



Deliverable 5.2: Risk awareness: guidelines

Mitigating the risk of flooding and landslides via artificial intelligence
with a view to extreme climate events



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Abstract	This document is Deliverable 5.2 of the project “ <i>Mitigating the risk of flooding and landslides via artificial intelligence with a view to extreme climate events (SAFE-LAND)</i> ”. The deliverable describes the process through which risk-awareness guidelines for flood and landslide scenarios are determined for real users, starting from expert-defined reference guidelines and using the risk-awareness level inferred by the AI system.
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1. Introduction

Risk awareness plays a key role in how people perceive hydrogeological hazards, interpret warnings, and decide whether and how to act. In flood- and landslide-prone areas, insufficient or inappropriate awareness of risk can result in delayed reactions, unsafe behaviors, and limited compliance with recommended protective measures. At the same time, excessive or poorly calibrated guidance may generate confusion, mistrust, or unnecessary alarm. These are the reasons why risk-awareness interventions must be carefully designed and grounded in an explicit understanding of both the hazard context and the characteristics of the exposed population. This is key in situations involving heterogeneous communities, where differences in physical abilities, cognitive conditions, access to information, and support networks significantly affect how guidance is understood and applied.

Deliverable 5.2 focuses on the process through which risk-awareness guidelines can be determined for real people, starting from a set of reference guidelines proposed by experts (see Deliverable 3.3) and taking into account context-dependent analytical information. This deliverable does not introduce new content for the guidelines and does not aim to redefine the general principles of risk communication. Instead, it shows that existing reference guidelines, defined through expert knowledge and multidisciplinary analysis, can be operationally selected and shaped for specific situations. The emphasis is therefore on the *mechanism* that links analytical outputs to actionable guidance.

The reference guidelines considered in this deliverable are described in Deliverable 3.3 and have been defined by domain experts based on consolidated knowledge of hydrogeological risk scenarios, preparedness practices, and response actions. These reference guidelines represent a validated and structured knowledge base, designed to cover a range of flood- and landslide-related situations. However, reference guidelines must be selected to support effective risk awareness in real settings, in order to account for differences in awareness levels, user capabilities, or situational constraints. Deliverable 5.2 addresses this gap by explaining how such reference guidelines can be used as a basis for generating context-appropriate recommendations.

A central element of the approach described in this deliverable is the use of the risk-awareness level inferred by the AI system presented in Deliverable 4.2. This inferred level provides an assessment of how well a given population or user profile is expected to understand and respond to risk-related information in a specific context. In Deliverable 5.2, the term *tailoring* is used to indicate the process by which reference guidelines are selected and presented according to this AI-inferred risk-awareness level. Tailoring does not imply altering the scientific or technical validity of the guidelines, but rather determining which recommendations should be emphasised, how explicitly actions should be stated, and when additional support or coordination measures should be considered.

This perspective enables a structured decision-support process that links analytical assessment with operational guidance. The steps are as follows:

1. the AI system analyzes the available information and infers a risk-awareness level for a given context and target population;
2. this inferred level is used to guide the selection and prioritization of reference guide-

lines, ensuring that recommendations are appropriate to the expected understanding, capabilities, and needs of the users;

3. the resulting guidance can support the coordination of help by informing preparedness activities, targeted communication strategies, and the identification of situations where assistance from authorities, emergency services, caregivers, or local support networks is required.

Finally, feedback from the use of the proposed guidance can be exploited to refine both the tailoring criteria and the operational formulation of recommendations, contributing to the progressive improvement of the decision-support process.

The decision-support loop described above is particularly relevant when addressing specific needs. In these cases, standard recommendations may be impractical or unsafe if they assume capabilities or resources that are not available. By explicitly linking risk-awareness assessment with guideline selection, the approach described in this deliverable supports a more informed coordination of assistance, helping stakeholders identify when additional measures are necessary and how support should be organized. This contributes to reducing the gap between high-level risk assessments and the concrete actions required to protect exposed individuals in real scenarios.

The scope of Deliverable 5.2 is thus methodological and operational. It provides a clear description of how reference guidelines can be used within a structured workflow to select actionable and tailored recommendations, without replacing official warning systems or emergency-response procedures. Instead, the deliverable complements such systems by supporting preparedness and awareness activities and by improving the usability of analytical outputs for decision-making. The guidelines derived through the process described in this deliverable are intended to be robust under uncertainty and applicable even when detailed information is limited, which is often the case in rapidly evolving hydrogeological events.

The rest of this deliverable is organized as follows. Section 2 presents the background and motivation for structured risk-awareness guidance in hydrogeological scenarios. Section 3 describes in detail how reference guidelines are selected and prioritized based on the AI-inferred risk-awareness level, with particular attention to vulnerable groups and persons with disabilities. Section 4 provides an illustrative example showing how the proposed approach can be applied in flood and landslide risk situations. Finally, Section 5 summarizes the main points and outlines directions for further refinement and integration.

2. Background

The Trustworthy AI models described in Deliverable 4.2 provide a diagnostic classification of individuals along four cognitive and psychological dimensions: *Experience*, *Knowledge*, *Awareness*, and *Worry*. These models enable the identification of dominant risk-awareness profiles, but diagnostic classification alone is not sufficient to support effective risk mitigation. To bridge the gap between diagnosis and action, the activity described by this deliverable introduces an intervention framework that operationalizes the concept of tailoring, defined as the adaptation of guidelines to the specific risk profile inferred by the AI models developed in the SAFE-LAND project and described in Deliverable 4.2. Within this framework, communication strategies, educational content and corresponding “Key Actions” are dynamically adjusted according to whether an individual is classified in a *low*, *adequate*, or *high* class for each dimension. This structured logic ensures that model outputs are consistently translated into targeted and context-appropriate risk awareness interventions.

