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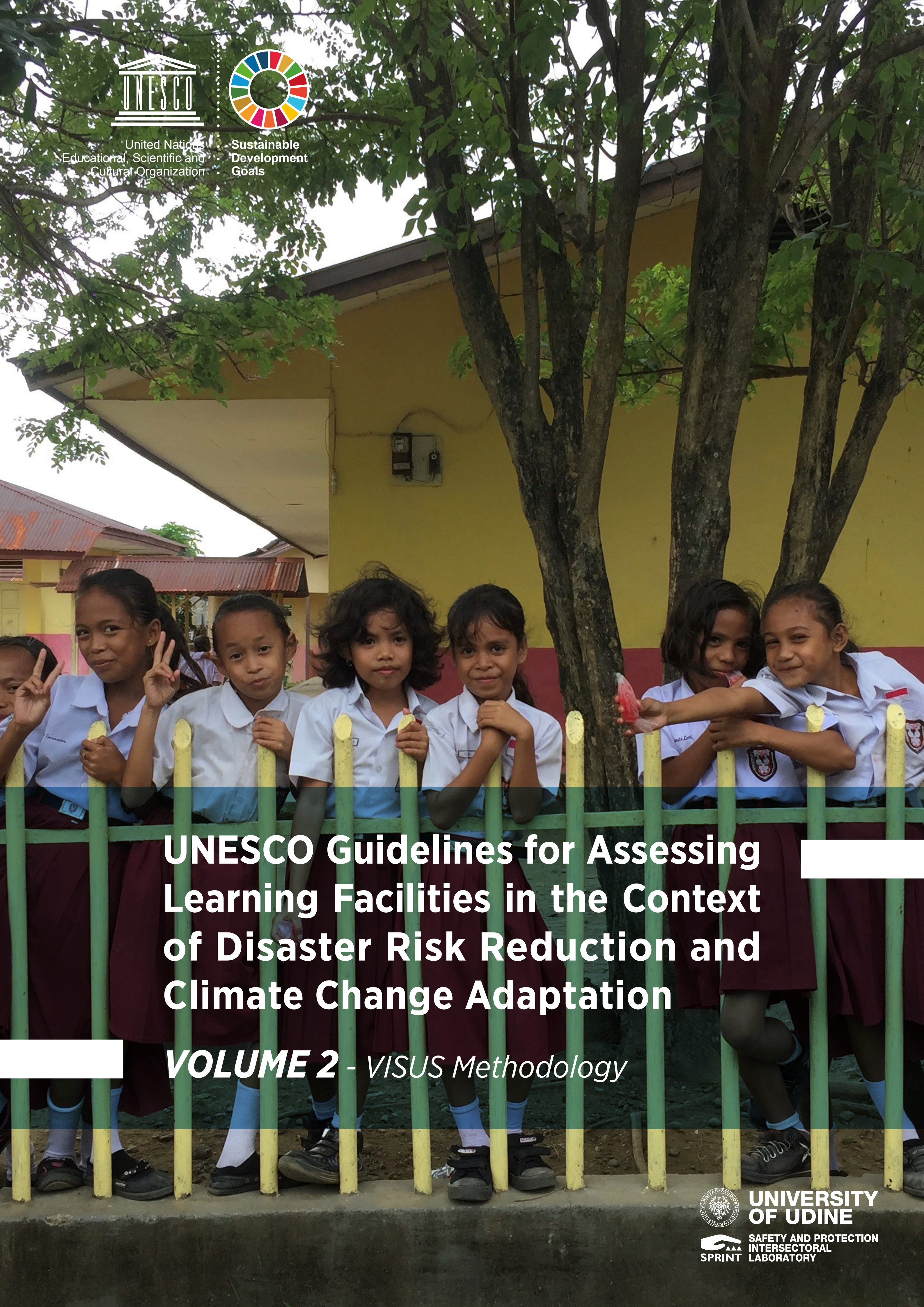

UNESCO Guidelines for Assessing Learning Facilities in the Context of Disaster Risk Reduction and Climate Change Adaptation

VOLUME 2 - *VISUS Methodology*

UNIVERSITY
OF UDINE

SPRINT SAFETY AND PROTECTION
INTERSECTORAL
LABORATORY

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UNESCO Chair on Intersectoral Safety
for Disaster Risk Reduction and Resilience
SPRINT-Lab, University of Udine, Italy

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VOLUME 2

VISUS Methodology

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Authors: *Stefano Grimaz, Petra Malisan*

UNESCO Chair on Intersectoral Safety for Disaster Risk Reduction and Resilience, SPRINT-Lab, University of Udine, Italy

With the collaboration of:

Enrico Del Pin, Alessia Movia, Andrea Pividori, Elisabetta Ruzzene and Fabio Zorzini

Researchers of UNESCO Chair on Intersectoral Safety for Disaster Risk Reduction and Resilience, SPRINT-Lab, University of Udine, Italy

Soichiro Yasukawa, Jair Torres, Lucille Anglès*

*Unit on Disaster Risk Reduction and Resilience, Earth Science and Geo-hazards Risk Reduction, Natural Science Sector
PhD student of the University School for Advanced Studies, IUSS Pavia, Italy

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INTRODUCTION

The UNESCO Guidelines for Assessing Learning Facilities in the Context of Disaster Risk Reduction and Climate Change Adaptation provide comprehensive information on the Visual Inspection for defininig Safety Upgrading Strategies (VISUS) methodology.

The VISUS methodology aims at identifying the necessary actions for upgrading the safety of existing schools in a multi-hazard perspective, while reducing as much as possible the time and costs of the safety assessment. VISUS has adopted a triage approach for quantifying and prioritizing the safety upgrading needs of a large number of schools.

The guidelines are structured in three volumes, as follows.

Volume 1 (**Introduction to learning facilities assessment and to the VISUS methodology**) contextualized the concept of school safety and showcases its relevance in the various frameworks contributing to the Global 2030 Agenda. It provides decision-makers with clear understanding of the outcomes of the implmentation of the VISUS methodology.

Volume 2 (**VISUS Methodology**) explains the theoretical aspects of the VISUS methodology, and presents in its annexes the rules and criteria that are the basis for assessment and evaluation.

Volume 3 (**VISUS Implementation**) explains the phases of VISUS implementation and presents in its annexes the tools developed for it.

In particular, Volume 2 aims to:

- Present the goals of the VISUS methodology within the school safety frameworks illustrated in Volume 1
- Explain the motivations and criteria that led to specific assumptions in the design of VISUS
- Provide an overview of the methodology, highlighting the specificity and the logic structure
- Illustrate the pre-codified evaluation rules and criteria, which are implemented in the VISUS algorithms

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1. BASIS OF THE VISUS METHODOLOGY

1.1 What is VISUS?

Visual Inspection for defining Safety Upgrading Strategies (VISUS) (Fig. 1.1) is a safety assessment methodology that was designed for supporting decision-making on the identification of safety upgrading strategies for a large number of learning facilities.

Fig. 1.1 *VISUS logo*

The VISUS methodology was developed in pursuit of the five goals outlined below and depicted in Figure 1.2.

Decision-making support. A commitment to school safety frameworks and plans requires that decision-makers define policies for risk mitigation in existing schools. In particular, with reference to Comprehensive School Safety (CSS) pillar 1 ("Safe learning facilities", see Volume 1, section 2.1), administrators and policy-makers need to understand the actual safety situation in schools in order to be able to define appropriate strategies and interventions. VISUS aims at providing decision-makers with decision support information in this regard.

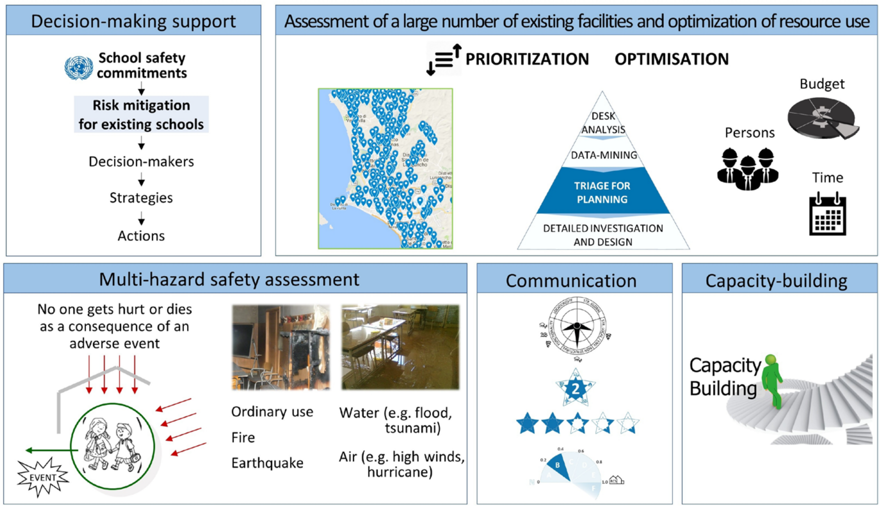
Assessment of a large number of existing learning facilities and optimization of resource use. Reducing risks in existing schools of a specific district, city, region or other territory generally requires assessing a large number of facilities. Decision-makers need an overall picture of the safety situation before they can adopt effective strategies for risk reduction. As the availability of resources (mainly financial, but also those related to time and skills of personnel) is often restricted, intervention priorities among all schools must be well defined. For this reason, as well as an overview of the safety situation, decision-makers require a set of indicators that will support them in their decision-making.

Multi-hazard safety assessment. Safety assessments should consider all potential hazards that could have an impact on a school and result in casualties or losses. Safety during the ordinary day-to-day use of a school should also be assessed.

Communication of safety assessments. For the VISUS methodology to be effective, it is essential that its results are properly communicated. VISUS adopts graphical indicators developed for improving both communications and the application of outcomes of the assessment.

Capacity-building. Capacity development is a high priority for United Nations agencies and is one of the main strategic functions of UNESCO in pursuing Education for All (UNESCO, 2013). VISUS aims at defining a safety assessment methodology that could be easily applied and directly used for building the capacity of the local people involved in its application.

Fig. 1.2 *Goals of the VISUS methodology*



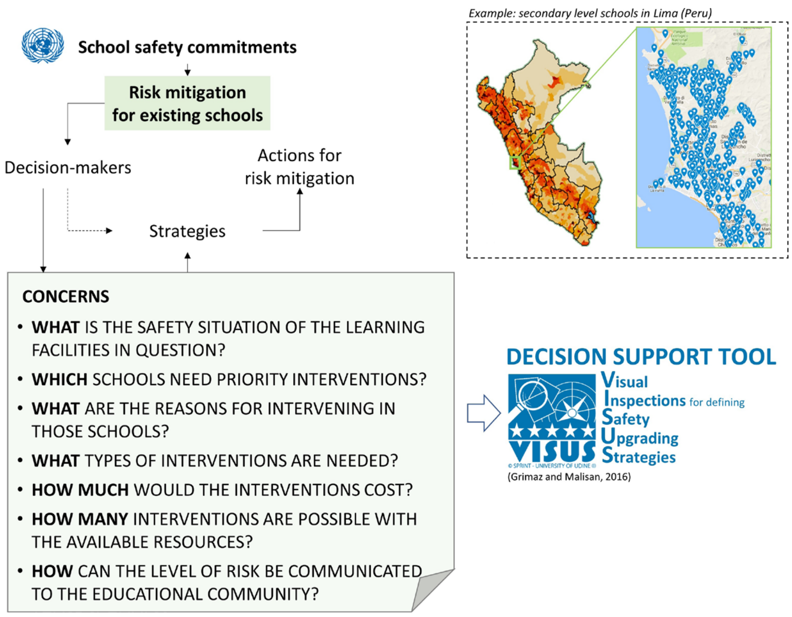
1.1.1 VISUS for decision-making support

In order to establish effective disaster risk reduction strategies when assessing many at-risk buildings, decision-makers must first gain an overall understanding of the situation. In particular, with reference to CSS pillar 1 (Safe Learning Facilities), administrators and decision-makers are often called upon to determine (Fig. 1.3):

- What is the safety situation of the learning facilities in question?
- Which schools need priority interventions?
- What are the reasons for intervening in those schools?
- What types of interventions are needed?
- How much would the interventions cost?
- How many interventions are possible with the available resources?
- How can the level of risk be communicated to the educational community?

VISUS aims at providing decision-makers with information that allows them to answer these and other questions and at supporting them in rational and effective strategic planning for the safety upgrading of existing schools.

Fig. 1.3 *Concerns of decision-makers regarding rational and effective strategies for risk mitigation in a large number of schools*



1.1.1.1 VISUS in the decision-making process

In the traditional view of the structure of a decision support system, the decision-making process can be divided into three main phases:

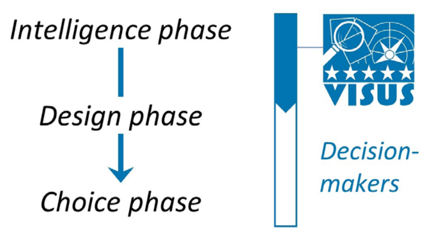
1. Intelligence (or investigation)
2. Design
3. Choice

The intelligence phase comprises data collection and evaluation with the purpose of collating information useful for the decision support system. The design phase aims at identifying a set of possible solutions to the particular problem under analysis. In the choice phase, one of the solutions is adopted.

Managers and decision-makers need information in a format that effectively assists them in making decisions. This means that outcomes should be summarized and provided efficiently.

VISUS mainly focuses on the first phase of the decision-making process, intelligence, providing decision-makers with the information they need to define strategies and choices (Fig. 1.4). In so doing, the methodology guides decision-makers through the subsequent phases.

Fig. 1.4 *Role of VISUS in the decision-making process*

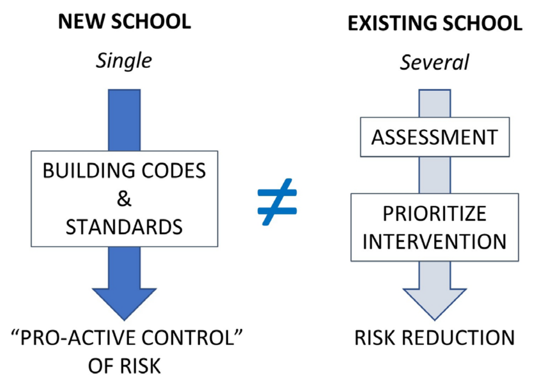


1.1.2 VISUS for the assessment of a large number of existing learning facilities and optimization of resource use

According to GADRRRES (2016), the main targets for pillar 1 of the CSS framework are that (a) every new school is a safe school, and (b) existing schools are systematically made safer.

When a new school is built, safety conditions should be respected by complying with building codes and standards (Fig. 1.5). Existing schools, however, require an assessment of their safety situation in order to define strategies for upgrading their safety status. Safety upgrading is required only for existing facilities that are unsafe, and upgrading should be defined giving consideration to the necessary interventions.

Fig. 1.5 *Safety approaches for new and existing schools*

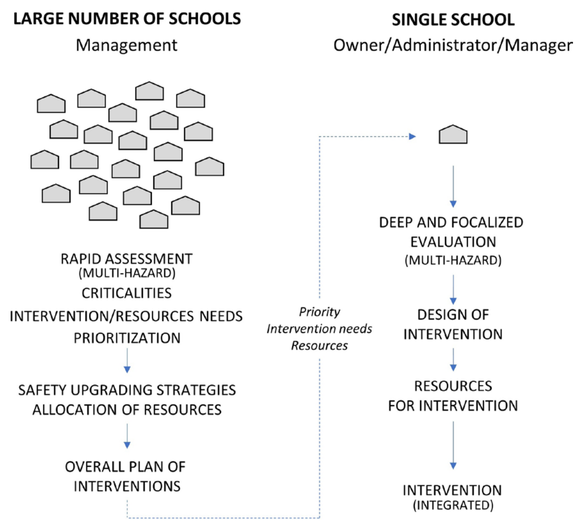


VISUS aims at providing support to decision-makers in outlining risk reduction strategies at city, district, region or country level (or other territory). This generally means that when considering several existing schools, priorities must be identified so as to be able to decide which schools it is appropriate to start with upgrading. Information relevant to identifying priorities might be available only after a preliminary phase of the decision-making process in which a rapid safety assessment of each facility is undertaken. Making this assessment allows decision-makers to identify priorities and to estimate intervention needs and the corresponding resources required for improving the safety level in every school (Fig. 1.6).

Figure 1.6 illustrates the different approach used for defining management policies for several schools compared with the one used for a single school. The management of several schools requires the identification of strategies and the prioritization of interventions in accordance with rules and criteria defined by decision-makers. A rapid safety assessment of each school is necessary to identify the information required for decision-making. The assessment will ideally consider all the hazards that could have an impact on the schools, and identify the critical issues, the interventions required for their removal, and the resources for these interventions.

The rapid safety assessment of many schools allows decision-makers to identify the priorities for intervention; that is, to establish which schools are to be made safer first. For these schools, safety upgrading will follow a specific process that is based on VISUS outcomes but requires a more detailed analysis of each school's conditions (Fig. 1.6). When managing a single school, an in-depth safety assessment is required, in response to which specific interventions for safety upgrading will be designed. The identification of specific interventions is also relevant for determining resource requirements in detail, as well as the phases and modalities of the implementation of these interventions.

Fig. 1.6 *Approach for defining management policies for a large number of schools compared with the one for a single school*



When considering risk reduction for a number of schools in a certain territory, decision-makers must consider the limits to available resources, which are mainly financial, but also relate to the time and skills of personnel. When resources are limited, the prioritization of interventions is crucial. The risk level, safety weaknesses, and the interventions needed and their potential costs for each school is essential information that enables decision-makers to plan which schools to approach first. Such a plan should take into account for how many schools interventions could be implemented with the available resources. Furthermore, the decision-making process should meet political requirements (e.g. the development of a specific zone, the availability of funds for addressing specific issues). An initial assessment is therefore required to identify all factors relevant to outlining the prioritization strategy.

Various approaches exist for the safety assessment of existing schools, and these are based on different levels of assessment (Fig. 1.7). Each level requires specific information and adopts a distinct approach; consequently, each level generates different information for decision-making support. A general subdivision of the approaches categorizes the analysis of available documentation, data mining (the rapid collection of data through questionnaires, forms, checklists, etc.) for many facilities and in-depth assessment on the basis of detailed investigation of safety conditions.

The VISUS methodology is placed at an intermediate level of assessment – between data mining and detailed investigation of safety conditions. VISUS is based on the visual inspection of schools by trained surveyors. The protocol for the inspection has been developed as a pragmatic approach that allows essential information for the decision-making process to be acquired (see section 1.1.1). VISUS can be seen as a triage for planning; that is, a quick but reliable safety assessment methodology that enables the identification of priorities through characterization of the safety situation. It supports decision-makers with concrete information for the decision-making process.

The VISUS approach to the safety assessment of a large number of schools is shown in Figure 1.8.

Fig. 1.7 *Different approaches for safety assessment, and the position of VISUS as a triage methodology*

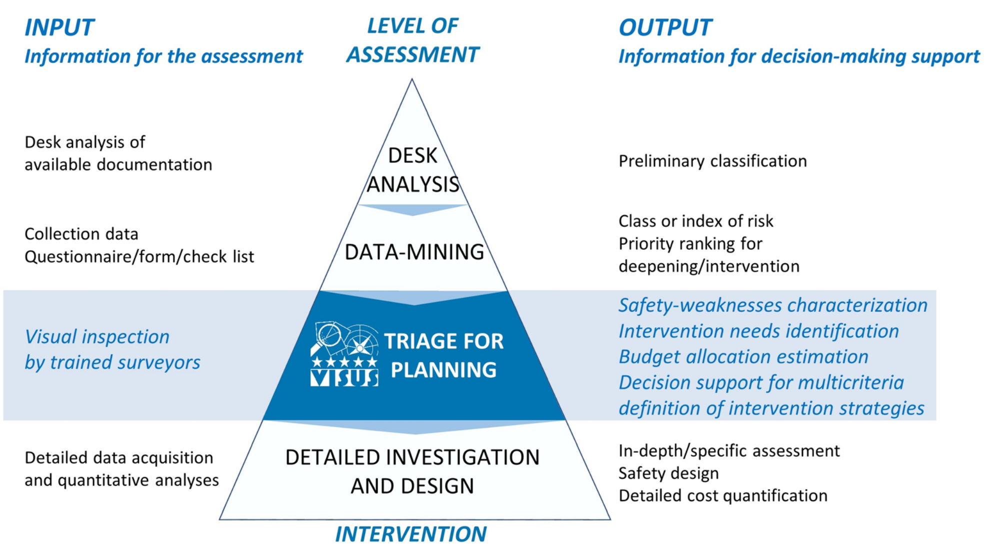
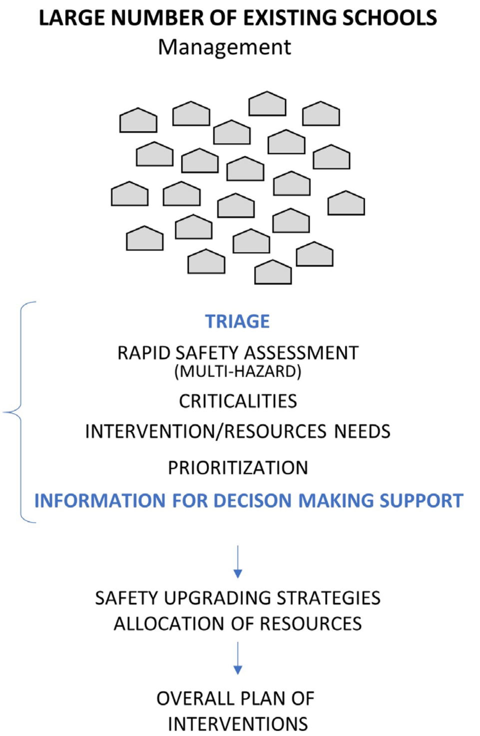


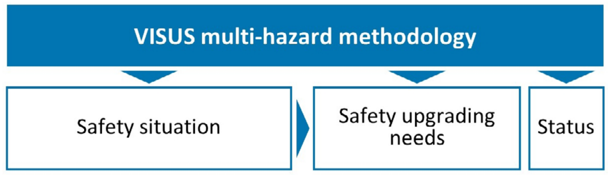
Fig. 1.8 *Approach for the safety assessment of a large number of schools*



1.1.3 VISUS for multi-hazard safety assessment

VISUS was established as a multi-hazard safety assessment methodology, taking into account hazards related to air, earth, fire and water, as well as the hazards that might arise during ordinary use, that is, the day-to-day functioning of a facility. In addition to assessing the safety situation of schools, VISUS aims at identifying the needs for safety upgrading (including required actions and their expected budget allocation), and the status (quality of conditions) (Fig. 1.9).

Fig. 1.9 *Outcomes of the VISUS multi-hazard methodology*

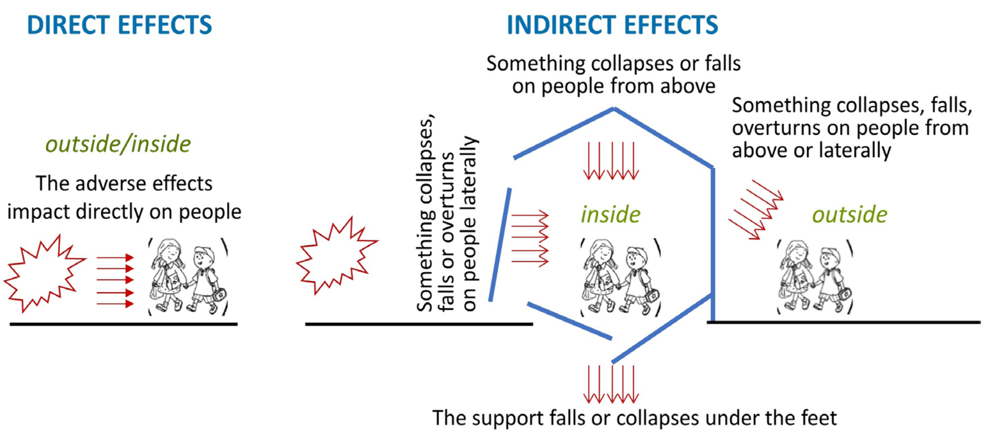


1.1.3.1 Assessment of the safety situation

The key concept of the VISUS methodology is safety. When considering human safety in schools, it is important to include every adverse event that could result in death, injury or a difficulty of some nature (Fig. 1.10). Because all potential adverse events should be considered in a safety assessment, the adoption of a multi-hazard approach is required.

This way of viewing safety also indicates that an interdisciplinary, holistic approach is necessary for the assessment. A holistic approach to considering the safety situation in schools takes into account not only the structural performance of buildings, but also all other aspects that could cause death, injury or difficulties to people; for example, falling non-structural elements or the impossibility of evacuation of a building.

Fig. 1.10 *Safety assessment of learning facilities requires consideration of every adverse event that could result in death, injury or a difficulty of some nature*



The VISUS methodology identifies potential criticalities in schools under five broad safety issues, which are outlined below and summarized in Fig. 1.11.

Location/site. This issue refers to the environment and context in which the learning facilities are located. It is essential to identify the presence of any natural threats or human-induced threats, as well as any conditions that could increase the adverse impacts of a hazardous event.

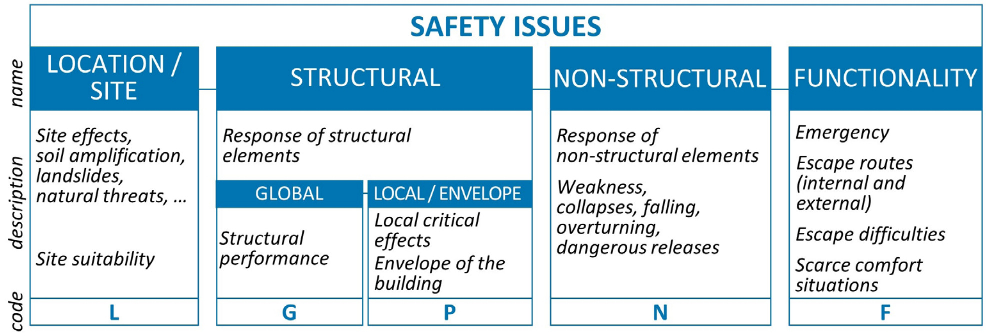
Structural global. This issue refers to the overall structural response of buildings to a hazardous event. It is essential to assess whether the structure of each school building could withstand the adverse events, and whether there would be any issues concerning the entire (i.e. global) structure.

Structural local/envelope. This issue refers to parts of structures and/or to building envelopes (e.g. cladding, roofing, windows and doors), and their potential collapse.

Non-structural. This issue refers to non-structural elements of buildings. Non-structural elements (e.g. false ceilings, chimneys) can fall or overturn, causing death or injury. Non-structural elements include those located inside buildings, such as bookcases, fans, and heating, ventilation and air-conditioning systems, and outside buildings, such as ornaments and decorative elements.

Functionality. This issue refers to access and egress paths and emergency procedures (e.g. evacuation to safe zones, early warning systems) to be activated in the case of a specific hazard (e.g. earthquakes, tsunamis). Particular attention should be paid to the access to safe areas and egress of people. Difficulties in prompt access to the learning facility by emergency services in the case of an emergency should also be taken into consideration. Under ordinary use circumstances, this issue relates also to the presence of discomforts in schools with potential consequences on health.

Fig. 1.11 *Safety issues assessed by VISUS*



1.1.3.2 Assessment of safety upgrading needs

In order to define policies for managing a large number of schools, decision-makers require an indication of the expected needs of those schools. VISUS assesses safety upgrading needs, and provides decision-makers with an indication of safety upgrading actions (i.e. generic solutions to improve the safety in a school) and of budget required for implementing these actions.

The VISUS methodology provides for each school also an indication on the advantage of intervening in a school instead of building a new one.

A precise evaluation of detailed interventions and costs will be made after a detailed investigation of each learning facility (see section 1.1.2).

1.1.3.3 Assessment of status

Status refers to the quality of conditions at the assessed school, and is concerned with accessibility, water and sanitation, furnishing and equipment, maintenance, comfort and security.

A distinction is made between permanent, semi-permanent and temporary buildings, depending on the purpose for which the infrastructure was built (see section 3.2.3).

Status information is useful for supporting decision-makers in deciding whether it is worth intervening at a school or whether it would be more appropriate to build a new one. The latter option is especially relevant in the case of poorly constructed buildings or those with poor services.

1.1.4 VISUS for the communication of safety assessments

The effective communication of results is crucial for an efficient application of the school safety assessments in risk mitigation policies. VISUS mainly addresses public administrators and decision-makers who do not necessarily have a technical background. For this reason, VISUS predominantly uses graphics to communicate safety assessment results. In order to provide a synthesized visualization of the outcomes of assessment, the VISUS methodology has adopted a set of graphical indicators. These have been developed with the following principles of visual representation and communication methods in mind:

- **Functionality**. The visual representation should provide all the information required by the end user, making it functional for the purpose of communicating the outcomes of assessment.
- **Effectiveness**. The visual representation should provide the end user with a better (or at least equal) knowledge of the message than the onegained using a traditional approach.
- **Efficiency**. The visual representation should communicate the message to the end user more effectively and rapidly than traditional communication methods would.
- **Usability**. The end user should benefit from the visual representation for his or her purposes.
- **Usefulness**. The visual representation should hold information that is useful to the end user.

