



# The application of analytical hierarchy process to assess adaptation strategies for flood and landslides risks: A case study of a multi-risk area community

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## ABSTRACT

The increasing frequency of flood-related emergencies has heightened discussions on climate adaptation and risk management. Despite investments in infrastructure, early warning systems, urban planning improvements, and awareness initiatives, sustained attention and action are essential. The efficacy of preventive measures relies heavily on local community decisions and their cooperation with authorities, impacting the entire risk management cycle. This study investigates the factors influencing flood and landslide adaptation strategies and their perception by citizens in vulnerable areas, aiming to identify key variables that shape citizen behaviour for effective planning and management of adaptation actions. Focusing on Ischia Island, Italy, a multi-risk area, the study applied the Analytic Hierarchy Process (AHP) in focus groups to achieve three objectives: i) Highlight the critical role of citizen perceptions in forming adaptation strategies, emphasizing the need for cohesive efforts among policymakers, experts, and communities to enhance resilience. ii) Examine residents' views on flood and landslide risks to understand local concerns and vulnerabilities. iii) Use multi-criteria analysis to evaluate the importance of factors shaping adaptation strategies, providing a systematic framework for decision-making in disaster risk management. Findings reveal an optimism bias in respondents' perceptions of their home security despite recognizing the area's vulnerability and mistrust in authorities. Environmental and social factors are deemed most important, with environmental strategies focused on harm reduction and local environment enhancement, and social strategies emphasizing information dissemination and mortality reduction. This research offers valuable insights into community perceptions and factors influencing adaptation strategies for flood and landslide risks.

## 1. Introduction

Climate change can influence flood risks by altering precipitation patterns, sea levels, and extreme weather events (Bronstert, 2003; Merz et al., 2021; Tabari, 2020). The relationship between climate change and flood risks, to understand future scenarios and develop adaptation strategies, is widely investigated. A study by Kundzewicz et al. (2018) examined the impact of climate change on flood risks globally and highlighted the need for adaptive measures to reduce vulnerability. The literature acknowledges that flood and landslides risks are influenced by socioeconomic factors, including population density, urbanization, and infrastructure development (Botzen et al., 2009; Lim and Skidmore,

2019; Yang et al., 2023; Shah et al., 2024). Scientists analyse these factors to assess vulnerability and understand the social and economic consequences of floods (Bouaakkaz et al., 2023). A study by Di Baldassarre et al. (2010) investigated the relationship between socioeconomic factors and flood risk in Europe, emphasizing the importance of considering both physical and social dimensions in flood risk assessments.

The perception of flood and landslides risk refers to how individuals and communities perceive and understand the potential dangers and impacts associated with floods and landslides. Various factors influence how individuals perceive flood and landslides risks, including personal experiences, cultural beliefs, social networks, and media coverage

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(Samaddar and Tatano, 2012; Bempah and Øyhus, 2017; Thistlethwaite et al., 2018; Xue et al., 2021; Lechowska et al., 2022; Rawluk et al., 2017). A study by Grothmann and Reusswig (2006) examined the factors influencing flood risk perception in Germany and found that personal experience, trust in authorities, and media coverage significantly influenced people's perception of flood risks. While, Terpstra and Lindell (2013) examined the influence of social interactions on flood risk perception in the United States and found that individuals who discussed flood risks with their social contacts had a higher perception of flood risk.

However, the majority of the studies focuses on preparedness and response phases. Only few studies address the topic of risk perception in the prevention phase, which is the core of the present paper contributing to fill this gap in research.

Studies have shown that individuals with higher perceived flood risks are more likely to take preventive measures and engage in preparedness activities (Terpstra, 2011; Ngo et al., 2020). A study by Botzen et al. (2009) investigated the relationship between flood risk perception and preparedness behaviour in the Netherlands and found that individuals with higher perceived risks were more likely to have flood insurance and take protective measures. Furthermore, effective risk communication plays a vital role in shaping people's perception of flood risks and together with the management of flood risks are essential for reducing the impacts of floods (Kellens et al., 2013; Allaire, 2018; Tariq et al., 2020; Gammoh et al., 2023; Tan et al., 2024). Clear and accurate communication can help individuals understand the potential dangers and take appropriate actions. Indeed, Wachinger et al. (2013), found that transparent and participatory communication processes can enhance people's understanding and acceptance of flood risks. They investigated also how the importance of sources of information and found that individuals who received information from multiple sources had a higher perception of flood risk. Moreover, risk communication strategies, public perception, and decision-making processes to improve flood risk management are crucial in shaping people's preparedness, response, and decision-making regarding flood events (Rollason et al., 2018; Bodoque et al., 2019; Forsyth et al., 2023). Bubeck et al. (2012) examined the role of risk perception and communication in flood preparedness and found that effective communication can enhance public response and reduce vulnerability.

Perception of flood and landslides risks also influences decision-making processes, such as land-use planning, infrastructure development, and emergency response. To this aim, Scolobig et al. (2012) explored the role of flood risk perception in decision-making processes in Italy and highlighted the importance of incorporating local knowledge and perceptions into flood risk management strategies.

Researchers continue to explore these variables to gain a better understanding of how individuals perceive and respond to flood risks, which can inform effective risk communication and flood risk management strategies. Studies on people's behaviour in the context of flood risk focus on understanding how individuals and communities respond to flood warnings, evacuation orders, and other protective measures (Terpstra et al., 2009; Demeritt et al., 2013; Pagneux et al., 2020). These studies examine factors that influence decision-making, evacuation behaviour, and the effectiveness of risk communication strategies. Understanding how individuals make decisions during flood events and their subsequent evacuation behaviour is crucial for effective emergency management.

A study by Lindell and Perry (2004) investigated decision-making processes and evacuation behaviour during Hurricane Floyd in the United States and found that factors such as perceived risk, trust in authorities, and social networks influenced individuals' decisions to evacuate. Similar findings were reported by Mahdavian et al. (2020), whose survey on risk perception, preparedness, information usage, trust in authorities, and evacuation behaviour revealed significant correlations between individuals' perceptions, preparedness, and behaviours regarding flood risk, as well as their trust and attitudes toward public

authorities in flood contexts. A research by Siegrist and Gutscher (2008) explored the influence of risk perception on protective behaviour during flooding in Switzerland and found that individuals with higher perceived risks were more likely to take protective actions such as installing flood barriers or moving belongings to higher ground. Also, to understand people's behaviour during flood events, the influence of effective risk communication plays a key role. A study by Bostrom et al. (2016) examined the impact of different communication strategies on behaviour change. They investigated the effectiveness of different risk communication messages on flood preparedness behaviour in the United States and found that messages emphasizing personal vulnerability and the effectiveness of protective actions were more likely to lead to behaviour change. Scientific literature also focuses on understanding community resilience and recovery processes following flood events, examining factors that contribute to community resilience, such as social capital, community networks, and post-disaster support systems. For example, Meyer (2018) explored community resilience in the aftermath of the 2011 floods in Thailand and highlighted the importance of social networks and community-based organizations in facilitating recovery. Similarly, Norris et al. (2008) investigated the factors contributing to community resilience following natural disasters, including floods. It emphasized the importance of social support, community cohesion, and access to resources in facilitating recovery and enhancing resilience.

Researchers persist in investigating these subjects to enhance comprehension of human behaviour during flood occurrences. This understanding can significantly contribute to devising successful risk communication tactics, evacuation plans, and strategies for post-flood recovery, ultimately aiding in the development of effective measures to mitigate their impacts. However, there is a noticeable gap in the literature regarding empirical analyses of variables that affect people's participation in flood and landslides adaptation strategies. While some studies have explored aspects of community participation and engagement in mitigation efforts, there remains a need for more systematic and empirical research to understand the specific factors influencing individuals' willingness to engage in adaptation activities. Many existing studies often rely on qualitative methods or theoretical frameworks to explore community attitudes and behaviours towards flood mitigation. While these approaches offer valuable insights, they may lack the quantitative rigor needed to identify precise variables and their effects on participation levels. Moreover, the literature often lacks consistency in measuring and defining key variables related to participation, making it challenging to compare findings across different studies. Factors such as socio-economic status, education level, past flood and landslides experiences, trust in authorities, and perceived efficacy of mitigation measures are likely to influence participation but require more nuanced empirical analysis (Cisternas et al., 2024; Coombs, et al., 2024).

By addressing this gap in the literature through robust empirical studies, this work proposes to provide policymakers and practitioners with evidence-based insights to develop more effective and targeted flood and landslides adaptation strategies. In this context, the Analytic Hierarchy Process (AHP) represents a valuable tool for addressing the gap in empirical analysis of variables affecting people's participation in flood and landslides adaptation strategies, considering the multi-criteria characterizing the topic.

Understanding citizens' perceptions of risk and their attitudes towards flood and landslides adaptation strategies is critical for effective disaster prevention, preparedness and response efforts. While scientific models and engineering solutions play a crucial role in managing flood and landslides risks (analysing various factors such as flood frequency, vulnerability of exposed populations and infrastructure, and the potential consequences of flooding), the success of mitigation measures ultimately depends on the cooperation and engagement of local communities (Kourtis et al., 2020). By examining how people perceive and interpret flood and landslides risks, authorities can tailor their strategies to address specific concerns, enhance public awareness, and foster community resilience.

The present study falls precisely within this domain, with the main aim of evaluating the perceptions of local citizens regarding current issues surrounding flood and landslides disasters and determining the weight of factors influencing flood and landslides adaptation strategies' perception.

We pursue the following specific objectives: i) Explore the significance of citizens' perceptions in shaping flood and landslides adaptation strategies, emphasizing the necessity for collaboration among policy-makers, experts, and the public to develop safer and more resilient communities; ii) Highlight citizens' perceptions of flood and landslides risk in a multi-risk area, such as the Island of Ischia (Italy), to better understand local concerns and vulnerabilities; iii) Apply multi-criteria analysis to evaluate the weights of factors influencing flood and landslides adaptation strategies, providing a structured approach to decision-making and resource allocation in flood and landslides risk management.