Tab. 2
Intervention Guidelines for Experience

Profile / Class	Strategic Aim	Key Action Logic
No / Indirect Experience	Build historical memory to counter the illusion of invulnerability.	Reconstruct local territorial history (past events) via sensitization campaigns to create a “proxy” for direct experience.
Direct Experience	Transform trauma/memory into actionable competence.	Promote structured reflection on past responses to analyze effectiveness and improve future mitigation behaviors.

Tab. 3
Intervention Guidelines for Knowledge

Profile / Class	Strategic Aim	Key Action Logic
Low Knowledge	Build foundational understanding of systems and behaviors.	Distribute official materials on warning systems, emergency plans, and specific protective behaviors.
High Knowledge	Maintain readiness and prevent skills decay.	Organize refresh courses and updates on territorial vulnerability and emergency procedures.

2.1 Intervention Logic for Risk Dimensions

The intervention logic shown in Tables 2-5 summarizes the psychological analysis of the project into actionable entries for each target dimension: Experience, Knowledge,

Awareness, and Worry. Each table maps the relevant deficit or state (for example, “Low Awareness” or “High Worry”) to:

1. a concise strategic aim;
2. one or more Key Action logics that specify the type of content, activity and behavioral objective recommended for that class.

The more detailed rationale and the original set of recommended interventions are documented in Deliverable 3.3. Tables 2-5 here thus provide the operational summary used by the tailoring pipeline.

In particular, the tables have two functions. First, they act as a human-readable specification of what the system should deliver for each predicted class (e.g., sensitization campaigns and local mapping for Low Awareness; refresher training and updates for High Knowledge). Second, they provide the mapping rules used by the tailoring procedure: for each user, the classifier’s predicted class for a dimension selects the corresponding Key Action row, whose content metadata (message type, suggested channel, and behavioral objective) determines the concrete communication or training artifact to be generated or recommended.

Finally, these tables are integrated with transversal elements, the risk communication principles, and personality-informed considerations, so that the selected Key Actions can be further adapted in tone and format (e.g., reassuring operational instructions where worry is high, or evocative testimonies where experience is low). This layered arrangement ensures that the tailoring process remains both evidence-based (see D3.3 for full guidelines) and flexible to local and contextual constraints.

Tab. 4
Intervention Guidelines for Awareness

Profile / Class	Strategic Aim	Key Action Logic
Low Awareness	Align perception with objective local risk.	Mapping of risk/safe areas and clarification of exposure levels for one’s specific residence.
High Awareness	Reinforce vigilance.	Continuous monitoring of official channels and reinforcement of causes/impacts understanding.

2.2 Strategic risk communication

Beyond the dimension-specific guidelines, the tailoring process is informed by transversal risk communication principles. Regardless of the individual profile, all interventions are embedded within a multichannel communication strategy designed to ensure clarity, coherence, and consistency of the messages delivered by the different authorities and services involved in the warning and emergency management processes.

Within this shared framework, the style and emphasis of communication are further modulated according to the individual’s level of risk perception, as summarized in Table

Tab. 5

Intervention Guidelines for Worry

Profile / Class	Strategic Aim	Key Action Logic
Low Worry	Contrast underestimation and passivity.	Highlight potential dangers to trigger proactive behavior and attention to early warning signs.
High Worry	Prevent panic and dysfunctional emotional reactions.	Provide reassuring, operational instructions to channel anxiety into effective decision-making; address mental health risks.

6. By combining these transversal principles with the intervention logic matrices and the outputs of the AI classifiers, the system implements the tailoring process as the dynamic selection and delivery of the most appropriate Key Action (as defined in Section 3) in response to a user’s predicted needs.

Tab. 6

Risk Communication Strategy based on Perception Levels

Target Scenario	Communication Strategy Characteristics
<p>Regulating High Risk Perception (Managing Alarm/Panic)</p>	<ul style="list-style-type: none"> • Avoid ambiguous information that fosters unfounded alarmism. • Offer clear, operational, and reassuring instructions calibrated to the real risk. • Enhance self-efficacy by showing positive examples where correct behavior saved lives. • Acknowledge dysfunctional emotions (fear, anxiety) and provide support resources.
<p>Regulating Low Risk Perception (Countering Denial/Underestimation)</p>	<ul style="list-style-type: none"> • Communicate up-to-date data regarding the real severity of the risk. • Highlight the consequences of <i>not</i> activating protective behaviors. • Involve direct testimonies of people who have experienced similar events to stimulate identification.

3. Tailoring guidelines

This section defines the operational framework used to translate the AI diagnostic outputs into personalized risk mitigation guidelines. In this context, tailoring is the rule-based adaptation of pre-defined intervention guidelines to the class predicted by the Trustworthy AI models described in Deliverable 4.2.

For each cognitive and psychological dimension (Experience, Knowledge, Awareness, and Worry), the AI model associates an individual with a specific predicted class (e.g., Low, Adequate, High), based on the most influential features identified through SHAP analysis. Each predicted class is then directly assigned to a corresponding set of “Key Actions,” previously defined in Deliverable 3.3. The tailoring process thus consists of associating the AI-predicted value of each target variable with the appropriate guideline(s), ensuring that the recommended actions are consistent with the inferred risk profile of the individual.