The VISUS graphical indicators refer to:

- School characteristics (Fig. 1.12)
- Safety assessment (Fig. 1.13) (see section 3.3.1 for more information), which relates to:
  - Warning level
  - Warning rose (or rose of intervention needs)
  - Safety stars
  - Multi-hazard safety stars
- Safety upgrading needs (Fig. 1.14) (see section 3.3.2 for more information), which relate to:
  - Safety upgrading actions
  - Budget allocation
- Status (Fig. 1.15) (see section 3.3.3 for more information)

Fig. 1.12 *VISUS indicators for school characteristics*

SCHOOL CHARACTERISTICS

Icon	Name	Icon	Name	Icon	Name
	School complex		Permanent main or ancillary buildings		School size: small
	Location		Semi-permanent main or ancillary buildings		School size: medium
	Schoolyard		Non permanent main or ancillary buildings		School size: large
	Main buildings		Classrooms		
	Ancillary buildings		People in the school (male and female)		

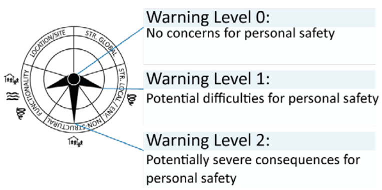
Fig. 1.13 *VISUS indicators for safety assessment*

VISUS MULTI-HAZARD ASSESSMENT

Warning level

Icon	Name
	Safety warning
	No concerns for personal safety
	Potential difficulties for personal safety
	Potentially severe consequences for personal safety

Warning rose or rose of intervention needs



Icon	Name
	Ordinary
	Fire
	Water
	Earthquake
	Air

Safety stars

☆☆☆☆☆	Unsuitable site
★☆☆☆☆	Suitable site
★★☆☆☆	Stability of the building
★★★☆☆	Life safeguard
★★★★☆	Rapid resumption of operations
★★★★★	Immediately operational

Multi-hazard safety stars

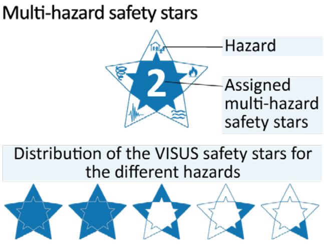


Fig. 1.14 *VISUS indicators for safety upgrading needs*

SAFETY UPGRADING ACTIONS

Classes

Icon	Name
RL	Relocation - site verification
RC	Reconstruction - technical verification
RT	Retrofitting
RF	Refurbishment
RS	Restoration self-made

Meaning of icon filling:

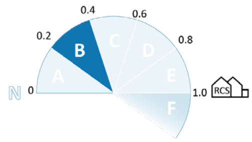
- Filled icon: class of action required for all (or almost all) facilities
- Half-filled icon: class of action required by some facilities
- Empty light-blue icon: class of action not required or already included in the other required classes

Types

Color	Name
n	No action required
s	Self actions
l	Light actions
m	Moderate actions
h	Heavy actions
r	Reconstruction
e/c	External or relocation actions

BUDGET ALLOCATION

Upgrading Requirements Class



N No interventions (UFC index null)

RCS Complete reconstruction of the school complex

Fig. 1.15 *VISUS indicators for status*

STATUS

Icon	Name	Icon	Name	Icon	Name
	Accessibility		Maintenance		Comfort
	Water and sanitation		Content / equipment		Security

1.1.5 VISUS for capacity-building

The development of a safety assessment methodology such as VISUS is strongly supported by the parallel capacity-building of the people involved in its implementation process.

According to the World Bank (2005), the key factors for capacity-building are:

- Suggesting solutions that empower country stakeholders (through, for example, learning-by-doing) rather than recommending pre-prepared solutions
- Adapting knowledge to the local context by creating a 'best local fit', paying attention to local characteristics and involving local experts rather than using 'best global practice', which may not be suitable to a country's circumstances
- Behaving as an enabler by nurturing effective behavioural competencies

The VISUS methodology takes into consideration these factors. VISUS provides specific trainings for the surveyors, trainers and decision-makers involved in the implementation of safety assessments. This distinction facilitates the transfer of knowledge concerning the topics of interest to each group.

The training for VISUS surveyors, who are usually students of engineering or architecture at local universities, increases their capacity to recognize problems in learning facilities. Training in the use of apps developed for mobile devices helps strengthen the information and communications technology skills of the surveyors. Furthermore, the learning-by-doing and teamwork approach to this training contributes to increasing their knowledge, especially concerning the local context and the country's unique circumstances. All these aspects of the training improve the capacity of the surveyors to perform safety evaluations in various contexts. By adapting their acquired knowledge, the surveyors become empowered by their own efforts, and apply their skills in other situations, such as in their individual houses.

Trainers are trained to understand how VISUS works and how to support implementation of the methodology. Decision-makers are trained to maximize their ability to use VISUS outcomes in their decision-making processes.

The positive results and feedback obtained in pilot projects in El Salvador, Haiti, Indonesia, Italy, Lao PDR, Mozambique and Peru (see Grimaz and Malisan, 2019, Peña et al., 2019) demonstrate that VISUS can be effectively used as a tool for the transfer of knowledge and of capabilities in multi-hazard safety assessment.

1.2 How does VISUS work?

VISUS uses a technical triage approach for the multi-hazard safety assessment of a large number of schools. The methodology is used for defining the elements of information that support decision-makers in the identification of safety upgrading strategies.

To understand how VISUS works, the following aspects of the methodology should be grasped:

- VISUS is based on expert reasoning
- VISUS is a pragmatic assessment approach based on technical triage, the Pareto principle and the pre-identification of potential consequences
- VISUS works as a performance-based assessment when applied to existing schools
- VISUS comprises two processes: reasoning (the theoretical aspect of the methodology) and implementation (application of the methodology)

1.2.1 Expert reasoning

VISUS simulates the expert reasoning so as to achieve a judgement of the same quality level as an expert's when applied to the same input data. The core idea of the VISUS methodology is supported by the understanding that, because it is based on the pre-codification of the expert reasoning process, the formulation of judgements on each of the evaluated issues can be provided in an automated manner, starting from the information collected by a trained surveyor. For this reason, the elicitation of expert knowledge and reasoning is one of the main techniques adopted for the development of the VISUS methodology.

The elicitation of expert reasoning requires an understanding of how an expert formulates a judgement. According to Larichev (2002) and Farrington-Darby and Wilson (2006), the following aspects of reasoning are required of experts:

- The capacity to quickly identify relevant issues that enable the formulation of a judgement on the subject
- The ability to simplify complex problems, along with the ability to strategically break problems down
- The capacity to apply strategies and organize knowledge
- The skill of forward reasoning, that is, starting from the characterization of a problem and working up to expressing a judgement on it (novices, in contrast, usually work backwards, starting from a set of possible judgements on the problem description and trying to identify the decision that best fits the case)
- The ability of fast reasoning to determine solutions to problems rapidly (this ability is often referred to as intuition)

Generally, experts are not fully aware of the intermediate steps of reasoning they follow to reach a decision starting from a specific problem description. This aspect of reasoning is known as unconscious expert knowledge (Kihlstrom, 1987).

When acquiring information, experts categorize it in accordance with pre-defined schemes built by means of the expert's knowledge and experience (Hutton and Klein, 1999). In addition, experts have a large library of pre-codified responses to typical conditions. These allow them to define rules and constraints for different tasks. They build a mental representation of the problem, and experts' elicitation permits to infer the relations he or she applies while evaluating a situation.

In risk analysis, an expert is called on to make a judgement on safety level following a rapid inspection (usually visual) and to elaborate a brief description of the identified criticalities and the intervention needs. The following questions are behind the expert's reasoning in this case:

- What should be looked for and collected as substantial information?
- Which are the most relevant problems or scenarios for which to make a judgement?
- How should the information seen or acquired be considered in evaluating the problem?
- How should the judgements be expressed?

The pre-codification of expert reasoning allows a procedure to be established that simulates the expert way of thinking. In order to formulate a judgement, experts use their abilities and, in particular, they answer the questions listed above.

The judgement is formulated from an expert's capacity to understand or interpret the reality through the identification of the 'substantial elements' (i.e. the elements of information essential for articulating the final judgements) and their evaluation. In the judgement-making process, the expert organizes the acquired information using conceptual frameworks and heuristics. The expert then applies specific rules and criteria to arrive at a judgement, which is presented in specific reports.

When making a judgement, an expert follows, consciously or subconsciously, the following phases (Fig. 1.16):

- **Acquisition of substantial information (by collection or observation).** The expert identifies the elements or situations that are essential for articulation of the final judgement. In VISUS this phase is called 'Characterization', and it defines the substantial elements that will be acquired by non-expert surveyors.
- **Processing of the information (by analysis or elaboration).** The expert uses his or her knowledge to deduce the problem given the observed elements. In VISUS this phase is called 'Evaluation', and the rules and criteria used by experts are gathered through elicitation questions and expressed in logical trees. This enables automated application of these rules and criteria through algorithms that simulate expert reasoning, starting from the substantial elements defined during the characterization phase.
- **Formulation of the judgement.** The expert delineates a concise judgement and defines communication indicators and reports them for decision-making purposes. In VISUS this phase is called 'Judgement'.

The VISUS methodology follows these three main phases and provides specific tools for each of them (Fig. 1.17):

- For characterization, a tool that enables a surveyor to acquire the substantial information
- For evaluation, a tool for formulating judgements, starting from the acquired information and moving through a pre-codified evaluation process
- For judgement, a tool for creating a set of standard, pre-defined outcomes to use in reporting

Fig. 1.16 *Phases implicit in expert reasoning for decision-making support*

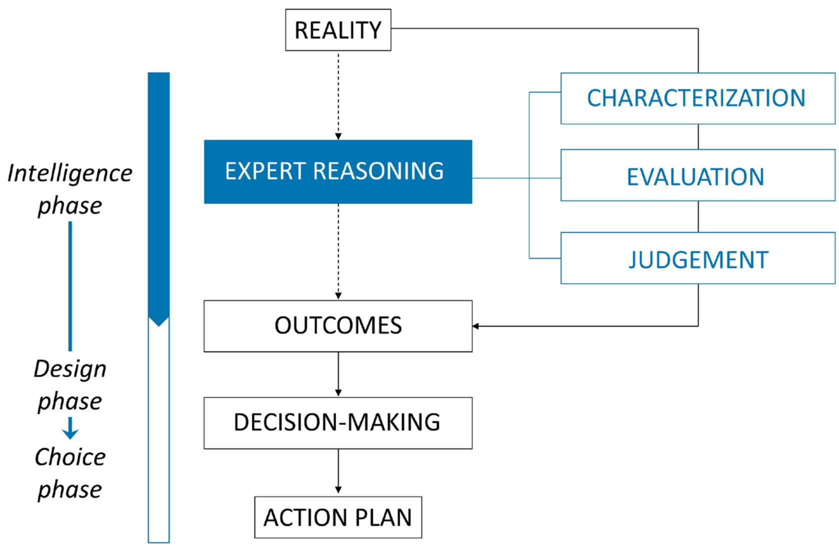
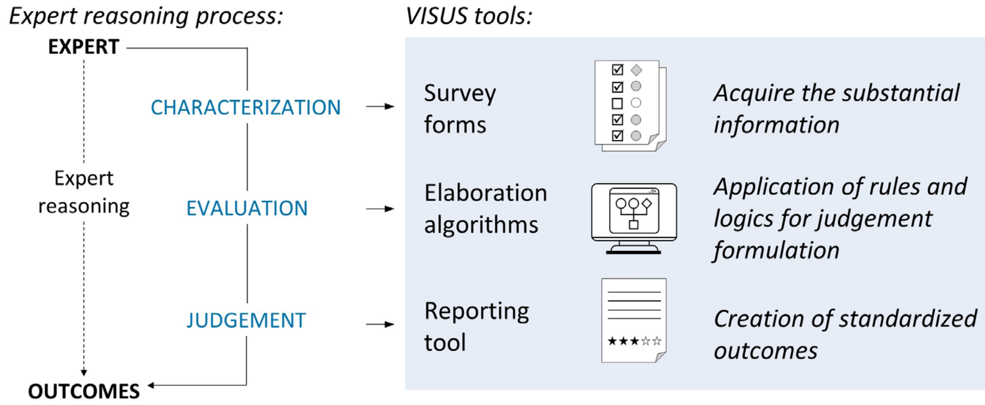


Fig. 1.17 *Expert reasoning process showing the tools designed for its characterization, evaluation and judgement phases*



1.2.2 Pragmatic assessment approach

The preliminary safety evaluation of schools for intervention prioritization requires several safety assessments while at the same time minimizing as much as possible the resources used for making these assessments. This aspect of school safety assessment is similar to disaster medicine, where the concepts of triage and expert evaluation are commonly applied in situations in which the large number of victims necessitates the objective prioritization of treatment in order to maximize the effective use of limited resources (Gunn 1992; Mackway-Jones et al., 2006).

By making an analogy between VISUS methodology and disaster medicine, the safety assessment of learning facilities adopts a technical triage approach aimed at defining the safety criticalities, the intervention needs and the most effective actions for safety upgrading. Elicitation of expert judgement enables the identification of the substantial elements to be acquired for evaluation by adopting the Pareto principle. The experts also identify the potential consequences of the adverse events, that is, the expected impact scenarios.

1.2.2.1 Technical triage

In disaster medicine, consolidated methodologies of triage exist for assessing, rapidly and pragmatically, a great number of patients, in order both to evaluate their needs and to recommend them the following interventions or cures. When working with limited resources (human, financial or time), triage allows their allocation as well as possible, in accordance with pre-defined values and objectives (Moskop and Iserson, 2007). In medical triage, the substantial elements that nurses collect on site are limited but these elements are pre-identified by the experts (emergency doctors). The rules and criteria for classification are pre-codified, and are defined considering the expected impact scenario of the patient (i.e. the evolution of his or her condition).

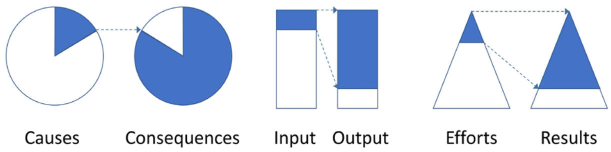
An analogous problem arises when it is necessary to assess the safety of a large number of school buildings by rapid visual inspection for the purpose of identifying and characterizing the specific intervention needs and supporting the definition of safety upgrading strategies at territorial level.

In order to facilitate the prioritization process when a large number of schools are to be assessed, VISUS adopts a technical triage process. Triage determines the gravity of the situation and defines the priorities for intervention in accordance with specific rules and criteria. The technical triage process provides a solid base of information with which to work during the decision-making process.

1.2.2.2 Pareto principle

In order to implement pragmatic technical triage for rapid safety assessment, the Pareto principle (also known as the 80/20 rule) has been adopted (Fig. 1.18). This principle states that the minority (about 20 per cent) of causes, inputs or efforts usually contributes to the majority (about 80 per cent) of results, outputs or rewards (Basile, 1996; Koch, 1998). The Pareto principle is mainly applied in economics, but also in business, sport, health and safety, software control, etc., and even applies to decision-making (Craft and Leake, 2002; Cervone, 2015).

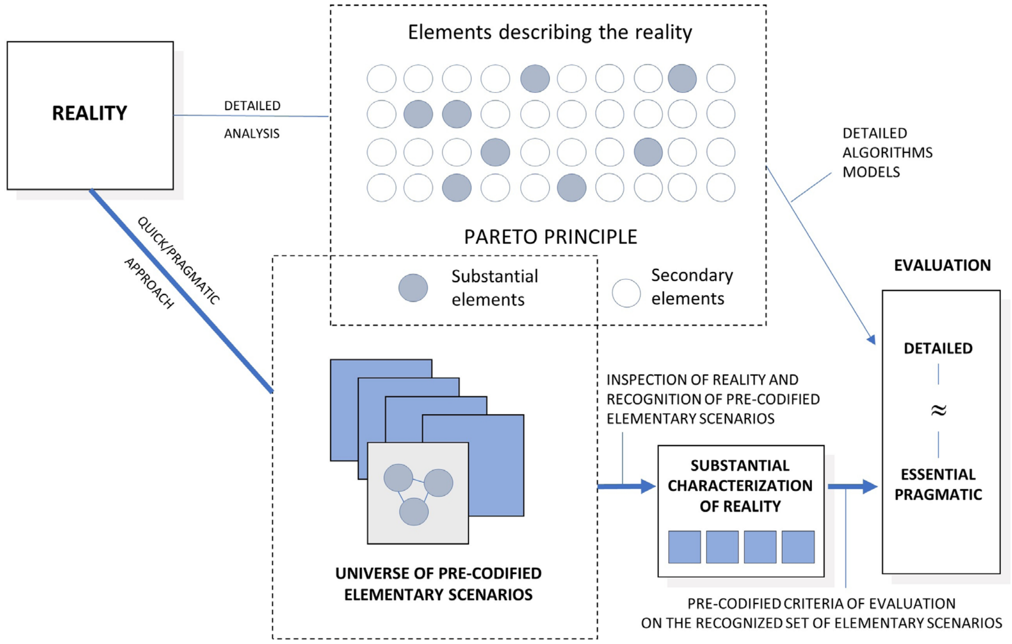
Fig. 1.18 *Visual representation of the Pareto principle*



The VISUS methodology adopts the Pareto principle to elicit expert knowledge for defining the substantial elements to be collected. Experts should expend their effort on identifying the most relevant elements describing the pre-codified substantial elements, and discard the secondary data. The identification of substantial elements intends to pre-codify and acquire only the information essential to achieving a sufficiently reliable judgement while keeping time taken, effort expended, and resources used to a minimum. The Pareto principle has been used in the expert elicitation process in order to ensure an assessment procedure sufficiently effective but as simple and quick as possible.

Figure 1.19 shows how the triage approach and the Pareto principle are used in the VISUS methodology for identifying the substantial elements that characterize the reality under judgement. The triage approach comprises a quick and pragmatic evaluation that acquires and elaborates the substantial elements (the 20 per cent under the Pareto principle) that provide most of the required information. The procedure results in a first estimation of the outcomes to be obtained with a detailed evaluation, with the advantage of the estimation being acquired by a method that requires a small amount of resources (financial, human and time). It is important to apply the methodology in such a way that the gap between the outcomes of the first estimation and the detailed evaluation is minimized. VISUS looks for a balance between resources and outcomes so that the outcomes define the intervention strategies with sufficient detail.

Fig. 1.19 *Triage approach and Pareto principle used for identifying the substantial elements that characterize the reality for the VISUS evaluation*



Source: Adapted from Grimaz et al. (2016b).

1.2.2.3 Expected impact scenarios

In disaster medicine, triage classification is pre-defined by doctors with reference to the potential scenarios foreseen for the patients assessed. In a similar manner, the technical triage classifies a school with reference to the expected impact scenarios arising from the occurrence of an adverse event or with reference to ordinary conditions.

The VISUS expected impact scenarios (EIS) summarize the critical impacts on learning facilities either during ordinary use or upon the occurrence of an adverse event. The scenarios are represented visually.

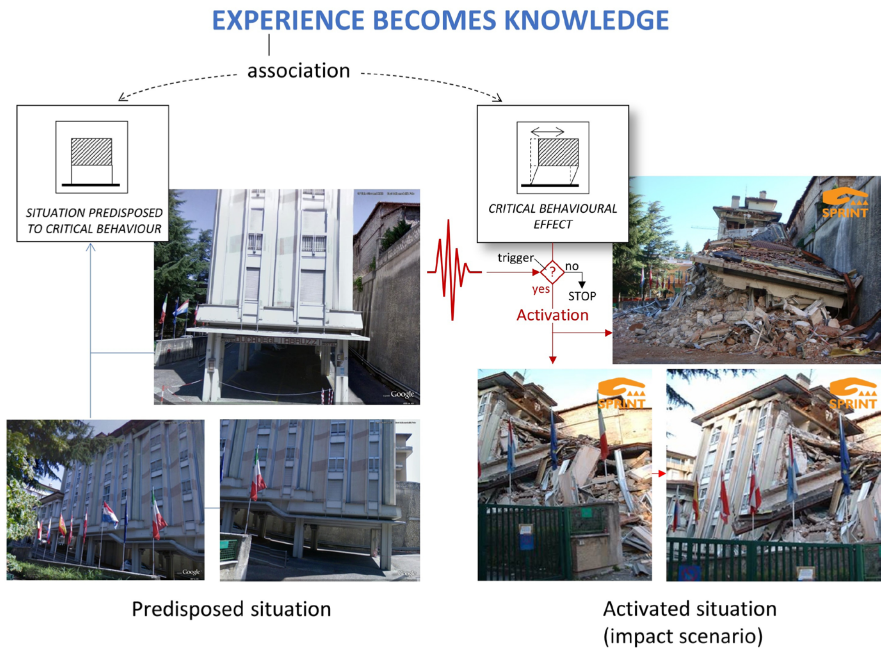
During the design of the VISUS methodology, the EIS were defined by experts, and the following questions were considered to arrive at them:

- What is expected to happen in the case of a hazardous event or during ordinary use at a school regarding the impact on the safety of the students and staff?
- Which are the most relevant cases for which to formulate a judgement?

Experts used their knowledge and experience to define the EIS, using, in particular, their observations and studies of the damage to facilities (especially buildings) after adverse events.

Figure 1.20 shows an example of how an EIS is identified by an expert. Analysing the damage after an earthquake allows experts to identify the specific features (predisposed situations) which were a priori associated with the critical situation observed. In particular, the expert recognizes the predisposed situation in a particular configuration (in the example, pilotis) and associates a specific critical behaviour (in the example, soft story effect). The expert also considers the magnitude of the adverse event that could occur at the facility and assesses the likelihood of the effective activation of the impact scenario, that is, if it is expected or not. Each EIS is associated with a determination of potential gravity in terms of personal safety, that is, difficulties, or severe consequences.

Fig. 1.20 *Observation of the damage to facilities after a hazardous event such as an earthquake, shown in the figure, allows experts to associate by a priori evaluation the features of specific critical situations*



Source: Adapted from Grimaz and Malisan (2016a).

The example in Figure 1.20 underlines the importance in the evaluation process of the expert of the conceptual distinction between predisposed and activated situations. It is clear that the absence of a predisposed situation implies that no activation of the EIS is possible for any level of action. The presence of a predisposed situation does not, however, mean that the impact scenario automatically happens. The predisposed situation has to be triggered by a specific level of action that is able to activate the impact scenario.

The identification of a complete set of impact scenarios strongly depends on expert knowledge and experience. Experts were asked to systematically identify the smallest set of impact scenarios capable of describing the most frequent and substantial critical effects of different adverse events.

The impact scenarios are grouped in accordance with the five main safety issues of VISUS: location/site, structural global, structural local/envelope, non-structural and functionality.

1.2.3 Performance-based assessment approach

The severe consequences of natural hazards highlight the necessity to design buildings that not only protect personal safety, but also enable post-event occupancy and function. In this regard, structural engineers have developed a design approach called performance-based design. Performance-based design enables engineers to anticipate the acceptable level of building damage for a given design event (i.e. the performance objective). Performance-based design is intended to associate specific performance objectives with different buildings, considering, for example, their use. For example, with the performance-based design approach, it is acceptable for a house to be severely damaged after a strong earthquake, but a hospital must maintain full operational capability after the same event.

Nowadays, most building codes in hazard-prone areas adopt a design philosophy based on performance-based approaches. The performance concepts are usually incorporated into the design of buildings, facilities and services by defining specific goals they must achieve during and after a hazardous event.

The minimum performance level for each building type and adverse event is generally defined in country standards, codes and regulations.

Table 1.1 shows the performance levels defined in the United States Federal Emergency Management Agency (FEMA) design guide for improving school safety in earthquakes, floods, and high winds (FEMA, 2010), which are described with reference to the corresponding impact scenario.

Table 1.1 *Performance objectives of buildings according to FEMA (2010)*

Performance level	Description (impact scenario)
Operational	The building is safe to use during a hazardous event. Absence of structural damage. Fully operational non-structural systems (both for normal and emergency use). Minimal extent of contents damage and damage is minor in cost. Minimal (or no) release of hazardous materials into the environment. Injuries to occupants are minimal in number and minor in nature (although there could be localized areas with higher numbers of and more serious injuries, for example in the case of fire hazard).
Immediate occupancy	Some delay in occupancy is expected. Presence of moderate structural damage that could be repaired. Fully operational non-structural systems (both for normal and emergency use), although some clean-up might be needed. Damage to contents may be locally significant, but are generally moderate in extent and cost. Some hazardous material could be released into the environment, but with contained risk to the community. Injuries to occupants may be locally significant, but generally moderate in number and nature.
Life safety	Significant delays in re-occupancy can be expected. Presence of significant damage to structural elements, but without the collapse of large debris. It is possible to repair the structure after the event. The non-structural systems are significantly damaged and are inoperable. Egress could be difficult because of debris. Emergency systems could be significantly damaged, but remain operable. Damage to contents is significant (and also locally total). Hazardous materials could be released into the environment, with the potential need for the relocation of buildings and facilities in the proximity. Injuries to occupants may be significant, with a high risk to life, but are generally moderate in number and nature. The likelihood of a single loss of life is moderate and the likelihood of multiple loss of life is low.
Collapse prevention	The building is not safe for re-occupancy. Presence of substantial structural damage, but the significant components continue to carry gravity load demands. Repair may be not technically feasible. Non-structural systems are completely inoperable. Emergency systems may be substantially damaged and inoperable. Damage to contents can be total. Significant release of hazardous materials into the environment, with relocation needed beyond the immediate vicinity. Injuries to occupants may be high in number and significant in nature. The likelihood of a single loss of life is high and the likelihood of multiple loss of life is moderate.

A specific level of performance is required by the standards and codes of each country depending on the magnitude of the design event. The magnitude is related to the mean return period of the natural hazard (see Table 1.2 for an example).

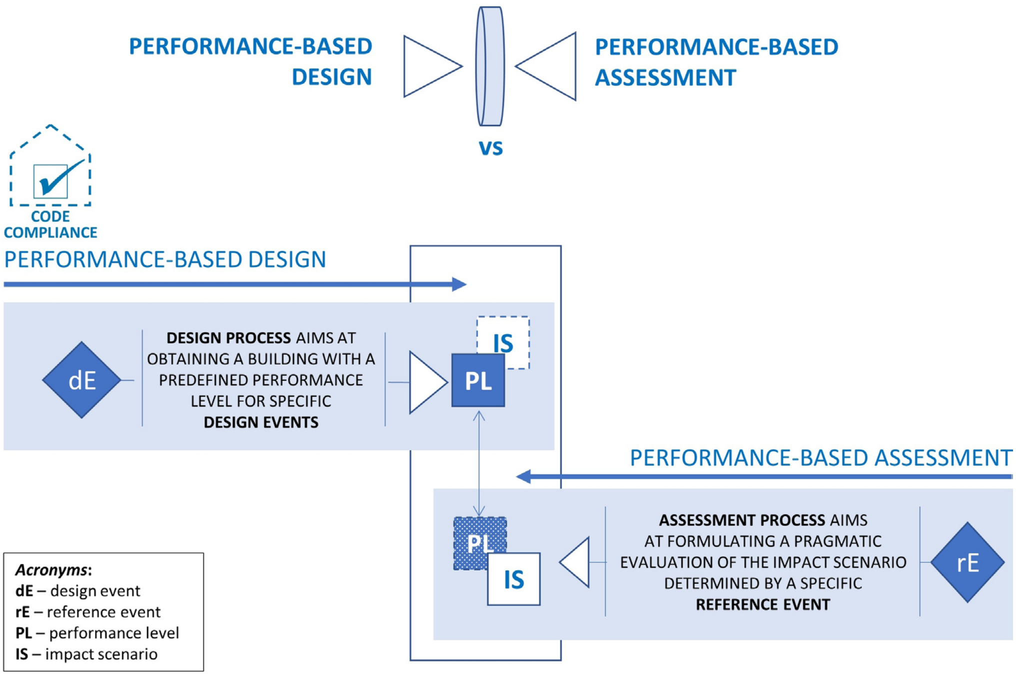
Table 1.2 *Mean return period for earthquake, flood and wind hazards and for various magnitude definitions (FEMA, 2010)*

		Design event (mean return period)		
		Earthquake	**Flood**	**Wind**
Magnitude of the design event	Very large (very rare event)	2,475 years	Determined on a site-specific basis	125 years
	Large (rare event)	475 years	Determined on a site-specific basis	100 years
	Medium (less frequent event)	72 years	500 years	75 years
	Small (frequent event)	25 years	100 years	50 years

The design process aims at obtaining a building with a predefined performance level for a specific design event.

