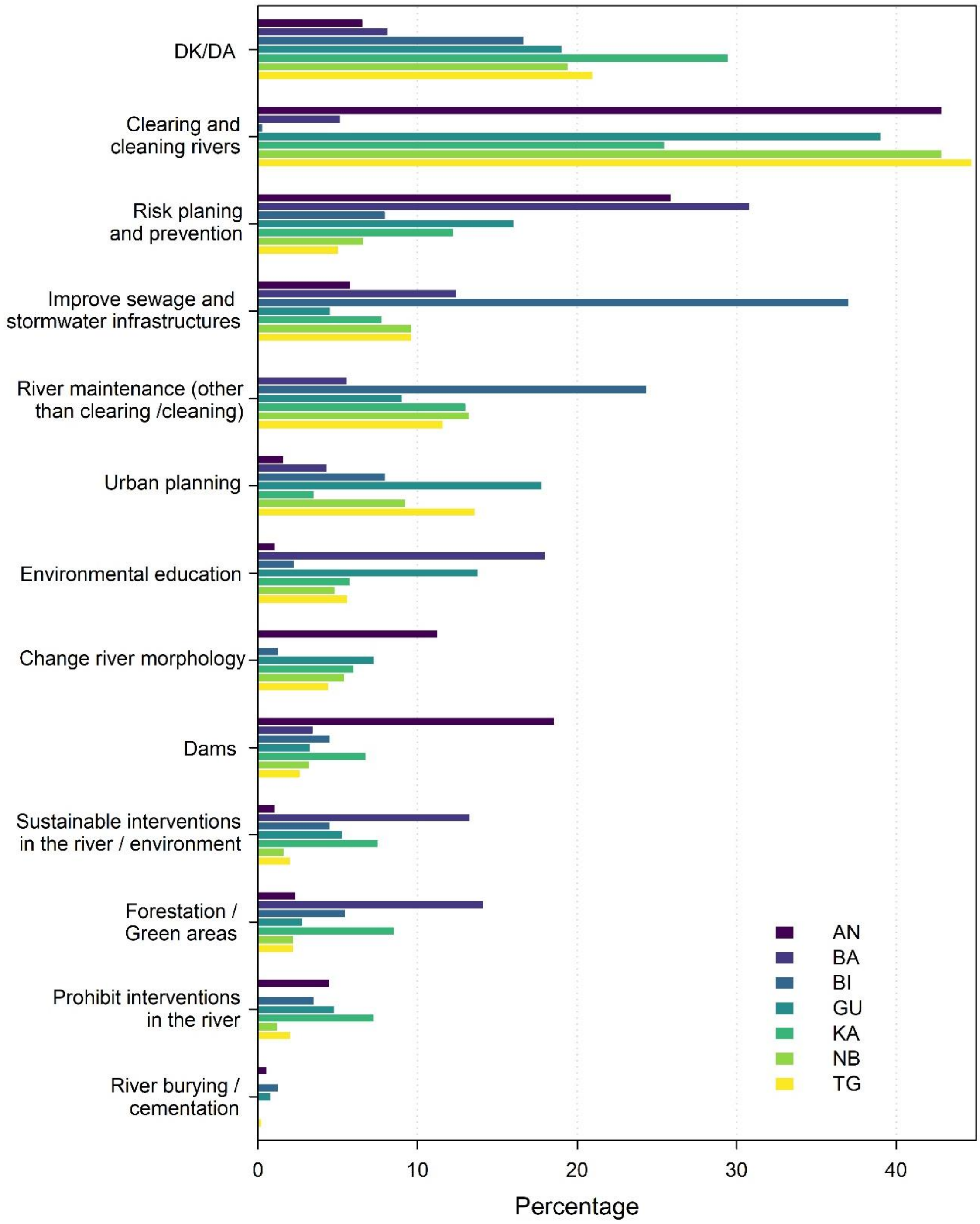

Figure 7. Percentage of survey respondents by pilot case regarding what are the best solutions to reduce flood risk and its consequences in their area (Q9). *AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).*

Regarding people's responses about which actions they should follow if a flood occurs in their area, the most common response overall, and specifically for four of the pilot cases (Anthemountas, Gurri catchment, Torrent de Na Bàrbara, and Torrent Gros), was to move to higher elevation (Figure 6). Taking shelter was the most common response in the Birkirkara–Msida pilot case, while "Don't know/Didn't answer" (DK/DA) was the most common response in Kamchia-Varna and Bari city. The percentage of survey respondents who selected DK/DA ranged from 9.5% to 25.6% in six of the pilot cases but reached 40.1% in Kamchia-Varna (Figure 6). Avoiding travel and evacuating quickly were also common responses, particularly in Birkirkara-Msida and Anthemountas, respectively.

Less common responses included helping/alerting other people, calling emergency services, following protocols and recommendations, and protecting their houses and belongings. Additionally, some people mentioned praying, assisting companion animals, and avoiding the use of cars. Interestingly, some respondents mentioned "saving" their cars as a specific action, which is an unrecommended action because it may increase their exposure to flood risk. Overall, people's knowledge of appropriate actions to take during floods is limited, highlighting the need for improvement through educational initiatives.

Based on these responses, we calculated the percentage of people who reported behaviors indicative of general safety measures that may apply in all flash flood situations (i.e., moving to higher elevation, taking shelter, avoiding travel, following protocols and recommendations, or avoiding car use). Using this metric, the pilot cases could be grouped into two main categories. The first group consisted of four pilot cases with a higher percentage of respondents demonstrating clear safe behaviors: Gurri catchment (43%), Torrent Gros (37.1%), Torrent de Na Bàrbara (33.8%), and Anthemountas (31.3%). The second group included three pilot cases where safe behavior was mentioned less frequently: Kamchia-Varna (16%), Birkirkara–Msida (13.9%), and Bari city (7.7%). Although this metric is conservative, it provides useful insights.

Regarding public opinions on the best solutions to reduce flood risk, there is a widespread misconception that clearing river vegetation and cleaning rivers are key solutions (Figure 7). While removing trash or specific vegetation from certain river sections can be environmentally sustainable and may help reduce flood risk, clearing natural vegetation from the streambed is often environmentally unsustainable and can increase water velocity, thereby elevating the hazard level during floods.