The paper is organized as follows: [Section 2](#) outlines the methodology used to analyse risk perception and weigh factors influencing flood and landslides adaptation strategy perception. [Section 3](#) presents the case study. [Section 4](#) details the data processing procedures. [Section 5](#) presents and discusses the results. Finally, [Section 6](#) concludes the study.

## 2. Methodology

The challenges inherent in mitigating natural disasters often involve multiple stakeholders with divergent values and perspectives, a multitude of potential outcomes, and considerable uncertainty. Addressing these challenges requires consideration of various aspects and diverse measures, encompassing both qualitative and quantitative parameters.

This raises the question: Are there mathematical and econometric approaches that can accommodate parameters of different types to identify the optimal solution?

Multi-Criteria Decision Analysis (MCDA) stands as a powerful tool widely utilized across various fields. Within flood risk management, numerous studies have explored spatial MCDA applications related to flood vulnerability and risk assessment ([De Brito and Evers, 2016](#); [Shivaprasad Sharma et al., 2018](#); [Perosa et al., 2022](#)). Some studies have applied MCDA, particularly Analytic Hierarchy Process (AHP), to analyse flood vulnerable areas ([Papaioannou et al., 2015](#); [Rincón et al., 2018](#); [Radwan et al., 2019](#); [Vignesh et al., 2021](#); [Mudashiru et al., 2022](#); [Ayoubli, et al., 2024](#)) and floodplain management ([Tzioutzios and Kastridis, 2020](#); [Alam et al., 2023](#)). Notably, [Zhang et al. \(2020\)](#) utilized a GIS-based spatial AHP model to comprehensively examine the impacts of floods, including economic, social, and environmental aspects, focusing on the spatial distribution of flood risk in the Yangtze River Basin in China. Conversely, [Porthin et al. \(2013\)](#) employed MDCA to support a multi-stakeholder decision process in evaluating different flood protection alternatives in Pori, Finland, and ranked various flood protection alternatives.

While AHP has found extensive application in various aspects of flood management, including risk assessment, infrastructure planning, and emergency response, there are no documented cases of its direct application to evaluate the perception of variables affecting flood and landslide adaptation strategies. The principles of AHP, which entail structuring complex decision problems, determining criteria, and weighting them based on stakeholder preferences, have already been applied to assess perceptions in other fields (including healthcare decision making, environmental management, urban planning and development, and business management) ([2020](#); [Souza and Leitão, 2020](#); [Lam et al., 2020](#); [Wachowiak and Bartkowiak, 2021](#)) and can be adapted for flood and landslide adaptation strategies.

The evaluation of perception often involves qualitative aspects and subjective judgments, which can be incorporated with stakeholder input and preferences through interviews, surveys, or focus group discussions, to quantify and prioritize these perceptions within a decision-making framework.

This research aims to explore the feasibility and effectiveness of applying AHP to evaluate the perception of variables affecting flood and landslide adaptation strategies. This could involve developing appropriate criteria, eliciting stakeholder preferences, and integrating qualitative insights into the decision-making process to enhance the resilience of flood-prone communities. Its flexibility and versatility make it a valuable tool for addressing the complex and multi-dimensional nature of perception of flood and landslide adaptation strategies.

AHP provides a structured and systematic approach to handling subjective preferences in decision-making. It involves decomposing complex problems into hierarchical structures of criteria and sub-criteria, allowing decision-makers to analyse and prioritize various factors in a methodical manner ([Saaty and Vargas, 2001](#)).

A key aspect of AHP is the consideration of preferential independence, where criteria can be represented as a weighted average if they are independent. This simplifies the decision-making process by breaking down multidimensional problems into multiple one-dimensional scaling problems. Each criterion is evaluated individually through pairwise comparisons, where decision-makers assess the relative importance of each criterion in relation to others ([Saaty and Vargas, 2001](#)).

AHP relies on the principal eigenvalue method to derive ratio scale priority vectors from positive reciprocal matrices, which are constructed based on pairwise comparisons ([Barzilai et al., 1987](#); [Saaty and Hu, 1998](#)). These comparison matrices, also known as judgments matrices, capture decision-makers' preferences and perceptions regarding the importance of different criteria.

To ensure the consistency of pairwise comparisons, AHP employs a specific consistency test, which evaluates the coherence of the judgments made by decision-makers. This helps to identify and mitigate inconsistencies in the decision-making process, ensuring the reliability and robustness of the final results ([Saaty and Vargas, 2001](#)).

By employing methods like AHP, decision-makers can systematically evaluate and prioritize these diverse criteria, thereby facilitating a comprehensive and transparent decision-making process. AHP enables stakeholders to articulate their preferences, weigh the relative importance of different criteria, and arrive at consensus-based decisions that reflect the collective values and priorities of the community. Through such approaches, effective flood and landslide adaptation strategies can be developed and implemented to enhance the resilience and sustainability of communities facing flood and landslide risks.

Four steps are employed to assess AHP to evaluate adaptation strategy perception ([Fig. 1](#)):

### STEP 1: Problem Structuring

AHP offers a systematic framework for identifying and structuring the key variables influencing individuals' participation in flood and landslides mitigation efforts. This structured approach ensures comprehensive consideration of all relevant factors.

### STEP 2: Weight Evaluation

AHP allows researchers to quantify preferences and the relative importance of different variables through pairwise comparisons. By gathering input from stakeholders, including community members and experts, researchers can assign weights to each variable based on perceived influence on participation. AHP enables examination of interrelationships between variables, such as socio-economic status, trust in authorities, and past flood and landslides experiences, to understand their collective impact on participation levels.

### STEP 3: Summary of Priorities

AHP facilitates ranking of criteria and sub-criteria affecting adaptation strategies based on their effectiveness in addressing community perceptions. This process helps identify the most promising approaches for increasing community engagement in flood and landslides mitigation efforts.

### STEP 4: Sensitivity Analysis

AHP incorporates sensitivity analysis techniques to evaluate the

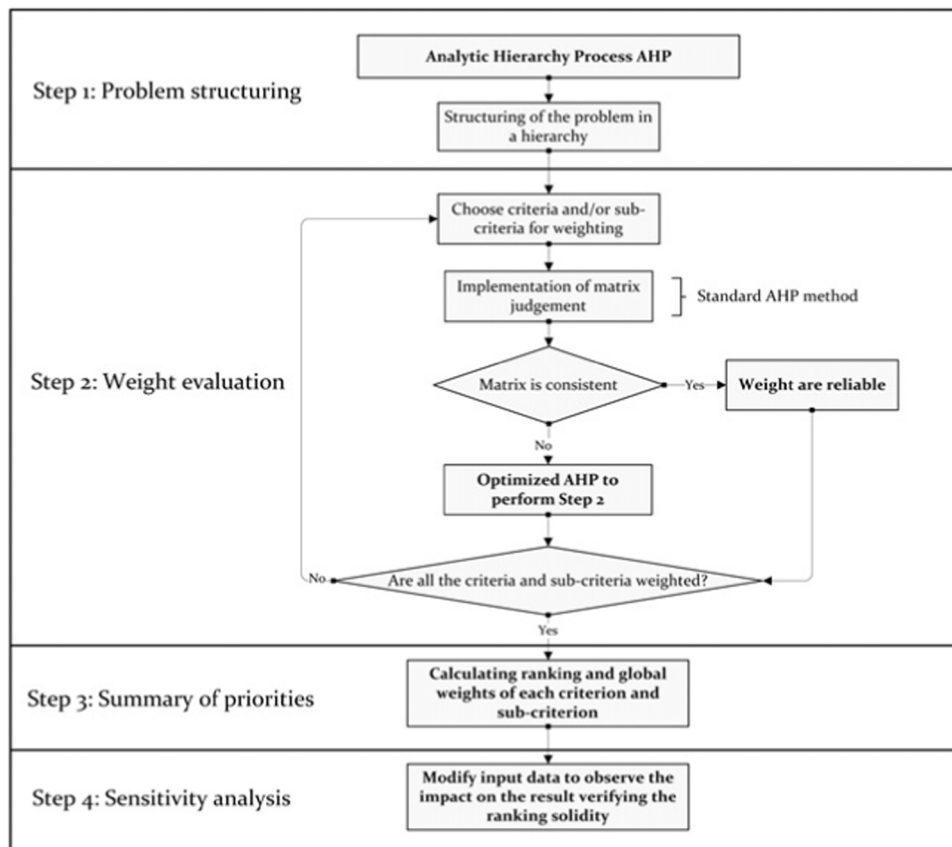


Fig. 1. Steps of Optimized-AHP (Caporale et al. 2020).

robustness of results and assess the impact of uncertainty in variable weights on decision outcomes.

Through the application of AHP methodology, researchers can gain deeper insights into the complex dynamics shaping individuals' participation in flood and landslides adaptation strategies.

### 2.1. Utilizing AHP in focus group discussions (FGD)

In the literature, AHP has been successfully combined with focus groups (FGs) in diverse research studies spanning different domains. For example, in healthcare decision-making, Lee and Li (2019) employed AHP within focus group discussions to prioritize factors influencing healthcare decision-making. By eliciting preferences from diverse stakeholders, AHP facilitated consensus-building and informed decision-making in urban development projects (Girard and Torre, 2012; Sangiorgio et al., 2018).