In the case of the assessment of an existing construction, performance-based assessment is required instead of performance-based design (Fig. 1.21). Performance-based assessment aims at formulating a pragmatic evaluation of the impact scenario determined by a specific reference event and then identifying the performance level. As a consequence of this interpretation, VISUS can be considered as a visual performance assessment. The identified impact scenario is the EIS defined in section 1.2.2.3. The performance level is obtained from the impact scenario in accordance with the definitions presented in Table 1.1.

Fig. 1.21 *Comparison between performance-based design and performance-based assessment*



Source: Adapted from Grimaz et al. (2016b)

During the VISUS adaptation process (see Volume 3, section 2.2), a local committee is asked to define the performance objectives expected for the schools being assessed. The objectives are usually the same as those established, coherently with hazard maps, in the local building code, which also define the reference events for the assessment.

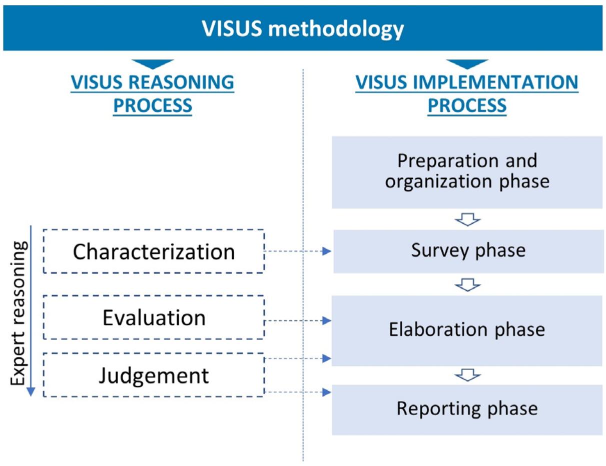
1.2.4 Reasoning and implementation processes

The VISUS methodology comprises two main processes: reasoning and implementation (Fig. 1.22).

The VISUS reasoning process is the theoretical approach of the VISUS methodology, and is based on eliciting expert knowledge for replicating expert reasoning. The process distinguishes characterization, evaluation and judgement phases, and it forms the methods and criteria that are the foundation of the VISUS methodology.

The VISUS implementation process comprises the phases in which the VISUS rules and criteria are applied, enabling the determination of outcomes for decision-makers. The rules and criteria are defined through the VISUS reasoning process. Implementation is divided into the following phases: preparation and organization; survey (visual inspections done by trained surveyors), which strictly depends on the substantial elements identified in the characterization phase of the reasoning process; elaboration, during which the expert rules and criteria are automatically applied for evaluation and judgement; and reporting, in which reports based on the outcomes of the elaboration are automatically created.
The VISUS reasoning process is described in detail in Chapter 4, and the VISUS implementation process in Volume 3.

Fig. 1.22 *VISUS methodology: phases of the reasoning and implementation processes*



1.3 What does VISUS assess?

The VISUS methodology is applied for multi-hazard safety assessment of the physical environment of a school under pillar 1 of the CSS framework - Safe Learning Facilities (see Volume 1, section 2.1). VISUS looks at both the school complex and its location (Fig. 1.23).

The safety assessment of a school requires distinguishing the parts that constitute its physical environment. Fig. 1.24 shows the main components of a school complex together with the symbols used in VISUS for their representation. The following terminology is adopted:

- **School complex** (or sometimes simply 'school'): the set of schoolyard and school buildings
- **Schoolyard:** the uncovered area of the school complex (usually used as a playground or a sports field)
- **School buildings:** the buildings used for educational activities and/or related services, which are differentiated as:
  - **Main buildings:** buildings hosting the main school activities (classrooms, offices, laboratories, etc.)
  - **Ancillary buildings:** buildings hosting only the main services that are useful for the functioning of the school (toilets, storage, etc.)
  - **Accessories:** structures that are not fully configurable as buildings and that do not need a specific evaluation of safety, but that could affect the safety assessment of the school (gazebos, sheds, carports, etc.)

Fig. 1.23 *VISUS works within pillar 1 of the Comprehensive School Safety framework and looks at the physical environment of schools*

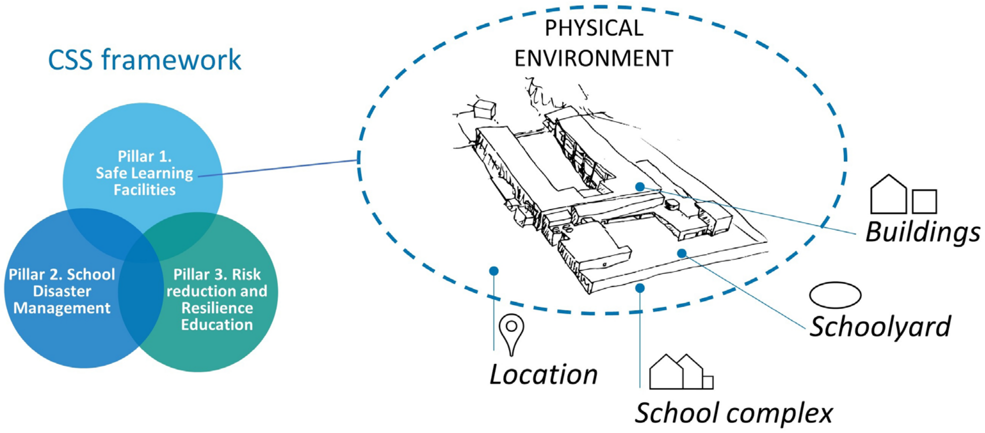
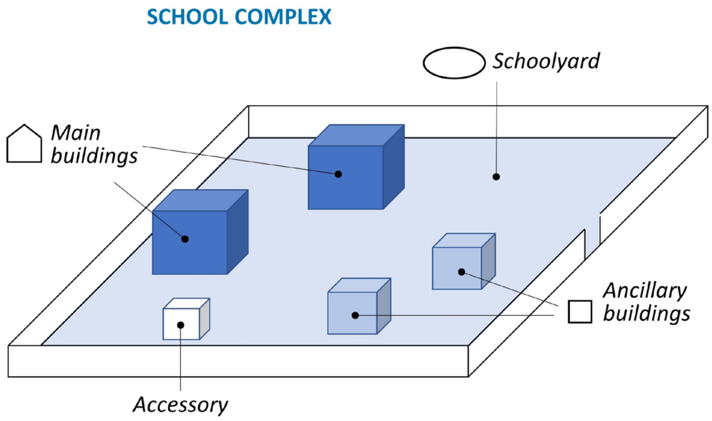


Fig. 1.24 *Components of a school complex*



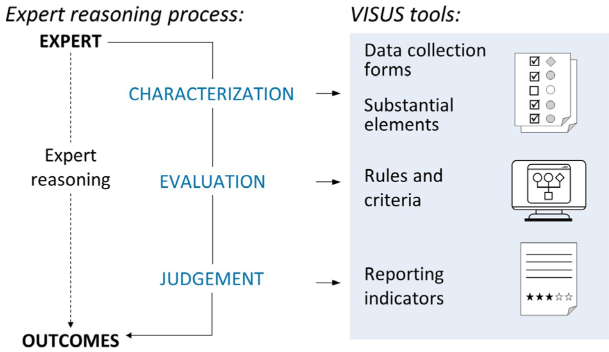
2. APPROACHING THE VISUS METHODOLOGY

The purpose of this chapter is to introduce the VISUS reasoning process and the VISUS 'language' by using a case study as a straightforward example. Readers already familiar with the VISUS language can skip this chapter.

The VISUS methodology follows three main phases of expert reasoning for decision-making: characterization (the identification of the substantial elements), evaluation (the combined evaluation of these elements) and judgement (the formulation of the final judgement). For each of these phases, the methodology uses specific tools that enable a decision-maker to go step by step through the pre-codified reasoning process of the expert.

The example has been conceived in order to permit the reader to become familiar with the three phases of the expert reasoning process (Fig. 2.1). The pre-codification of the process will be made explicit using specific VISUS symbols as the language of the methodology. The rules and criteria used by the expert for the evaluation phase will be reconstructed as logical trees using the VISUS language. Specific VISUS indicators for summarizing the final judgement are also introduced.

Fig. 2.1 *VISUS expert reasoning phases and their corresponding tools*

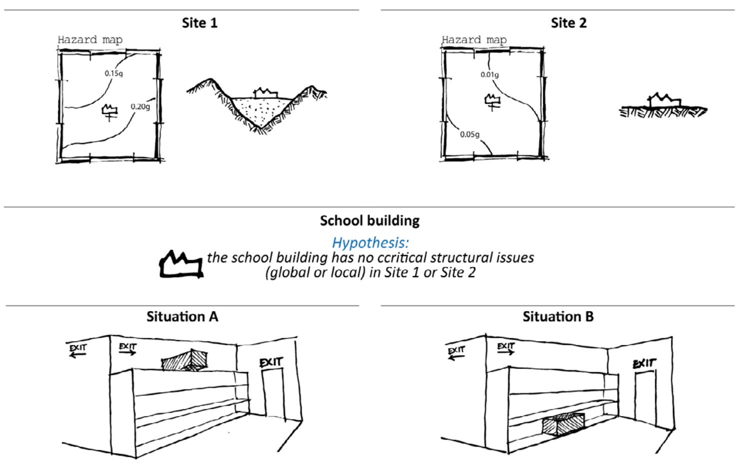


This chapter summarizes the expert reasoning process behind evaluating the question 'What could happen in terms of safety in this specific situation, that is, in the event of the expected earthquake?'

Figure 2.2 shows a simple example of application of the VISUS methodology to the seismic assessment of specific situations. Given that VISUS is a multi-hazard assessment, the process illustrated by the case study would be replicated for all hazards (i.e. those related to water, air and fire, as well as to the ordinary use of a school).

Section 2.2 discusses in depth the phases of the VISUS methodology and the meaning of the symbols and indicators of the VISUS language.

Fig. 2.2 *Case study of seismic assessment*



In the example, two sites and two situations have been adopted to illustrate how the VISUS methodology works. The two sites are:

- **Site 1.** The school is located in an area characterized by a peak ground acceleration (PGA) value of between 0.15 and 0.20 g according to the hazard map adopted as reference for the project. The school is located in a valley filled by a very soft soil (this information can usually be acquired by direct observation of the site or by the analysis of geological maps).
- **Site 2.** The school is located in an area characterized by a PGA value of between 0.01 and 0.05 g. The school is located in a flat site with very stiff soil.

The example assumes that the school buildings have no critical structural issues (global or local), whether the school is located at Site 1 or Site 2.

The situations illustrated in Figure 2.2 show a typical hallway leading to an exit. In the hallway, there are shelves holding a heavy object. The shelves are firmly anchored to the structure.

- Situation A. The heavy object is placed on the top shelf. The object is not anchored to the shelf or to the wall, and it sticks out from the shelf.
- Situation B. The heavy object is placed on the lowest shelf (approximately on the floor).

2.1 Expert reasoning

Figures 2.3 and 2.4 illustrate the expert reasoning process as it is used to assess the safety conditions in the case of an expected earthquake and provide a judgement on the situation. The figures include the questions that an expert asks herself or himself and the process she or he adopts to reach a judgement on the safety situation. The judgement is expressed in terms of the five broad VISUS safety issues (see section 1.1.3.1).

Fig. 2.3 *Expert reasoning process for the case study: consideration of two sites*

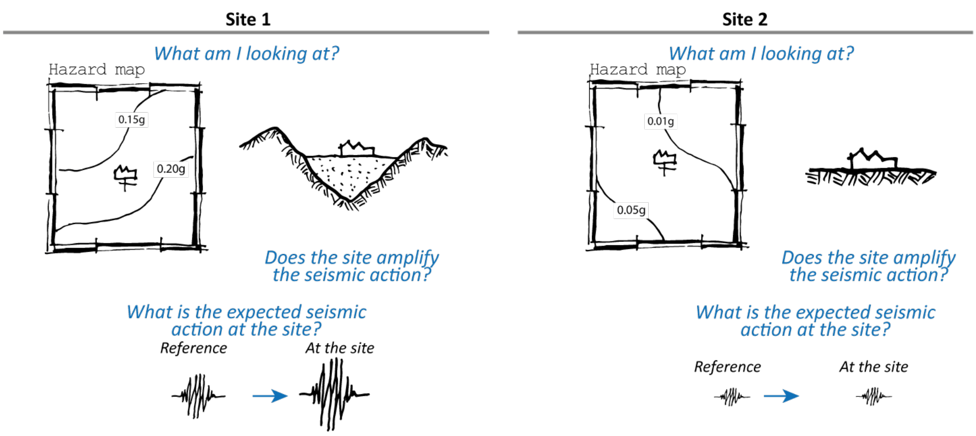


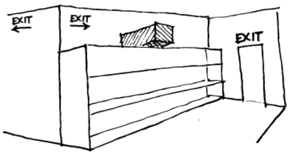
Fig. 2.4 *Expert reasoning process for the case study: consideration of two situations*

Location
Hypothesis:
the school is located in a suitable location without safety problems.

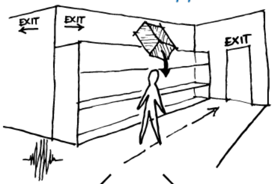
School building
Hypothesis:
the school building has neither structural global nor structural local problems in the Sites 1 and 2.

Situation A

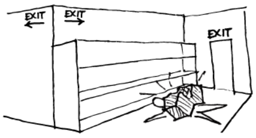
What am I looking at?

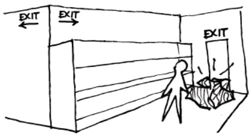


What could happen?



*What do I expect to happen for the expected seismic action of **Site 1**?*





Judgement

Location/site safety issues (L): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural global safety issues (G): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural local safety issues (P): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

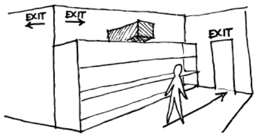
Non-structural safety issues (N): there could be severe consequences for personal safety caused by the fall of the objects.

Functionality safety issues (F): there could be difficulties for personal safety caused by the obstructed egress.

Judgement:
The performance of the school in case of the expected earthquake guarantees the structural stability but exposes occupants to dangerous situations caused by non-structural elements and/or related to functional aspects.

Safety upgrading requirements:
It is necessary to improve the safety conditions by removing the heavy object. The cost is negligible. The action of removing the heavy object could be self-made or, at least, self-organized.

*What do I expect to happen for the expected seismic action of **Site 2**?*



Judgement

Location/site safety issues (L): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural global safety issues (G): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural local safety issues (P): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Non-structural safety issues (N): there should be no concerns for personal safety.

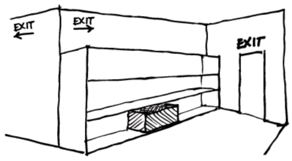
Functionality safety issues (F): there should be no concerns for personal safety.

Judgement:
The performance of the school in case of the expected earthquake guarantees the structural stability and does not expose occupants to dangerous situation related to the non-structural elements and functional aspects.

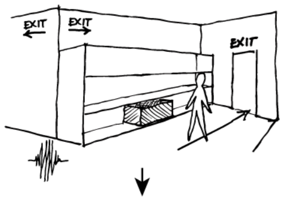
Safety upgrading requirements:
No action is necessary for improving the safety (although it could be suggested to remove/secure the heavy object).

Situation B

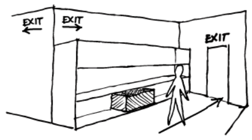
What am I looking at?



What could happen?



*What do I expect to happen for the expected seismic action of **Site 1** or **Site 2**?*



Judgement

Location/site safety issues (L): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural global safety issues (G): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Structural local safety issues (P): there should be no concerns for personal safety *(hypothesis of the simple case study)*.

Non-structural safety issues (N): there should be no concerns for personal safety.

Functionality safety issues (F): there should be no concerns for personal safety.

Judgement:
The performance of the school in case of the expected earthquake guarantees the structural stability and does not expose occupants to dangerous situation related to the non-structural elements and functional aspects.

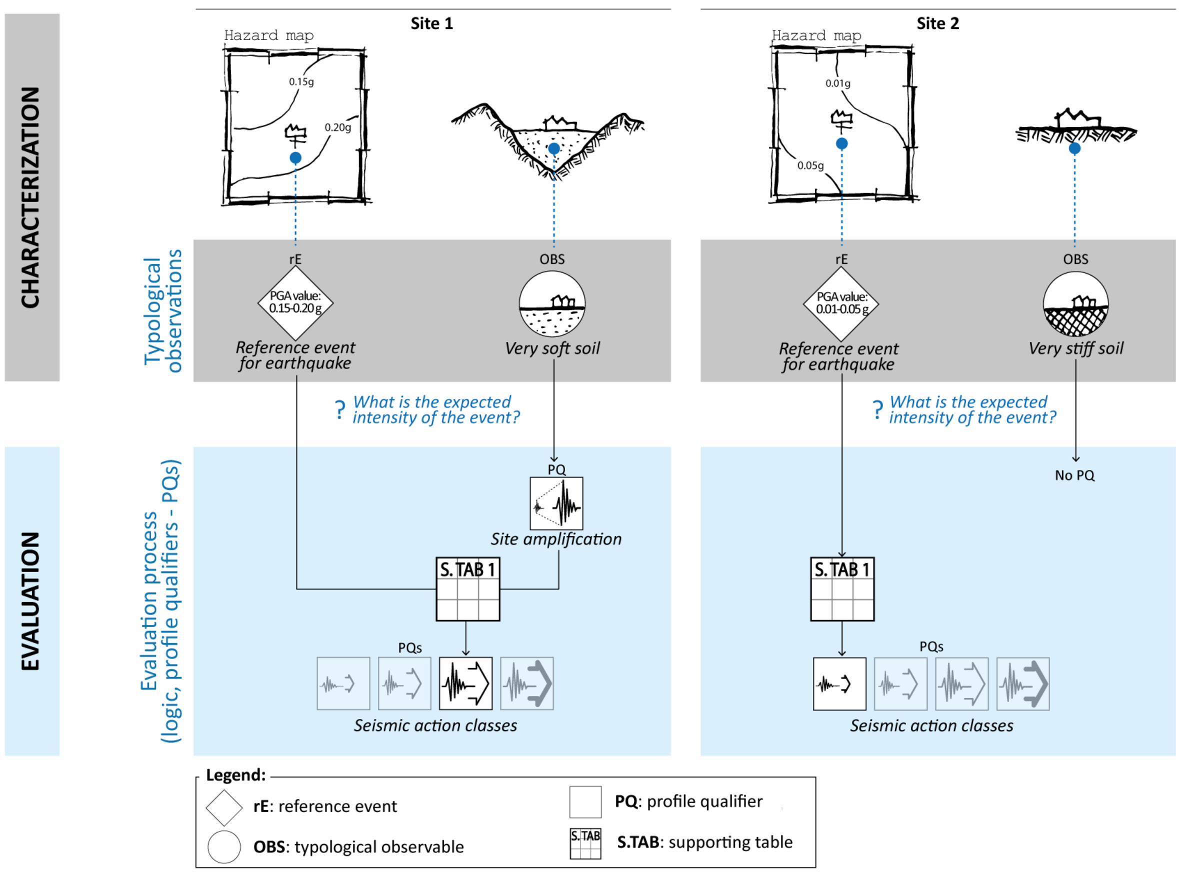
Safety upgrading requirements:
No action is necessary for improving the safety.

2.2 Codification of expert reasoning

Translation of the expert reasoning process to the VISUS methodology requires the definition of a specific terminology. In order to simplify the presentation of the VISUS methodology, the example of its application is presented in three figures (2.5, 2.6 and 2.7).

Figure 2.5 shows how the methodology characterizes and evaluates the seismic action that is expected to impact the two sites. An expert first acquires the substantial elements on the expected seismic action and determines if the site characteristics could modify (amplify or reduce) the action. In VISUS language, the substantial elements are referred to as the observables (OBS) and the reference event (rE). Because it has been pre-identified, the acquisition of the substantial elements is simple – a surveyor only has to recognize what is under observation.

Fig. 2.5 *Case study: application of the VISUS methodology to the characterization and evaluation of the seismic action class for two sites*



Observing Site 1, it is possible to acquire the following substantial elements:

- rE: PGA value 0.15–0.20 g
- OBS: very soft soil

The pre-codification of the substantial elements allows the definition of evaluation algorithms that replicate expert judgement. The evaluation process considers the OBS and rE, and uses them to assign profile qualifiers (PQs), allowing the acquired information to be rearranged in pre-identified classes. The rules for the assignment of the PQs, when they are not simple, are condensed in supporting tables (S.TABs).

At Site 1, the presence of local site effects (classified by the PQ 'site amplification') could modify shaking intensity, and, as a consequence, a high class of seismic action is determined.

Observing Site 2, the substantial elements are found to be:

- rE: PGA value 0.01–0.05 g
- OBS: very stiff soil

The soil OBS is not used for the assignment of any PQ for the seismic evaluations; the methodology assumes that there is no relevant variation of the seismic ground motion in the case of very stiff soil.

Considering the rE, the evaluation algorithms assign a seismic action class to Site 2; in the example, the assigned class is the lowest of the seismic action classes pre-codified as hazard qualifiers.

The PQs of the seismic action classes determined for Site 1 and Site 2 will be used in Figure 2.6.

After the study of the hazard potentially acting on the assessed school, the methodology assesses the safety of the two situations, A and B (Fig. 2.2). Recall here the assumption that the school building has no critical structural issues (global or local), whether it is located at Site 1 or Site 2.

Figure 2.6 summarizes the expert reasoning process when the surveyor evaluates 'What could happen in this specific situation, in the event of the expected earthquake?'

Looking at Situation A, an expert could immediately make the following substantial observations:

a. There is a heavy object on the top shelf
b. The object is not anchored to a structure
c. The object sticks out from the shelf
d. One of the exits is near the object
e. There is another exit

This information allows the expert to formulate a hypothesis on what could happen in the case of an earthquake:

f. The heavy object could fall on people
g. The main exit could be obstructed by the fall of the heavy object

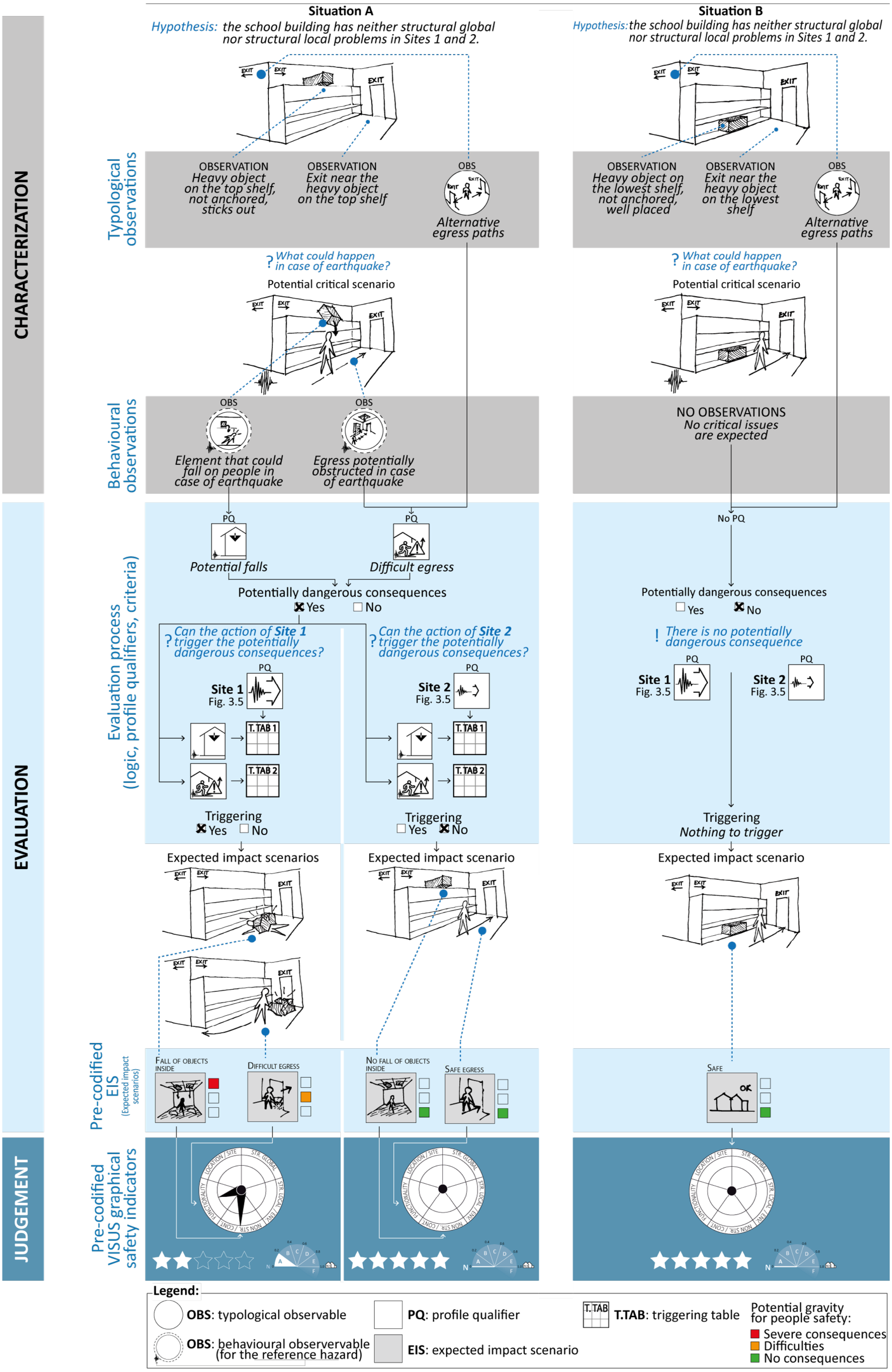
Point (e) is recognized as a typological observable (**typological OBS**, section 3.1.1), that is, a pre-codified substantial element that describes a characteristic essential for the VISUS assessment.

Points (a), (b) and (c), together with the hypothesis of what could happen in the case of an earthquake, lead to the behavioural observable (behavioural OBS) described in point (f). Points (a) to (d) together lead to the behavioural OBS described in point (g).

Behavioural OBS are pre-codified substantial elements that describe the potentially critical consequences of the rE. In order to assign a behavioural OBS, a preliminary evaluation of what could happen if the rE occurs is needed. The situations to evaluate with behavioural OBS are simple and surveyors are trained in this regard.

Determination of the typological and behavioural OBS allows the essential information for the VISUS evaluation process to be acquired. The VISUS phase concerning the identification of the OBS and rE is called characterization, and is done by trained surveyors.

Fig. 2.6 *Case study: application of the VISUS methodology to two situations*



The information acquired in the characterization of the situation (i.e. the OBS) is used in the VISUS evaluation process to identify what is expected to happen in the studied situation, given the expected hazard previously assessed (Fig. 2.5).

A **PQ** (section 3.2.1.2) summarizes the essential information that enables the EIS to be identified according to pre-codified dangerous consequences.

In Situation A of the case study, the OBS that a heavy object could fall on people in the case of an earthquake leads to the assignment of the 'potential falls' PQ. The OBS that egress could be obstructed in the case of an earthquake together with the OBS that there are multiple exits from the building lead to the PQ 'difficult egress' (note that, if the situation had been characterized by a single exit, the PQ 'impossible to exit' would have been assigned). This evaluation indicates that Situation A is predisposed to potentially dangerous consequences in the case of an earthquake.

If they are not simple, the rules for assigning the PQs are condensed into supporting tables (**S.TABs**), section 3.2.1.4.

The evaluation process determines whether the expected seismic action can (or cannot) trigger the potential consequences. For this purpose, the process uses triggering tables (**T.TABs**) (section 3.2.1.5). A T.TAB summarizes the expert evaluations and assigns the EIS, considering the predisposed PQs and the hazard PQs previously determined.

The seismic action class that results from the evaluation of Site 1 implies that the action triggers the potentially dangerous consequences, that is, they are expected to happen in the case of the rE.

The entire evaluation process is represented in VISUS through logical trees. The **logical trees** (section 3.2.1.3) summarize the evaluation logic: they combine the OBS and rEs to assign the PQs using S.TABs, and assign the EIS using T.TABs. Figures 2.7 and 2.8 show the VISUS logical trees that summarize the evaluations shown in Figure 2.5 and 2.6. The logical trees are interpreted using the 'if this ..., then that ...' approach.

The methodology then identifies the **EIS** (section 3.2.1.1), which summarize and depict visually the substantial critical effects that could affect the learning facilities either during ordinary use or in the case of an adverse event. In the case study, Situation 1, the EIS are that:

- The heavy object would fall from the shelf onto people in the hallway
- The heavy object would fall from the shelf and obstruct the nearest exit; people would have to use the other exit

The two described scenarios are pre-defined in the VISUS methodology through the EIS. Each EIS has an associated triggered **warning level** (section 3.3.1.1) that describes the potential gravity of the scenario in terms of safety through the use of colour, as follows:

- Red: severe consequences
- Orange: difficulties
- Green: no concerns

The first scenario for Situation 1 ('Fall of objects, inside') is classified as red, as it could result in serious consequences in terms of people's safety, while the second scenario ('Difficult egress') is orange, as it could cause difficulties (there is another exit that could be used) in terms of people's safety.