Risk planning and prevention were frequently mentioned as solutions in some pilot cases: 30.8% in Bari city, 25.8% in Anthemountas, and 16% in Gurri catchment. Improving sewage and stormwater systems was the most common solution proposed by respondents in the Birkirkara-Msida pilot site (37%), though it was less common in other pilots (<13%, see Figure 7). Urban planning was primarily mentioned in the Gurri catchment and Torrent Gros pilot cases (17.7% and 13.6%, respectively), while environmental education was highlighted as a potential solution in Bari city and Gurri catchment (17.9% and 13.7%, respectively).

Sustainable interventions, forestation efforts, and the creation of new green areas were less frequently mentioned but were proposed by over 10% of respondents in the Bari city pilot case. Building dams was an uncommon response in most pilot cases but was relatively popular in Anthemountas (18.5%) and still mentioned by a small percentage of respondents in other pilot cases (<7%).

Regarding the results derived from the Likert-scale battery (20 statements; Q10-Q29), they were analyzed together for all pilot sites (Figures 8 and 9) and separately for each pilot site (Annex II; Figures S1-S7). 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 suggest potential public support for natural and educational flood mitigation strategies, while structural interventions (such as damming or burying the river) are more contentious. 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.

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. In Birkirkara-Msida, this question showed the highest level of polarization (polarization value: 0.42, see Figure 7); 50% of respondents agreed or strongly agreed that they were informed about flood risk, while 36% disagreed or strongly disagreed (see Figure S3). These results align with those found in Q5 (see Figure 4).

- **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. This statement showed a high polarization in both Mallorca pilot sites: Torrent de na Bàrbara and Torrent Gros (polarization values of 0.64 and 0.57, respectively) (see Figure 9). Polarization was also considerable in the other pilot sites (0.34-0.42).
- **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 in 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. This diversity of opinions is also reflected in intermediate polarization values (0.32 to 0.53), with the highest polarization observed in the Mallorca sites, Torrent de na Bàrbara and Torrent Gros (polarization values of 0.53 and 0.50, respectively).
- **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. Polarization was moderate (0.31 to 0.55), with the highest polarization observed in Kamchia-Varna for both statements.
- **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, which contrasts with their responses to Q8 in which 40.1% of survey respondents answer DK/DA about what actions they should follow in case a flood occurs (Figure 6).
- **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). This statement showed high polarization in Torrent de na Bàrbara (0.56).

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 (Figure 8).
- **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 Bari pilot case, where the highest polarization was observed for this statement (0.49).
- **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). Notably, this statement exhibited high polarization in both Mallorca sites (0.48 and 0.47, respectively), contrasting with findings in Q23, Q25, and Q29, and 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). Responses in the Mallorca sites exhibited high polarization (0.66 for both sites).
- **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). Similarly to the channel modification measure, high polarization was also observed in the Mallorca sites (0.69–0.71), marking the highest polarization across questions and sites.
- **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), with low polarization (0.14–0.22). In contrast, Kamchia-Varna respondents exhibited less clear disagreement (mean value of 2.63) and high polarization (0.53). 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).