3.1 Experience

The AI classification models for Experience distinguish individuals based on the presence or absence of direct personal exposure to past flood or landslide events. SHAP analysis confirms that the feature @21a/b (Direct Experience of flood/landslide events) is the dominant and deterministic driver of the classification. Variations in this characteristic correspond directly to distinct levels of risk perception and, consequently, to differentiated intervention needs. Empirical evidence and domain knowledge consistently indicate that risk perception tends to be lower in areas where hazardous events are rare (or absent), whereas it increases significantly in individuals who have direct experience of past events. This behavioral pattern justifies the adoption of distinct guidelines and key actions depending on the predicted class.

3.1.1 No direct experience

Users classified in Class –1.0 for past experience (risk of floods and landslides) are characterized by low values in @21a/b, indicating the absence of direct personal experience of past events. These users show lower average risk-perception scores and a decreased propensity to adopt protective behaviors in baseline surveys. For this profile, risk perception is typically attenuated due to the lack of experiential memory. This condition may foster an illusory perception of invulnerability, particularly in territories that have not experienced recent hazardous events, even when the objective vulnerability remains high.

The purpose of these guidelines is to **strengthen the historical memory of floods and landslides**, particularly in contexts where direct personal experience is limited. The guidelines therefore comprehend the aspects as follows:

- **Objective:** Promote knowledge of local and territorial vulnerability related to previous flood and landslide events and compensate for the absence of personal experience through collective and historical memory.
- **Key Actions:** Promote sensitization campaigns and distribute official communication materials (for example, posters, brochures, digital content) that reconstruct

the historical occurrence of floods and landslides at a local and territorial scale. These materials should provide a comprehensive representation of past events, their impacts, and their recurrence patterns.

- **Operational Objectives:**

- Improve risk perception by making individuals aware that hazardous events can reoccur, even in areas that have not experienced recent disasters.
- Counteract the false sense of safety associated with the rarity of events.
- Increase attention to early warning signs and environmental precursors of risk.

- **Focus:** Enhance knowledge of preventive and protective behaviors, mitigation strategies, and existing warning and intervention systems, fostering preparedness through historically grounded awareness rather than direct experience.

3.1.2 Moderate-to-high direct experience

Users classified in Class 0.0 or 1.0 have moderate-to-high direct experience of past hazard events. The objective of these guidelines is to **promote structured reflection on previous personal experiences with floods and landslides**. This objective is pursued through the components as follows:

- **Objective:** Promote structured reflection on past personal experiences in order to improve protective responses and mitigation behaviors in future emergencies.

- **Key Actions:** Encourage individuals to reflect on their previous experiences with floods or landslides by:

- Comparing current environmental and territorial risk conditions with those experienced in the past.
- Identifying similarities and differences in the dynamics of hazards, warning signals, and response timelines.

- **Operational Objectives:**

- Analyze the effectiveness of the responses adopted during past events.
- Identify strengths, weaknesses, and gaps in previous behaviors and decision-making processes.
- Transform experiential memory into actionable knowledge.

- **Focus:** Refine personal mitigation strategies, improve adaptive capacity, and promote conscious, informed responses rather than reactive or emotionally driven behaviors during future emergencies.

3.2 Knowledge

Knowledge is the understanding that individuals have about the risks of floods and landslides in their local area, including territorial vulnerability, the functioning of warning systems, emergency plans, and effective protective behaviors. Knowledge is critical to support informed decision-making and the timely adoption of protective responses in case of emergency.

SHAP analysis in WP4 confirmed that the classification is mainly driven by a combination of features that capture the aspects as follows: knowledge of past local events (@22a/b), knowledge of response behaviors and emergency procedures (@29a/b), frequency of keeping informed about official warnings (@210a/b), and perceived self-efficacy in responding to floods or landslides (@212a/b).

Variations in these features reflect different levels of preparedness and directly motivate the adoption of differentiated guidelines and key actions for risk awareness and mitigation.

3.2.1 Low knowledge

Users with low knowledge may lack awareness of local hazards, warning systems, and protective behaviors, which can reduce self-efficacy in emergency situations. The objective of the guidelines for this group is to **improve knowledge of flood and landslide risks, while enhancing preparedness for protective actions.**

- **Objective:** Increase understanding of local flood and landslide hazards and available protective measures to foster effective emergency response.
- **Key Actions:**
 1. Promote sensitization campaigns, trainings, presentations in workplaces or schools, or distribute official materials to support:
 - Knowledge of territorial vulnerability with respect to past landslide/flood events.
 - Knowledge of how the local warning system and municipal emergency plans operate.
 - Knowledge of effective protective behaviors before, during, and after events, including personal/family emergency planning.
 2. Encourage keeping informed of local flood, landslide, and weather warnings through official channels to anticipate hazards and adopt timely protective measures.
- **Operational Objectives:**
 - Enhance self-efficacy in adopting protective responses.
 - Foster proactive involvement with emergency preparedness resources.
- **Focus:** Ensure that individuals understand both the hazards and proper mitigation strategies, improving preparedness even if prior personal experience is limited.

3.2.2 Correct/High Knowledge

Users with adequate or high knowledge have a sufficient understanding of local hazards, warning systems, and protective behaviors. The objective for this group is to **maintain and update knowledge to ensure ongoing preparedness**.

- **Objective:** Support continuous education to keep knowledge of local flood and landslide risks and protective behaviors up to date.
- **Key Actions:**
 1. Periodically organize refresh courses or distribute updated official materials to reinforce knowledge on:
 - Territorial vulnerability and historical events.
 - Functioning of the local warning system and municipal emergency plans.
 - Effective protective behaviors and updating personal/family emergency plans.
 2. Keep informed of local warnings through official channels to identify potential hazards early and adopt timely protective behaviors.
- **Operational Objectives:**
 - Maintain high awareness and preparedness over time.
 - Reinforce proper response behaviors in all phases of potential emergencies.
- **Focus:** Ensure ongoing competence and readiness to act effectively, integrating updated information and reinforcing prior learning.