The EIS are used to define the final safety judgement using the pre-codified VISUS graphical indicators (see section 3.3). In the case study, only the VISUS **warning rose** (section 3.3.1.2) is used. The rose summarizes the expert judgement for the five VISUS safety issues (see section 1.1.3.1) using a needle:

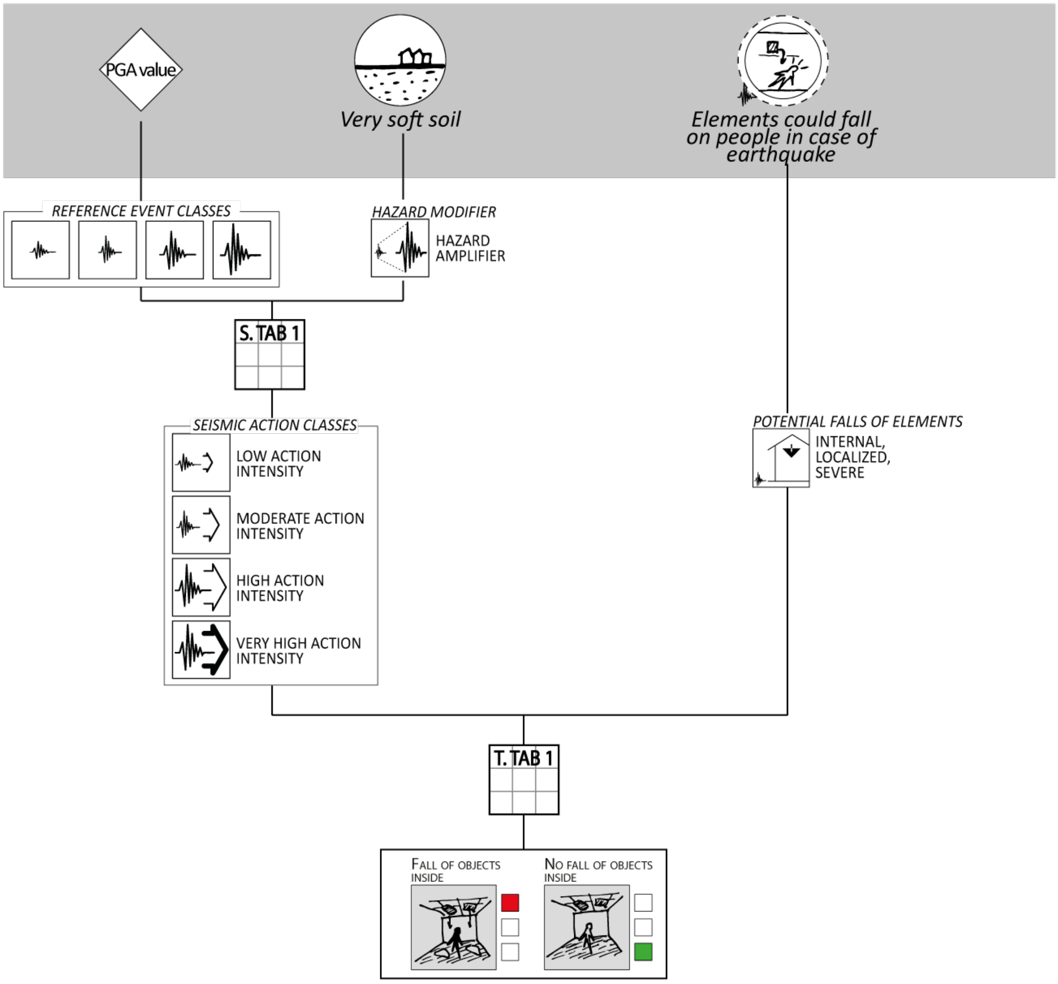
- No needle: no concerns for personal safety
- Short needle: potential difficulties for personal safety
- Long needle: potentially severe consequences for personal safety

In the Site 1/Situation A example, a concise safety judgement will state that, in the event of the expected hazard, there could be severe consequences for personal safety (i.e. deaths or severe injuries) connected to non-structural safety issues, and difficulties concerning the functional aspects of the structure.

This final judgement is graphically represented by stars, the number of which is associated with a specific performance level. For instance, two stars mean that site suitability and stability of a structure are guaranteed but there are concerns about non-structural or functional aspects of the facility. Five stars mean that site, structural, non-structural and functional performance do not present any concerns.

Finally, safety upgrading measures are assigned to the PQs, and considering all the measures, an overall action is assigned to the learning facility. In the case study, the measure is to remove or fix the object with the potential to fall, and the resulting action is a 'self' action, that is, it can be done directly by school personnel. There is no expected budget allocation for this action.

Fig. 2.7 *Logical tree describing the VISUS methodology evaluation process for the case study: Site 1, Situation A, with a focus on non-structural impact scenarios*



Supporting tables (S.TAB)

S. TAB 1

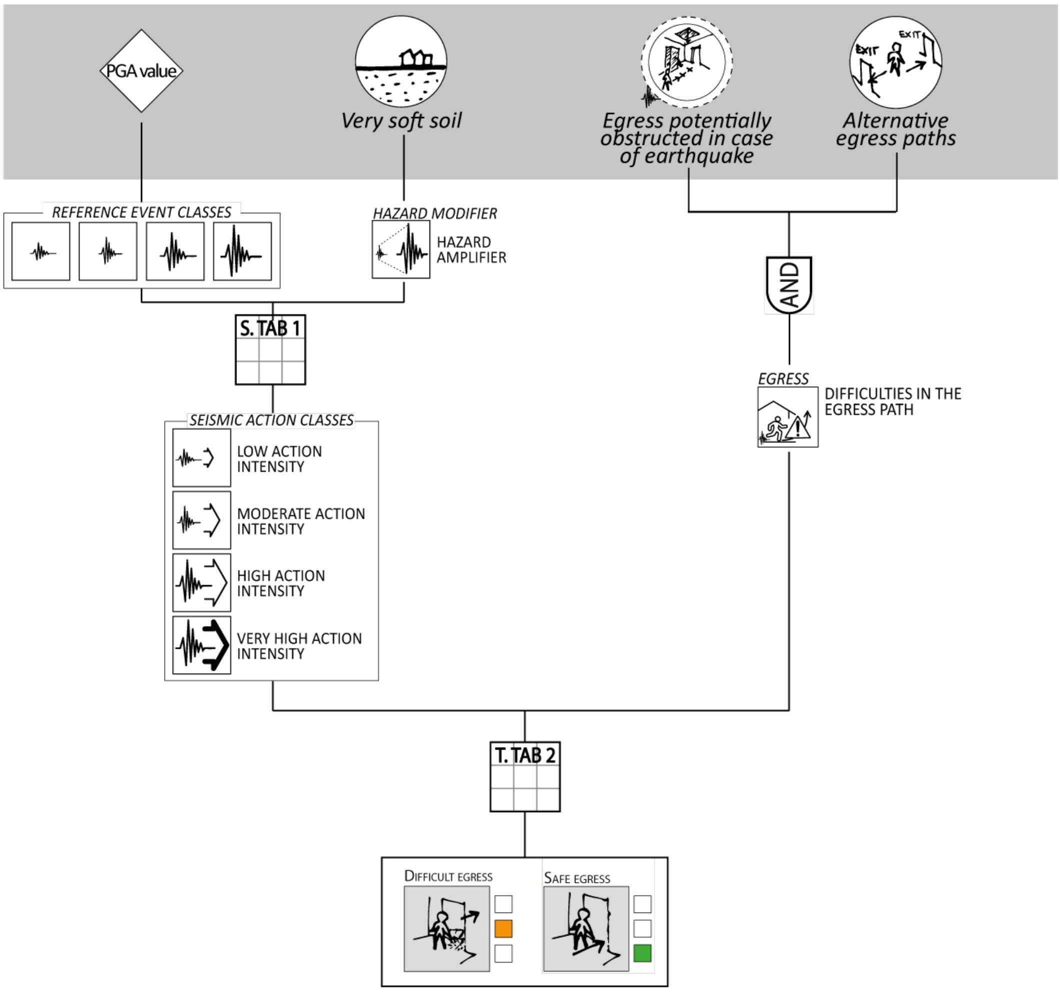
PGA values	REFERENCE EVENT	SEISMIC ACTION CLASSES: NO HAZARD AMPLIFIER	SEISMIC ACTION CLASSES: HAZARD AMPLIFIER
<0.05g	LOW	LOW ACTION INTENSITY	LOW ACTION INTENSITY
0.05-0.09g	LOW	LOW ACTION INTENSITY	LOW ACTION INTENSITY
0.10-0.14g	MODERATE	MODERATE ACTION INTENSITY	MODERATE ACTION INTENSITY
0.15-0.19g	MODERATE	MODERATE ACTION INTENSITY	HIGH ACTION INTENSITY
0.20-0.24g	MODERATE	MODERATE ACTION INTENSITY	HIGH ACTION INTENSITY
... continues	... continues	... continues	... continues

Triggering tables (T.TAB)

T. TAB 1

PQ (predisposed situation)	PQ of seismic action classes: low	moderate	high	very high
Potential falls of elements	NO FALL OF OBJECTS INSIDE	FALL OF OBJECTS INSIDE	FALL OF OBJECTS INSIDE	FALL OF OBJECTS INSIDE

Fig. 2.8 *Logical tree describing the VISUS methodology evaluation process for the case study: Site 1, Situation A, with a focus on functional impact scenarios*



Supporting tables (S.TAB)

S. TAB 1

PGA values	REFERENCE EVENT	SEISMIC ACTION CLASSES: NO HAZARD AMPLIFIER	SEISMIC ACTION CLASSES: HAZARD AMPLIFIER
<0.05g	LOW	LOW ACTION INTENSITY	LOW ACTION INTENSITY
0.05-0.09g	LOW	LOW ACTION INTENSITY	LOW ACTION INTENSITY
0.10-0.14g	MODERATE	MODERATE ACTION INTENSITY	MODERATE ACTION INTENSITY
0.15-0.19g	MODERATE	MODERATE ACTION INTENSITY	HIGH ACTION INTENSITY
0.20-0.24g	MODERATE	MODERATE ACTION INTENSITY	HIGH ACTION INTENSITY
... continues	... continues	... continues	... continues

Triggering tables (T.TAB)

T. TAB 2

PQ (predisposed situation)	PQ of seismic action classes: Low action intensity	Moderate action intensity	High action intensity	Very high action intensity
Difficulties in the egress path	SAFE EGRESS	DIFFICULT EGRESS	DIFFICULT EGRESS	DIFFICULT EGRESS

In the following paragraphs, Situation A, in which the school is located at Site 2, with a low seismic action, is evaluated. The feeble seismic ground motion that characterizes the seismic action class assigned to Site 2 is not sufficient to cause the heavy object to fall from the shelf. Therefore, people are not at risk from it falling on them and the hallway and exit will remain clear. A summary safety judgement will state that, for the Site 2/Situation A example, there are no concerns for personal safety.

Finally, looking at Situation B (Fig. 2.6), an expert would immediately observe that:

a. There is a heavy object on the lowest shelf
b. The object is not anchored to a structure
c. The object is well placed on the shelf
d. One of the exits is near the object
e. There is another exit

This information allows the expert to formulate a hypothesis on what could happen in the case of an earthquake:

f. The heavy object would not fall (at most it could slide on the shelf)
g. Egress remains unobstructed

These observations lead to only one VISUS OBS, that is, the presence of multiple exits from the building. Considering the evaluation of what could happen in the case of an earthquake, there are no behavioural observables.

As a result, there are no concerns for personal safety because there is no situation predisposed to potential impact scenarios. This implies that there are no actions and therefore there is no expected allocation of budget.

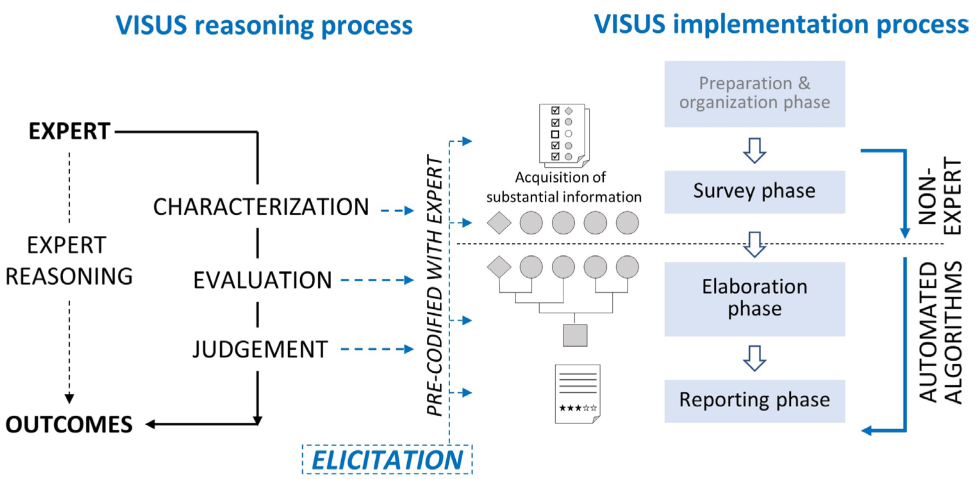
3. VISUS REASONING PROCESS

The previous chapters highlight how VISUS aims at simulating expert reasoning in order to make safety judgements for a large number of schools.

The VISUS methodology distinguishes between reasoning and implementation processes (see section 1.2.4). In the reasoning process, expert reasoning enables substantial elements to be acquired and rules and criteria to be defined so that the expert reasoning process can be replicated by non-experts. The information is used in the implementation process to create tools for its survey and elaboration phases.

Figure 3.1 illustrates the link between the VISUS reasoning and implementation processes and highlights the importance of expert elicitation for the entire VISUS methodology. The expert reasoning process is divided into characterization, evaluation and judgement phases. For each of these phases, expert reasoning pre-codifies the substantial information and the rules and criteria to be adopted for the implementation of VISUS. This permits to separate the implementation process in two steps. The first step reproduces the characterization phase of expert reasoning, and it is carried out by non-experts (trained surveyors). This step corresponds to the survey phase of the VISUS implementation process, which is characterized by the use of specific tools that support surveyors in the collection of the substantial elements pre-defined by the experts. The second step replicates the evaluation and judgement phases of expert reasoning, and it can be automatically executed through algorithms. This step corresponds to the elaboration and reporting phases of the VISUS implementation process. In the elaboration phase the substantial elements acquired during the survey phase are used as the inputs for the automated application of the rules and criteria previously elicited from experts. In the reporting phase the VISUS reports are automatically created using the outcomes of the elaboration phase and other information acquired during the survey (e.g. photos).

Fig. 3.1 *Link between the VISUS reasoning process and the VISUS implementation process*



In the following sections, the expert reasoning phases (i.e. characterization, evaluation and judgement) of the VISUS methodology are described in depth, introducing the elements and acronyms used for the pre-codification of the reasoning process.

The complete set of rules and criteria elicited from experts is presented in detail in Annexes AM1 to AM7.

3.1 Characterization phase

The characterization phase of the expert reasoning process aims at simulating the phase in which an expert acquires the information essential for the articulation of the final judgement. The foundation of this phase is the pre-codification of the substantial elements, which is achieved through expert elicitation.

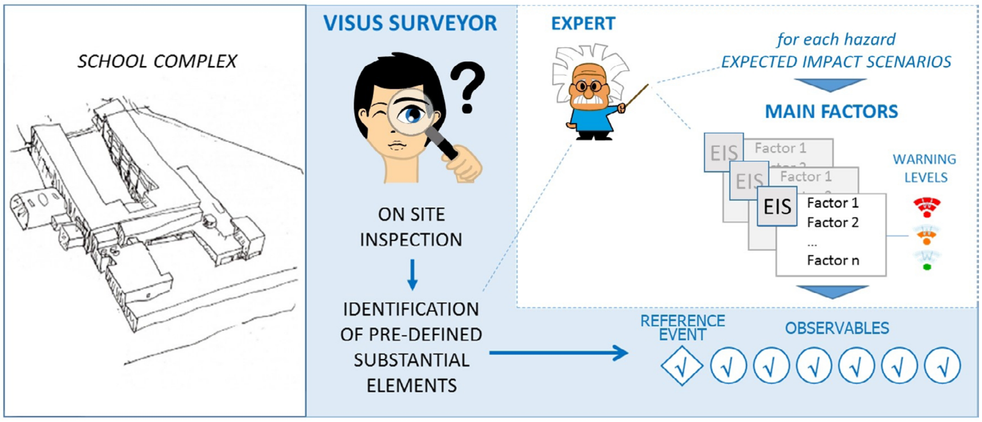
Pre-codification of the substantial elements required a high level of expertise, along with a specific approach. The experts identified the substantial elements considering the characteristics of VISUS, especially the necessity of making a quick, pragmatic safety assessment of a large number of learning facilities. Experts needed to simplify information acquisition as much as possible while making acquisition efficient. Elements that had a minor influence on the final judgement were, therefore, discarded; in this regard, experts adopted the Pareto principle (see section 1.2.2.2).

While the pre-codification of the substantial elements required a big effort from the methodological point of view, it considerably simplifies the characterization phase for non-expert (novice) VISUS surveyors. Furthermore, it improves the process of knowledge transfer from experts to non-experts.

Figure 3.2 illustrates how VISUS characterization pre-codifies the substantial elements and how, subsequently, a surveyor uses these substantial elements to characterize the school he or she is assessing. The surveyors have elementary technical skills and are trained to recognize the pre-codified substantial elements, reference events and observables in the reality they are observing. They acquire the information through VISUS survey forms that enable them to collect all the pre-codified substantial elements. This not only facilitates surveyors in their task but also improves the reliability of their observations.

In order to pre-codify the different substantial elements, VISUS uses specific terminology, acronyms, codes and symbols.

Fig. 3.2 *VISUS characterization phase: the surveyor identifies the pre-codified substantial elements in the school complex being inspected*



3.1.1 Observables and reference events

Definitions

The observables (OBS) are the substantial elements that a surveyor can observe in a school.

The reference events (rE) are substantial elements that a surveyor can acquire from hazard maps or local knowledge.

The VISUS OBS and rE are used for the characterization phase by non-expert but trained surveyors.

Principles

- The OBS and rE should be the smallest set that provides the required information for the evaluation.
- Each OBS is represented by a pictogram and includes a brief description (Fig. 3.3).
- The OBS refers to a typology (i.e. typological OBS), a behaviour (i.e. behavioural OBS) or a status (i.e. status OBS).

A typological OBS can be identified by surveyors by observation of the reality and direct association or identification (a sort of pattern recognition) with the element depicted in the pictogram. The pictogram is an outline of the conditions or features to be identified. The identification of a typological OBS is usually very simple for the surveyor, and not much training is required.

The behavioural OBS are based on the recognition of an expected response to a specific hazard. The identification of a behavioural OBS needs a deeper knowledge of the situation because the surveyor has first to recognize the different features that could characterize a specific response, and then evaluate if the response is credible for the rE. Therefore, the recognition of a behavioural OBS requires a trained surveyor, but this both reduces the work of the surveyor in terms of the number of features to recognize and simplifies the evaluation process, because simple evaluation will have already been done by him or her. The required knowledge of the surveyor is basic, as the behavioural OBS refer to simply assessable responses, such as the presence of non-structural elements that are poorly anchored and could fall on people during an earthquake. Experience has shown that these behaviours could be evaluated using logical trees, but the amount of required information highlighted that it is simpler to train the surveyors than to establish automated evaluation. Moreover, the ability to identify behavioural OBS should be learned by the surveyors; this implies that they should be adequately trained.

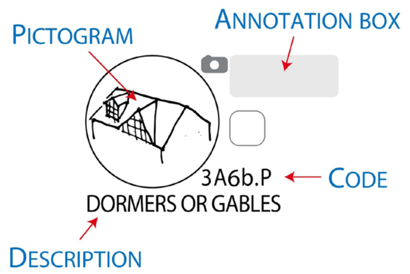
A status OBS is a specific OBS defined in order to acquire essential information for evaluating the status (quality of conditions) of the school.

Representation

The OBS are defined by the elements outlined below and shown in Figure 3.3:

- **Pictogram.** A graphical representation of the scenario to be identified. The representation recalls the information provided during the surveyors' training, and permits them to recognize, by analogy, the presence or absence of the OBS feature in the reality. The pictogram is an essential support tool for surveyors as it synthesizes the information better and more rapidly than the use of a textual description. However, the correct interpretation of the information in pictogram strongly depends on the training of the surveyors. The information also has to be interpreted considering the focus group in which the pictogram is included.
- **Description.** A brief textual description of the scenario or feature to be identified.
- **Code.** An unambiguous code assigned to each OBS.
- **Annotation box.** A place for annotating the photos representing the OBS, where the surveyor can write the name of the photo (usually, the shot number) that captures evidence of the presence (or, rarely, the absence) of the OBS.

Fig. 3.3 *Example of a VISUS typological observable showing the elements that define all observables*



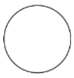
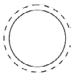
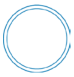
The OBS and rE are grouped in the VISUS survey forms in accordance with their features in order to make the survey clearer and to build the capacity of the people using the methodology. The OBS are grouped considering:

- Where the surveyor could observe the OBS (i.e. around the site of the school, in the schoolyard, outside the buildings, inside the buildings) – this criterion simplifies the survey strategies, i.e. the way of performing the survey
- The specific hazard each OBS refers to, and whether it is useful for general purposes, i.e. for all hazards
- Focus group, that is, a grouping that considers the specific meaning of the OBS and its potential implications in the evaluation phase

An unambiguous code characterizes each OBS in order to support surveyors while performing the survey. The code is defined by a sequence of five characters assigned in accordance with a precise logical structure (for more information, see Volume 3, section 3.1.3.1).

The three types of VISUS OBS (typological, behavioural and status) are distinguished by a different frame containing the pictogram, as illustrated in Table 3.1.

Table 3.1 *VISUS observable types have different frames for the pictogram*

Observables pictogram frame	OBS type
	Typological
	Behavioural
	Status

Example

Table 3.2 shows an extract from the list of OBS for ordinary use evaluations. The table shows the survey phase number of the survey form in which the OBS is recorded, and the focus group, unambiguous code, pictogram and name of the OBS.

Table 3.2 *List of observables used for ordinary use evaluation of schoolyards (extract)*

Survey phase	Focus group	Code	Observables	Name
1	U1 - Access to school	1U1a.L		Access via high-traffic street
		1U1b.L		Access via high-traffic street with traffic signals or lights
		1U1c.L		Unsafe transit to and from school

Elicitation questions posed to experts for the identification of OBS and rE

- What factors or conditions are most predisposed to potential adverse consequences?
- What adverse actions determine most of the severe consequences?
- Which factors or conditions are essential to detect in order to evaluate the situation?
- Is it possible to reduce the number of substantial elements without affecting the outcomes?

3.2 Evaluation phase

The evaluation phase of the expert reasoning process is the core of the VISUS methodology. It aims at simulating the process of evaluation performed by an expert when a judgement is called for after a rapid visual analysis of the situation. The evaluation phase is founded on the pre-codification of expert reasoning, that is, of the rules and criteria that experts adopt in order to formulate VISUS safety judgements. The pre-codification of expert reasoning is key to establishing an automated evaluation process.

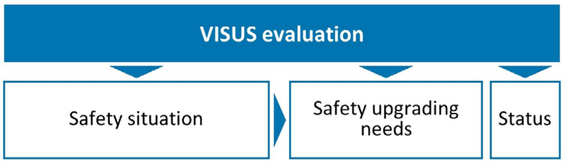
The pre-codification aims to comply with requirements that make the VISUS evaluations:

- Simple to understand and perform: non-expert (but trained) users should be able to read and understand the evaluation algorithms
- Educational: application of the evaluation algorithms should contribute to the capacity-building of the people performing the evaluations
- Able to be automated: the evaluations have to be implemented in software
- Objective: the results should not depend on who is applying the rules
- Fast and comprehensive
- Adaptable to local characteristics

The evaluation phase provides judgements on the following (Fig. 3.4):

- **Safety situation** (a warning of possible impact scenarios for the various components of the school complex)
- **Safety upgrading needs** (safety upgrading actions and estimation of budget allocation)
- **Status conditions** (a classification of the quality of the learning facility)

Fig. 3.4 *Outcomes of the VISUS evaluation phase*



The following sections provide an overview of each of these aspects to the judgement. More specific information is contained in Annexes AM1 to AM7.

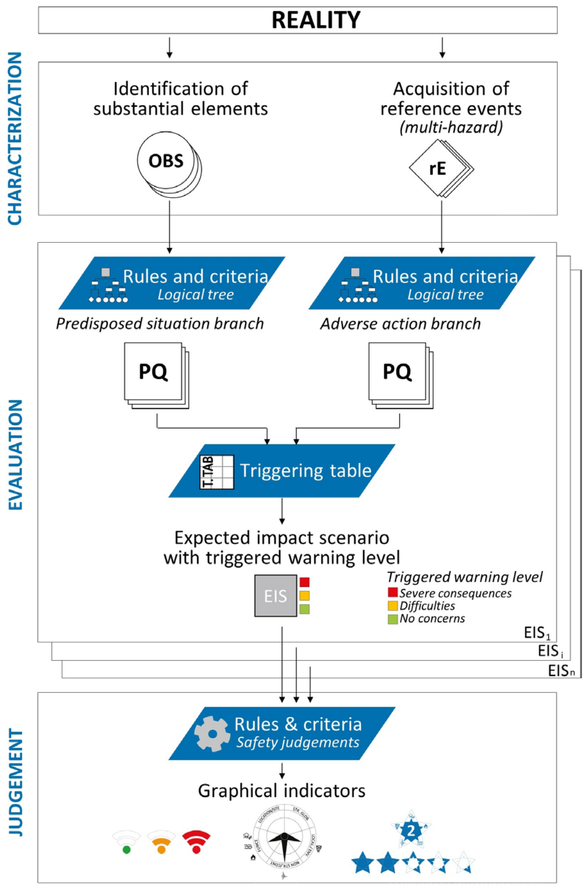
3.2.1 Safety situation

The evaluation phase includes all the aspects required to interpret the information acquired during the survey and associate a safety judgement with a report on the safety situation of the school.

The schema in Figure 3.5 summarizes the VISUS methodology, with a focus on the evaluation phase. The characterization information (OBS, rE and related photos) acquired by VISUS surveyors during the school inspection are the inputs to the evaluation process. The evaluation process expresses the pre-codified rules and criteria through logical trees (section 3.2.1.3). Rules and criteria of the logical trees permit an evaluation of the expected activation of specific expected impact scenarios (EIS). The reasoning process takes into account specific intermediate conditions (for instance the identification of situations predisposed to critical scenarios) that qualify an essential aspect of the situation. In VISUS, these specific conditions are pre-codified and named profile qualifiers (PQs). In the following subsections, the concepts of EIS, PQs and logical trees are presented more in detail.

Figure 3.5 shows the outcomes of the judgement phase for the safety situations (see section 3.3 for further explanation).

Fig. 3.5 *Schema of the VISUS reasoning process to determine the safety situation*



3.2.1.1 Expected impact scenarios

Definition

The EIS concisely describe the substantial critical effects that could affect the learning facilities either during ordinary use or in the case of an adverse event.

EIS are the key elements for the VISUS evaluation and reporting phases. The expert rules and criteria are elicited by using the description of the EIS as a starting point; experts are then asked to identify the conditions that lead to that scenario, and in turn identify the OBS and rE.

Principles

- In order to fulfil the requirements of the VISUS methodology, that is, to be effective, pragmatic and rapid, the EIS should represent the smallest set of impact scenarios capable of describing the most frequent and substantial critical effects of an adverse event.
- A 'potentially triggered warning level' (also 'warning level') must be associated with each EIS, considering the potential effects of the scenario on the safety of the people hypothetically affected.

- There are three warning levels, which describe the expected effects on the safety of people (Table 3.3): no safety concerns, potential difficulties for personal safety, and potentially severe consequences for personal safety. The assignment of the potential gravity of each scenario relies on expert knowledge and awareness.
- The EIS are divided by the five main VISUS safety issues (see section 1.1.3.1): location/site, structural global, structural local/envelope, non-structural and functionality.

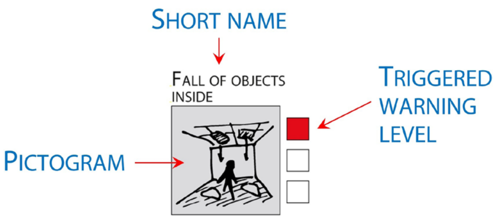
Table 3.3 *Definition of the VISUS warning levels*

Icon	Meaning
	**No concerns** No predisposed situation, or the scenario is not triggered
	**Potential difficulties for personal safety** The scenario is predisposed and triggered, and it is expected to cause difficulties for personal safety
	**Potentially severe consequences for personal safety** The scenario is predisposed and triggered, and it is expected to have severe consequences for personal safety, such as deaths or severe injuries

Representation

Each EIS is described by a short name, a pictogram, a short description of where the impact scenario could occur (schoolyard and/or building, and internally or externally) and the triggered warning level associated with its activation.