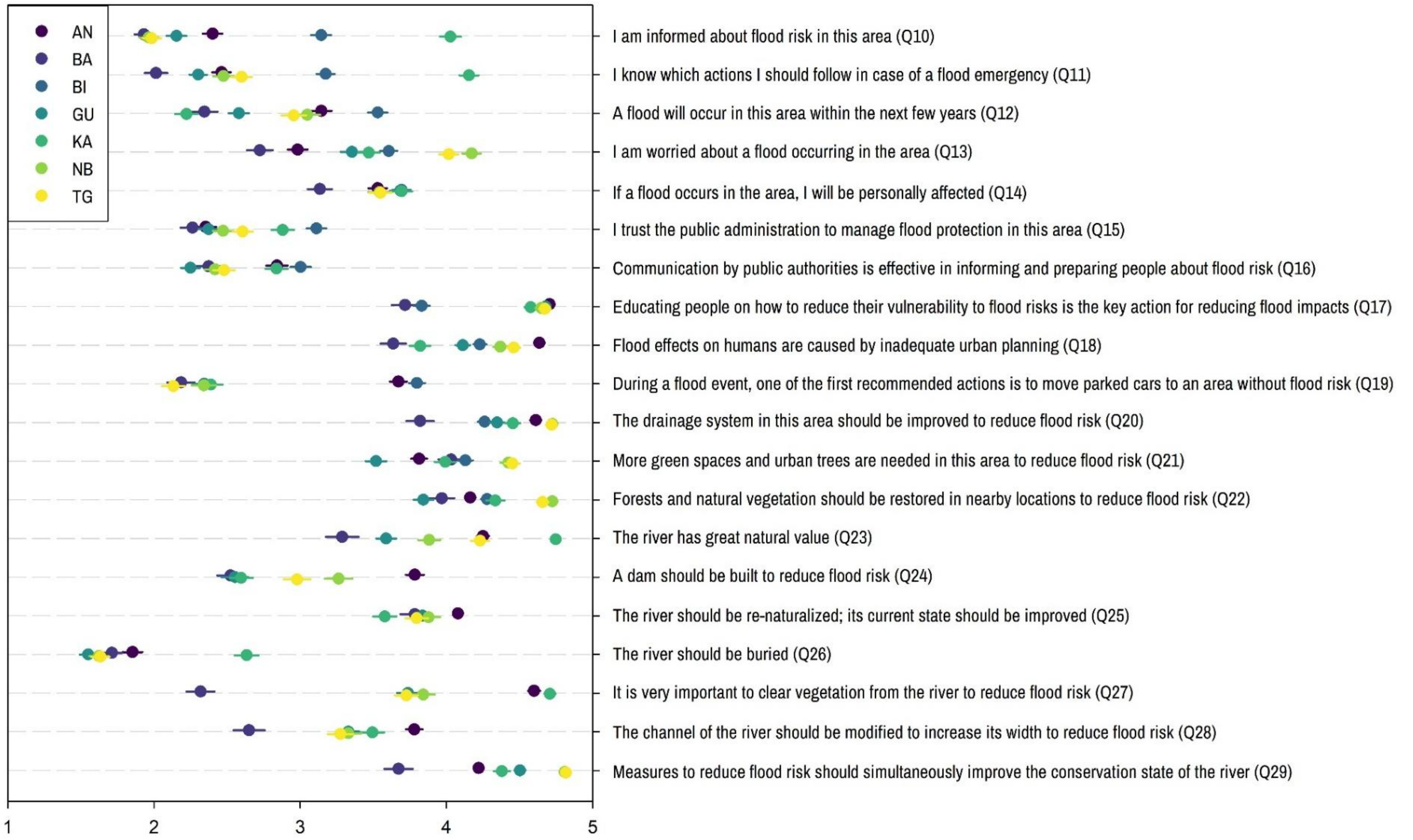

Figure 8. Agreement level (mean ± SE) to each of the 20 statements by pilot site. *5-point Likert-scale: 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree. AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).*

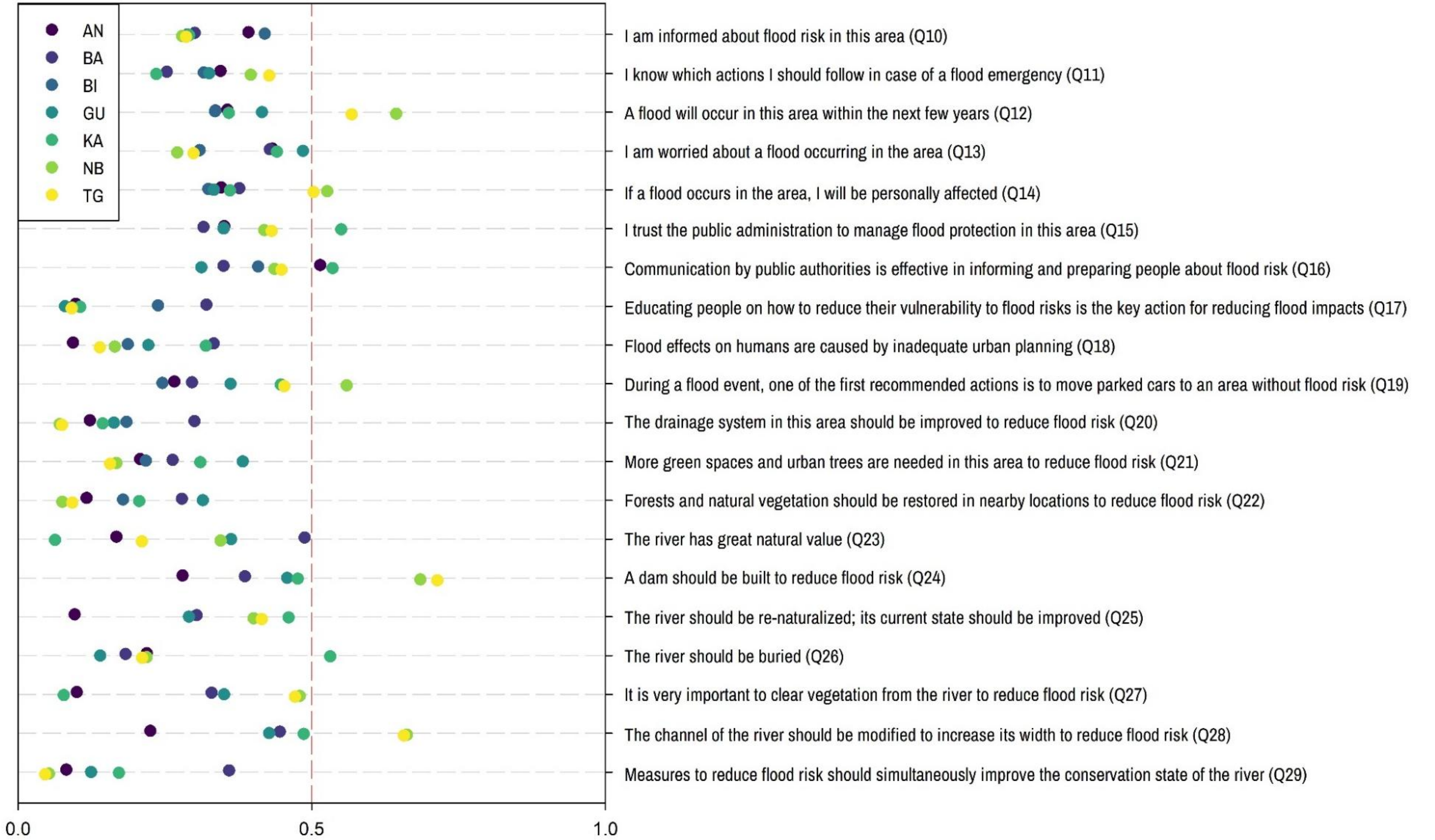

Figure 9. Polarization level to each of the 20 statements by pilot site*. Polarization scale from 0 (minimum, no polarization) to 1 (maximum, total polarization). AN: Anthemountas (Greece); BA: city of Bari (Italy); BI: Birkirkara – Msida (Malta); GU: Gurri Catchment (Catalunya, Spain); KA: Kamchia-Varna (Bulgaria); NB: Torrent de na Bàrbara (Mallorca, Spain); TG: Torrent Gros (Mallorca, Spain).*

4. Educational actions design

Based on the results, we propose a list of topics as a starting point for developing educational actions and tools to improve people adaptation capacity to flood risk. While it would be ideal to implement all possible educational actions across all pilot sites, we prioritized actions based on the results to recommend the most relevant topics for each site (Table 2).

In this vein, a participatory dynamic to brainstorm about potential educational actions was implemented with all project partners during the Steering Committee meeting that took place in Malta (12th – 13th November 2024). Building on this brainstorming, in Activity 2.3, educational actions will be designed and implemented using the results obtained in A1.3 and addressing the proposed topics, with the goal of enhancing people adaptability across the various pilot sites.