3.3 Awareness

Awareness refers to the perception and understanding of the causes, impact, and local hydrogeological risks of floods and landslides. Awareness enables individuals to recognize potential hazards in their environment and the risk of exposure to their residence or community, supporting informed decision-making and preparedness. SHAP analysis indicates that the classification is mainly driven by features that capture the awareness of living in a risk area (@26a/b), the perception of which areas of the city are most exposed (@27a/b), and the awareness of the causes of floods or landslides (@28a/b). Variations in these features reflect different levels of situational awareness and justify the adoption of differentiated guidelines aimed at strengthening realistic risk perception and supporting effective protective responses

3.3.1 Low Awareness

Users with low awareness may underestimate local hazards, lack understanding of the causes and potential impacts of floods and landslides, and be unaware of the real level of risk in their area. The objective for this group is to **increase awareness of local**

hazards and the personal and community risks associated with floods and landslides.

- **Objective:** Enhance perception of the causes, impacts, and local hydrogeological risks of floods and landslides to foster proactive preparedness and protective behaviors.
- **Key Actions:**
 1. Promote sensitization campaigns, trainings in workplaces or schools, or distribute official materials to support:
 - Awareness of the causes and potential impacts of floods and landslides at personal and community levels.
 - Awareness of the local hydrogeological risk, including mapping of areas at risk and safe zones.
 - Awareness of the exposure of one’s residence or neighborhood to hydrogeological risks.
 2. Encourage users to actively monitor official flood, landslide, and weather warnings to recognize potential imminent hazards and adopt timely protective actions.

- **Operational Objectives:**

- Increase vigilance and attention to environmental cues and official warnings.
- Promote proactive engagement with protective measures and emergency plans.

- **Focus:** Build a realistic perception of local hazards to compensate for low prior awareness, ensuring individuals understand both personal and community-level risks.

3.3.2 Correct/high awareness

Users with adequate or high awareness have a clear understanding of local hazards, their causes, impacts, and exposure levels. The objective for this group is to **maintain and update awareness to ensure ongoing preparedness and informed decision-making.**

- **Objective:** Support continuous education to maintain accurate perception of local flood and landslide risks and reinforce protective behaviors.
- **Key Actions:**
 1. Periodically organize refresh courses or distribute updated official materials to reinforce awareness on:
 - Causes and potential impacts of floods and landslides.
 - Local hydrogeological risks, including mapping of areas at risk and safe zones.

- Exposure of residences and communities to hydrogeological hazards.
- 2. Maintain regular monitoring of official flood, landslide, and weather warnings to support timely protective actions.
- **Operational Objectives:**
 - Sustain high vigilance and preparedness over time.
 - Reinforce the adoption of effective protective and mitigation behaviors.
- **Focus:** Ensure ongoing competence in recognizing hazards, understanding local risks, and taking informed protective actions, integrating new information as it becomes available.

3.4 Worry

Worry can influence risk perception by promoting higher levels of attention and preparedness. Worry was measured using the emotional response experienced or anticipated in the case of a flood or landslide (ranging from calm to terror) and the level of worry in response to an anticipated flood or landslide event.

SHAP analysis shows that the classification is mainly based on features that represent the intensity of experienced or anticipated emotions in case of an event (@23a/b) and the level of worry in response to an official warning (@24a/b). Variations in these features correspond to different emotional profiles, which justify the adoption of guidelines aimed at either activating attention and preparedness in low-worry profiles or supporting emotional regulation and effective decision-making in high-worry profiles.

3.4.1 Low worry

Users with low worry (class 0 and –1) tend to underestimate the risks associated with floods and landslides. This may lead to risky behaviors or delays in adopting protective measures. The objective of the guidelines for this group is to **increase awareness of hazards and promote proactive protective behaviors**.

- **Objective:** Counteract the underestimation of danger that could result in reckless behavior or delayed response.
- **Key Actions:**
 - Promote sensitization campaigns in schools, workplaces, or public spaces to raise awareness of flood and landslide hazards.
 - Provide historical and territorial information on past events to make users aware that hazards can occur even in areas without recent incidents.
 - Highlight official warning systems and recommended protective actions to encourage proactive preparedness.
- **Operational Objectives:**

- Increase vigilance and attention to early warning signs.
- Encourage proactive adoption of protective behaviors.
- Foster rational decision-making by grounding perception in factual hazard knowledge.
- **Focus:** Build a historically and territorially informed awareness to compensate for low personal worry, ensuring that people understand the real possibility of events even in areas that have not recently experienced disasters.

3.4.2 High Worry

Users with high worry (class 1 and 2) may experience intense or dysfunctional emotional reactions that can influence the rational decision-making, potentially leading to hasty or counterproductive behaviors. The objective of the guidelines for this group is to **promote balanced perception of risk and constructive emotional regulation.**

- **Objective:** Foster correct perception of risks to prevent excessive anxiety or panic that could compromise effective responses.
- **Key Actions:**
 - Provide guidance on coping strategies and mental health support following exposure to flood or landslide events.
 - Promote understanding of official warning and intervention systems to reduce uncertainty and prevent overreaction.
 - Offer contextualized hazard information to calibrate worry with realistic probabilities and impacts.
- **Operational Objectives:**
 - Reduce the risk of panic or emotional numbness caused by repeated exposure to high-risk situations.
 - Support rational assessment and effective decision-making under stress.
 - Transform high worry into actionable preparedness behaviors.
- **Focus:** Enable users to maintain an appropriate level of worry that motivates protective behavior without leading to dysfunction, considering both emotional regulation and realistic hazard assessment.