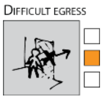
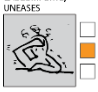
Fig. 3.6 *Example of representation of an expected impact scenario*



Example

The EIS are listed in Annexes AM1 to AM5 in tables such as the extract shown in Table 3.4. There are columns for the safety issue that characterizes the EIS, and its icon, name and the location where it could happen, as well as a brief description of the impact scenario and its effects in terms of safety.

Table 3.4 *Example of a table listing expected impact scenarios (here, for ordinary use)*

Safety issue	Icon	Name	Where	Description
Functionality	 DIFFICULT EGRESS	Difficult egress	Buildings	Presence of conditions that could cause difficulties for personal safety when leaving the learning facilities, such as obstacles to egress.
	 DISCOMFORTS, UNEASES	Discomfort, unease	Schoolyard or buildings	Presence of conditions that could cause difficulties for personal safety because of the existence of discomforts in the spaces the school students and staff use.

Elicitation questions posed to experts for the identification of EIS

- What is expected to happen in the case of a hazardous event (or ordinary use) in terms of impact on the safety of the students and staff of the school?
- Which are the most relevant cases for which to make a judgement?

3.2.1.2 Profile qualifiers

Definition

PQs are intermediate conditions in the reasoning process that qualify an essential aspect of the situation inside a logical tree. They are a sort of pre-codified situations that describe and qualify an aspect of the evaluation process. The set of PQs enables a first categorization of the OBS (and their combinations) in the VISUS logical trees (see section section 3.2.1.3). PQs are particularly useful for summarizing the description of the situation of each school in the reports, for simplifying the evaluation of the safety upgrading needs (see section 3.2.2) and for describing the situation of each school in the reporting phase.

PQs are defined as a logical combination of OBS and rE. A PQ can also result from the combination of other PQs. The rules and criteria for defining each PQ are given in Annexes AM1 to AM5.

Principles

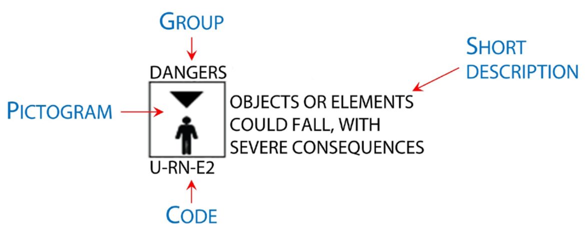
- The substantial elements should be identified in accordance with the Pareto principle (20 per cent of the known variables will account for 80 per cent of the results).

- The smallest set of PQs possible should be identified and defined for evaluating the occurrence of the EIS.

Representation

PQs are represented by a pictogram in a square frame (Fig. 3.7). The pictogram is digitally prepared (while EIS and OBS are hand drawn). PQs are categorized in focus groups in accordance with their meaning.

Fig. 3.7 *Example of representation of a profile qualifier*



Each PQ is characterized by a code aimed at simplifying its recognition. The definition of the PQ code adopts the following rules:

- First character: hazard (Table 3.5)
- Second to fourth characters: identification of the issue, distinguishing the main group of the issue and the focus (Table 3.6)
- Fifth character: sequential number

Table 3.5 *Letter assigned to each hazard for the first character of the profile qualifier code*

Letter	Meaning
U	Ordinary use
F	Fire
W	Water (flood, tsunami, heavy rain)
E	Earthquake
A	Air (wind)

Table 3.6 *Meaning of the second to fourth characters of the profile qualifier code*

Letters	Meaning (main group – focus)
AB-C	Action, Base – Class
AB-T	Action, Base – Type
AB-H	Action, Base – Height, depth
AB-V	Action, Base – Velocity
AI-M	Action, Induced – Human-induced
AI-N	Action, Induced – Natural
AI-T	Action, Induced – Type
AM-A	Action, Modifier – Amplification
AM-P	Action, Modifier – Protection
AM-R	Action, Modifier – Reduction
AP-T	Action, Predisposed – Type
AT-T	Action, Trigger – Type
RB-A	Response, Base – Anchorage
RB-C	Response, Base – Class
RB-T	Response, Base – Type
RB-W	Response, Base – Weight
RF-E	Response, Functional – Egress
RF-R	Response, Functional – Reachability
RF-H	Response, Functional – Healthiness
RF-S	Response, Functional – Suitability
RL-C	Response, Local – Concentration
RL-F	Response, Local – Failure
RL-N	Response, Local – No problems
RL-U	Response, Local – Undermining
RM-B	Response, Modifier – Behaviour

Letters	Meaning (main group – focus)
RM-P	Response, Modifier – Propagation
RM-Q	Response, Modifier – Quality
RM-S	Response, Modifier – Stress increase
RM-D	Response, Modifier – Distribution
RN-D	Response, Non-structural – Dangers
RN-E	Response, Non-structural – Elements
RN-P	Response, Non-structural – People

Example

Table 3.7 is an extract showing examples of PQs for school buildings in the case of an earthquake and their definition, starting from OBS.

Table 3.7 *Example of a table defining the profile qualifiers for school buildings in the case of an earthquake.*

Focus	Icon and code	Name	Evaluation logic
Egress	 E-RF-E1	Safe path to safe zones	(2E2a.F OR 4E9b.F) AND NOT(4G3b.F OR 4G3c.F OR 4G3d.F) AND [NOT(3E5a.F OR 4E9a.F) OR 'Early-warning for earthquake'=Yes]
	 E-RF-E2	Difficulties in the egress path	4G3b.F OR 4G3c.F

Elicitation questions posed to experts for the identification of PQs

- Which essential features (or categories or parameters) influence the occurrence of an impact scenario?
- How can these essential features be categorized?
- How can these essential features be characterized through a survey done by a VISUS surveyor?
- Which substantial elements characterize the essential features?

3.2.1.3 Logical trees

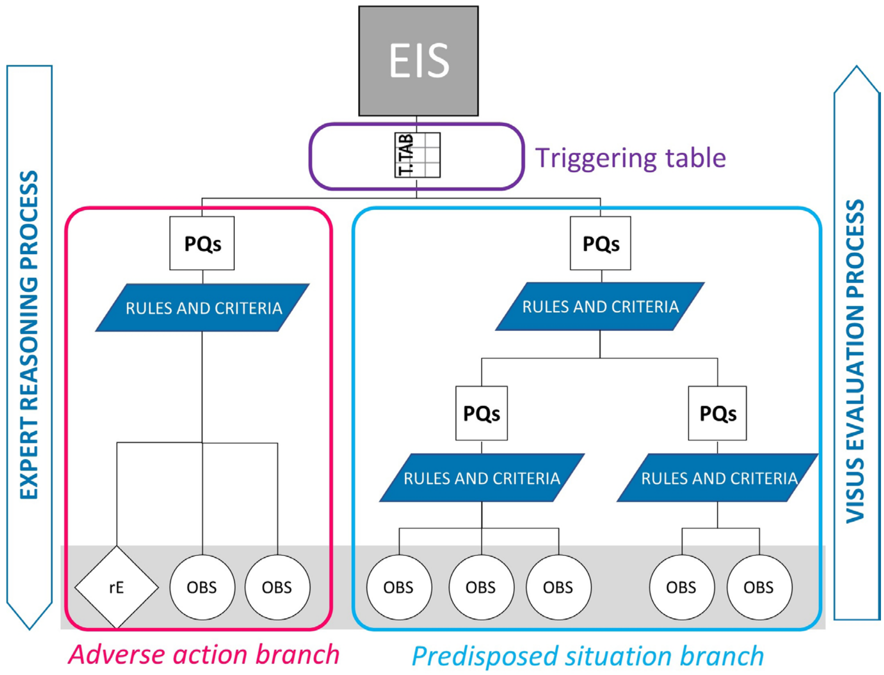
Definition

The VISUS logical trees graphically illustrate the logical relationship between the substantial elements (rE and OBS) influencing the occurrence of a specific EIS. The VISUS evaluation process is expressed through these logical trees, and passes through the stage of formulating PQs.

Principles

- The VISUS methodology should assist capacity-building efforts. The evaluation algorithms expressed in the logical trees should be understood by non-experts
- The substantial elements should be identified in accordance with the Pareto principle
- Information acquisition should be made as simple and effective as possible by reducing as much as possible the number of OBS.
- The logical trees are built from top to bottom, that is, starting from the EIS and identifying, through expert reasoning, the main features or conditions that correspond to the definition of that scenario (i.e. the elements for the characterization) (Fig. 3.8). In contrast, the VISUS elaboration phase applies the logical trees starting from the bottom (the information acquired during the survey phase, that is, the OBS and rE) and moving to the top (the EIS).

Fig. 3.8 *Schema of a VISUS logical tree*



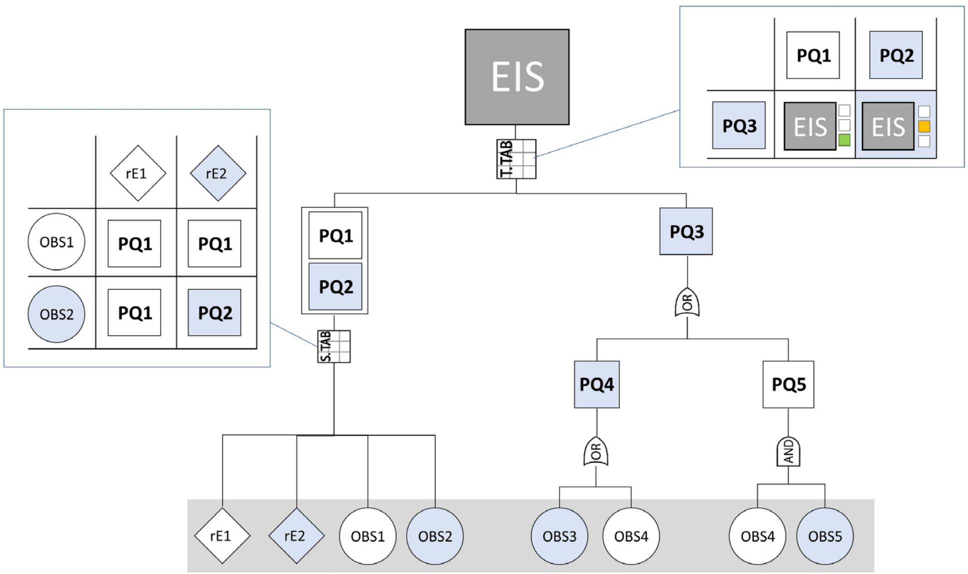
- The logical trees are divided into two main branches: the adverse action branch and the predisposed situation branch (Fig. 3.8). The adverse action branch classifies the hazard intensity by using pre-defined PQs that classify the severity of the action. The predisposed situation branch allows an evaluation of whether the situation is predisposed to specific EIS. These situations are identified by specific PQs.
- At the top of the logical trees, the adverse action and predisposed situation branches are combined through T.TABs (see section 3.2.1.5) for evaluating the EIS and the warning level.
- The logical trees are based on binary events, that is, an OBS can be 'identified' (on) or 'not identified' (off). If the event is on (e.g. in the case of an OBS, if it has been observed in the assessed situation), then it contributes to the definition of the event that depends on it.
- The logical tree rules and criteria work using the rule 'if this ..., then that ...'. The logical trees combine the events (OBS and PQs) through simple logical operators ('and', 'or' and 'not'). If appropriate, for the user's convenience, S.TABs that summarize specific rules and criteria are used to improve the readability of the logical trees.

Representation

Figure 3.9 shows a generic example of a VISUS logical tree. In the example, the OBS and rE identified during the characterization phase are shaded in blue. The tree should be read from the bottom to the top. At the end of the evaluation, an EIS with an orange warning level is assigned.

It is worth noting that the logical trees can also be used to understand where it is preferable to intervene in order to remove the EIS (generally, the best solution is to intervene on the predisposed situation branch).

Fig. 3.9 *Generic example of a VISUS evaluation logical tree*

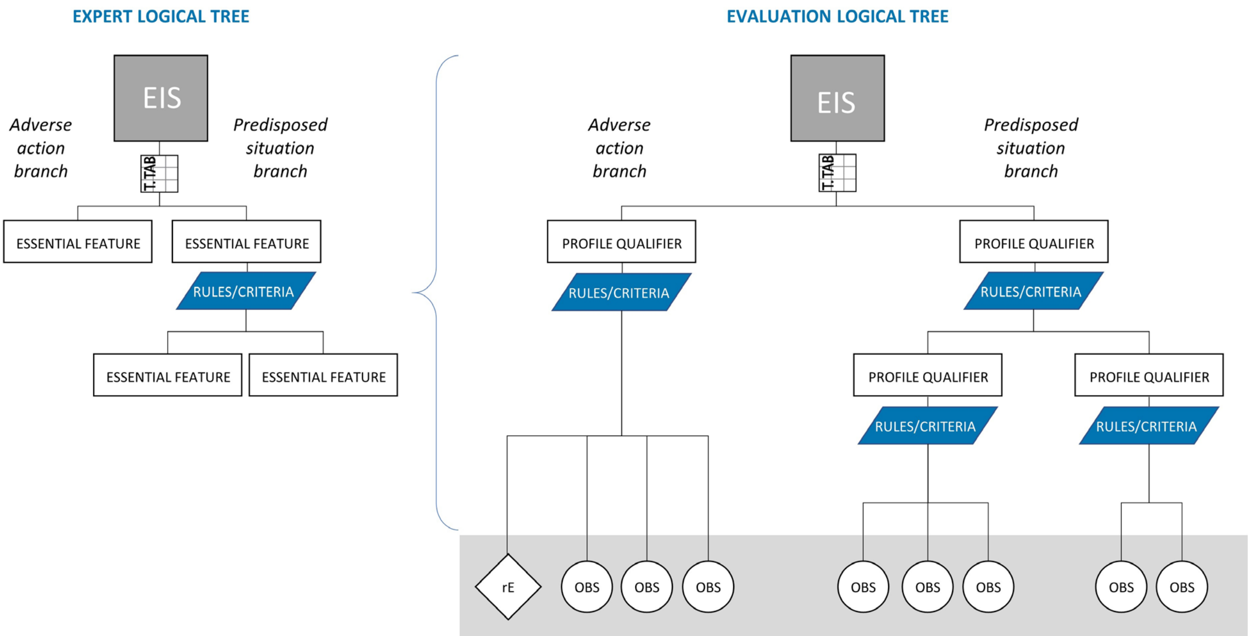


The logical trees are simple to read and apply and therefore their adoption for the evaluation is advantageous. They are also simply adaptable to changes required owing to local circumstances.

Logical trees for all the impact scenarios related to various hazards (i.e. air, earthquake, water and fire) and ordinary use are presented in detail in Annexes AM1 to AM5.

In these annexes, two types of logical trees are presented. First is the 'expert' logical tree, which illustrates expert reasoning and shows, through a brief description, the essential features that influence the occurrence of an impact scenario. Second is the 'evaluation' logical tree, which is the tree used in the VISUS algorithms. In this tree, the essential features identified in the expert logical tree are replaced with the PQs. The tree is further expanded to the identification of the substantial elements that correspond to the definition of each PQ, that is, to the definition of the OBS and rE. The OBS and rE are at the bottom of the logical tree and are shaded grey in order to highlight that they are the substantial elements for the characterization. Figure 3.10 provides examples of both expert and evaluation logical trees.

Fig. 3.10 *VISUS expert and evaluation logical trees*



In the logical trees developed for water, earthquake and air hazards, the adverse action and predisposed situation branches are separated. The logical tree for ordinary use has no adverse action branch, as there is no hazard having an impact on the situations under ordinary use. The fire logical trees adopt a slightly different layout to the water, earthquake and air trees, despite being possible to recognize, in the definition of some PQs, the presence of a triggering action (e.g. a heat source) acting on a predisposed element (e.g. flammable material).

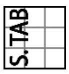
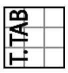
The relationships among the elements of the trees are expressed through:

- Logical expression or direct links
- S.TABs (see section 3.2.1.4)
- T.TABs (see section 3.2.1.5)

The rules are applied assuming that a selected (checked) OBS corresponds to 'true'; if it is not checked, it corresponds to 'false'.

In order to simplify the evaluation algorithms, only the logical expressions 'AND', 'OR' and 'NOT' are used, with their custom definitions (see Table 3.8).

Table 3.8 *Symbols used in the VISUS logical trees*

Symbol	Name	Definition
———	Direct link	Direct link to an issue.
	AND	The statement 'A AND B' is true if A and B are both true; otherwise, it is false.
	OR	The statement 'A OR B' is true if A or B (or both) are true. The statement is false if both A and B are false.
 	NOT	The statement 'NOT(A)' is true if and only if A is false.
	Supporting table	Table that simplifies the definition of the profile qualifiers.
	Triggering table	Table that links the predisposed situation and the adverse action branches, and enables the expected impact scenarios to be defined.

Example

Figures 3.11 and 3.12 show examples of an expert logical tree and an evaluation logical tree, respectively, for an earthquake hazard EIS.

Fig. 3.11 *Earthquake hazard: example expert logical tree for the expected impact scenario 'Fall of objects, inside'*

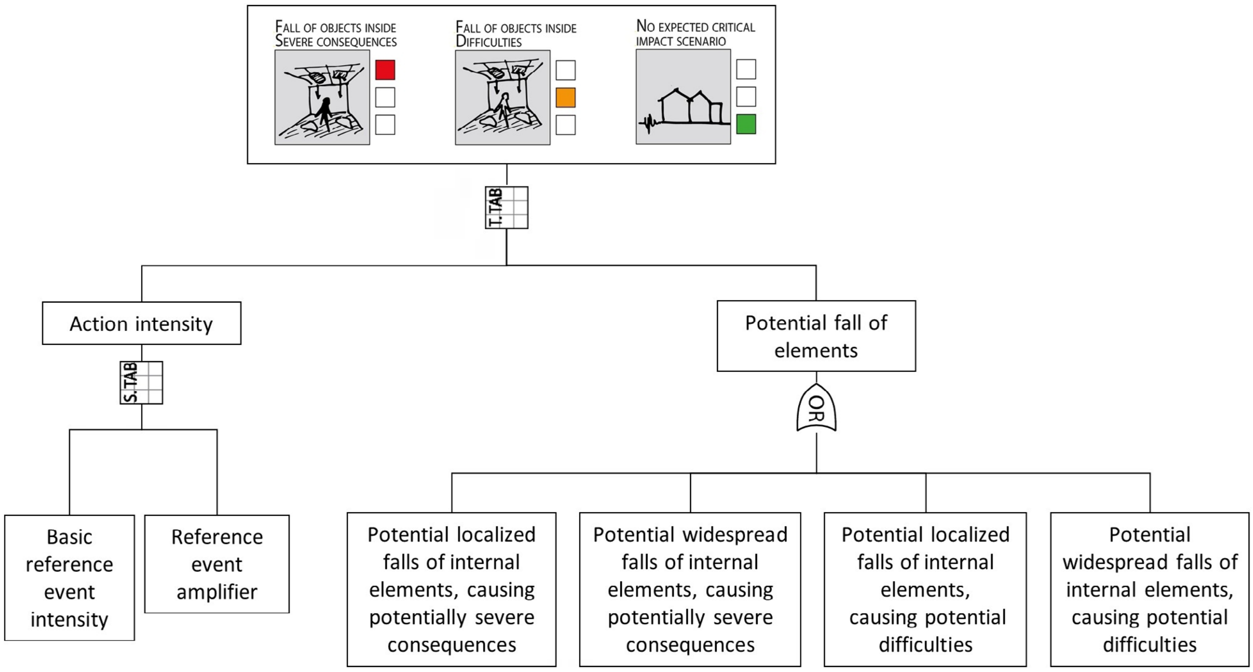
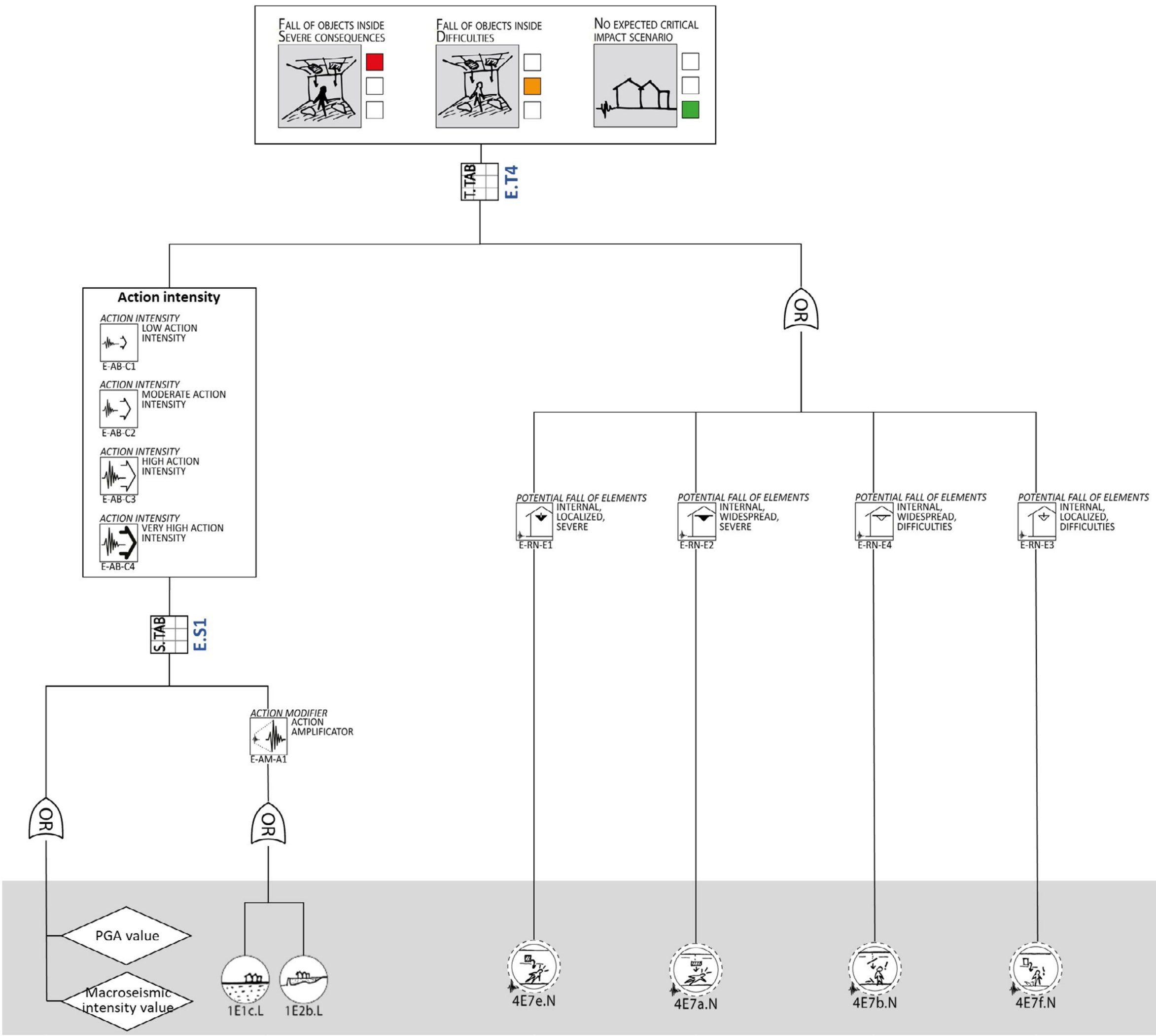


Fig. 3.12 *Earthquake hazard: example evaluation logical tree for the expected impact scenario 'Fall of objects, inside'*



Elicitation questions posed to experts for the definition of logical trees

- Which logical rules allow a description of the cause–effect relationship, from observations up to the impact scenario?
- How can the essential features be characterized through a survey done by a VISUS surveyor?
- How detailed should the logical tree be in order to identify the substantial elements and, at the same time, ensure a rapid, effective and pragmatic evaluation?
- Which substantial elements should be kept, considering the Pareto principle?

3.2.1.4 Supporting tables

Definition

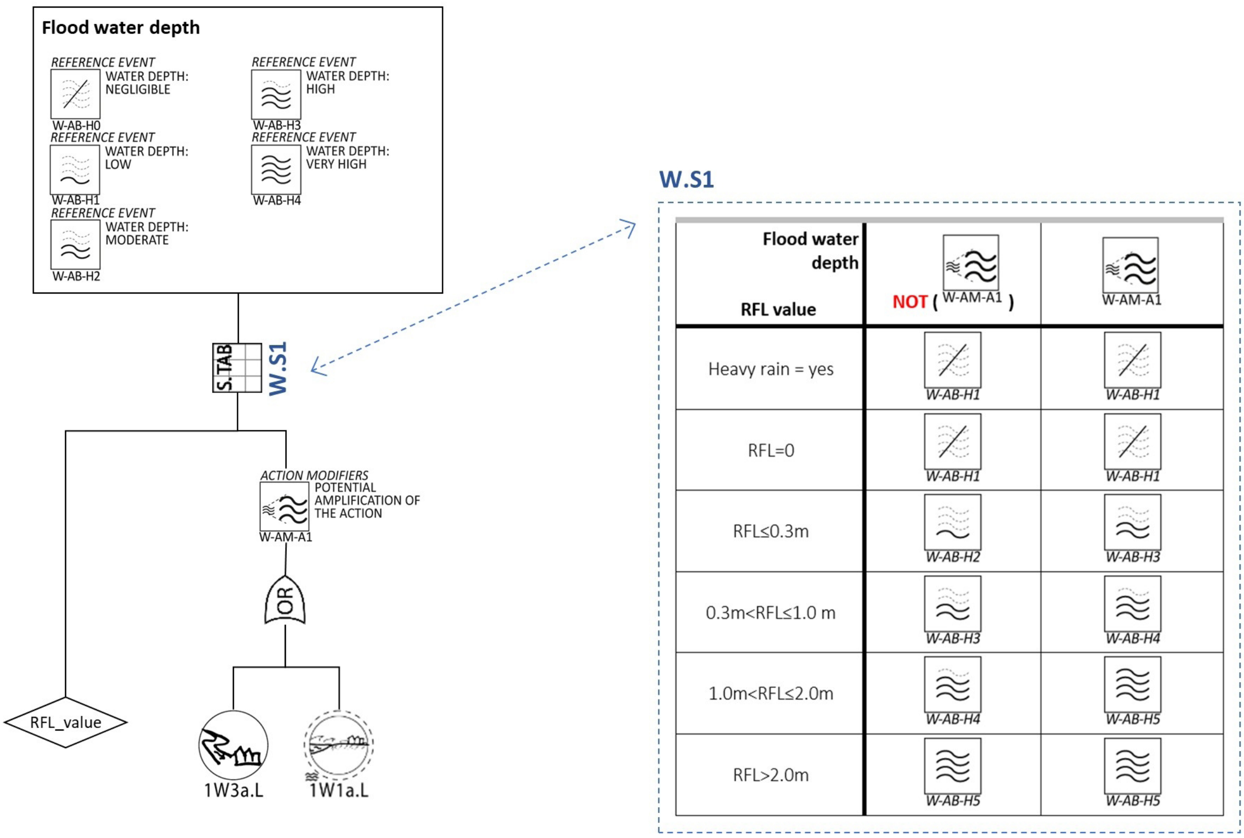
S.TABs are tables that simplify the readability of the logical trees.

Representation

The S.TABs are identified by a specific symbol and code. The first letter of the code refers to the hazard (according to the common definitions of VISUS in Table 3.5), and the following ‘S’ indicates it is a ‘supporting table’. The code ends with a sequential number.

When S.TABs are used with the logical trees, the elements that are the inputs to the table are grouped in a rectangle that is directly linked to the S.TAB symbol (Fig. 3.13). All the potential outputs of the S.TAB are grouped above the S.TAB symbol (Fig. 3.13).

Fig. 3.13 *How supporting tables are used in the VISUS logical trees (left) and defined (right)*



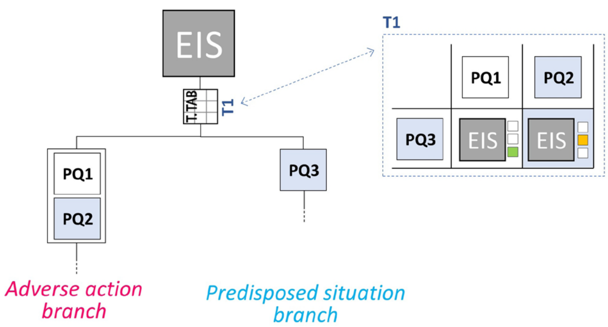
Flood water depth / RFL value	NOT (W-AM-A1)	W-AM-A1
Heavy rain = yes	W-AB-H1	W-AB-H1
RFL=0	W-AB-H1	W-AB-H1
RFL≤0.3m	W-AB-H2	W-AB-H3
0.3m<RFL≤1.0 m	W-AB-H3	W-AB-H4
1.0m<RFL≤2.0m	W-AB-H4	W-AB-H5
RFL>2.0m	W-AB-H5	W-AB-H5

3.2.1.5 Triggering tables

Definition

T.TABs link the predisposed situation and the adverse action branches of the VISUS logical trees and enable the EIS to be assigned (Fig. 3.14).