Table 2. 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 to be covered by education actions:	**AN**	**BA**	**BI**	**GU**	**KA**	**NB**	**TG**
Human-River Connection	X	XX		X		X	X
Meteorological alerts & Emergency Plans			X		XX		
Early Warning Systems		X	X	XX	X	XX	XX
Nature Based Solutions	XX	XX	XX	XX	XX	XX	XX
EU Flood Directive & Flood Risk Maps	X	X	X	X	X	X	X
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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Annexes

Annex I. Survey

Section 1. Informed Consent

We are conducting a survey, which will only take 5-10 minutes, to examine flood risk perceptions related to the "river name" by people living and/or working in this area. Your participation will help us acquire valuable scientific knowledge to propose better management actions regarding the "river name". All responses to this survey are valid; there are no wrong answers because we are interested in your opinions and views.

This study is conducted by [Institution], and it is part of the European research project LocAll4Flood, co-funded by the European Union and several European institutions through the Interreg Euro-MED program.

This survey is anonymous, and your responses will be kept completely confidential. No personally identifiable data will be collected, and no one will be able to link your answers back to you. By responding this survey you authorize the use of the collected information for research purposes only. You have the right to interrupt your participation and revoke your consent at any time.

Do you confirm your voluntary participation in this study by completing this questionnaire?

Section 2. Context

Q1. Just indicate if the person lives or works in the area (result of the initial conversation during the first approach to carry out the interview)

a. Person lives in the area
b. Person works in the area (commuter)
c. Person lives and works in the area

Section 3. Human-River Relationship

Q2. On a scale from 1 to 5, how connected do you feel with nature? 1 = not at all; 5 = very much *(Likert scale 5 points)*

Q3. On a scale from 1 to 5, how connected do you feel with the "name of the river"? 1 = not at all; 5 = very much *(Likert scale 5 points)*

Q4. Can you explain in your own words why you have chosen that answer about your connection with the "name of the river"? *(Open question; it is important to write down the different aspects listed by the interviewee in the same order as stated)*

Section 4. Perception

Q5. Have you ever experienced a flood directly?
a. Yes, in this area
b. Yes, in another area
c. No d. DK/DA

Q6. Are you aware that this area is a flood risk area?
a. Yes
b. No
c. DK/DA

Q7. Are you familiar with any of the following terminology? Please select all that apply.
a. European Union Flood Directive
b. Flood Risk Maps
c. Emergency Plans
d. Meteorological alerts
e. Early Warning Systems
f. Nature Based Solutions
g. Green solutions
h. None of the above

Section 5. Open Questions on Behavior and Solutions

Q8. What actions should you follow if a flood occurs in this area? *(Open question)*

Q9. What are the best solutions to reduce flood risk and its consequences in this area? *(Open question; it is important to write down the solutions proposed by the interviewee in the same order as stated)*

Section 6. Likert Scale Battery

Please indicate your level of agreement with the following statements by selecting a number from 1 to 5, where: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree; DK/DA = Do not Know / Do not Answer.

Q10. I am informed about flood risk in this area.
Q11. I know which actions I should follow in case of a flood emergency.
Q12. A flood will occur in this area within the next few years.
Q13. I am worried about a flood occurring in the area.
Q14. If a flood occurs in the area, I will be personally affected (in terms of physical integrity or material loss).
Q15. I trust the public administration to manage flood protection in this area.
Q16. Communication by public authorities is effective in informing and preparing people about flood risk.
Q17. Educating people on how to reduce their vulnerability to flood risks is the key action for reducing flood impacts.
Q18. Flood effects on humans are caused by inadequate urban planning.
Q19. During a flood event, one of the first recommended actions is to move parked cars to an area without flood risk.
Q20. The drainage system (i.e., sewerage) in this area should be improved (i.e., maintenance, sizing) to reduce flood risk.
Q21. More green spaces and urban trees are needed in this area to reduce flood risk.
Q22. Forests and natural vegetation should be restored (better managed) in nearby locations to reduce flood risk.
Q23. The "name of the river" has great natural value.
Q24. A dam should be built to reduce flood risk.
Q25. The "name of the river" should be re-naturalized; its current state should be improved (e.g., eliminating concrete and channelization).
Q26. The "name of the river" should be buried (directed into pipes or totally covered by concrete).
Q27. It is very important to clear vegetation from the "name of the river" to reduce flood risk.
Q28. The channel of the "name of the river" should be modified to increase its width to reduce flood risk.
Q29. Measures to reduce flood risk should simultaneously improve the conservation state of the "name of the river".

Section 7. Socio-demographics

Q30. What is your age?

Q31. What is your gender?

a. Female
b. Male
c. Other (please specify):

Q32. What is the highest formal level of education you have completed?

a. No formal education
b. Primary education
c. Secondary education (High School)
d. Post high school non-university education
e. Bachelor's degree
f. Postgraduate (master's, PhD)

Q33. How long have you lived/worked in this area?

a. Less than 1 year
b. 1-5 years
c. 5-10 years
d. Over 10 years
e. Since I was born

Q34. Do you have any physical disability or mobility impairment?

a. Yes
b. No
c. DK/DA

Only for residents (people living in the area; see Q1):

Q35. Do you have private insurance that covers your house and/or assets in case of a flash flood?

a. Yes
b. No
c. I have insurance, but I am not sure if it covers flood impacts.

Q36. Do you live with the following dependents? Please select all that apply.

a. Kid(s)
b. Elderly person/people
c. Person/people living with disabilities
d. Other dependent person
e. No dependents

Section 8. Acknowledgements

Thank you so much for your time. If you want to receive more information about this project and participate in future specific workshops related to flood risk in this area, please contact us at *[email of a person in the institution].*
For information regarding the project, you can visit the webpage: https://locall4flood.interreg-euro-med.eu/

ANNEX II. SUPPLEMENTARY FIGURES

Annex II contents seven supplementary figures showing the agreement level to each of the 20 statements for each of the seven pilot site.