Moreover, AHP has been employed during focus groups to evaluate alternative environmental management strategies, such as watershed management practices or conservation initiatives. Participants collaboratively assessed the importance of various environmental criteria and trade-offs, informing decision-making processes aimed at sustainable resource management (Hussain et al., 2021; Rajabpour et al., 2022). In disaster risk reduction contexts, AHP has been integrated into focus group discussions to prioritize disaster preparedness measures, assess vulnerability factors, and identify adaptation strategies. By engaging community members and stakeholders, AHP facilitated the identification of actionable strategies to enhance resilience and reduce disaster risks (Nguyen et al., 2020; Akola et al., 2022).

Additionally, focus groups combined with AHP have been utilized to explore factors influencing technology adoption decisions, such as renewable energy technologies or information systems. Participants evaluated criteria such as usability, cost-effectiveness, and perceived

benefits, providing valuable insights into the adoption process and informing technology development strategies (Caporale et al., 2020; Yudini et al., 2021; Li et al., 2021).

Overall, the integration of AHP with focus groups offers a structured and participatory approach to decision-making, enabling stakeholders to collaboratively prioritize criteria, evaluate alternatives, and reach consensus on complex issues across diverse domains.

### 3. Description of the study area: Ischia Island (Italy)

Ischia Island, situated in the Tyrrhenian Sea, stands as a captivating and geologically diverse landmass off the coast of Italy's Campania region. Renowned for its striking natural landscapes, thermal springs, and volcanic terrain, Ischia draws visitors seeking a blend of relaxation, history, and outdoor pursuits.

Considered a multi-risk area, Ischia contends with various natural hazards owing to its geological makeup. These hazards encompass volcanic eruptions, seismic activity (earthquakes), landslides, coastal erosion, and flooding. Mount Epomeo's volcanic activity presents a notable hazard, with the potential for eruptions unleashing lava flows, volcanic ash, and toxic gases. Additionally, Ischia's location in a seismically active region renders it susceptible to earthquakes of varying magnitudes. Landslides pose a concern, particularly given the island's steep slopes, while coastal erosion and flooding threaten its low-lying coastal regions.

The island's susceptibility to floods and landslides primarily stems from its topography. Ischia's rugged terrain, characterized by steep slopes and valleys, accelerates surface runoff during heavy rainfall, leading to rapid accumulation in low-lying areas and an increased risk of flash floods. Furthermore, dense urbanization along the coastal areas has altered natural drainage patterns, exacerbated by the proliferation of impervious surfaces like roads and buildings. Inadequate drainage

infrastructure further compounds the issue, as poorly maintained or outdated systems struggle to cope with heavy rainfall events, resulting in localized flooding.

Coastal flooding from storm surges, high tides, and sea-level rise poses additional risks to Ischia's vulnerable coastal regions, threatening infrastructure, properties, and beaches. The combination of steep terrain, impermeable surfaces, and intense rainfall can trigger flash floods with minimal warning, endangering residents, tourists, and motorists. Fig. 2 shows the multi-hazard index map of Ischia island.

The island's vulnerability is further heightened during peak tourist seasons, when a surge in population density increases exposure to flood and landslide risks. Climate change projections indicate a potential escalation in the frequency and intensity of extreme weather events, exacerbating Ischia's susceptibility to flooding and landslides.

The history of floods and landslides on Ischia dates back over a century, with devastating events recorded, including the catastrophic flood of October 1910 and the more recent mudflow in November 2022, which claimed lives and displaced hundreds.

In summary, Ischia Island confronts a multitude of natural hazards, with its vulnerability shaped by factors such as population density, urban development, infrastructure, and climate change. Effective risk management and mitigation efforts are imperative to safeguard the island's communities and infrastructure from the impacts of floods and landslides.

#### 4. Data: the key to informed decision-making

Five focus groups were established, each comprising 8–9 non-expert citizens, resulting in a total sample size of 44 participants. Their role was to review and assess the potential causes of flood and landslide disasters identified in the primary phase. Furthermore, these groups provided valuable insights into the typical public perceptions of the factors contributing to flooding risk on the island.

A focus group discussion was conducted to gain insights into the perceptions, attitudes, and experiences of flood and landslide victims. This discussion aimed to explore the causes of the recurrent floods and landslides, as well as the role and effectiveness of national and local disaster management within the affected communities. The objective of the FGDs was to engage flood and landslide victims in group settings to identify shared constructions of meaning and understanding among them regarding these critical issues.

Using a qualitative research approach offers several strengths, primarily its ability to provide valuable insights into the social interactions and experiences of the people and communities being studied. Qualitative research allows us to delve into the rich tapestry of human experiences and perspectives.

However, it is important to acknowledge that qualitative research

strategies do come with limitations. One notable limitation is that concepts like neutrality and objectivity, which are foundational principles in quantitative studies, cannot be directly applied in qualitative research. In qualitative studies, the findings essentially represent the collective views and opinions of the participants, and these viewpoints are likely to contain a degree of subjectivity inherent to the individuals' experiences and perspectives.

To gather quantitative citizen information on residents' perceptions of flood and landslide adaptation strategies, this study employed an AHP survey during focus groups. The survey included the collection of socio-demographic data alongside some risk perception questions from the respondents. To ensure a broad spectrum of socio-demographic representation, the focus groups were promoted through social media channels and on-site announcements, with participants being recruited in the field during July 2023. Participation in these sessions was entirely voluntary, and to address privacy concerns, the survey was conducted anonymously.

##### 4.1. A Roadmap for effective flood and landslides adaptation procedures

Developing comprehensive strategies to mitigate the impact of floods and landslides requires a systematic approach that encompasses various phases, from risk assessment to implementation (Fig. 3). These essential phases emphasize the importance of a structured framework in enhancing resilience and minimizing damage.

##### 4.2. Designing focus groups in perception of flood and landslides risk and adaptation strategies

The FGD focuses on examining the variables that impact the adoption of adaptation strategies in response to floods, inundation, and landslide events. Additionally, it investigates how these strategies are perceived by citizens. The ultimate goal is to propose effective approaches for planning and managing risk adaptation actions, providing a comprehensive understanding of the factors influencing adaptation to natural disasters and informing future strategies and policies for risk reduction and management.

During the FG, participants were asked to discuss and provide their opinions regarding: the perception of flood and landslide risk, the assessment of adaptation strategies and possible problems, information on adaptation strategies, and variables to improve adaptation strategies. The discussion encompassed various aspects, including the assessment of flood and landslide hazards, the exposure of valuable assets to potential risks, and the vulnerability of the territory to flood and landslide events. Additionally, the discourse extended to considerations regarding institutional frameworks, community engagement, and the overall perception of floods and landslides among residents.

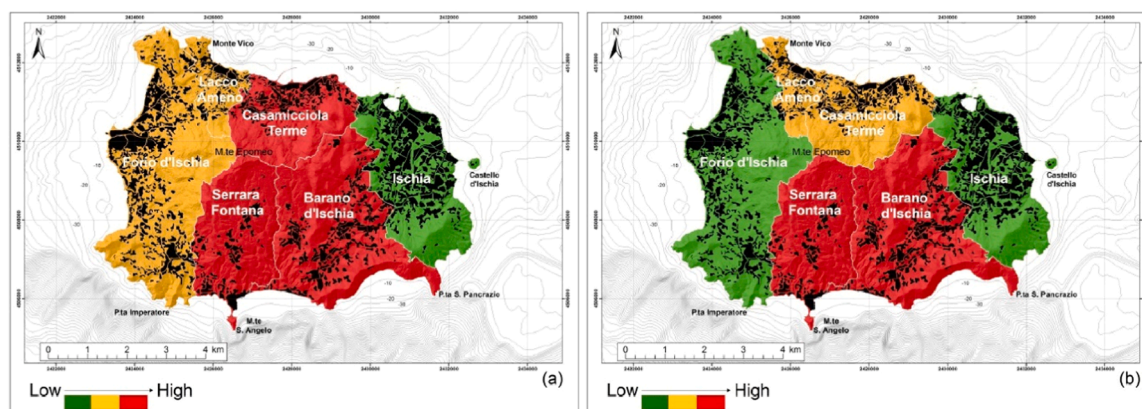


Fig. 2. Multi-hazard index map of Ischia island considering: all the indices of natural hazards affecting the island (a), only the landslide, flooding and coastal hazard indices (b).

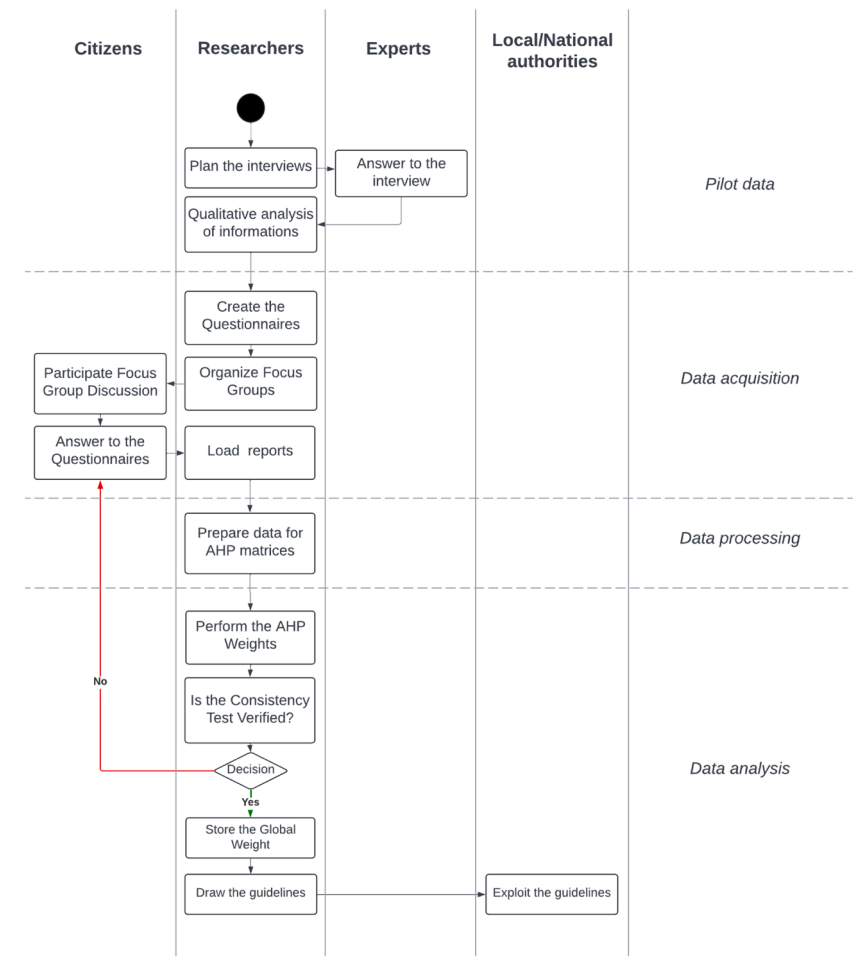


Fig. 3. Flowchart describing procedure phases for the evaluation of perception of flood and landslides adaptation strategies created using UML framework.