Fig. 3.14 *How triggering tables are used in the VISUS logical trees (left) and defined (right)*

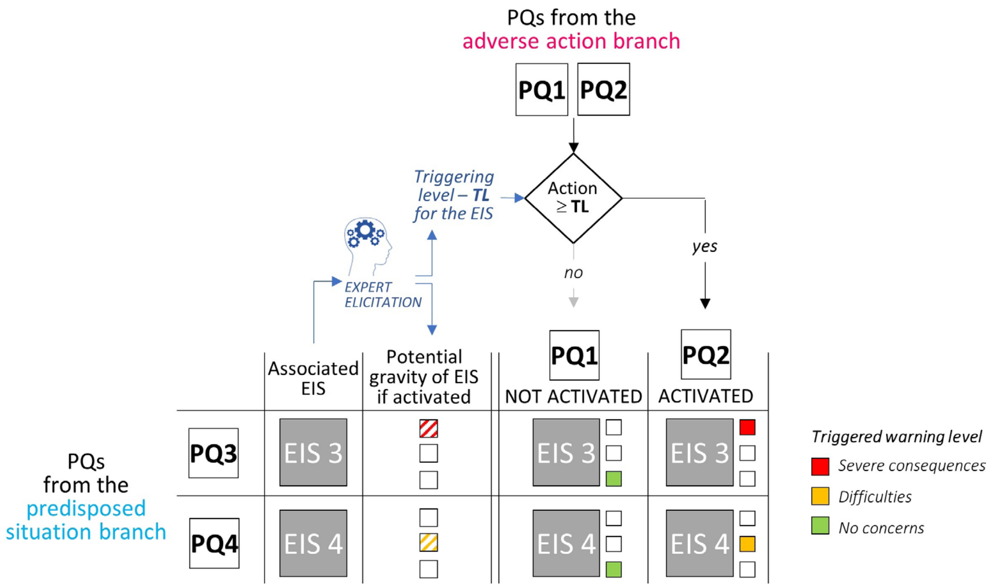


these PQs the potential gravity of the associated EIS, if it is activated. Furthermore, experts established the triggered warning level, that is, the action that could activate the event. If the reference action identified by the PQs in the adverse action branch of the tree (top of the figure) is large enough to activate the EIS and its potential gravity, then the EIS with the triggered warning level is assigned. If the action is not large enough, then the T.TAB associates the EIS with a green warning level, that is, there are 'no concerns' (see Table 3.3 for warning level definitions).

Figure 3.15 shows in detail how T.TABs are defined. The PQs resulting from the predisposed situation branch of a logical tree are considered (bottom left of the figure); each of these PQs is associated with an EIS in the VISUS logical trees. Experts defined for

The ordinary use evaluation does not require a T.TAB because it is the usage of a learning facility that poses the hazardous conditions.

Fig. 3.15 *Framework for the definition of the VISUS triggering table*



Principles

- The input information for the assignment of the EIS should be simplified as much as possible.
- The triggering table can be defined by interpreting and adapting existing studies. For example, information on fragility curves can be used to define the triggering table (see Volume 3, section 2.2 for more information).

Representation

The columns in a T.TAB contain the adverse action intensity classes defined through the PQs, and the rows contain the PQs related to the predisposed situations. The outputs are the EIS with triggered gravity evaluated in the logical tree.

Example

Table 3.9 shows an example of T.TAB for the local critical issues logical tree for the earthquake hazard.

Table 3.9 *Example of a triggering table for the 'structural local (partial) critical issue' set of impact scenarios for the earthquake hazard*

Profile qualifier	Action intensity			
	ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
LOCAL CRITICAL ISSUES LOCALIZED FAILURES SEVERE CONSEQUENCES E-RL-C5	NO EXPECTED CRITICAL IMPACT SCENARIO	PARTIAL COLLAPSE	PARTIAL COLLAPSE	PARTIAL COLLAPSE
LOCAL CRITICAL ISSUES LOCALIZED STRESS CONCENTRATED DIFFICULTIES E-RL-C2	NO EXPECTED CRITICAL IMPACT SCENARIO	LOCAL FAILURE	LOCAL FAILURE	LOCAL FAILURE
LOCAL CRITICAL ISSUES LOCALIZED FAILURES DIFFICULTIES E-RL-C4	NO EXPECTED CRITICAL IMPACT SCENARIO	LOCAL FAILURE	LOCAL FAILURE	LOCAL FAILURE

Elicitation questions posed to experts for the definition of T.TABs

- What are the most relevant hazard intensity classes to use for defining the T.TABs?
- What is the triggered warning level for each EIS?
- What are the potential consequences in terms of safety of each impact scenario?

3.2.2 Safety upgrading needs

After an evaluation of the safety situation of a learning facility has been carried out, the VISUS methodology provides decision-makers with indicators concerning the potential needs for improving its safety. For this purpose, the VISUS evaluation phase incorporates expert reasoning and the rules and criteria experts adopt to identify and assign actions required to improve the safety of learning facilities. Furthermore, in order to answer the questions of decision-makers (see section 1.1.1), the methodology provides also a first assessment of the potential budget allocation required to implement the suggested measures.

The definition of safety upgrading needs is based on the concept of VISUS as a triage methodology that provides a first assessment of a school in order to suggest interventions (see section 1.1.2 and in particular Figures 1.5 and 1.6). The methodology therefore provides only a preliminary description of the safety upgrading needs. Detailed assessments, including detailed cost evaluations, must be prepared after an in-depth inspection of a school.

In order to provide preliminary information on safety upgrading needs, the methodology estimates the needs as a percentage of the cost necessary for the construction of a new school, called the reference construction school (RCS). The RCS would have the same dimensions and services of the assessed school, but it would be built in accordance with national standards. The percentage is expressed by the index Intensity of Upgrading Actions for School Complex (I^{UAS}). This approach leads to an estimate of the budget potentially required to upgrade the safety of the school. This budget allocation is calculated by multiplying I^{UAS} by the cost of a new school per square metre and by the area of the entire new school (Fig. 3.16).

Fig. 3.16 *Relationship between budget allocation and Intensity of Upgrading Actions for School Complex (I^{UAS}) index.*

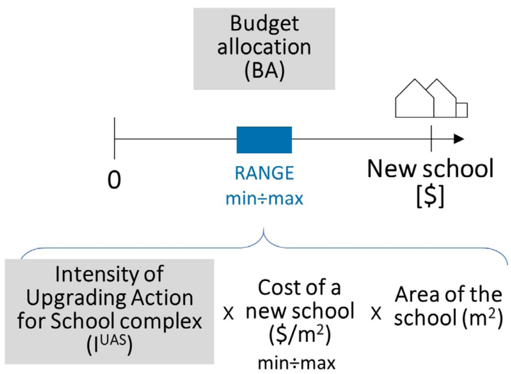
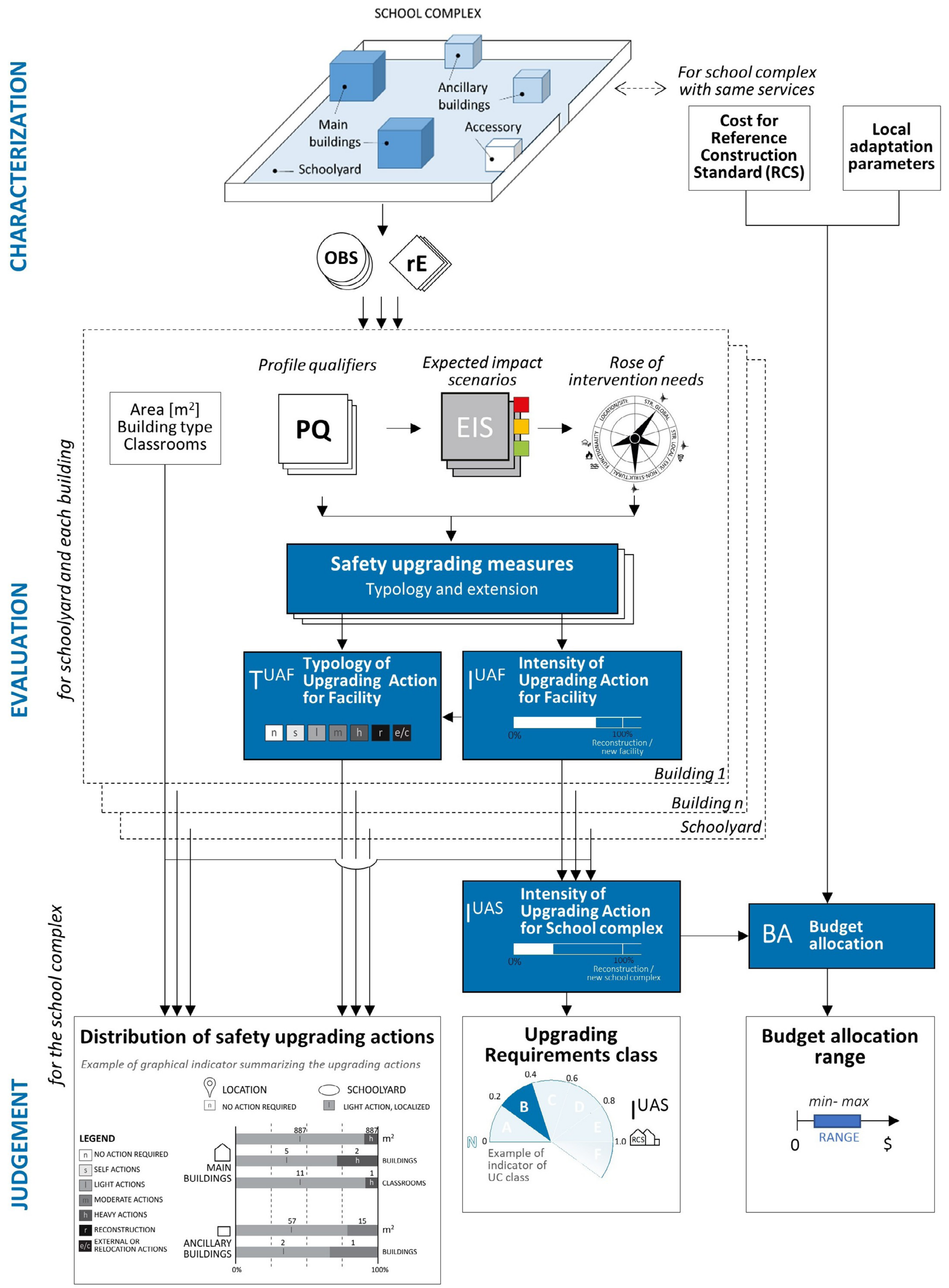


Figure 3.17 shows the framework for evaluating safety upgrading needs. The process provides for the assignment of safety upgrading measures and then uses them to determine the safety upgrading actions and the budget allocation. The framework is described in detail in the following paragraphs.

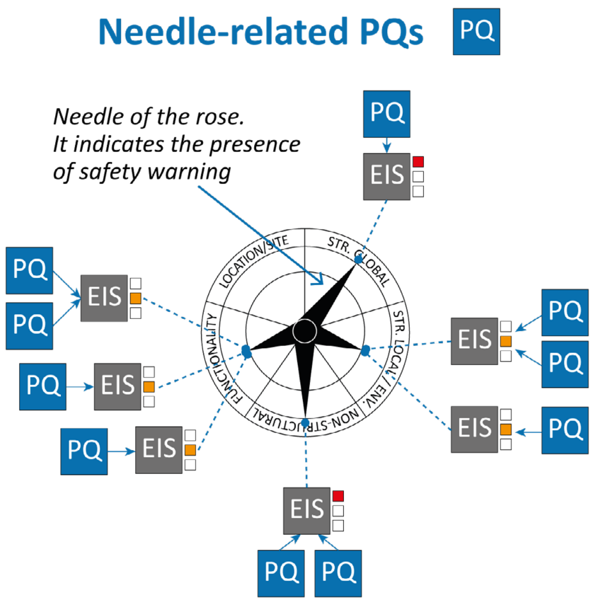
VISUS makes a distinction between measures and actions: measures are technical solutions for removing dangerous situations connected to specific PQs (e.g. 'secure or remove the falling elements'); actions are general approaches to improve the safety in a school's buildings (e.g. 'reconstruction' or 'relocation') and are defined by combinations of measures.

Fig. 3.17 *VISUS framework for evaluating safety upgrading needs*



The characterization of each learning facility and the subsequent evaluation of its safety situation entails assignment of PQs and, considering the PQs, identification of the EIS. Then, in the judgement phase (see section 3.3.1), the EIS are used to determine the rose of intervention needs (also called the warning rose, presented in section 1.1.4 as one of the VISUS safety indicators). Figure 3.18 illustrates how PQs lead to the EIS being defined, which, in turn, lead to the needles in the VISUS rose of intervention needs being assigned. The PQs connected to the needles of the rose, called 'needle-related PQs', are used as the input for evaluating the safety upgrading measures.

Fig. 3.18 *Definition of the profile qualifiers related to the needles of the warning rose ('needle-related PQs')*

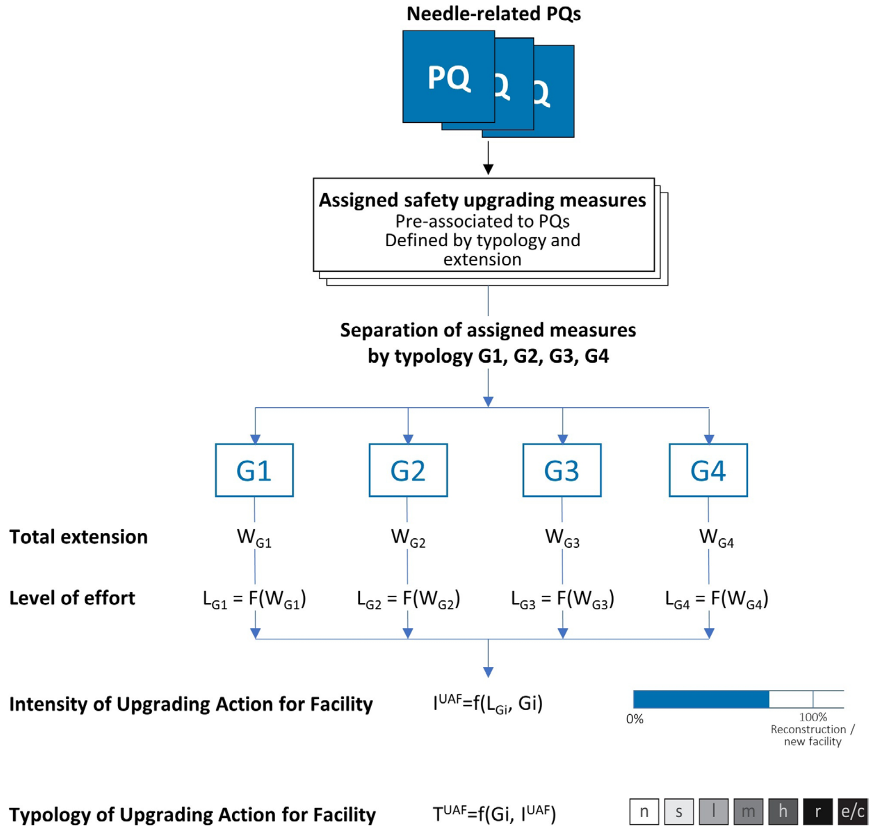


VISUS associates pre-identified safety upgrading measures to each needle-related PQ, giving a specific extension to each measure. All the measures assigned to a specific learning facility are considered together to assign the indices Typology of Upgrading Actions for Facility, T^{UAF}, and Intensity of Upgrading Actions for Facility, I^{UAF} (these indices are assigned to every building and the schoolyard). Figure 3.19 shows how I^{UAF} and T^{UAF} are determined. The algorithm considers the needle-related PQs and assigns the safety upgrading measures. The safety upgrading measures are then grouped by typology. For each typology, the overall extension is calculated by summing the specific extensions of each measure. This allows to estimate the level of effort value for each typology. The values of the level of effort determined for each typology lead to calculation of the I^{UAF} index and to assignation of the T^{UAF} value.

The value of I^{UAF} and the area of each building and of the schoolyard allow I^{UAS} to be calculated (note that I^{UAF} refers to a single building while I^{UAS} refers to the entire school complex). Finally, with I^{UAS} the potential budget allocation can be calculated, given the cost of the RCS, defined in the adaptation phase (see Volume 3, i.e section 2.2). Figure 3.17 shows the outcomes of the judgement phase, which are presented in section 3.3.

The following subsections provide information on I^{UAS} and budget allocation, while the algorithms are presented in Annex AM6.

Fig. 3.19 *Procedure for the determination of the Typology and Intensity of Upgrading Actions for Facility indices for each learning facility*



3.2.2.1 Budget allocation

Definition

The budget allocation is an estimate of the financial resources that would be required to implement the safety upgrading actions in the school complex.

Principles

- The budget allocation should provide an indication of the funds potentially required to implement the safety upgrading actions.
- The budget allocation should not be seen as the cost of the actual interventions required by a school – this cost can be defined only after a detailed technical inspection.

Representation

The budget allocation is indicated as a range of minimum and maximum values, usually using United States dollars as the currency.

Elicitation questions posed to experts for the definition of budget allocation

- Which indicators could be useful for expressing a financial evaluation, considering that the VISUS methodology is based on a triage approach and not on a detailed technical assessment?
- What is the substantial information?
- Which essential parameters influence the calculation of budget allocation?
- How is it possible to reduce, as much as possible, the required information?
- What reference value for calculating budget allocation can be simply provided by all countries?

3.2.2.2 Intensity of Upgrading Actions for School Complex index

Definition

The I^{UAS} index is one of the summary indicators concerning the safety upgrading needs. It expresses the intensity of the actions required to upgrade the safety of the school by comparing the actions with the efforts required to build a new school. The I^{UAS} is expressed as the percentage of the expected efforts for implementing the safety upgrading actions with respect to the efforts required for the construction of a new school. The index usually varies between zero and one, although values larger than one are also possible and indicate that building a new school could require less financial resources.

Principles

- The I^{UAS} index should account for the comprehensive influence of all the measures assigned to each learning facility.
- The value of the I^{UAS} index is less than one when it is expected that it would be more economical to implement the safety upgrading actions in the school than to build a new school.
- The value of the I^{UAS} index is greater than one when it is expected that it would be more economical to build a new school than to implement the safety upgrading actions in the learning facilities.

Representation

The I^{UAS} index is a number, and therefore has no representation. However, it contributes to defining the VISUS graphical indicator upgrading requirements class (see section 3.3.2.3).

Elicitation questions posed to experts for the definition of the I^{UAS} index

- Which indicators could be useful for expressing the intensity of the actions required to upgrade the safety of the school, considering that the VISUS methodology is based on a triage approach and not on a detailed technical assessment?
- How can this index be calculated?
- Which essential parameters influence the calculation of the index?
- How is it possible to reduce, as much as possible, the required information?

3.2.2.3 Safety upgrading actions

Definition

The VISUS safety upgrading actions are general intervention approaches to improve the safety of school buildings and schoolyard.

The VISUS safety upgrading actions are classified in terms of the following requirements:

- **No action.** No action is required to improve safety of the school.
- **Self-actions.** Simple measures for non-structural elements are required to improve safety. The measures could be implemented directly by school personnel or by workers with no specific technical skills. Self-actions do not usually disrupt occupancy or use.
- **Light actions.** One or more safety upgrading measures are required for non-structural elements. The measures are performed incrementally, thus reducing or avoiding disruption to occupancy and use. Light actions are usually carried out by skilled workers and usually do not involve alterations to the structural elements of buildings.
- **Moderate actions.** One or more safety upgrading measures are required for structural elements. The measures are performed incrementally, thus reducing disruption to occupancy and use. Moderate actions usually entail the installation of a small construction site by groups of skilled workers or a small construction company, and normally involve restricted or localized alterations to the structural elements of buildings.
- **Heavy actions.** One or more safety upgrading measures are required for structural elements. All the measures are performed in a single stage and require the disruption of occupancy and use for a certain time period (which could affect school activities). Heavy actions usually entail the installation of a construction site by a large construction company, and normally involve large and heavy alterations to the structural elements of buildings.
- **Reconstruction.** The demolition and reconstruction of a building in accordance with the building standards of the country.
- **Relocation.** The building is suggested to be moved to a safer site. Relocation is suggested in all cases in which the site is unsuitable for school activities.
- **External actions.** A safety upgrade sometimes requires actions to be taken at the location of a school, such as intervention against potential landslides or rockfalls, as well as actions to upgrade the safe transit of children to the school. External actions are not the responsibility of the school, but of competent administrations.

Note. *The choice between relocation and external actions depends on detailed inspections and on the decision-makers' strategies. The two types of action are therefore always presented together, leaving to decision-makers the choice of the most appropriate solution.*

The safety upgrading actions are grouped in the following classes:

- **Restoration self-made.** Actions, which can be simply applied by school personnel or persons with no specific technical skills, to remove or fix unsafe situations usually caused by non-structural elements. This class of action comprises self-actions.

- **Refurbishment.** The act or process of repairing, fixing, restoring or removing unsafe non-structural elements. Refurbishment usually avoids or limits its disruption to occupancy and use. This class of action comprises light actions.
- **Retrofitting.** The process of modifying or repairing the structural system or its parts with new or modified parts. These works have to improve the performance of the building, notably in regard to natural hazards. Retrofitting could disrupt occupancy and use. This class of action comprises moderate and heavy actions.
- **Reconstruction – technical verification.** The action of demolishing an existing building and constructing a new one in the same location. Reconstruction should be applied after detailed technical verification of the structural performance of the existing buildings. This class of action comprises reconstruction.
- **Relocation – site verification.** The action of moving a school to a new location because of threats caused by the current site. Relocation requires detailed site verification for establishing whether relocating the school or intervening in the site-critical situation is the better solution. This class of action comprises relocation and external actions.

Principles

- The identification and assignment of safety upgrading actions are both conducted following the triage approach adopted by the VISUS methodology. Similarly to medical triage, which aims to direct a patient to the proper treatment, not to provide a cure, the VISUS methodology indicates which treatment is needed (upgrading actions).
- The safety upgrading actions make the distinction between the commitment required to implement the measures and the potential disruption to school activities. Retrofit actions can be of two types: incremental or single stage. Generally, incremental action implies a disruption to school activities in limited areas of the school, although for a longer time than single stage actions. Single stage actions imply the disruption to all school activities, even if for a short time.

Representation

The safety upgrading actions are indicated by a letter in a grey shaded square, as shown in Figure 3.20. Darker grey squares imply heavier actions.

Fig. 3.20 *Representation of the safety upgrading actions*

n	NO ACTION REQUIRED
s	SELF ACTIONS
l	LIGHT ACTIONS
m	MODERATE ACTIONS
h	HEAVY ACTIONS
r	RECONSTRUCTION
e/c	EXTERNAL OR RELOCATION ACTIONS

Elicitation questions posed to experts for the definition of the safety upgrading actions

- Which safety upgrading actions are essential?
- How can the safety upgrading actions be defined?
- How can a safety upgrading action be assigned?
- Which substantial measures should be prescribed or suggested in order to improve safety deficiencies?

3.2.2.4 Safety upgrading measures

Definition

Safety upgrading measures are generic descriptions of what to do in order to remove a potentially dangerous situation connected to specific needle-related PQs.

Safety upgrading measures belong to the following groups:

- **Group 0.** Work on the location to protect the school, or relocation of the school to a safer site.
- **Group 1.** Measures concerning non-structural elements, performed directly by school personnel or by workers with no specific technical skills.
- **Group 2.** Measures concerning non-structural elements, usually performed by skilled workers.
- **Group 3.** Restricted or localized work on structural elements, usually entailing the installation of a small construction site by groups of skilled workers or a small construction company.
- **Group 4.** Significant work on structural elements, usually entailing the installation of a construction site by a large construction company.

Principles

- A measure is associated with each needle-related PQ for which it is possible to intervene (e.g. it is usually not possible to intervene for PQs concerning an adverse event, while it is possible to intervene for PQs describing some situations predisposed to potentially dangerous situations).

- Each measure is associated with one or more expected classes of extension (see Annex AM6), that is, to the maximum volume (or surface) of the school potentially related to the measure itself and its realization (e.g. space for site installation).
- Each measure belongs to one or more groups.
- Multiple measures should be combined to assign the final safety upgrading actions to a school. If the same measure is assigned multiple times (e.g. because it is connected to PQs assigned by different hazards), it is computed only once, considering the largest assigned extension class (see the example that follows).
- In the case of multiple measures of the same typology, the total influence is calculated as the sum of all the considered measures. If the total extension of the activated measures exceeds a certain reference value, these measures are considered as a single intervention of more severe typology (see Annex AM6).

Example

Table 3.10 shows an extract from the list of safety upgrading measures in Annex AM6.

As an example, if the E-RN-E2 (potential falls of elements, internal, widespread and causing potentially severe consequences, related to earthquake; blue in Table 3.10) and A-RN-E4 (potential falls of elements, internal, widespread and causing potential difficulties, related to air hazard; blue in Table 3.10) are assigned, then the measure 'Confirm the stability of non-structural elements and eventually stabilize, remove or replace them' is assigned only once, having a limited influence on the school building related to the measure.

Table 3.10 *Extract from the list of VISUS safety upgrading measures*

Measure	Group	Needle-related profile qualifiers	Extension
Confirm the stability of non-structural elements and eventually stabilize, remove or replace them	Group 1	U-RN-E1: *DANGERS* OBJECTS OR ELEMENTS COULD FALL WITH CONSEQUENT DIFFICULTIES U-RN-E2: *DANGERS* OBJECTS OR ELEMENTS COULD FALL WITH CONSEQUENT SEVERE CONSEQUENCES	Limited
	Group 1	E-RN-E1: *POTENTIAL FALL OF ELEMENTS* INTERNAL, LOCALIZED, SEVERE A-RN-E1: *POTENTIAL FALL OF ELEMENTS* INTERNAL, LOCALIZED, SEVERE CONSEQUENCES	Localized
Confirm the stability of non-structural elements and eventually stabilize, remove or replace them	Group 2	E-RN-E3: *POTENTIAL FALL OF ELEMENTS* INTERNAL, LOCALIZED, DIFFICULTIES A-RN-E3: *POTENTIAL FALL OF ELEMENTS* INTERNAL, LOCALIZED, DIFFICULTIES A-RN-E5: *POTENTIAL FALL OF ELEMENTS* EXTERNAL, LOCALIZED, SEVERE CONSEQUENCES	Localized
	Group 2	E-RN-E2: *POTENTIAL FALLS OF ELEMENTS* FALLS, INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES E-RN-E4: *POTENTIAL FALL OF ELEMENTS* INTERNAL, WIDESPREAD, DIFFICULTIES E-RN-E9: *POTENTIAL FALL OF ELEMENTS* EXTERNAL, WIDESPREAD, SEVERE A-RN-E2: *POTENTIAL FALL OF ELEMENTS* INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES A-RN-E4: *POTENTIAL FALL OF ELEMENTS* INTERNAL, WIDESPREAD, DIFFICULTIES A-RN-E6: *POTENTIAL FALL OF ELEMENTS* EXTERNAL, WIDESPREAD, SEVERE CONSEQUENCES	Limited

Elicitation questions posed to experts for the definition of the safety upgrading measures

- Which generic measures should be applied in order to upgrade safety, considering the potential dangers linked to the VISUS PQs (noting that a measure could be associated with multiple PQs)?
- How can each measure be described in a general way?
- Which needle-related PQs are associated with each measure?
- What is the class of extension of the identified measures?
- What is the typology of each measure?

3.2.3 Status

The VISUS methodology evaluates the status of each school building, of the schoolyard, and of the school complex. This status is an important integrative element of information that the decision-maker could and should take into account for evaluating whether it is opportune or not to proceed with the safety upgrading actions or with a new construction.

Definition

Status considers the condition of a structure as well as the situation regarding specific conditions or services of the school.

School buildings are identified during the survey and from their characteristics, they are assigned one of the following status conditions:

- Temporary building: the structure is conceived to be used for a limited number of years (approximately less than 10).
- Semi-permanent building: the structure is built on a permanent site and has foundations. Generally, the ground floor and the foundations of the building are permanent, while the structures in elevation (e.g. walls, roof) are usually temporary.
- Permanent building: the structure is built to last for more than 10 years and is built on a permanent site.