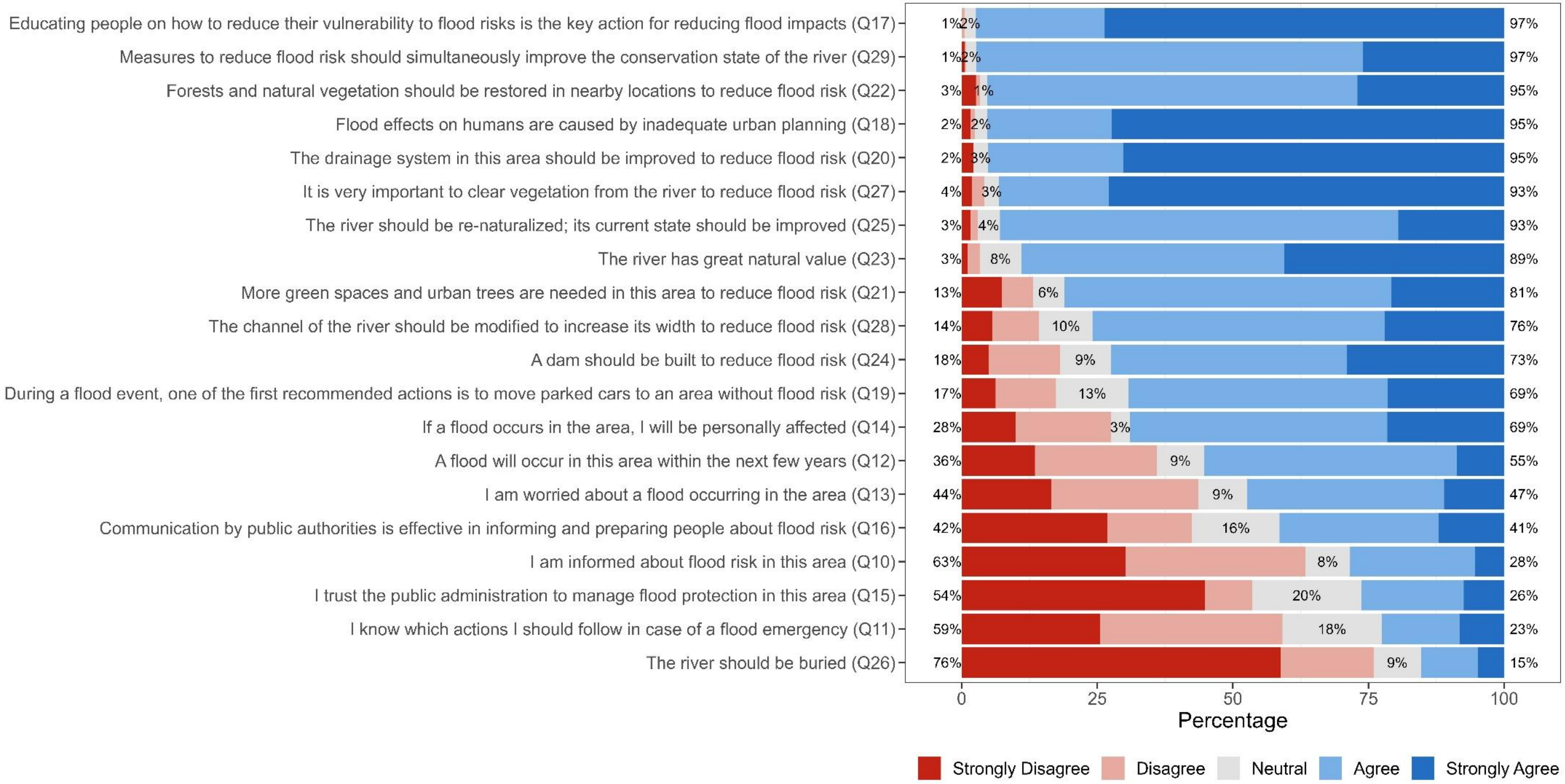

***Figure S1. Agreement level to each of the 20 statements at the Anthemountas (Greece) pilot site*.**

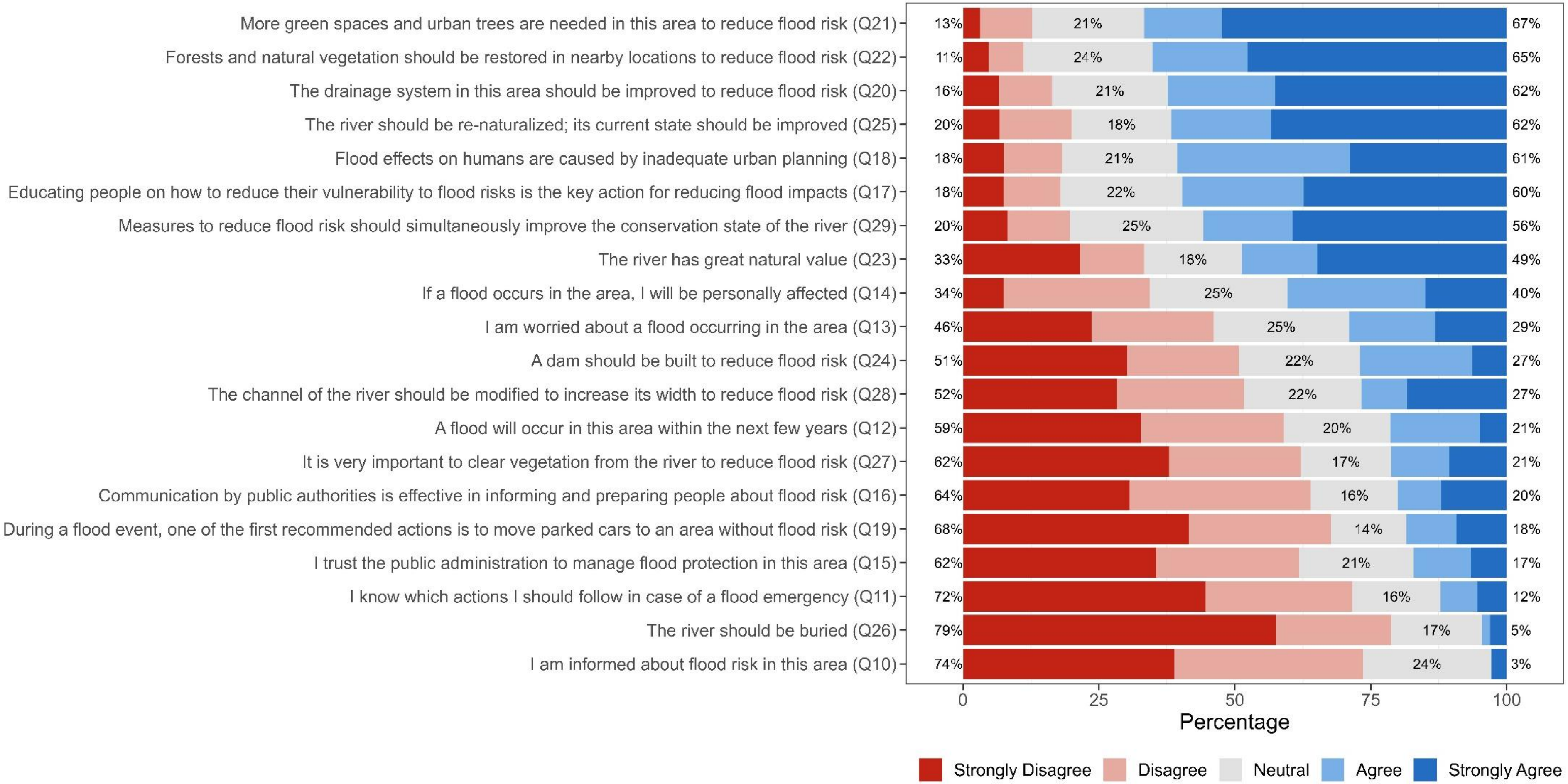