4.3. A practical application of AHP in flood and landslides adaptation strategies

Participants in focus groups are asked to identify and prioritize criteria relevant to the perception of flood and landslide adaptation strategies. AHP is then used to weigh the importance of these criteria based on participants' pairwise comparisons, resulting in a hierarchy of criteria that reflects their relative significance.

STEP 1: Problem Structuring - Identifying Flood and Landslide Risk Factors

The first step in applying AHP to flood and landslide risk perception is to identify and define the relevant risk factors or criteria. These factors include economic, social, environmental, and management aspects. It is important to involve relevant stakeholders and experts to ensure a comprehensive list of factors. Therefore, interviews were conducted with 9 experts with diverse specializations, including hydraulic engineering, hydrology, psychology, geology, and agricultural economics. The aim was to discern the primary adverse effects of floods and landslides, ascertain corresponding adaptation measures, and explore global perceptions of extreme flood and landslide events. Importantly, these experts were selected based on their lack of conflicts of interest, such as affiliations with regional administrative bodies or companies with economic stakes in flood-affected watersheds. Insights gleaned from these expert interviews were instrumental in identifying factors influencing flood and landslide risk and perceptions of adaptation strategies, as well as in structuring the problem hierarchically.

4.3.1. Establishing a hierarchy

Once the risk factors are identified, the next phase involves structuring the problem into a hierarchical framework. This hierarchical scheme provides a systematic and structured decomposition of the overarching problem 'Evaluation of the relevance of adaptation strategies for flood and landslide risk' into its fundamental components: *Economic, Social, Environmental, and Management*. The hierarchy allows for a systematic evaluation of the criteria by breaking them down into sub-criteria and organizing them logically. For example, economic can be broken down into sub-criteria such as potential harm to economic losses and effects on employment. Fig. 4 shows the hierarchical scheme adopted for the goal of relevance of flood and landslide adaptation strategies.

STEP 2: Weight Evaluation - Quantify Preferences and Analyse Interrelationships

In the AHP framework, weights are assigned to each criterion and sub-criterion based on their relative importance. These weights reflect the perceived significance or priority of the criteria in evaluating the relevance of adaptation strategies for flood and landslide risk. Respondents assign weights through pairwise comparisons, where criteria are compared against each other to determine their relative importance (Fig. 5). This process helps quantify the subjective judgments of their perception.

4.3.2. Pairwise comparisons

Pairwise comparisons involve comparing each criterion against every other criterion in the hierarchy. The judgments are made based on a scale that reflects the relative importance or preference between two

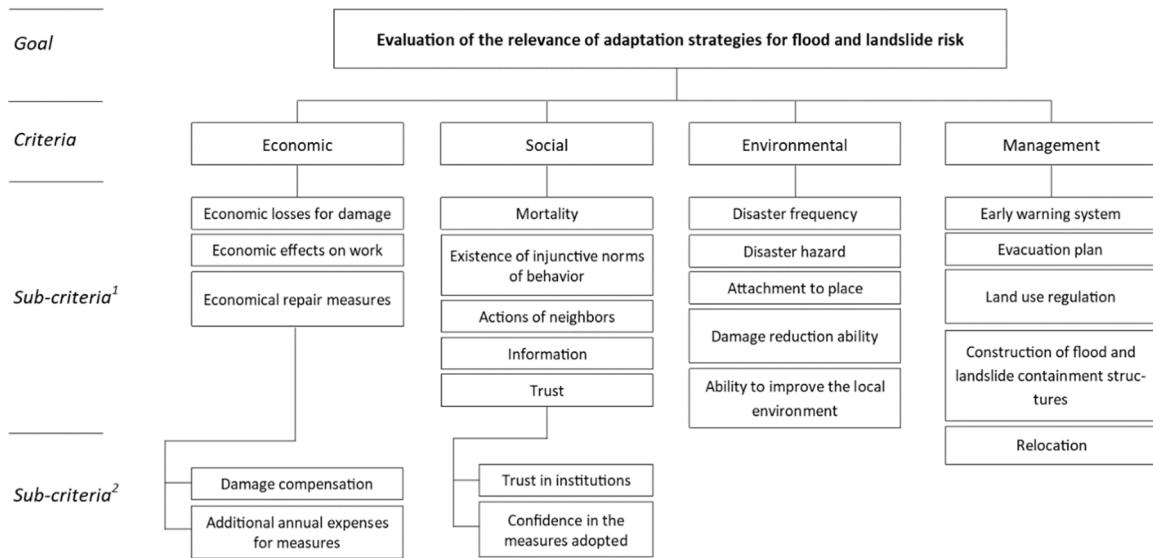


Fig. 4. Hierarchical scheme.

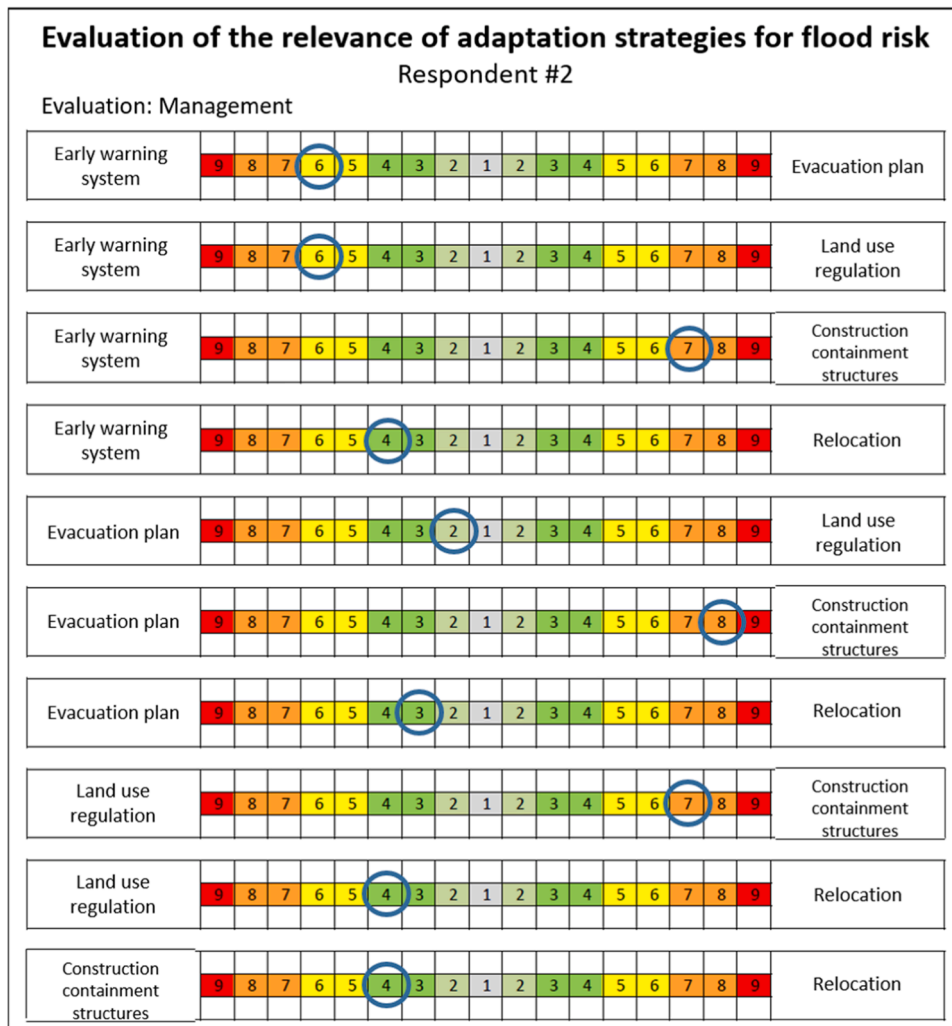


Fig. 5. Example of the questionnaire asking directly the numerical values, questions regarding the importance of sub-criteria with respect to the Management criterion.

criteria. For example, a stakeholder might be asked to compare the importance of *Economic* criterion versus *Social* criterion and assign a score indicating which factor they perceive as more significant. These comparisons are repeated for all sub-criteria, and judgments follow a scale from "extremely less important" to "extremely important," as shown in Fig. 6.

As an example, let's examine the dataset concerning the perception of the *Management* criterion provided by respondent #2, a resident of the Island of Ischia (Italy). In total, this citizen responded to 41 questions, with 10 of them focusing on the *Management* criterion. This criterion encompasses several sub-criteria, including the *Early Warning System*, the *Evacuation Plan*, *Land Use Regulation*, *Construction of Containment Structures*, and *Relocation*. Thus, the 10 questions posed to user #2 aimed to gather their subjective assessments regarding these aspects of *Management*.