4. Example of operational guidelines for flood and landslide risk

The following use cases illustrate how model-inferred targets can be translated into operational guidelines, following the intervention framework defined in Deliverable 5.2.

Two complementary perspectives are presented:

1. a **regional comparison**, highlighting territorial differences in experience, awareness, knowledge and worry;
2. a **demographic comparison** based on age groups.

Together, these examples show how the same set of guidelines can be consistently applied while being adapted to different levels of aggregation of the model outputs.

4.1 Use case: Regional contrasts and tailored guidelines

In this use case analyses, we aggregated the results for six Italian regions (Piemonte, Lombardia, Sicilia, Campania, Emilia Romagna, Lazio) and mapped the observed differences to region-specific recommendations (see Fig. 1 and Fig. 2). Sample sizes vary across regions (from $n = 7$ in Campania to $n = 50$ in Lombardia).

Floods. The regional mean of experience is approximately 0.01. Emilia Romagna (0.38) and Campania (0.14) are clearly above this value, indicating a higher level of direct or indirect experience with flood events.

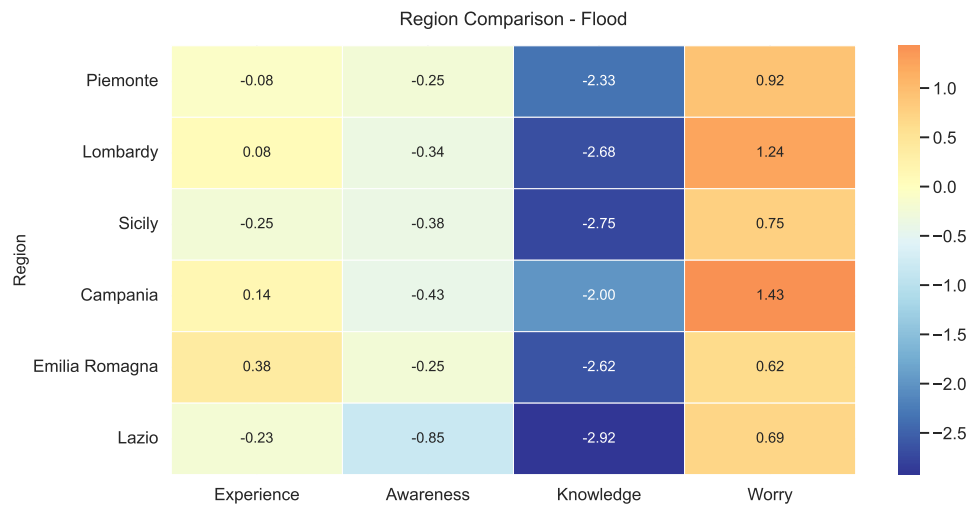
In line with the guidelines, these regions can benefit from interventions that leverage experiential knowledge, such as reflection on recent events, consolidation of lessons learned, and community-based narratives. Lombardia (0.08) lies close to the mean, whereas Piemonte (-0.08), Lazio (-0.23) and Sicilia (-0.25) fall below it, suggesting the need for sensitization actions aimed at strengthening historical memory and reducing the risk of underestimation.

Awareness of flood risk is low for all regions, with an average value of approximately -0.42 . Piemonte and Emilia Romagna (both -0.25) show relatively higher awareness, whereas Lazio (-0.85) and Campania (-0.43) show the lowest levels. According to the guidelines, all regions would benefit from awareness-building interventions. However, priority should be given to Lazio, Sicilia and Lombardia, where targeted communication on exposure, hazard maps, and flood dynamics is particularly needed.

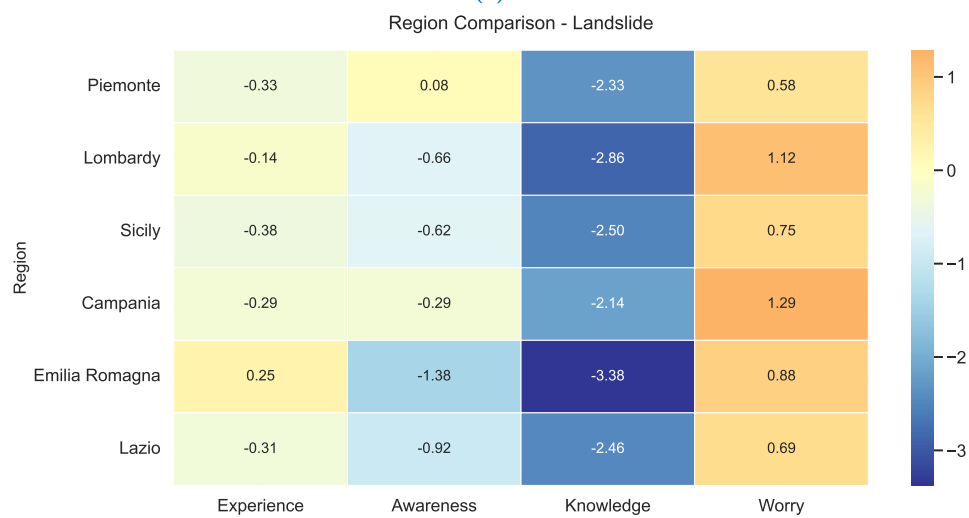
Flood-related knowledge is uniformly very low, with a mean of approximately -2.55 . Campania (-2.00) shows the least negative value, while Lazio (-2.92) and Sicilia (-2.75) have the lowest levels. This pattern indicates the need for structured educational and training activities in all regions, ranging from basic information on warning systems to practical guidance on protective behaviors and emergency planning. More intensive and long-term programmes appear especially relevant for Lazio and Sicilia.