Figure S2. Agreement level to each of the 20 statements at the city of Bari (Italy) pilot site.

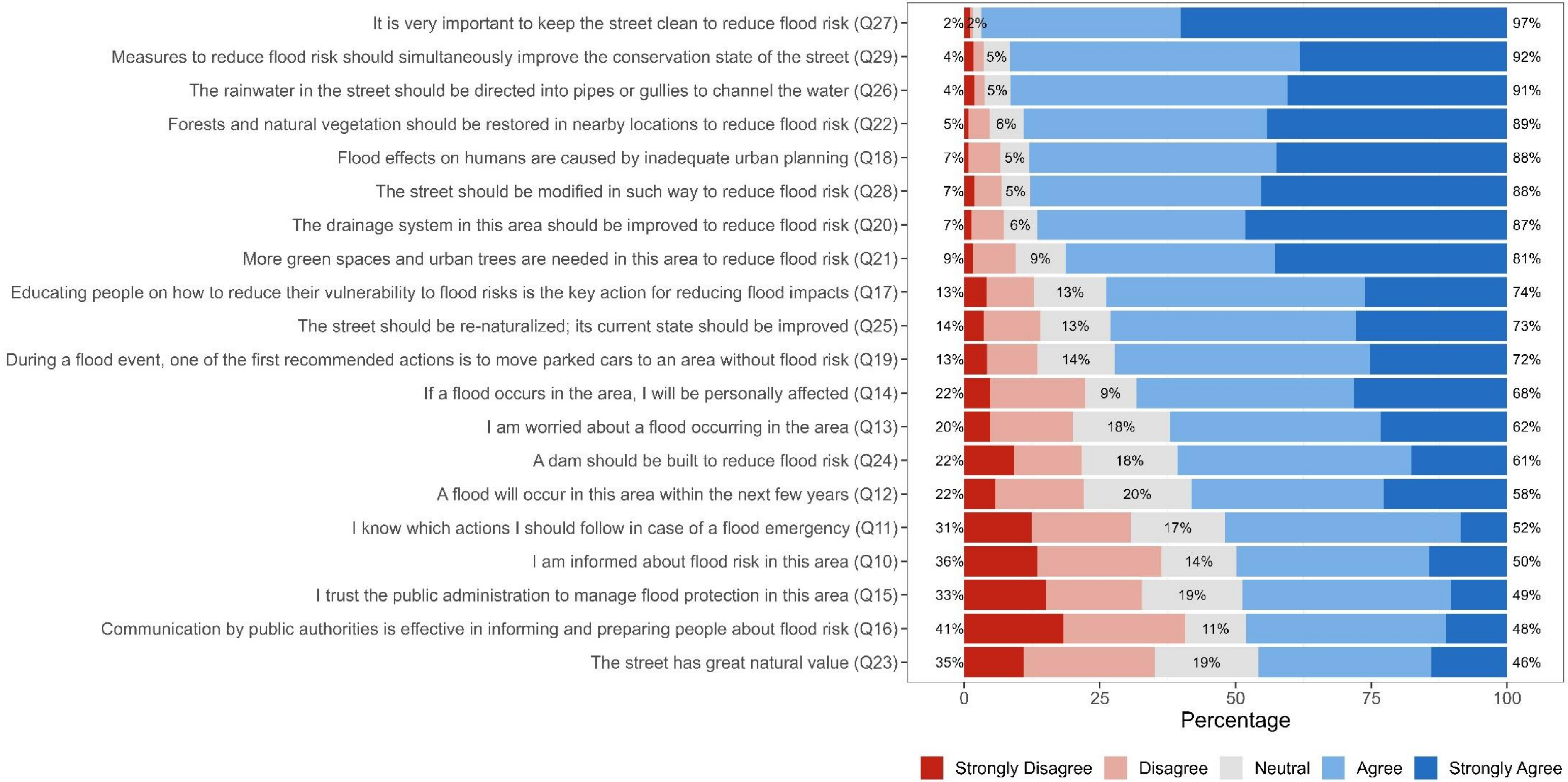

Figure S3. Agreement level to each of the 20 statements at the Birkirkara – Msida (Malta) pilot site.