Answer 1: *Early Warning System* is **strongly more** important than *Evacuation Plan*;

Answer 2: *Early Warning System* is **strongly more** important than *Land Use Regulation*;

Answer 3 *Early Warning System* is **very strongly less** important than *Construction of Containment Structures*;

Answer 4: *Early Warning System* is **moderately more** important than *Relocation*;

Answer 5: *Evacuation Plan* is **moderately more** important than *Land Use Regulation*;

Answer 6: *Evacuation Plan* is **extremely less** important than *Construction of Containment*;

Answer 7 *Evacuation Plan* is **moderately more** important than

*Relocation*;

Answer 8: *Land Use Regulation* is **extremely less** important than *Construction of Containment*;

Answer 9: *Land Use Regulation* is **moderately more** important than *Relocation*;

Answer 10: *Construction of Containment* is **moderately more** important than *Relocation*.

#### 4.3.3. Processing respondents' perception data

After the respondent completes the questionnaire, the data are processed to populate the Judgment Matrices. For instance, let's consider the numerical values corresponding to the answers to the 10 questions acquired by respondent #2. These responses are converted into numerical values to populate the respective Judgment Matrix for the *Management* criteria for respondent #2, as shown in Table 1:

The comparison matrix, which assesses local weights, lies at the heart of the method and furnishes the essential weights for establishing the ranking. During this stage, each facet of the decision problem undergoes individual scrutiny. To accomplish this, an  $n \times n$  judgments matrix  $A$  is established, where each upper diagonal element  $a_{ij} > 0$  is determined by comparing the  $i$ -th element with the  $j$ -th one using the fundamental scale of absolute numbers (Fig. 6). The number of judgments needed ( $rg$ ) to finalize each matrix depends on the number of parameters involved ( $n$ ) and, consequently, the matrix's dimensions, calculated as follows:

$$rg(n) = \frac{n(n-1)}{2}$$

Number value $a_{ij}$	Verbal scale	Explanation
$a_{ij} = 1$	Equal importance	Two activities contribute equally
$a_{ij} = 3$	Moderate importance of one over another	Experience and judgment slightly favour one activity over another
$a_{ij} = 5$	Strong importance	Experience and judgment strongly favour one activity over another
$a_{ij} = 7$	Very strong importance	An activity is favoured very strongly over another
$a_{ij} = 9$	Extreme importance	An activity is favoured by at least an order of magnitude
1.5–4–6–8	Intermediate value	Used a compromise between two judgments
<i>The reciprocal number express an opposite judgment</i>		<i>Experience and judgment dominates one activity by another</i>
$a_{ij} = 1/3$	Moderate less importance of one over another	Experience and judgment slightly dominates one activity by another
$a_{ij} = 1/5$	Strong less importance	Experience and judgment strongly dominates one activity by another
$a_{ij} = 1/7$	Very strong less importance	An activity is dominated very strongly by another
$a_{ij} = 1/9$	Extreme less importance	An activity is dominated by at least an order of magnitude

Fig. 6. Fundamental scale of absolute values by Saaty (2003), (2008).

**Table 1**

Judgment Matrix (A) to evaluate the importance of sub-criteria with respect to the *Management* criterion according to the perception of respondent #2.

	Early warning alert	Evacuation plan	Land use regulation	Containment structures	Relocation	CR	Weights (w)
Early warning alert	1	6	6	1/7	4	0016	0,28
Evacuation plan	1/6	1	2	1/8	3		0,12
Land use regulation	1/7	1/8	1	1/9	4		0,12
Containment structures	7	8	7	1	4		0,74
Relocation	1/1	1/2	1/3	1/4	1		0,10

To finalize the lower triangular segment of the judgment matrix A, reciprocal values from the upper triangular segment are utilized. Specifically, the elements in the transposed position of the matrix are assigned their reciprocal values:  $a_{ji} = 1/a_{ij}$  or  $a_{ji} \cdot a_{ij} = 1$ . Moreover, if  $a_{ij} \cdot a_{jk} = a_{ik}$  for all i, j, and k, then matrix A is considered consistent, with its principal eigenvalue being  $\lambda_{max} = n$ .

In the standard AHP procedure, the weights are derived by solving the following eigenvector problem:

$$A \cdot w = \lambda_{max} \cdot w$$

where w denotes the principal right eigenvector linked with the principal eigenvalue  $\lambda_{max}$ . If minor inconsistencies are introduced, then  $\lambda_{max} > n$  (Saaty, 2003).

**4.3.4. Consistency analysis**

AHP includes a consistency analysis step to ensure the validity and reliability of the pairwise comparisons. Inconsistencies in the judgments are identified and adjusted to improve the overall reliability of the results. This step helps to minimize biases and inconsistencies in the decision-making process.

A suitable method for assessing consistency is to conduct a consistency test on each matrix to determine if the judgments have been consistently assigned. Saaty (2003), (2008) introduced the consistency index (CI) for this purpose, which measures the consistency of the assigned judgments. The CI increases proportionally with the inconsistency of the matrix (Noble and Sanchez, 1993):

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Ensuring consistency is essential in decision-making, although it alone does not guarantee validity. Saaty proposed using the Consistency Ratio (CR), which is the ratio of the consistency index (CI) to the corresponding index for randomly generated matrices, denoted as RI(n), to implement the concept of consistency:

$$CR = \frac{CI}{RI(n)}$$

Saaty determined RI(n) by averaging the consistency indices (CIs) calculated for numerous matrices with randomly generated entries using his 1–9 absolute scale. The purpose of the CR is to discern whether the judgments in a matrix are made systematically or randomly, reflecting careful consideration of the problem. It was not designed as a statistical test. Noble and Sanchez (1993) proposed various values for RI, with Saaty ultimately adopting their recommendations, as outlined in Table 2. Based on several empirical studies, Saaty established that a Consistency Ratio (CR) below 0.10 is considered acceptable (Saaty, 2008).

Therefore, when assessing the values within the Judgment Matrix (A) to gauge the significance of sub-criteria relative to the *Management* criterion as perceived by respondent #2, the Consistency Ratio (CR) indicates consistency, as  $0.016 < 0.10$  (Table 1)

**Table 2**

Noble’s random consistency index (Noble and Sanchez, 1993).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI (n)	0	0	0.49	0.82	1.03	1.16	1.25	1.31	1.36	1.39	1.42	1.44	1.46	1.48	1.49

**STEP 3. Summary of priorities: rank alternatives**

**4.3.5. Aggregating results**

Once the pairwise comparisons are completed, the results are synthesized to calculate the overall priorities or weights for each criterion. This is achieved through a mathematical process that combines the judgments and weights assigned during the pairwise comparisons.

After assessing the local weights, the global weights V1, V2, and V3 of the sub-criteria can be computed by multiplying the weights of a criterion with the weights of the sub-criteria, and then summing up the results based on the connections established in the problem’s structure, as follows:

$$V1 = v1 * w1,1 + v2 * w2,1$$

$$V2 = v1 * w1,2 + v2 * w2,2$$

$$V3 = v2 * w2,3 + v3 * w3,3.$$

In conclusion, the weights can be aggregated either using the factorial formula or through the weighted sum method to derive the global weights, which are useful for determining the final ranking.

The aggregated results provide an overall assessment of flood and landslides risk perception, reflecting the relative importance of each criteria in the hierarchy.

Returning to the example of the evaluation of the importance of sub-criteria with respect to the *Management* criterion according to the perception of respondent #2, the final ranking is shown in Fig. 7.

By applying AHP to risk perception, decision-makers can gain insights into how different factors contribute to the perception of risk. This can aid in understanding public concerns, designing effective risk communication strategies, and informing policy and decision-making processes related to risk management. However, it is important to note that risk perception is subjective and influenced by various factors, including cultural, social, and psychological aspects. AHP serves as a structured framework to capture and analyse these subjective perceptions but should be complemented with other methods and considerations to gain a comprehensive understanding of risk perception.

**STEP 4. Sensitivity Analysis**

In the concluding phase of this study, a robustness analysis is conducted to verify the accuracy and consistency of the findings. Potential factors such as inconsistencies, subjectivity, or insufficient attention could undermine the reliability of the results, potentially leading decision-makers astray. Hence, sensitivity analysis proves invaluable in assessing the reliability of the outcomes, offering insights into their robustness and validity.

Sensitivity analysis is a crucial step in AHP to assess the robustness of the decision-making process and the stability of the results. It involves testing the effects of variations in input parameters or weights on the overall outcome. The approach to conducting sensitivity analysis in AHP is to examine the impact of changes in pairwise comparison judgments or criteria weights on the final rankings of alternatives. Sensitivity analysis has been performed by recalculating the rankings using different sets of judgments or weights and comparing the resulting

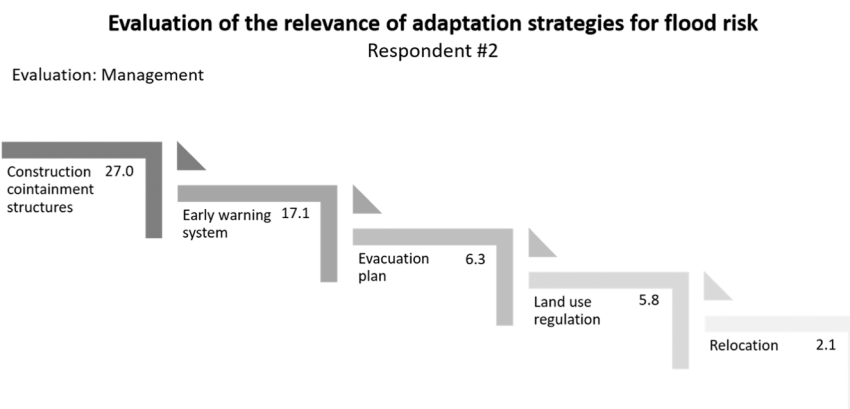


Fig. 7. Ranking of importance of sub-criteria with respect to the *Management* criterion according to the perception of respondent #2.

outcomes. This allows decision-makers to identify which criteria or judgments have the most significant influence on the final decisions and to assess the reliability of the rankings.