Worry about floods is generally high, with a regional mean of approximately 0.94. Campania (1.43) and Lombardia (1.24) show the highest worry levels, suggesting the importance of applying guidelines aimed at regulating emotional responses and transforming concern into constructive preparedness through clear, actionable and reassuring instructions. Emilia Romagna (0.63) and Lazio (0.69) are characterized by a relatively lower worry level, and may benefit from balanced messaging that maintains attention without inducing unnecessary alarm.

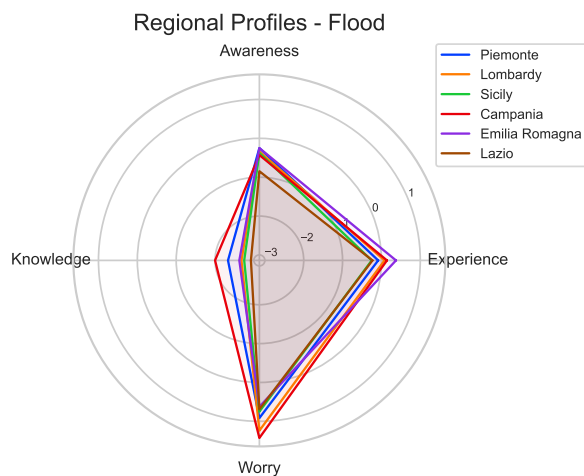
Landslides. For landslides, the mean experience score is approximately -0.20 . Emilia Romagna (0.25) is the only region above this mean, indicating greater familiarity with



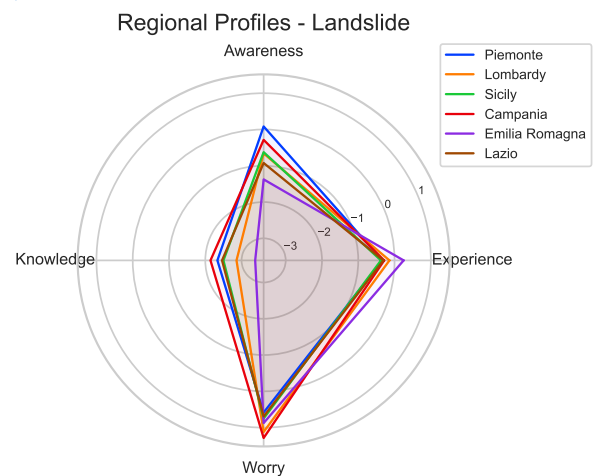
(a)



(b)



(c)



(d)

Fig. 1: Heatmaps (a) and (b) show the mean scores for Experience, Awareness, Knowledge, and Worry regarding floods and landslides. Radar charts in (c) and (d) illustrate the distinct regional profiles (Lazio, Lombardia, Piemonte, Campania, Sicily, Emilia Romagna), highlighting territorial contrasts in psychological drivers