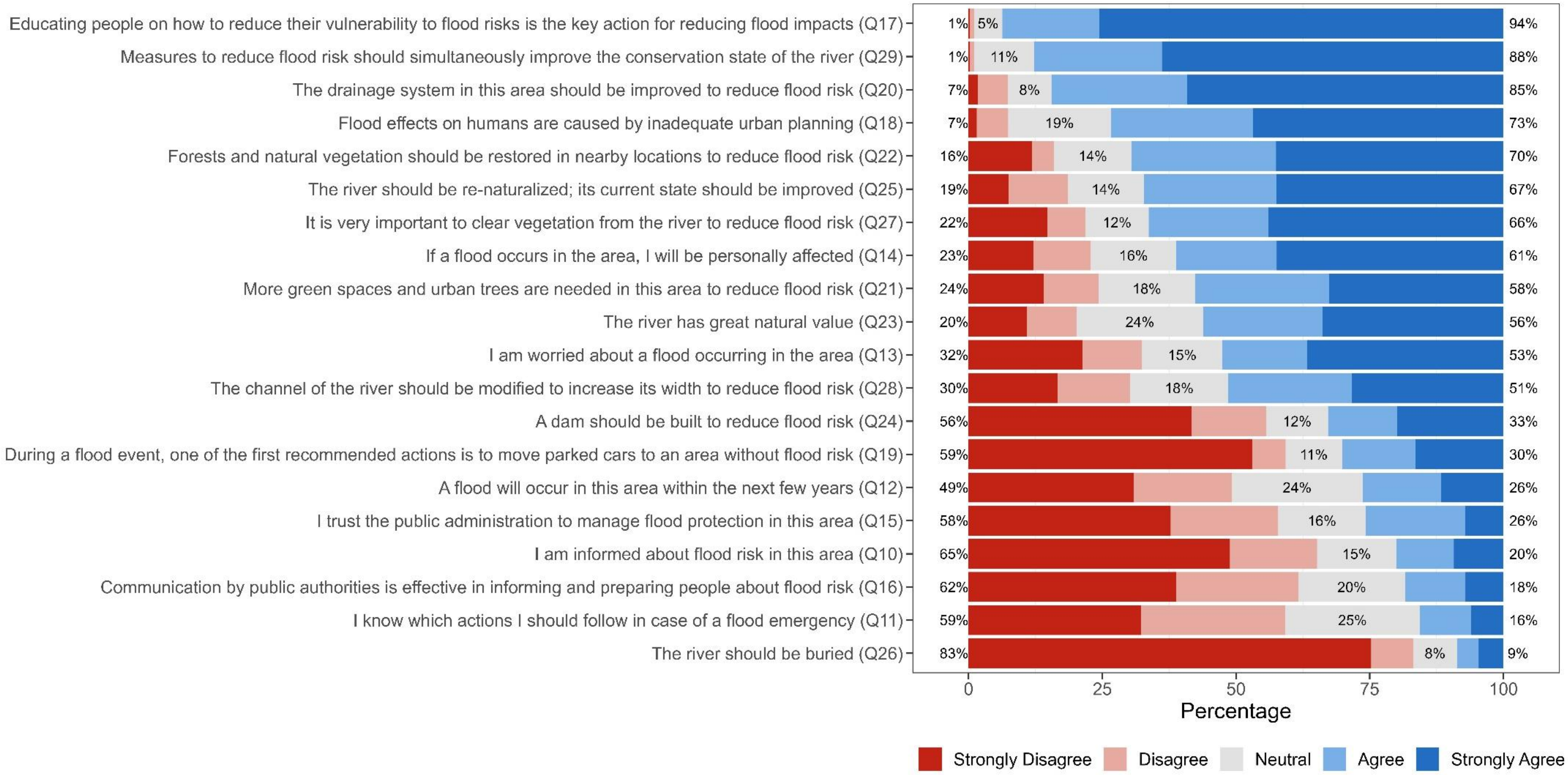

Figure S4. Agreement level to each of the 20 statements at the Gurri catchment (Catalunya, Spain) pilot site.