Sensitivity analysis also helps to evaluate the consistency of the decision model and to detect any inconsistencies or biases in the judgments provided by stakeholders. Overall, sensitivity analysis enhances the transparency and credibility of the decision-making process in AHP by ensuring that the results are robust and reliable across different scenarios and input variations.

### 5. Results and discussion

By employing the AHP methodology during the five focus groups conducted in Ischia Island, a combined total of 44 observations were collected and analysed. Subsequently, comprehensive analyses were performed to evaluate participants' perception of flood and landslides risk and to calculate the global weights of both criteria and sub-criteria.

#### 5.1. Navigating perceptions: participant demographics and FGDs evidences

The sample exhibits a balanced distribution across genders and age groups. Predominantly, participants hail from the municipalities of Ischia Porto and Casamicciola Terme, comprising 38 % and 33 % of the total, respectively. Furthermore, a substantial 86 % of respondents own property on Ischia Island, with 47 % located in Ischia Porto, 42 % in Casamicciola Terme, and 11 % in Barano. Table 3 summarizes the main socio-demographic information of the sample.

Fig. 8 The sample primarily consists of residents who live and work on the Island of Ischia, with the majority (64 %) having encountered flood and landslide events before (Fig. 9). More specifically, 14 % have directly experienced damages as a result of such natural disasters, while 32 % are acquainted with individuals who have suffered personal losses or damage to their properties (Fig. 9). Even among those who have not directly experienced these disasters, 32 % are familiar with individuals who have faced such events and incurred harm (Fig. 8).

Broadly, the participants in the focus groups show a moderate perception of the predictability of flood and landslide risks in their locality. For example, they consider flood events as predictable in advance to a minimal or moderate extent and that they can occur at a considerable temporal distance. This perception persists despite acknowledging the relatively predictable nature of flood occurrences. Furthermore, respondents characterize floods as possessing substantial strength, occurring swiftly, and posing significant danger. The perceptions of floods and landslides among participants reflect a complex blend of personal experiences, societal attitudes, and future expectations. While many participants report direct encounters with these natural disasters, their overall perception of the severity and frequency of such

Table 3  
Socio-demographic information of the sample.

Variable	Obs.	Freq.	Perc.	Mean	Std. Dev.
<i>Gender</i>	44				
Male		26	59		
Female		18	41		
<i>Age</i>	44			44.4	13.06
20-35		16	35		
36-55		16	35		
>55		12	30		
<i>Residence</i>	44				
Ischia Porto		18	38		
Casamicciola Terme		14	33		
Barano		2	5		
Forio		6	14		
Other		4	10		
<i>Properties in Ischia Island</i>	44				
Yes		38	86		
No		6	14		
<i>City of properties</i>	38				
Ischia Porto		18	47		
Casamicciola Terme		16	42		
Barano		4	11		
<i>Education</i>	44				
Elementary/Junior high school		2	5		
High school degree		14	33		
Bachelor degree		22	52		
Post-graduate degree		4	10		
<i>Employment</i>	44				
Employee		12	29		
Self-employed		26	62		
Student		2	5		
Retired		2	5		

events appears to be nuanced. Despite recognizing the potential dangers associated with floods and landslides, there is also a sense of distance or rarity attributed to these occurrences. This paradoxical view, where events are both feared yet perceived as infrequent, suggests a need for deeper examination into the factors shaping individuals' risk perceptions.

Interestingly, despite the perceived low frequency of floods and landslides, participants express heightened concern about future occurrences. This anticipation of increased events in the future could be influenced by various factors, including climate change projections, historical trends, or media coverage of similar events in other regions. Consequently, participants exhibit a strong inclination toward the need for intervention and mitigation measures to address these anticipated challenges. This proactive stance underscores the recognition of the potential risks posed by floods and landslides and highlights the importance of adaptive strategies in mitigating their impacts.

Numerous studies have consistently shown that individuals who have directly experienced natural hazards tend to perceive them as more

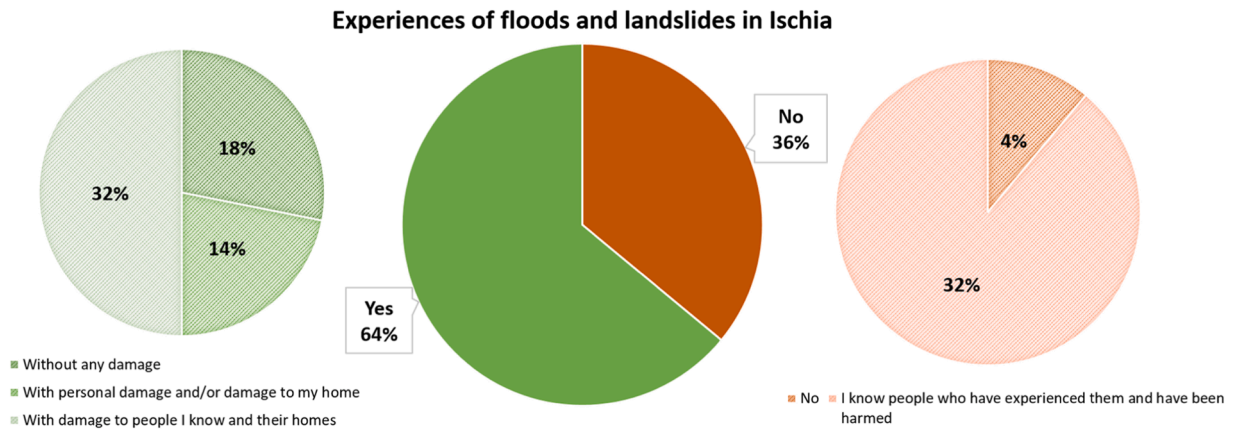


Fig. 8. Percentages of the sample's experience of flood and landslides in Ischia.

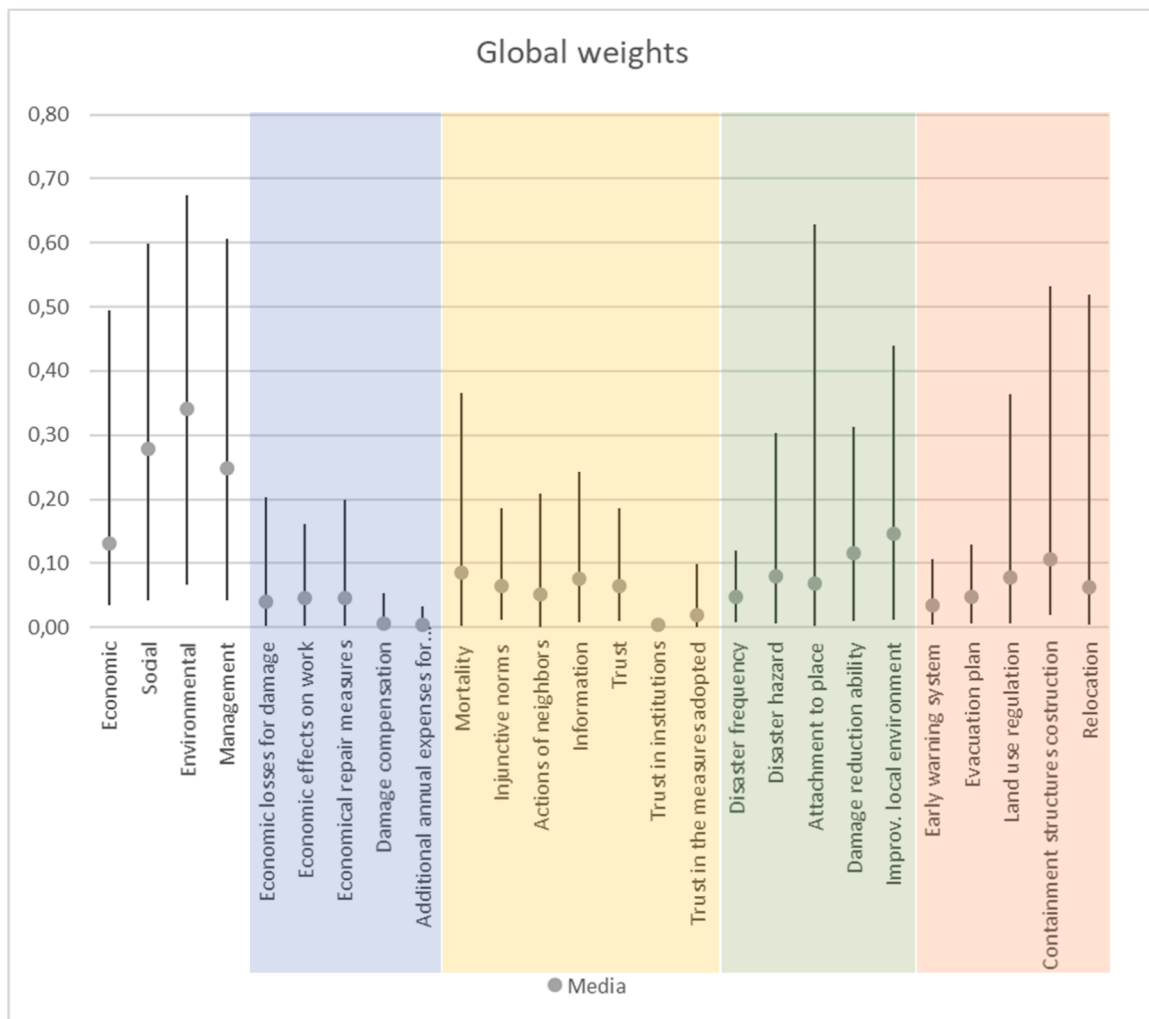


Fig. 9. Final weights distribution for the sample.

significant and express greater concern about future occurrences (Dow and Cutter, 2000; Terpstra and Lindell, 2013; Mishra and De Sherbinin, 2019; Birkmann et al., 2020). This pattern may also be applicable to our case, particularly given that the most recent flood and landslide event occurred in November 2022. Indeed, Perry (2005) discusses how individuals' perceptions of disasters are shaped by their direct experiences and the social context in which they occur. This finding is consistent

across research on floods, landslides, and other natural disasters.