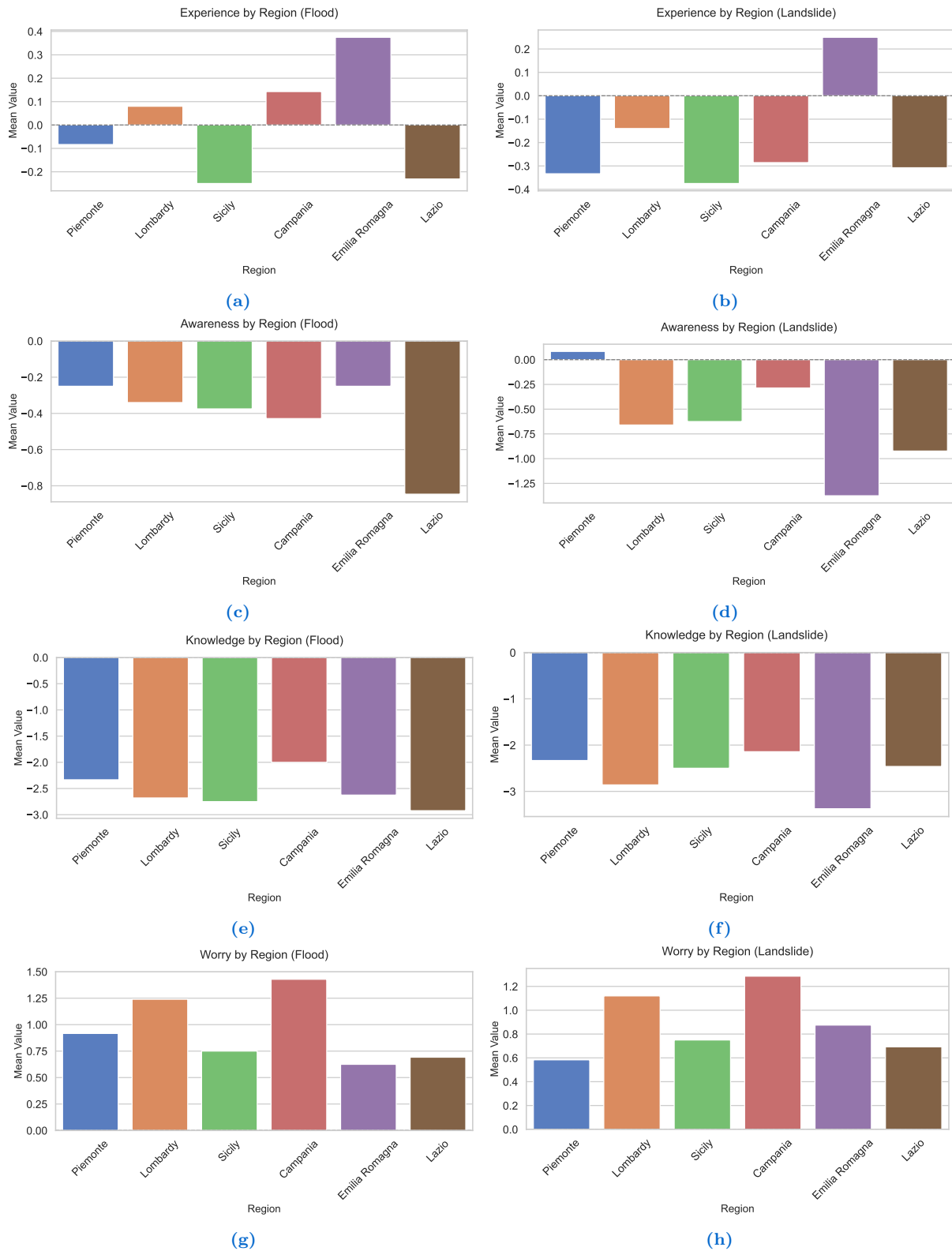


Fig. 2: Detailed regional breakdown of risk perception indicators. The bar charts display the mean scores for Experience (a, b), Awareness (c, d), Knowledge (e, f), and Worry (g, h) across the six analyzed regions (Piemonte, Lombardy, Sicily, Campania, Emilia Romagna, Lazio). The plots distinguish between Flood (left column) and Landslide (right column) risks, visualizing the specific variances discussed in the text.

landslide events and supporting the adoption of experience-based and reflective interventions. All other regions show negative values, which highlights the need to reinforce collective and historical knowledge of landslide risk.

Awareness of landslides shows strong regional contrasts, with an average value of approximately -0.63 . Piemonte (0.08) is the only region with positive awareness and should therefore focus on maintaining accurate risk perception. Emilia Romagna (-1.38) and Lazio (-0.92) exhibit very low awareness, indicating a clear priority for awareness-raising actions, such as communication on territorial susceptibility and the localization of landslide-prone areas.

Knowledge of landslides is again very low in general, with a mean of approximately -2.61 . Campania (-2.14) performs relatively better, while Emilia Romagna (-3.38) shows the lowest score. In line with the guidelines, all regions require dedicated training and information campaigns addressing triggers of landslides, early warning signs, and appropriate self-protective behaviors, with particular emphasis on Emilia Romagna and Lombardia.

Finally, landslide-related worry averages approximately 0.89 . Campania (1.29) and Lombardia (1.12) again show the highest levels of worry, and should be targeted with interventions that balance concern and efficacy, ensuring that worry leads to preparedness rather than anxiety or inaction. Piemonte (0.58) shows lower worry and may require messaging that slightly increases perceived relevance while avoiding alarmism.

Cross-region implications. The regional comparison is efficient in highlighting the need for differentiated intervention strategies. Emilia Romagna and Campania can build on higher experiential signals; Lazio and Sicilia require strong investments in awareness and knowledge; Lombardia combines high worry with low awareness and knowledge, calling for integrated communication and training actions; and Piemonte shows relatively better awareness but still low knowledge, suggesting maintenance combined with targeted educational efforts. This use case had the purpose of demonstrating how aggregated regional outputs can directly inform the contextual application of the guidelines.

4.2 Use case: Age comparison (18–35 vs 36–55)

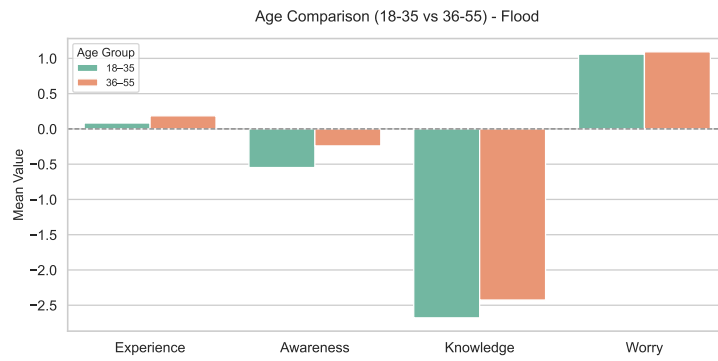
This subsection applies the same mapping logic to two age cohorts (young adults 18–35, $n = 84$; adults 36–55, $n = 54$) and shows how the guidelines can be adapted by modifying communication strategies and training formats rather than their substantive content (see Fig. 3).

For floods, adults report slightly higher *experience* (0.19 vs 0.08 , $\Delta = +0.10$) and significantly higher *awareness* (-0.24 vs -0.55 , $\Delta = +0.31$). This suggests that adults are marginally more familiar with past events and current exposure, whereas younger individuals tend to be less informed about local flood risk. At the same time, both groups show very low *knowledge* (-2.43 vs -2.68) and comparably high *worry* (1.09 vs 1.06). In line with the guidelines, this combination requires complementary approaches: for adults, interventions can build, for example, on existing familiarity through family- and community-oriented drills and practical workshops; for younger adults, brief and mobile-friendly formats (e.g., short simulations or digital content) are more suitable to foster

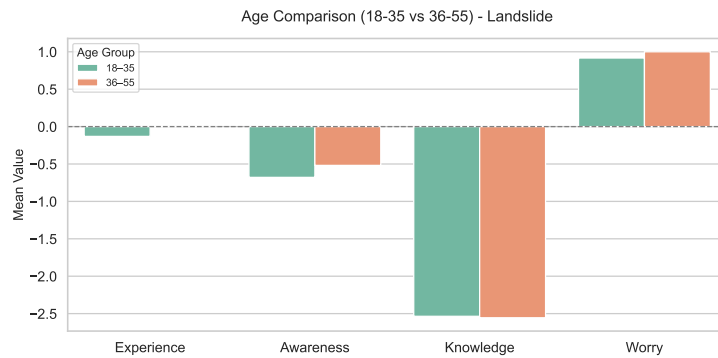
awareness and engagement. For both groups, clear and actionable guidance is key to ensure that high worry is oriented precisely toward preparedness.