Logical rules have been adopted to evaluate the status conditions of the quality conditions of each building (and of the entire school complex), considering:

- **Accessibility.** An evaluation of the possibility of people with mobility impairments attending the school. The OBS require identification of the presence of mobility barriers in the schoolyard or in the buildings and the presence of services for people with disabilities.
- **Water and sanitation.** An evaluation of the main conditions related to hygiene, considering the presence and the quality of water and the type of sanitation system, both in the schoolyard and in the buildings.
- **Contents/equipment.** An evaluation of the presence and of the quality of furnishings, equipment and materials.
- **Maintenance.** An evaluation of whether the school is kept in a suitable condition, through scheduled or unscheduled interventions aimed at conserving as close to, and for as long as possible its original condition, while compensating for normal physical deterioration caused by age, use and weather.
- **Comfort.** An evaluation of the presence of conditions that could hinder student attendance in classes or conversely, conditions that contribute to a feeling of well-being.
- **Security.** An evaluation of the security conditions of the school, assessing the protection of students from external dangers.

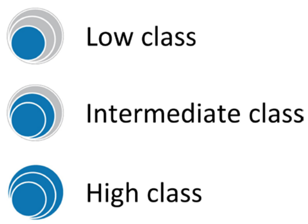
Principle

- Status outcomes should be able to be correlated with the outcomes of other assessment approaches that have a different level of detail (e.g. Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, WHO/UNICEF, 2019).

Representation

The status conditions are classified into three classes (Fig. 3.21), and assigned using logical rules applied to the characterized status OBS. The rules and criteria adopted for the status evaluation are detailed in Annex AM7.

Fig. 3.21 *Representation of the status classes*



Elicitation questions posed to experts for the definition of status

- How necessary is it to differentiate buildings in accordance with their construction characteristics?
- Which status conditions should be taken into account to provide decision-makers with useful information?
- How can the status conditions be classified?

3.3 Judgement phase

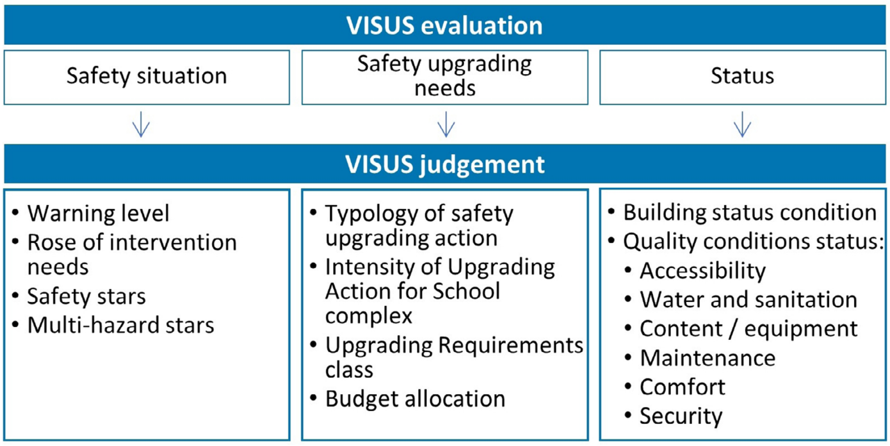
VISUS provides decision-makers with indicators and reports that support them in defining strategies for the safety upgrading of a large number of learning facilities.

The judgement phase of the VISUS methodology aims at summarizing the outcomes of the expert reasoning process in terms of:

- Safety situation
- Safety upgrading needs
- Status

Figure 3.22 summarizes the outcomes of the VISUS judgement phase for each of these aspects of evaluation.

Fig. 3.22 *Outcomes of the VISUS judgement phase*



VISUS uses a specific language to communicate the results of evaluation efficiently to the end users (mainly public administrators and decision-makers who do not necessarily have a technical background). In order to allow a synthesized visualization of the outcomes, the VISUS methodology adopts a set of graphical indicators. The VISUS outcomes are reported with reference to the following indicators.

The indicators for the safety situation are:

- **Warning level**, which expresses the level of concern of the safety judgement
- **Warning rose** (or rose of intervention needs), which reports on the situation by distinguishing the safety judgements in accordance with the five VISUS safety issues
- **Safety stars**, a global judgement of the safety situation for each hazard
- **Multi-hazard safety stars**, an overall safety performance indicator which provides an overall safety evaluation considering all hazards, and also synthesises the safety assessments for each hazard so that it is possible to determine for which hazard there is a lack of safety

The indicators for the safety upgrading needs are:

- **Safety upgrading actions**, which identify quickly the main action typology suggested in order to improve safety conditions
- **I^{UAS} index**, which defines the value of the intensity of the action required to upgrade the safety of the school by comparing it with the effort required to build a new school
- **Upgrading requirements class**, which highlights the class of the I^{UAS} index with respect to the reconstruction of the school complex
- **Budget allocation**, which provides values for the range of the potential budget allocation for safety upgrading

The indicators for the status are:

- **Building conditions**, which illustrate the general condition of the school buildings
- **Quality conditions** (i.e. accessibility, water and sanitation, contents/equipment, maintenance, comfort and security), which classify the quality conditions of the school

The VISUS graphical indicators synthesize the judgements on the safety of each learning facility or group of facilities (i.e. a school usually comprises multiple facilities in the same area and in this case a judgement is provided both for the entire school complex and for each facility). Furthermore, the indicators distinguish between the judgements for each hazard and for each main safety issue, and they address the safety upgrading needs for each school.

Furthermore, the indicators address the necessary interventions for each school. The indicators facilitate the definition of a list of priorities for risk reduction actions that are in accordance with political and administrative criteria. At the same time, the graphical indicators help present a clear view of the overall scenario.

The VISUS outcomes are finally summarized in VISUS assessment reports, namely:

- **Individual reports** for each school assessed
- A **collective report** for the set of schools assessed in a country, region or district (or assessed as part of a specific project)

All the outcomes and reports are geolocated and can be visualized on a map – the VISUS web map. The reports and map constitute the reporting phase of the VISUS implementation process.

In the following subsections, brief overviews of the VISUS graphical indicators are presented, while the VISUS reports and maps are described in Volume 3, sections 5.2, 5.3 and 5.4.

3.3.1 Safety situation judgements

3.3.1.1 Warning level

The warning level expresses the level of concern in terms of potential negative consequences for personal safety, using a symbol that visually recalls the acoustic level of a siren and traffic-light colours (green, orange and red) to highlight the severity of the concern (Table 3.11). The meaning of the colours is in line with the VISUS warning levels shown in Table 3.3.

Table 3.11 *VISUS warning levels: code, graphical indicator (symbol) and description*

Code	Symbol	Description
WL0		No concerns for personal safety
WL1		Potential difficulties for personal safety
WL2		Potentially severe consequences for personal safety

3.3.1.2 Warning rose

The warning rose summarizes in a graphical indicator the main critical situations of the building assessed in accordance with the evaluation of the five VISUS safety issues (i.e. location/site, structural global, structural local/envelope, non-structural and functionality).

The warning rose synthesizes the judgements on the five safety issues by associating a warning needle with each of them. The length of each needle identifies the warning level (see section 3.3.1.1):

- No needle (WL0): no concerns for personal safety
- Short needle (WL1): potential difficulties for personal safety
- Long needle (WL2): potentially severe consequences for personal safety

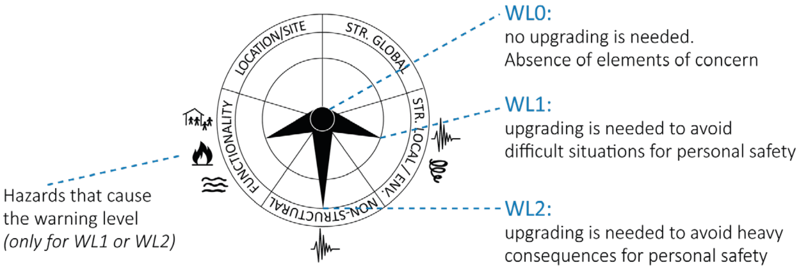
The indicator is also called the rose of intervention needs because the needles point out where (which safety issue) the priority safety upgrading interventions are. For example, for a building, one or more needles in the rose indicate the presence of safety warnings, while a rose without needles means that the building has achieved the safety goal and no intervention is required. A symbol reported close to the safety issue name (outside the rose) indicates the hazard/s causing the maximum level of warning (hazards are not reported in the case of no concerns).

The warning rose could refer to a single learning facility (building, schoolyard) or to an entire school complex. When the rose refers to a school complex, it is assigned considering the worst cases of the rose of each school building and of the schoolyard.

Figure 3.23 shows an example of a warning rose. Supposing that the rose refers to a school building, it is interpreted as follows:

- With regard to the location/site and structural global safety issues, there are no concerns for the building
- With regard to the structural local/envelope safety issue, there could be scenarios of difficulties for personal safety in the case of earthquake and air hazards
- With regard to the non-structural safety issue, there could be scenarios of severe consequences for personal safety in the case of earthquake hazard
- With regard to the functionality safety issue, there could be scenarios of difficulties for personal safety in the case of ordinary use and of fire and water hazards

Fig. 3.23 *Example of a VISUS warning rose (rose of intervention needs)*



3.3.1.3 Safety stars

A global judgement of the safety situation is synthesized by the assignment of the safety stars. The concept behind the safety stars is similar to the ones adopted in other situations where a comprehensive judgement on quality is required (e.g. hotel rating).

At the end of the assessment, stars are assigned when specific requirements are satisfied. The stars are assigned progressively, in accordance with the following performance criteria:

- No star assigned: unsuitable site
- First star assigned: suitable site – there are no severe natural or human-induced threats affecting the site where the school is located
- Second star assigned: stability of the building (no WL2 for the structural global safety issue) – the global collapse of the building is very unlikely considering the adverse action defined in the reference events
- Third star assigned: life safeguard (no WL2 for all safety issues) – there are no critical situations with potentially severe consequences for personal safety (no collapse or critical fall of non-structural elements)
- Fourth star assigned: rapid resumption of operations (no WL1 for the structural global and local safety issues) – there are only criticalities that could lead to difficulties for personal safety (no diffuse damage)
- Fifth star assigned: immediately operational (no WL1 for all safety issues) – after an event, it is possible to immediately use the school without interventions

Figure 3.24 summarizes these criteria and shows the VISUS safety stars. Note that the stars are yellow and that they have a different layout than the VISUS multi-hazard safety stars in order to avoid potential confusion between the two.

Fig. 3.24 *VISUS safety stars: indicators and criteria for their assignment*

The meaning associated with the VISUS safety stars is strictly related to the expected consequences. Table 3.12 associates the requirement for obtaining each star, the expected consequence and the performance objectives, as defined by FEMA (2010).

Table 3.12 *Association of the VISUS safety stars with the performance objectives of FEMA (2010)*

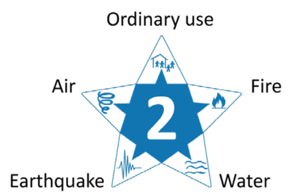
Requirements for VISUS safety stars	Expected consequences	FEMA P-424 performance level
Unsuitable site 	Serious problems with the location. The school should be relocated or actions performed at the site.	–
Suitable site 	The school buildings could collapse. The site is acceptable, but buildings after an event should probably be demolished.	–

Requirements for VISUS safety stars	Expected consequences	FEMA P-424 performance level
Stability of the building ★★☆☆☆	Severe structural and non-structural damage. After an event, the buildings are not repairable.	Collapse prevention
Life-safeguard ★★★☆☆	Significant damage to structural elements, but no collapse of large debris. After an event the buildings will probably require extensive interventions.	Life safety
Rapid resumption of operations ★★★★☆	Concerns arising from non-structural elements or from functional aspects of the school. Delay to school activities during the repairs.	Immediate occupancy
Immediately operational ★★★★★	No concerns. The school can be used during an event or immediately after it.	Immediately operational

3.3.1.4 Multi-hazard safety stars

The VISUS multi-hazard safety stars indicator summarizes the outcomes of the VISUS safety stars assigned to each hazard – each point of the star represents a hazard (Fig. 3.25).

Fig. 3.25 *VISUS multi-hazard safety star: identification of the hazards for each point of the summary star*



Using the multi-hazard safety stars, the multi-hazard safety assessment of a school can be made using the definition of the safety star of each hazard (Fig. 3.24). The indicator allows the safety level of the school for each hazard to be quickly grasped.

The indicator is assigned both to a single learning facility and to the school complex.

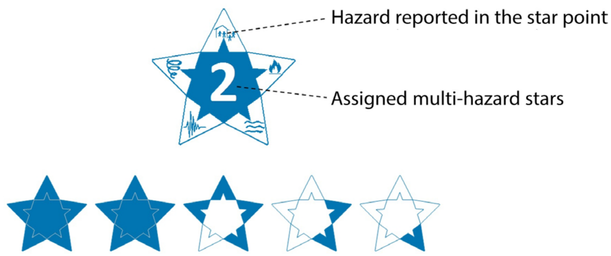
A VISUS multi-hazard safety star is assigned when all the points of the summary stars are 'turned on'.

Figure 3.26 shows an example of the VISUS multi-hazard safety stars. Supposing that the indicator refers to a school complex, the image is interpreted as follows:

- The school has an overall evaluation of two stars (i.e. stability of the buildings)
- The number of stars for each hazard is:
  - Three stars for ordinary use
  - Four stars for fire hazard
  - Five stars for flood hazard
  - Two stars for earthquake hazard
  - Three stars for air hazard

Another interpretation of the VISUS multi-hazard safety stars is made by looking at what to do to reach a pre-defined level. For example, in Figure 3.26, intervention in the problems related to the earthquake hazard would be sufficient to reach the overall level of three stars (the performance level of life safety).

Fig. 3.26 *Example of VISUS multi-hazard safety stars: the upper part of the figure shows the summary star; the bottom part shows an example of VISUS multi-hazard safety stars summarizing the outcomes for each hazard*



3.3.2 Safety upgrading needs judgements

3.3.2.1 Safety upgrading actions

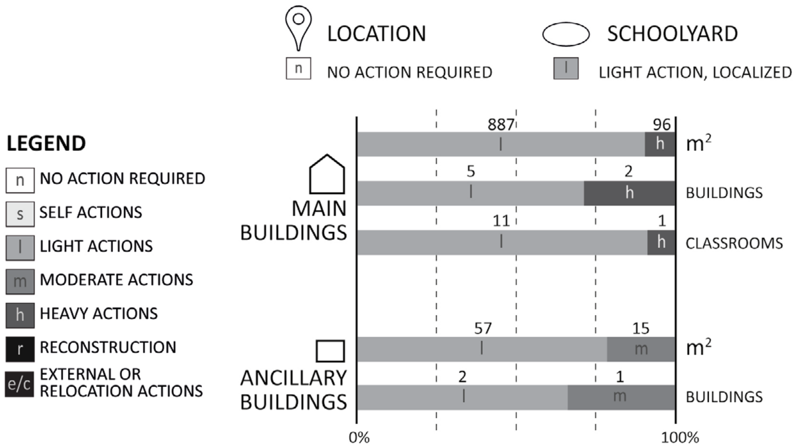
The required safety upgrading actions are indicated through a grey-scale shaded box with a letter signifying the name of the action. Table 3.13 illustrates the symbols adopted for identifying the different safety upgrading actions (see also section 3.2.2.3). The safety upgrading actions are also divided according to the classes of Table 3.13.

Table 3.13 *VISUS safety upgrading actions and their adopted symbols*

Symbol	Name	Description	Class
n	No action required	No action is required to improve safety of the school	No class
s	Self-actions	Simple measures for non-structural elements are required to improve safety. The measures could be implemented directly by school personnel or by workers with no specific technical skills. Self-actions do not usually disrupt occupancy or use	Restoration self-made
l	Light upgrading actions	One or more safety upgrading measures are required for non-structural elements. The measures are performed incrementally, thus reducing or avoiding disruption to occupancy and use. Light actions are usually carried out by skilled workers and usually do not involve alterations to the structural elements of buildings	Refurbishment
m	Moderate upgrading actions	One or more safety upgrading measures are required for structural elements. The measures are performed incrementally, thus reducing disruption to occupancy and use. Moderate actions usually entail the installation of a small construction site by groups of skilled workers or a small construction company, and normally involve restricted or localized alterations to the structural elements of buildings	Retrofitting
h	Heavy upgrading actions	One or more safety upgrading measures are required for structural elements. All the measures are performed in a single stage and require the disruption of occupancy and use for a certain time period (which could affect school activities). Heavy actions usually entail the installation of a construction site by a large construction company, and normally involve large and heavy alterations to the structural elements of buildings	
r	Reconstruction	The demolition and reconstruction of a building in accordance with the building standards of the country	Reconstruction – technical verification
c	Relocation	The building is suggested to be moved to a safer site. Relocation is suggested in all cases in which the site is unsuitable for school activities	Relocation – site verification
e	External upgrading actions	A safety upgrade sometimes requires actions to be taken at the location of a school, such as intervention against potential landslides or rockfalls, as well as actions to upgrade the safe transit of children to the school. External actions are not the responsibility of the school, but of competent administrations	

Figure 3.27 shows an example of indicator illustrating the distribution of the upgrading actions among the components of a school complex. The indicator showing the required safety upgrading actions for the school complex is a bar graph, where the width of the bars refers to how extensive the required actions are considering three parameters: (i) the buildings area (m^2); (ii) the number of buildings to which the action is assigned; and (iii) the number of classrooms affected by the action (this value is calculated by considering the number of classrooms in each building and assigning the action to all the classrooms in the building). The entire width corresponds to all the learning facilities. The interventions for the schoolyard and those external to the school complex are shown at the top of the figure.

Fig. 3.27 *Example VISUS indicator for the upgrading actions assessed for a school complex*



The creation of the safety upgrading actions graphical indicator requires the following data:

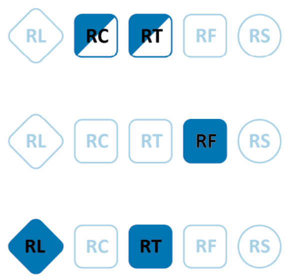
- The type of upgrading actions assigned to the location
- The type of upgrading actions assigned to the schoolyard
- The area of the schoolyard
- The type (main or ancillary) of the building
- The area and the number of classrooms in each building
- The type of upgrading actions assigned to each building

All the above elements are illustrated in Annex AM6.

The class(es) of safety upgrading actions is assigned only to the school complex and depends on the safety upgrading actions assigned to the location, schoolyard and school buildings (main and ancillary). Figure 3.28 shows the indicator used to represent the class(es) of safety upgrading actions, and its relative legend.

Fig. 3.28 *Examples of the VISUS indicator for the upgrading action class and legends for symbols and filling*

Examples:



Meaning of icon symbols:

Icon	Name
RL	Relocation - site verification
RC	Reconstruction - technical verification
RT	Retrofitting
RF	Refurbishment
RS	Restoration self-made

Meaning of icon filling:

Filling	Meaning
Filled	Filled icon: class of action required for all (or almost all) facilities
Half-filled	Half-filled icon: class of action required by some facilities
Empty	Empty ligth-blue icon: class of action not required or already included in the other required classes

3.3.2.2 Intensity of Upgrading Actions for School Complex index

The value of the I^{UAS} index is simply represented by a number.

3.3.2.3 Upgrading requirements class

The graphical indicator for the upgrading requirements class (Fig. 3.29) represents the value of the I^{UAS} index in seven classes, according to the values assigned in Table 3.14. The letter 'N' refers to the case in which no action is required, and RCS refers to the case in which complete reconstruction of the school complex is required, with the cost being equal to the cost of constructing a new school (the RCS) in accordance with national building standards.

Fig. 3.29 *VISUS upgrading requirements class indicator*

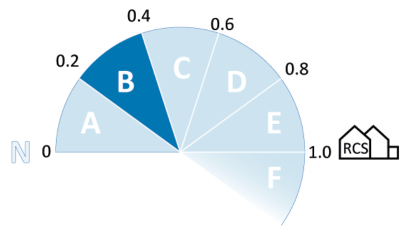


Table 3.14 *Range of the VISUS upgrading requirements classes*

Value of the Index of Intensity of Upgrading Actions for School Complex	Class name
0	N
> 0.0 and ≤ 0.2	A
> 0.2 and ≤ 0.4	B
> 0.4 and ≤ 0.6	C
> 0.6 and ≤ 0.8	D
> 0.8 and ≤ 1.0	E
> 1.0	F

3.3.2.4 Budget allocation

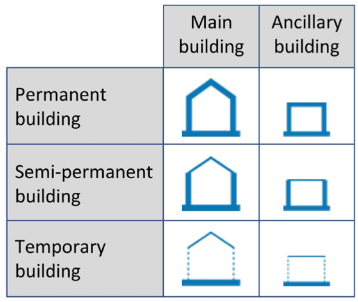
The budget allocation is expressed by the minimum and maximum values identified by the evaluation rules (see section 3.2.2.1). The values are usually expressed in thousands of United States dollars, however, local currency can also be used.

3.3.3 Status judgements

3.3.3.1 Building conditions

Figure 3.30 illustrates the symbols adopted to represent the building conditions (permanent, semi-permanent or temporary, see section 3.2.3), both for main and ancillary buildings.

Fig. 3.30 *VISUS indicators for building conditions*



3.3.3.2 Quality conditions

The status of quality conditions concerns accessibility, water and sanitation, contents/equipment, maintenance, comfort and security. For each of these aspects of conditions at a school, a pictogram assigns the level of quality as one of three classes – low, intermediate or high. Table 3.15 shows the association of each pictogram with its corresponding meaning.

Table 3.15 *VISUS indicators for quality conditions*

Status name and icon	Pictogram	Description of meaning
Accessibility (usability)	NOT ACCESSIBLE	People with mobility impairments are not able to attend the school
	PARTIALLY ACCESSIBLE	People with mobility impairments have partial access to the school and to basic services
	ACCESSIBLE	People with mobility impairments have full access to the school and the school services
Water and sanitation	POOR	Poor water and sanitation conditions; absence of drinking water
	BASIC	Basic water and sanitation conditions; presence of drinking water
	GOOD	Good water and sanitation conditions; hygiene is guaranteed
Content / equipment	POOR	Minimal educational equipment, very poor contents
	BASIC	Intermediate contents
	HIGH TECH	High-tech contents

Status name and icon	Pictogram	Description of meaning
Maintenance	POOR	Evidence of poor maintenance and/or unrepaired damage in most of the main buildings
	BASIC	Intermediate conditions
	GOOD	All the school buildings (both main and ancillary) have good maintenance conditions
Comfort	POOR	Some students attend classes with uncomfortable conditions
	BASIC	Intermediate comfort conditions
	GOOD	Good comfort conditions
Security	UNCONTROLLED OR UNLIMITED ACCESS	Access to the schoolyard and/or buildings is not controlled or limited: anyone can enter the school
	LIMITED ACCESS	No access control, but access to the school is limited by fences
	CONTROLLED ACCESS	Access to the schoolyard and buildings is controlled

3.3.4 Use of the judgements for supporting the definition of safety upgrading strategies

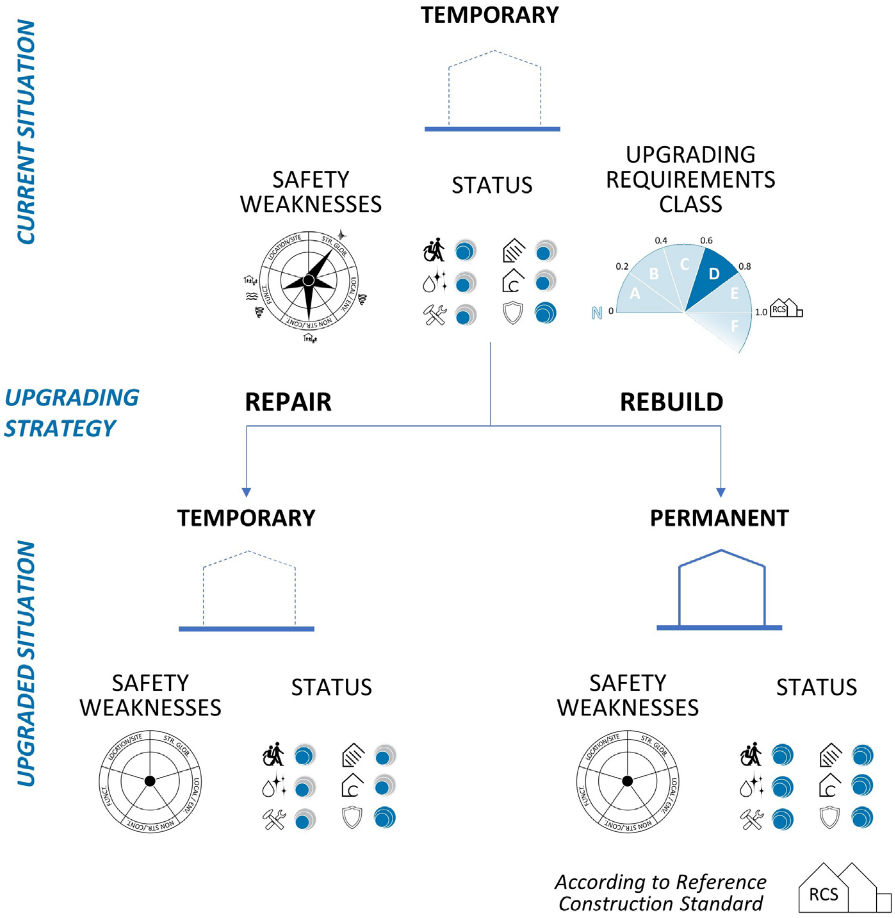
The VISUS safety indicators expressing the judgements are essential for making the outcomes of the VISUS assessments comprehensible. The graphical indicators have been developed to support decision-makers in defining risk mitigation policies and consequently safety upgrading strategies. These strategies depend on many elements of information, and their development requires the simultaneous consideration of all the indicators expressing the judgements.

Decision-makers should consider the safety condition of the school, the safety upgrading needs, and, in particular, an estimate of the required budget allocation. At the same time, they need to know whether it is worth intervening in the school buildings or if it would be better to reconstruct them – for this purpose the status judgements of the school should be considered jointly with the other judgements.

Figure 3.31 shows an example of how the VISUS indicators are used for defining safety upgrading strategies. The example considers a school comprising one temporary building. The school has specific safety weaknesses (summarized in the warning rose) that require safety upgrading measures with an I^{UAS} index that corresponds to upgrading requirements class ‘D’ (between 60 and 80 per cent of the cost of a new construction). The school has generally poor status judgements. Using this information, decision-makers could decide whether it is appropriate to plan heavy actions or the reconstruction of the building, considering that both solutions remove the safety weaknesses. However, reconstruction would be done in accordance with the RCS, that is, a permanent school would be built with the quality conditions of a new construction. Repair strategies would only remove the safety issues without improving the status situation.

VISUS provides decision-makers with elements of information that support decision-making, without directly prioritizing schools. A prioritization in accordance with decision makers’ defined safety upgrading strategies can however be done using the VISUS indicators.

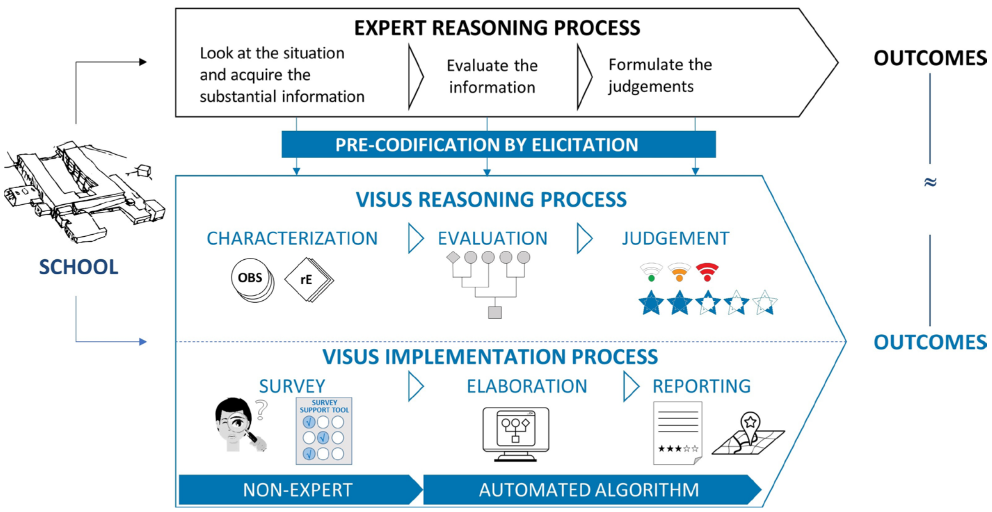
Fig. 3.31 *Example of the use of the VISUS safety indicators to define safety upgrading strategies*



4. VISUS METHODOLOGY CONCLUDING OVERVIEW

The VISUS methodology is used to carry out a multi-hazard safety assessment of schools in order to define safety upgrading strategies. VISUS aims at reproducing the expert reasoning process by pre-codifying the three main phases of the methodology: characterization, evaluation and judgement. The pre-codified information is subsequently adopted in the implementation phases of the methodology: survey, elaboration and reporting, which roughly correspond to characterization, evaluation and judgement, respectively (Fig. 4.1). The pre-codification of expert reasoning and the definition of implementation phases mean that the assessment process can be divided into two steps. The first – acquisition of the substantial elements – is carried out by non-experts, and the second – production of the final indicators and reports for decision-makers – is automated using algorithms that replicate expert judgement.