Similarly to our findings, different research has shown that individuals may underestimate the frequency of certain natural hazards, particularly if they have not experienced them frequently (Grothmann and Patt, 2005; Botzen et al., 2009). For instance, Fielding et al. (2013) found that individuals tend to underestimate the frequency of others' negative emotions in social conflicts, indicating a potential bias in

affective forecasting. While Grothmann and Reusswig (2006) investigated why some residents take precautionary action against flooding while others do not. They identified factors such as perceived risk, trust in authorities, and social norms as influencing individuals' decisions to undertake protective measures.

Despite perceiving their territory as neglected and disorganized, as well as dangerous and vulnerable, participants express confidence in the safety, stability, and limited vulnerability of their houses. They hold the belief that their residences adhere to requisite regulations, contributing to their perceived security. This dichotomy between the perceived state of the broader territory and the perceived safety of individual homes underscores the subtlety nature of individuals and community perceptions and suggests a potential specific area for further investigation of overconfidence bias.

However, it results evident the prevailing negative sentiments toward institutions and citizenship that highlight significant concerns within the community (Bonfanti et al., 2023). Specifically, perception of misinformation, incompetence, and inadequate preparedness suggest a lack of trust in authorities and public services responsible for managing flood and landslide risks. This lack of confidence can have far-reaching consequences, affecting public cooperation, compliance with safety measures, and overall community resilience. It is coherent with the study of Bubeck, Botzen, and Aerts (2012) who conducted a review of risk perceptions and factors influencing flood mitigation behaviour. They found that risk perceptions, past experiences, social networks, and trust in authorities all play significant roles in shaping individuals' decisions regarding flood risk mitigation. Similarly, Cutter et al. (2008) highlighted the importance of local context and community characteristics in shaping resilience strategies and outcomes. As reported by Bonfanti et al. (2023) in communities where there is a strong sense of mutual trust among individuals, there is a greater inclination to take proactive measures before disasters occur. Conversely, in environments where trust in local government officials is lacking, the motivation to engage in such actions decreases.

Misinformation and perceived incompetence surely undermine public awareness efforts and emergency response plans, leading to ineffective risk communication and coordination during disaster events. Moreover, a sense of unpreparedness among authorities and the public alike exacerbate the impacts of natural disasters, hindering timely and efficient response efforts.

Several studies discuss concerns about the effectiveness of authorities' communication efforts, preparedness measures, and response capabilities (Ofori and Yankson, 2017; Smith and Johnson, 2018; Morrow-Jones and Hanemann, 2020). Specifically, Okot-Okumu and Wronski (2019) examine community perceptions of disaster preparedness and response in the context of flooding in Eastern Uganda. They identify concerns among residents regarding the timeliness and effectiveness of government interventions, highlighting gaps in communication and preparedness measures. While Dewan and Nishigaki (2018) observe public perceptions of flood risk and management in Jakarta, Indonesia. They analyse community attitudes towards government communication strategies, preparedness measures, and response capabilities in the context of recurrent flooding events.

Addressing these concerns requires a multi-faceted approach that involves improving communication and collaboration between institutions and citizens. This could include enhancing transparency in decision-making processes, providing accurate and accessible information about risks and mitigation measures, and fostering community engagement in disaster planning and response initiatives.

Furthermore, efforts to build trust and confidence in institutions should prioritize accountability, competency, and responsiveness to community needs. By addressing these underlying issues, communities can better prepare for and respond to flood and landslide events, ultimately enhancing their resilience and ability to adapt to changing environmental conditions.

In light of these findings, it becomes evident that effective disaster

risk management requires a comprehensive understanding of both the physical hazards and the socio-psychological dimensions of risk perception. Strategies aimed at enhancing community resilience should not only focus on infrastructure development and emergency response mechanisms but also on fostering informed decision-making, promoting risk awareness, and building trust between authorities and citizens. By addressing both the tangible and intangible aspects of risk perception, policymakers and stakeholders can develop more robust and sustainable approaches to mitigate the impacts of floods and landslides on communities.

## 5.2. The distribution of global weights to assess factors influencing risk perception

The preceding results underscore the complexity of community attitudes and perceptions towards flood and landslide events, revealing nuances in how individuals perceive the severity, frequency, and potential impacts of these hazards. Such diverse perceptions emphasize the necessity for structured approaches to systematically evaluate and weigh the various factors influencing risk perception. Herein lies the importance of employing the Analytical Hierarchy Process (AHP) methodology, which offers a systematic framework for capturing and analysing these intricate perceptions. By leveraging AHP, decision-makers can effectively integrate the diverse opinions and perspectives of stakeholders, thereby gaining a comprehensive understanding of the factors shaping risk perception. Furthermore, AHP facilitates the identification of key criteria and sub-criteria, enabling decision-makers to prioritize interventions and allocate resources more effectively towards enhancing community resilience and disaster preparedness.

All participants underwent the AHP procedures to express their individual perceptions as weights. Additionally, Fig. 9 illustrates the statistical graph of the combined global weights for each participant. Specifically, the black lines represent the weight distribution, with the grey points indicating the sample average. Despite significant variance, the *Environmental* criterion consistently exhibits the highest average value, suggesting its perceived importance among participants. In contrast, the *Economic* criterion and its five sub-criteria consistently receive lower weights, indicating their perceived lesser importance across respondents.

The *Environment* criterion consistently receiving the highest average weight across respondents suggests a collective recognition of its significance in the decision-making process. This could indicate a strong emphasis on environmental considerations within the decision context. Conversely, the relatively low weights assigned to the *Economic* criterion and its sub-criteria indicate a perceived lesser importance in comparison. This may reflect a prioritization of environmental concerns over economic factors among respondents. The consistency of these perceptions across participants remarks the robustness of the findings and highlights the potential for informed decision-making based on aggregated perceptions. However, the presence of significant variance in the weights suggests that individual perspectives may still vary considerably, indicating the need for further exploration and discussion to reconcile differing viewpoints. Overall, these results provide a valuable foundation for understanding user preferences and priorities, which can inform more effective decision-making processes.

Within the realm of *Environmental* sub-criteria, the highest weights are attributed to the *Ability of Flood Adaptation Strategies to Mitigate Damages* and *Enhance the Local Environment*. These aspects are closely followed by considerations of disaster hazard, attachment to the place, and disaster frequency. Notably, all these sub-criteria are weighted more heavily when compared to those within the economic domain. This suggests a pronounced emphasis on environmental factors in shaping perceptions of flood adaptation strategies, reflecting a prioritization of resilience-building and environmental sustainability over purely economic considerations. Such findings underscore the importance of incorporating environmental concerns into decision-making processes

surrounding flood management and adaptation.

Results suggest that *Social* criteria, particularly those related to *Mortality*, *Information*, and *Trust*, are perceived as highly relevant in the evaluation of flood adaptation strategies. This underscores the importance of considering not only environmental factors but also social dynamics and human aspects when designing and implementing flood risk management measures. The prioritization of criteria related to *Mortality* highlights the significance of safeguarding human lives in adaptation efforts. Additionally, the emphasis on *Information* and *Trust* underscores the role of effective communication, transparency, and community engagement in enhancing resilience and fostering trust in authorities and institutions responsible for flood risk management. These results align with the broader literature on the importance of social resilience and community participation in disaster preparedness and response (Kwok et al., 2016; Lwin et al., 2020; Lin and Lee, 2023).

### 5.3. Regression analysis: assessing security and vulnerability perception variables

Table 4 presents the ordered logit regression results for participants' perceptions of home security, indicating statistically significant 95 % confidence intervals (C.I.). Specifically, both the *Evacuation plan* and the *Construction of containment structures* show significant 95 % C.I. The coefficients reveal an intriguing trend: as individuals perceive their homes as more secure, they tend to assign less importance to implementing *Evacuation Plans* and *Constructing Containment Structures*.

In light of the flood events described in the previous paragraph, our findings diverge from those of Bubeck et al. (2012). These authors suggest that individuals who have experienced flooding are more inclined to invest in protective measures for their properties. Other studies exploring community attitudes toward disaster risk reduction often find a strong inclination among participants toward implementing intervention and mitigation measures (Paton et al., 2005; Zahran et al., 2008). This inclination is particularly pronounced in areas prone to recurrent natural hazards, where communities actively seek solutions to reduce vulnerability and enhance resilience. However, our findings do not align with this perspective and notably contradict the conclusions of Grothmann and Reusswig (2006). Their study investigated the factors influencing residents' decisions to undertake precautionary measures against flooding and found that individual perceptions of risk and trust in authorities play significant roles in determining adaptive behaviours.

Our findings are consistent with the hypothesis of optimism bias, which suggests that individuals tend to underestimate the likelihood of negative events befalling them compared to others (Weinstein, 1980). In the realm of disaster prevention and preparedness, this bias may manifest as individuals downplaying the perceived risk to their own homes

**Table 4**

Ordered logit model estimates of perception of security of the participants' house.

Variable	Coefficient	St. error	p-Value	95 % Confidence Interval
Early warning system	20.260	28.536	0.478	[-35.669] [76.189]
Evacuation plan	-43.496**	20.862	0.037	[-84.385] [-2.608]
Land use regulation	0.273	6.378	0.966	[-12.228] [12.775]
Construction of containment structures	-29.546**	13.177	0.025	[-55.372] [-3.719]
Relocation	-4.081	13.173	0.757	[-29.900] [21.738]
<i>Log-Likelihood</i>	-13.4981			
<i>Obs.</i>	22			

Source: Our elaborations.