For landslides, adults again show a small advantage in *experience* (0.00 vs -0.13 , $\Delta = +0.13$) and *awareness* (-0.52 vs -0.68 , $\Delta = +0.16$). Knowledge levels are comparably low in both cohorts (-2.56 vs -2.54), and worry is modestly higher among adults (1.00 vs 0.92). These results suggest that adults can be more readily engaged in practical preparedness actions at the community level. On the other hand, outreach to younger adults should focus on concise and shareable explanations of territorial vulnerability and simple preventive behaviors. Given the uniformly low level of knowledge, scalable training solutions are required for both cohorts, with differences mainly in format and delivery rather than content.

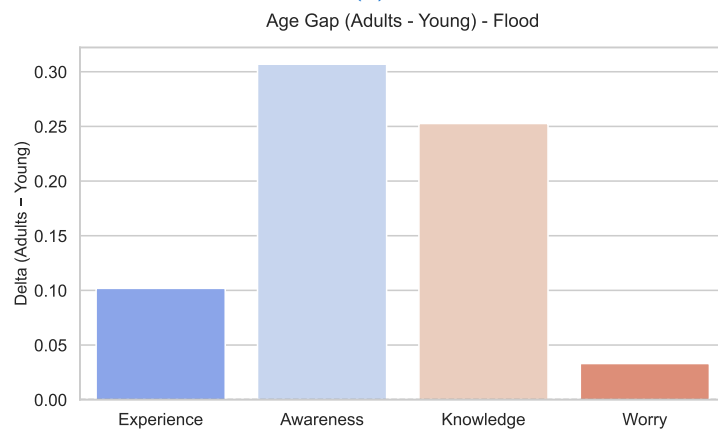
With the age-based use case, we thus showed that the guidelines can be applied consistently across demographic groups by adapting *how* information and training are delivered. Younger adults benefit more from engaging, digital-first approaches that simulate familiarity, whereas the 36–55 group responds better to practical, family- and community-centered actions that have slightly higher baseline experience. Also, this use case shows how model outputs can support the implementation of the guidelines in real-world scenarios.



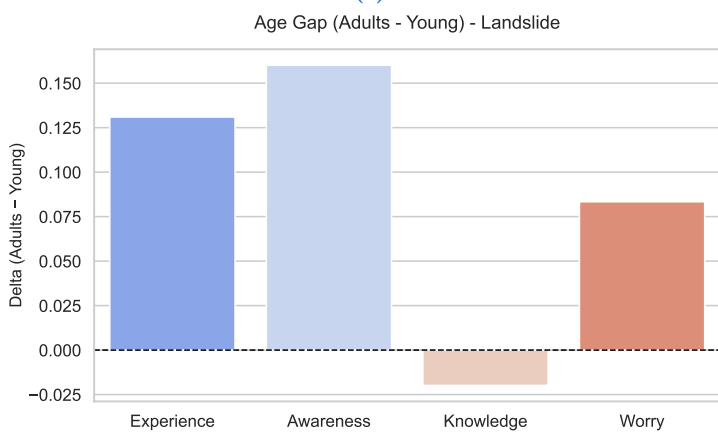
(a)



(b)



(c)



(d)

Fig. 3: Panels (a) and (b) contrast the mean scores of Young Adults (18-35) and Adults (36-55) across the four key indicators for flood and landslide risks. Panels (c) and (d) detail the specific gap (Delta: Adults - Young) for each dimension, quantifying the differences in Experience, Awareness, Knowledge, and Worry between cohorts

5. Conclusions

This deliverable has presented a structured framework for translating AI-inferred risk-awareness profiles into operational guidelines aimed at mitigating flood and landslide risks through improved awareness, knowledge, and preparedness. Building on the modeling and explainability results developed in earlier phases of the SAFE-LAND project, particularly Deliverable 4.2, the guidelines the system selects represent a concrete step towards the practical use of trustworthy AI in disaster risk reduction.

A central contribution of this document is the use of model outputs through clear key actions, grounded in SHAP-based interpretability, which ensures that each recommended intervention can be traced back to the underlying drivers of the AI classification.

This document acknowledges the multidimensional nature of risk perception and the need for differentiated interventions. The guidelines demonstrate how the same core principles can be consistently applied while being adapted to diverse contexts, as illustrated by the regional and age-based use cases. These examples show how aggregated model outputs can inform the selection of appropriate communication strategies, training formats, and preparedness actions without relying on individual-level targeting, thereby preserving scalability and ethical robustness. At the same time, the analyses highlight the importance of contextual interpretation, especially when differences in territorial characteristics may influence the strength of the observed signals.

The activity described in this deliverable contributes to the SAFE-LAND objective of integrating advanced AI methods with socially grounded risk-mitigation strategies by providing a practical and replicable framework for decision-makers and practitioners. The guidelines are directly applicable in real operational settings and can be interpreted by experts. Their effective deployment requires a joint reading of all risk dimensions, transparent communication of the rationale for the modeling, and iterative validation in the field.

In this way, the framework supports the responsible use of AI to improve risk awareness and preparedness, contributing to more resilient communities in the face of increasingly frequent and severe hydrogeological hazards.