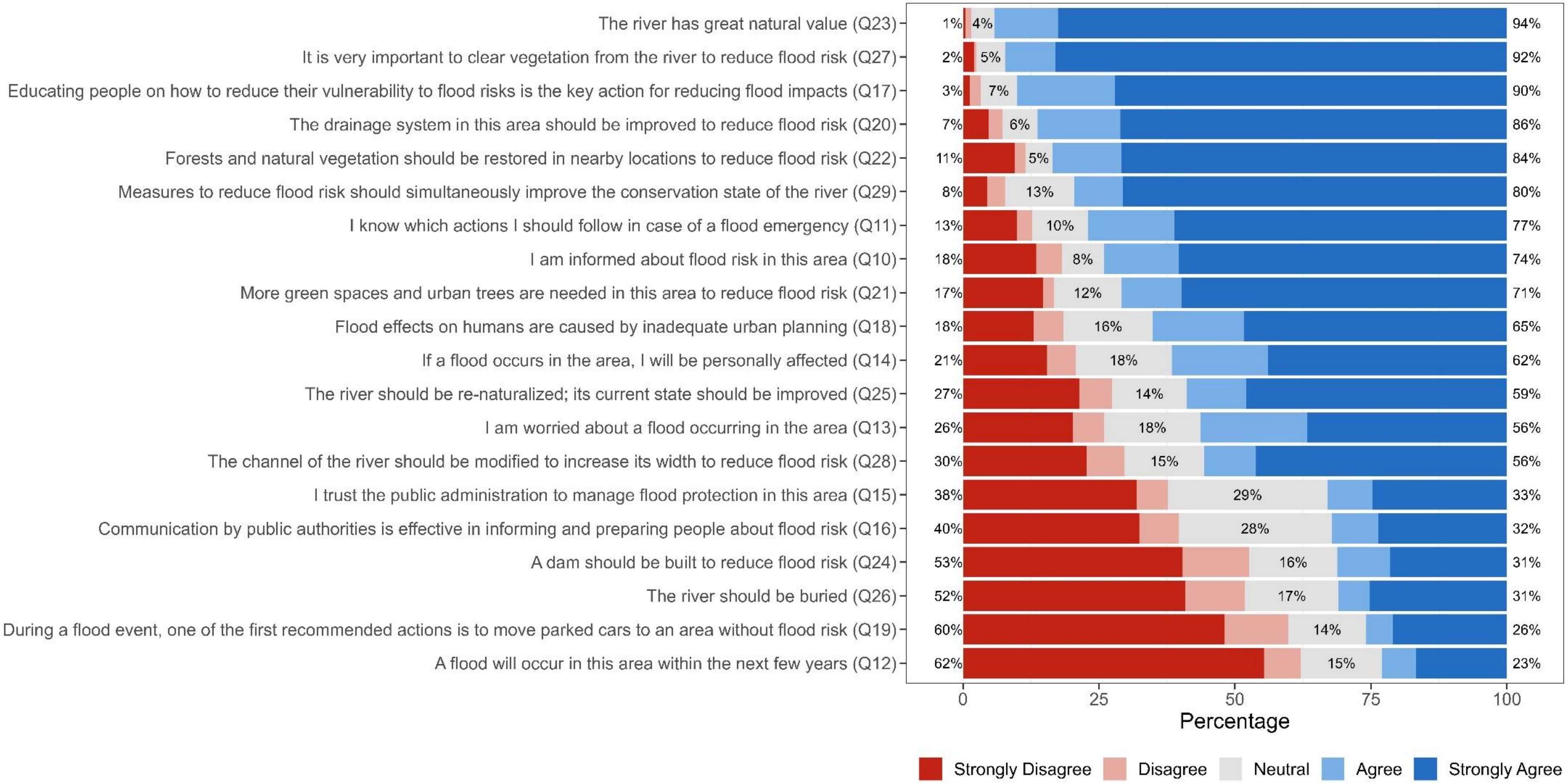

Figure S5. Agreement level to each of the 20 statements at the Kamchia-Varna (Bulgaria) pilot site.

Figure S6. Agreement level to each of the 20 statements at the Torrent de na Bàrbara (Mallorca, Spain) pilot site.

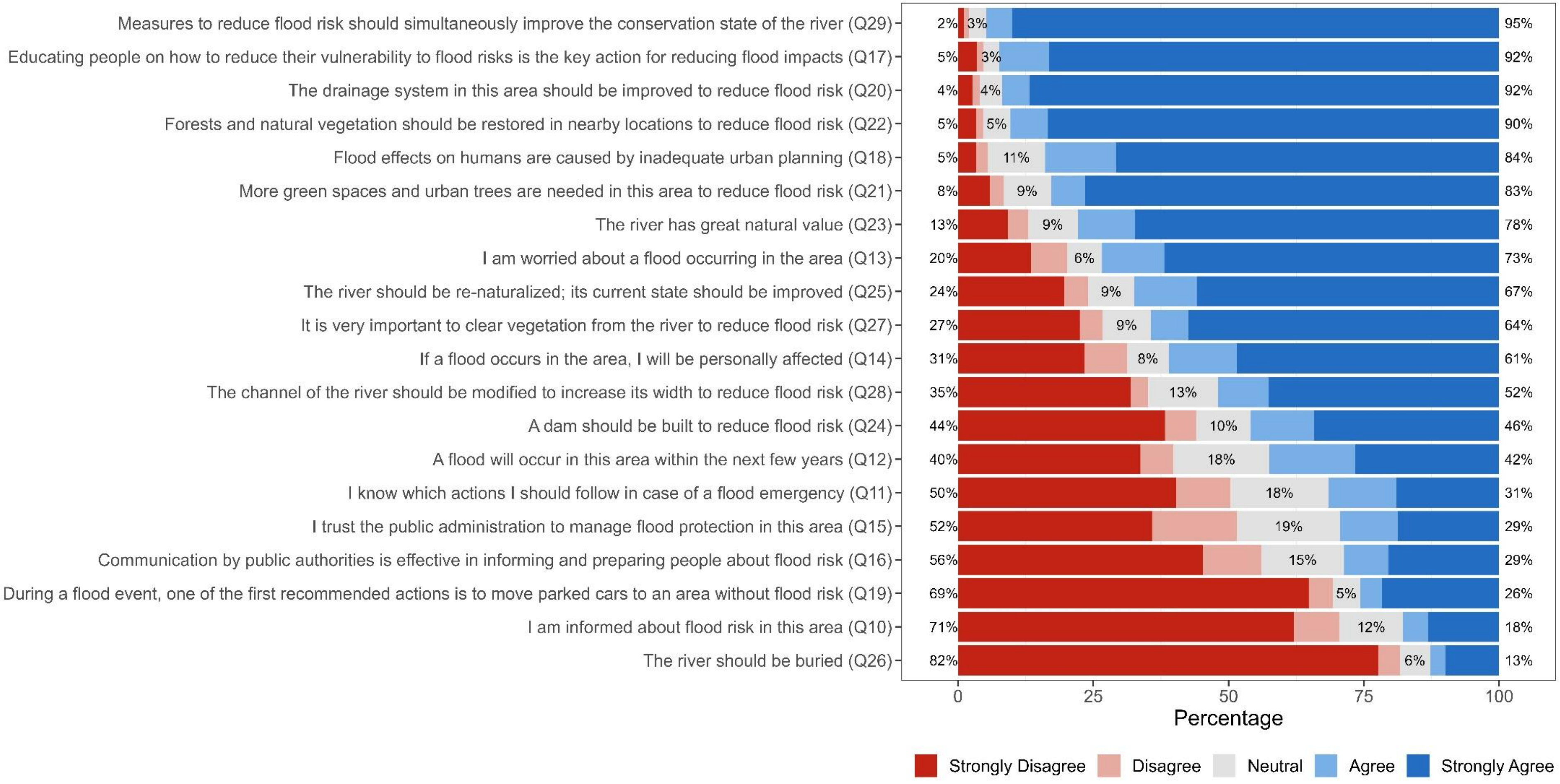

***Figure S7. Agreement level to each of the 20 statements at the Torrent Gros (Mallorca, Spain) pilot site*.**