\*\*\*, \*\*, \* => Significance at 1 %, 5 %, 10 % level.

Prob>chi2 = 0.0319

and communities, thereby prioritizing other factors over disaster mitigation measures. Such bias can be attributed to various cognitive and psychological factors, including a desire to maintain a positive outlook, confidence in one's ability to cope with adverse events, and a tendency to underestimate the severity of potential threats. Consequently, individuals may overlook or minimize the importance of proactive measures such as evacuation planning and structural reinforcement, particularly if they feel secure in their current living situation (Johnson, 1990). Additionally, the underestimation of the necessity of adaptation measures may also be influenced by the affect heuristic (Slovic et al., 2002), wherein individuals rely on emotions rather than logic or rationality to evaluate risks.

Overall, our study provides evidence that optimism bias can shape individuals' perceptions of risk, leading them to underestimate the likelihood and severity of negative events such as flood and landslide disasters.

The presence of optimism bias is further supported by the estimates presented in Table 5. The ordered logit model examining the perception of vulnerability regarding the territory (significant at the 95 % confidence interval) reveals that as the perception of vulnerability increases, the perceived importance of the *Evacuation plan* and *Land Use Regulation* diminishes. Conversely, the significance of the *Early warning system* increases. Interestingly, the *Construction of containment structures* and *Relocation* do not exhibit statistical significance in influencing perceptions of vulnerability. These results underscore the complex interplay between risk perception and the perceived efficacy of adaptation strategies, highlighting individuals' tendency to underestimate the severity of potential hazards and overestimate their ability to control or mitigate their impact.

Therefore, our results appear to be consistent with the theory of the illusion of control (Langer, 1975). This psychological phenomenon suggests that individuals tend to overestimate their ability to control or influence outcomes, even when they have little or no actual control. In the context of our study, participants perceiving their homes as secure despite potentially lacking robust evacuation plans or containment structures could reflect an illusion of control (Langer and Roth, 1975; Thompson et al., 1998). They may believe that their actions or circumstances afford them a greater degree of security than objectively warranted. This tendency to overestimate control can lead individuals to underestimate risks and neglect precautionary measures, contributing to a sense of security that may not align with objective realities. Studies such as those by Langer (1975) and Alloy and Abramson (1979) provide insights into how individuals perceive control over uncertain events, supporting the notion that people often overestimate their influence on outcomes to maintain a sense of psychological well-being.

Some studies demonstrate how the illusion of control can influence risk perception, decision-making, and preparedness behaviours in the

**Table 5**

Ordered logit model estimates of vulnerability perception of the territory.

Variable	Coefficient	St. error	p-Value	95 % Confidence Interval
Early warning system	103.419	44.243	0.019	[16.704] [190.134]
Evacuation plan	-47.000**	23.715	0.047	[-93.481] [-0.520]
Land use regulation	-17.306	8.668	0.046	[-34.295] [-0.317]
Construction of containment structures	-6.721**	10.671	0.529	[-27.637] [14.195]
Relocation	11.799	9.494	0.214	[-6.808] [30.406]
<i>Log-Likelihood</i>	-15.1923			
<i>Obs.</i>	22			

Source: Our elaborations.

\*\*\*, \*\*, \* => Significance at 1 %, 5 %, 10 % level.

Prob>chi2 = 0.0308

face of natural disasters and climate-related hazards. For instance, [Howe and Leiserowitz \(2013\)](#) explored the illusion of control in the context of climate change adaptation. Results suggested that individuals may exhibit an illusion of control by overestimating their ability to mitigate the impacts of climate change through personal actions, such as reducing energy consumption or supporting policy measures. Moreover, a study by [Botzen et al. \(2013\)](#) investigates how individuals perceive their level of control over flood risks and examines the implications of this perception for flood risk management strategies. Similarly to our study, they found that individuals tend to overestimate their level of control over flood risks, exhibiting an illusion of control. This illusion leads people to believe that they have more influence over the occurrence and consequences of floods than they actually do.

Certainly, the illusion of control can have significant implications for flood risk management strategies. For instance, it may lead individuals to underestimate the need for protective measures or to engage in risky behaviours during flood events. This aspect is corroborated by the findings of our study.

## 6. Conclusions

The application of AHP within focus groups in the multi-risk area of Ischia Island (Italy) aimed to assess the most relevant factors for citizens in flood adaptation strategies. This study sheds light on the community's perceptions and priorities regarding disaster risk management, filling a literature gap about the prevention phase. Through the systematic analysis of weighted criteria and sub-criteria, participants collaboratively evaluated the multifaceted dimensions of flood risk and adaptation measures. Indeed, AHP facilitated a structured and transparent decision-making process, enabling participants to assign relative importance to various factors influencing flood adaptation strategies. This approach elucidated the complex interplay between environmental, economic, social, and management factors in shaping community perceptions and preferences. AHP offers a robust framework for synthesizing diverse perspectives and identifying consensus priorities among stakeholders. On a policy implication side, the integration of AHP into participatory decision-making processes should inform evidence-based flood risk management strategies tailored to local contexts and reflective of community values.

Findings about citizens' perception of floods and landslides among participants seem to reflect a complex interplay of experiences, beliefs, and expectations. We find a paradoxical trade-off between participants' direct experiences with these natural disasters and their overall risk perception. Despite recognizing the severity and potential danger associated with floods and landslides, there is also a sense of distance from these events in terms of frequency and severity. This discrepancy between personal experience and perceived risk signals a need for deeper exploration into the factors shaping individuals' disaster perceptions.

These findings shed light on the intricate dynamics of flood risk perception and management. Notwithstanding the self-reported awareness of their territory's vulnerability to floods, participants appear to exhibit an optimism bias, feeling a sense of security in their homes: they underestimate the significance of certain adaptation measures as their perceived vulnerability increases. Specifically, the perceived importance of evacuation plans, construction of containment structures, and land use regulation diminishes, preferring early warning systems. These results suggest the necessity of tailored interventions that address the gap between perceived risk and the effectiveness of adaptation strategies.

Furthermore, the study highlights the importance of enhancing public awareness and understanding of flood risks to foster more informed decision-making and resilience-building efforts. The negative perception of institutions and governance reflects broader issues of trust and confidence in authorities' ability to manage disaster events effectively. The perceived lack of preparedness and misinformation contributes to feelings of confusion and worry among participants, leading

to a reliance on instinctive actions rather than informed decision-making. Effective risk communication, community engagement, and policy interventions are crucial for building resilience and fostering adaptive responses to floods and landslides.

This study confirms the well-known need for increased community engagement in flood risk management initiatives. By involving local residents in the decision-making process, stakeholders can gain valuable insights into community priorities, concerns, and preferences. This participatory approach can foster greater ownership of flood resilience efforts and facilitate the development of context-specific solutions. Additionally, future efforts should prioritize enhancing risk communication strategies to bridge the gap between perceived risk and actual vulnerability. Providing accurate and accessible information about flood risks and adaptation measures can empower individuals to make more informed decisions and take proactive steps to mitigate potential impacts.

Furthermore, policymakers should carefully consider the findings of this study when designing and implementing flood risk management policies and programs. Efforts should be made to address the underlying factors contributing to optimism bias and illusion of control. As already shown in the literature, mistrust in institutions should also be taken into account by improving governance structures, enhancing transparency, and building institutional capacity to effectively respond to community needs and concerns.

In conclusion, continuous research and monitoring efforts are essential for understanding evolving flood risks and community perceptions over time. Longitudinal studies can provide valuable insights into changes in risk perception, adaptation strategies, and resilience-building efforts, thereby informing policy development and decision-making processes.

### 6.1. Future directions for research

Future research should expand the application of the AHP methodology to other natural disasters, such as earthquakes, wildfires, and droughts, to explore whether similar patterns of risk perception and decision-making emerge across different hazards. Comparative studies in diverse geographic contexts, including urban and rural areas or developed and developing regions, could uncover how socio-economic, cultural, and environmental factors influence community priorities. Technologies like virtual and augmented reality (VR/AR) present opportunities to enhance public risk perception by simulating disaster scenarios, making risks and adaptation measures more tangible. Integrating big data and machine learning to analyse community-generated content, such as social media, could provide real-time insights into public sentiment, further improving participatory decision-making processes.

Psychological and behavioural factors, including optimism bias and the illusion of control, warrant deeper exploration to understand their role in disaster preparedness. Longitudinal studies could track changes in risk perception and adaptation strategies over time, offering valuable insights for dynamic and context-sensitive interventions. Enhanced communication strategies, such as gamification or storytelling, tailored to different demographic groups, could make risk information more engaging and accessible, improving public understanding and response.

Lastly, exploring the impact of climate change on risk perception and preparedness is critical, with scenario-based studies informing proactive policies. By addressing these areas, research can refine participatory methodologies like AHP, enhance resilience, and develop evidence-based solutions that align with community values and local needs.

### Ethical Approval

The research adhered to applicable guidelines and regulations and received approval from the Ethics Committee of the Behavioral Economics and Risk Lab at the University of Bari Aldo Moro (Approval

Code: 2023-BERL-R003) on June 1, 2023, prior to the initiation of the study.

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## CRedit authorship contribution statement

**Diana Caporale:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anna Rinaldi:** Writing – review & editing, Supervision, Resources, Project administration, Conceptualization, Validation, Investigation.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgments

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## Data Confidentiality

The confidentiality of participants' personal information and responses was strictly maintained throughout the study. Data were anonymized and stored securely, accessible only to authorized personnel.

## Publication Statement

This manuscript has not been published previously and is not under consideration for publication elsewhere. All authors have read and approved the final version of the manuscript for submission.

## Data availability

Data will be made available on request.

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