Fig. 4.1 *VISUS methodology for decision-making support, from observation to outcomes*



In the characterization phase, the substantial elements that a surveyor will require during the survey phase are identified. These substantial elements are the essential information that experts consider fundamental for evaluating a school's safety. The evaluation rules and criteria are applied by algorithms in the elaboration phase. Finally, in the reporting phase, algorithms based on the safety judgements defined by experts create the VISUS reports, which summarize the outcomes of the VISUS process.

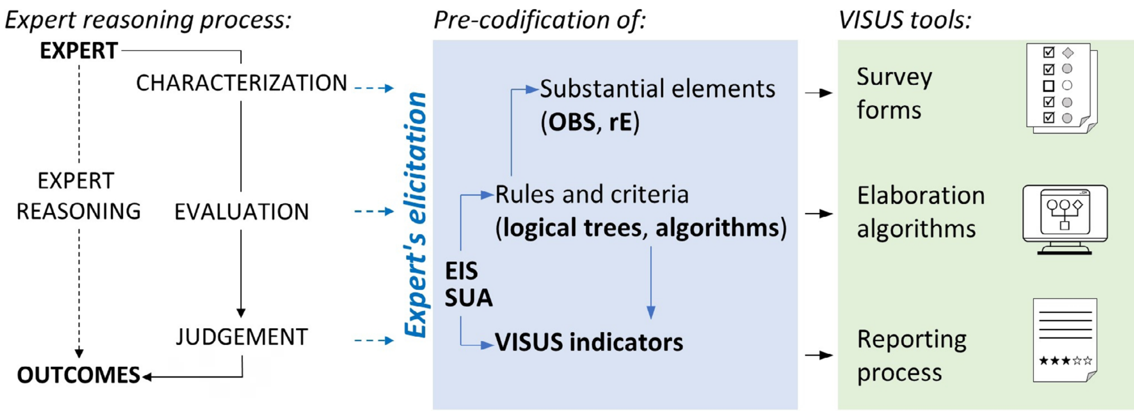
The main features of the VISUS methodology are that:

- It is derived from the elicitation of expert knowledge
- It can be implemented by the systematic collection of inputs carried out by non-experts followed by automated processing of the data collected

Figure 4.2 depicts in more detail how the elicitation of expert knowledge enables to pre-codify the EIS, and the safety upgrading actions. For these elements, rules and criteria for the evaluation are defined (as logical trees and algorithms), as are the substantial elements (OBS and rE) and the VISUS safety indicators for expressing the judgements. Pre-codification allows a set of VISUS tools to be used for the implementation of the VISUS methodology. The tools are the VISUS survey forms, the elaboration algorithms and the reporting algorithms.

The outcomes of the VISUS methodology support decision-makers in defining safety upgrading strategies.

Fig. 4.2 *VISUS methodology for decision-making support, from expert reasoning to VISUS tools*



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Annex to the VISUS Methodology

| AM1 Evaluation Criteria: Ordinary Use

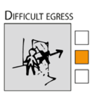
Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

1. EXPECTED IMPACT SCENARIOS

Table 1.1 lists the substantial expected impact scenarios identified for ordinary use evaluated with the Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology. The VISUS logical trees for ordinary use do not include the branch concerning adverse action. Considering that in the case of ordinary use the building 'acts' as the triggering hazard, the potential critical scenarios are always considered as triggered.

Table 1.1 *Expected impact scenarios for ordinary use*

Safety issue	Icon	Name	Where	Description
Location/site critical issues		Unsuitable location	Schoolyard and buildings	The location is unsuitable for school.
		Difficult reachability	Schoolyard	The school is difficult to reach. The path to the school is not safe for students and staff.
Structural global critical issues		Structural collapse	Buildings	Presence of very poor structural conditions that suggest the possibility of global or local collapse of the structure, even during ordinary use.
		Structural warning	Buildings	The condition of the structure warns of potential safety problems, especially if it is neglected.
Structural local/envelope critical issues		Falls of people	Schoolyard and buildings	Presence of conditions under which people could fall from high places, with potentially severe consequences.
		Tumbles or bumps	Schoolyard and buildings	Situations in which people could tumble or bump into protruding elements.
Non-structural critical issues		Non-structural failures – severe consequences	Buildings	Presence of conditions that could cause falls of non-structural elements. This scenario could have severe consequences for personal safety.
		Non-structural failures – difficulties	Buildings	Presence of conditions that could cause falls of non-structural elements. This scenario could present difficulties for personal safety.
		Dangerous contacts – severe consequences	Schoolyard and buildings	Presence of conditions that could have severe consequences for personal safety, such as electrocution, because of dangerous contacts.
		Dangerous contacts – difficulties	Schoolyard and buildings	Presence of conditions that could cause difficulties for personal safety because of dangerous contacts, for example, with dangerous animals or with objects at high temperature.
Functionality critical issues		Difficult egress	Buildings	Presence of conditions that could cause difficulties for personal safety when leaving the school facilities, such as obstacles to egress.
		Discomfort, unease	Schoolyard and buildings	Presence of conditions that could cause difficulties for personal safety because of the existence of discomforts in the spaces the school students and staff use.

2. LOGICAL TREES

The VISUS logical trees define the substantial elements and the rules and criteria that correspond to the definition of the expected impact scenarios.

2.1 Logical trees for the schoolyard

Fig. 2.1 *Ordinary use: expert logical tree for the 'Unsuitable location' impact scenario*

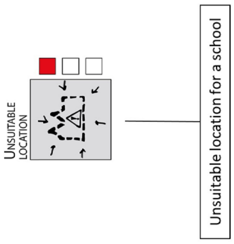


Fig. 2.2 *Ordinary use: evaluation logical tree for the 'Unsuitable location' impact scenario*

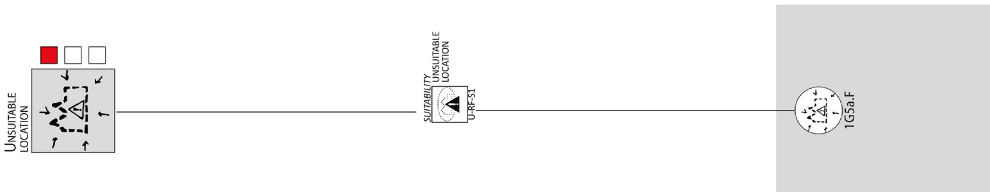


Fig. 2.3 *Ordinary use: expert logical tree for the 'Difficult reachability' impact scenario*

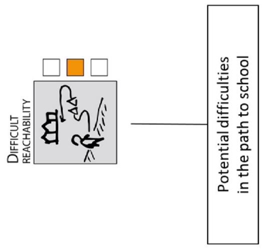


Fig. 2.4 *Ordinary use: evaluation logical tree for the 'Difficult reachability' impact scenario*

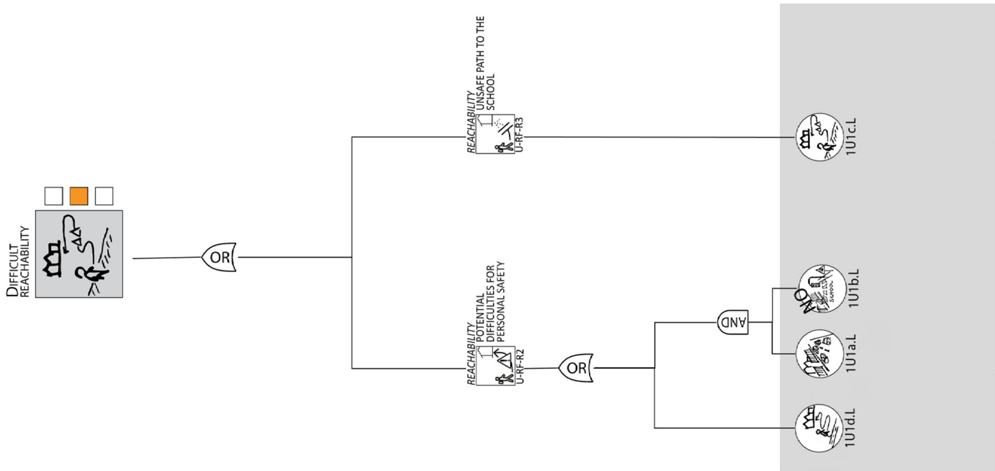


Fig. 2.5 *Ordinary use: expert logical tree for the 'Falls of people' impact scenario*

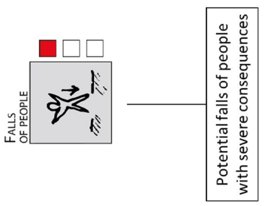


Fig. 2.6 *Ordinary use: evaluation logical tree for the 'Falls of people' impact scenario*

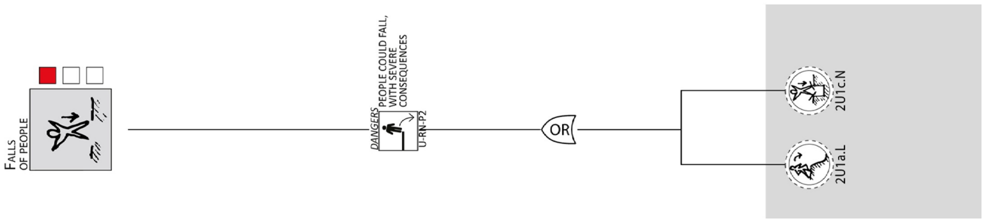


Fig. 2.7 *Ordinary use: expert logical tree for the 'Tumbles or bumps' impact scenario*

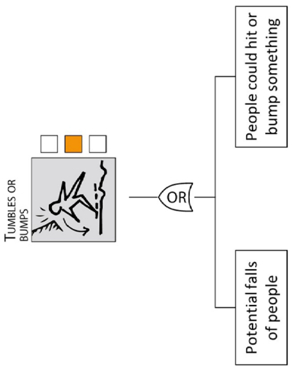


Fig. 2.8 *Ordinary use: evaluation logical tree for the 'Tumbles or bumps' impact scenario*

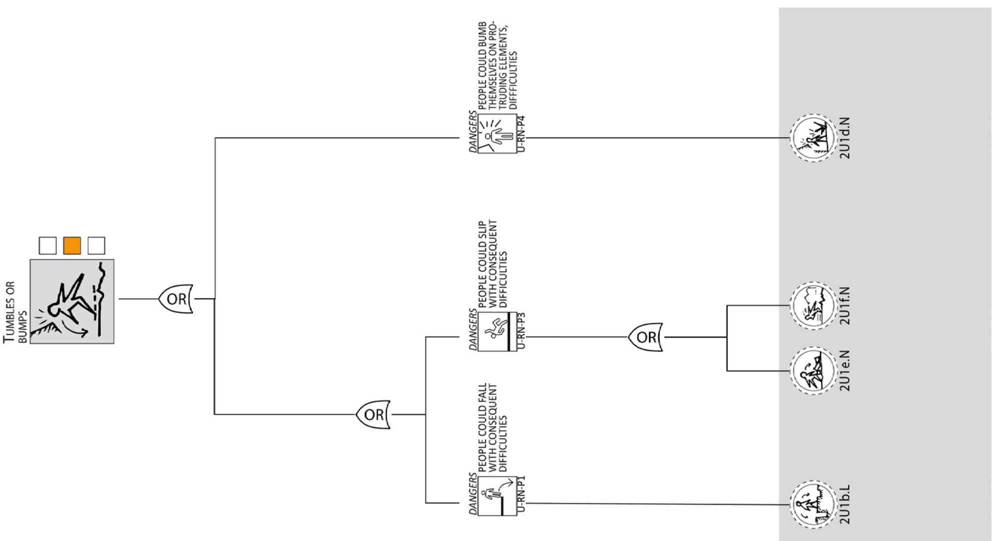


Fig. 2.9 *Ordinary use: expert logical tree for the 'Dangerous contacts – severe consequences' impact scenario*

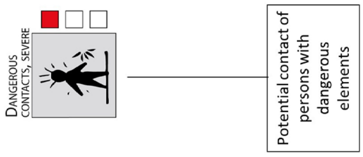


Fig. 2.10 *Ordinary use: evaluation logical tree for the 'Dangerous contacts – severe consequences' impact scenario*

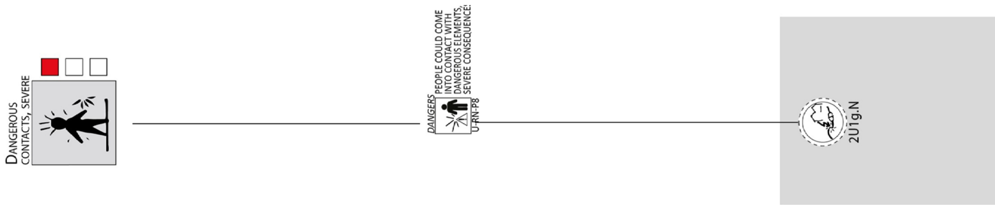


Fig. 2.11 *Ordinary use: expert logical tree for the 'Dangerous contacts – difficulties' impact scenario*

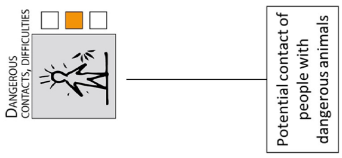


Fig. 2.12 *Ordinary use: evaluation logical tree for the 'Dangerous contacts – difficulties' impact scenario*

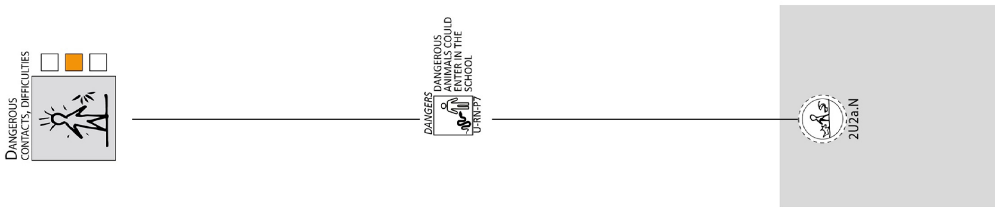


Fig. 2.13 *Ordinary use: expert logical tree for the 'Discomfort, unease' impact scenario*

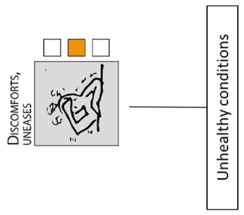
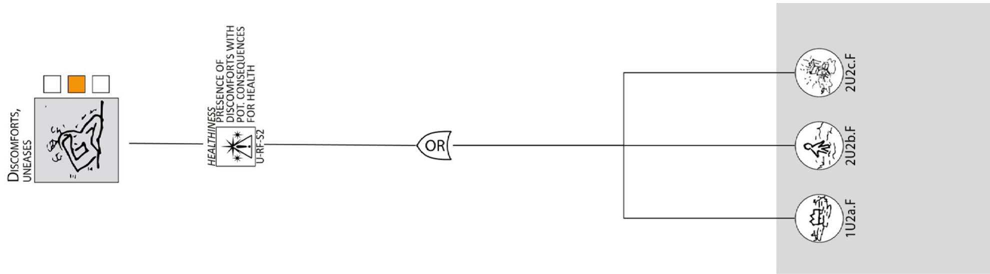


Fig. 2.14 *Ordinary use: evaluation logical tree for the 'Discomfort, unease' impact scenario*



2.2 Logical trees for school buildings

Fig. 2.15 *Ordinary use: expert logical tree for the 'Unsuitable location' impact scenario*

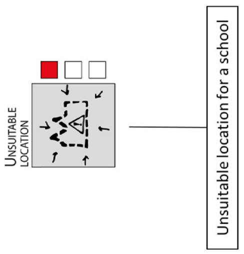


Fig. 2.16 *Ordinary use: evaluation logical tree for the 'Unsuitable location' impact scenario*

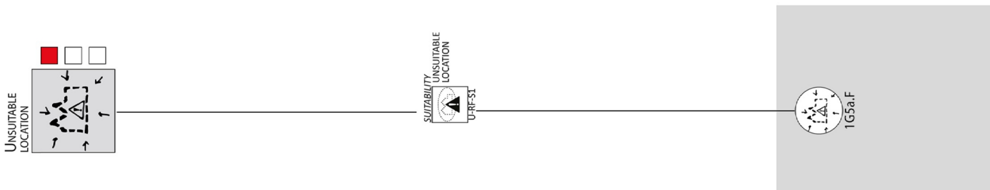


Fig. 2.17 *Ordinary use: expert logical tree for the 'Structural collapse' impact scenario*

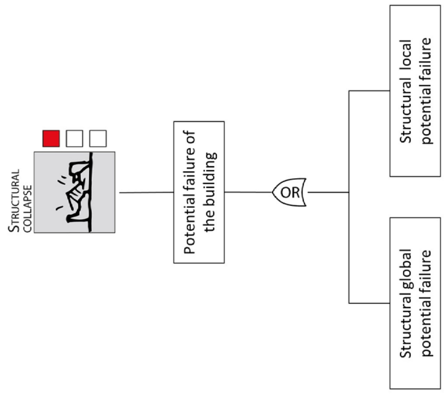


Fig. 2.18 *Ordinary use: evaluation logical tree for the 'Structural collapse' impact scenario*

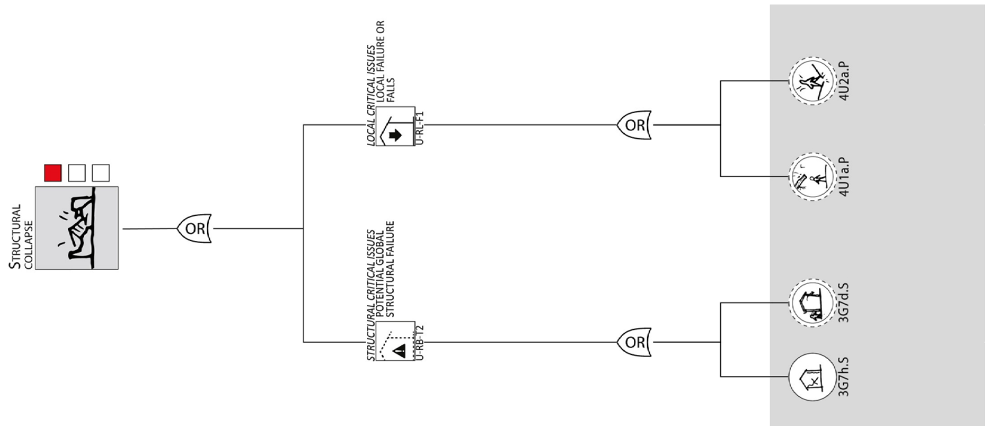


Fig. 2.19 *Ordinary use: expert logical tree for the 'Structural warning' impact scenario*

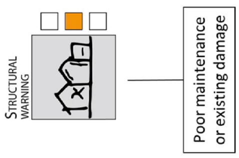


Fig. 2.20 *Ordinary use: evaluation logical tree for the 'Structural warning' impact scenario*

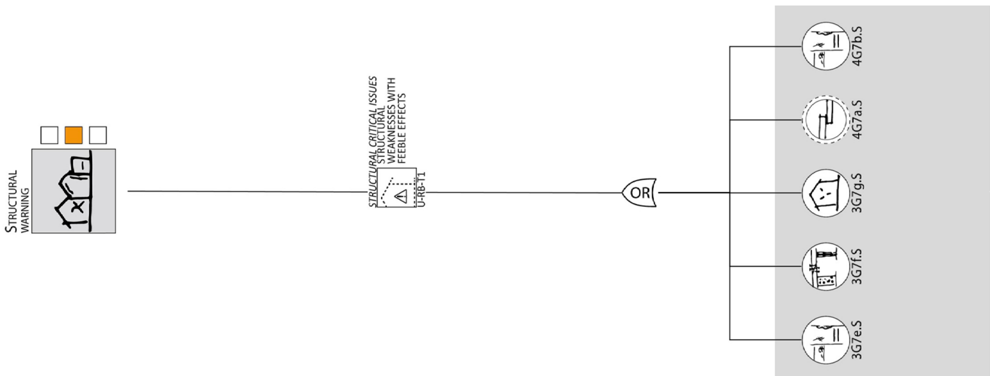


Fig. 2.21 *Ordinary use: expert logical tree for the 'Falls of people' impact scenario*

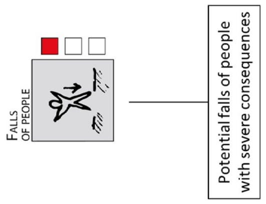


Fig. 2.22 *Ordinary use: evaluation logical tree for the 'Falls of people' impact scenario*

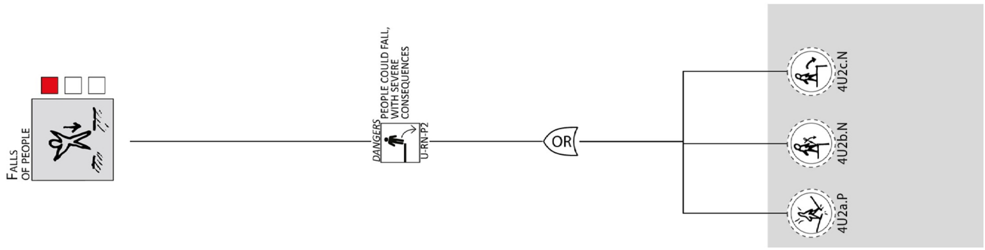


Fig. 2.23 *Ordinary use: expert logical tree for the 'Tumbles or bumps' impact scenario*

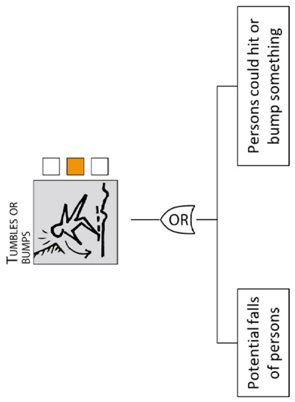


Fig. 2.24 *Ordinary use: evaluation logical tree for the 'Tumbles or bumps' impact scenario*

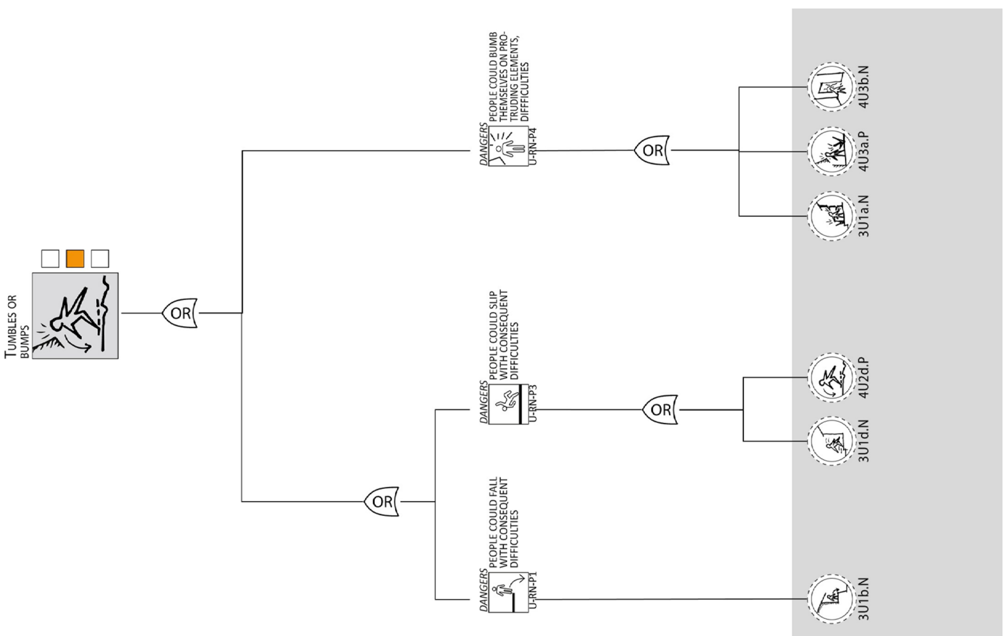


Fig. 2.25 *Ordinary use: expert logical tree for the 'Non-structural failures – severe consequences' impact scenario*

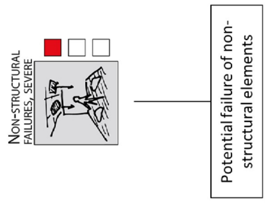


Fig. 2.26 *Ordinary use: evaluation logical tree for the 'Non-structural failures – severe consequences' impact scenario*

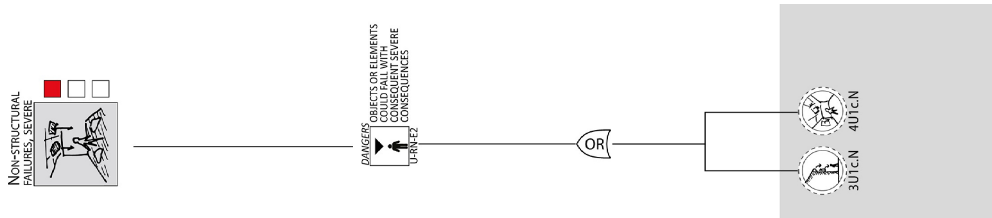


Fig. 2.27 *Ordinary use: expert logical tree for the 'Non-structural failures – difficulties' impact scenario*

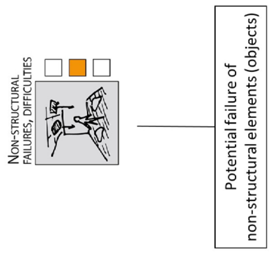


Fig. 2.28 *Ordinary use: evaluation logical tree for the 'Non-structural failures – difficulties' impact scenario*

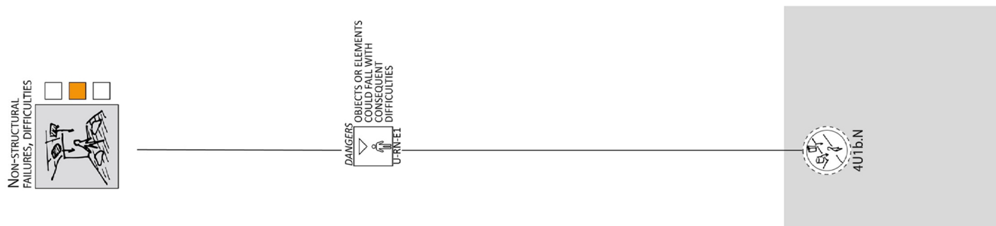


Fig. 2.29 *Ordinary use: expert logical tree for the 'Dangerous contacts – severe consequences' impact scenario*

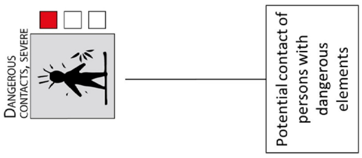


Fig. 2.30 *Ordinary use: evaluation logical tree for the 'Dangerous contacts – severe consequences' impact scenario*

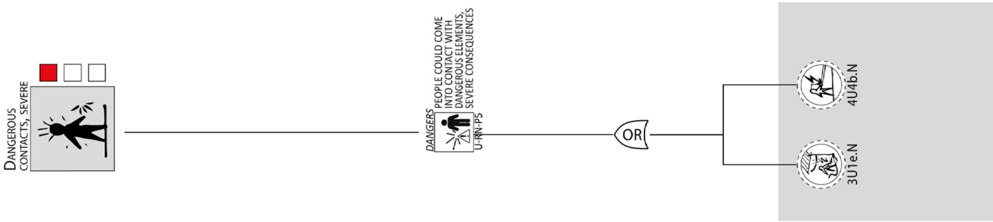


Fig. 2.31 *Ordinary use: expert logical tree for the 'Dangerous contacts – difficulties' impact scenario*

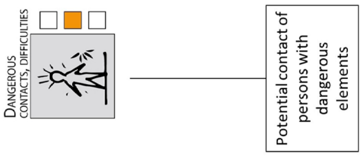


Fig. 2.32 *Ordinary use: evaluation logical tree for the 'Dangerous contacts – difficulties' impact scenario*

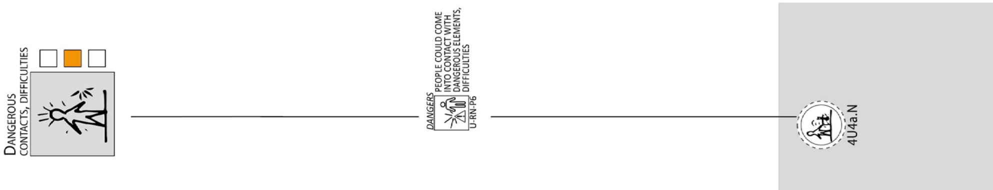


Fig. 2.33 *Ordinary use: expert logical tree for the 'Difficult egress' impact scenario*

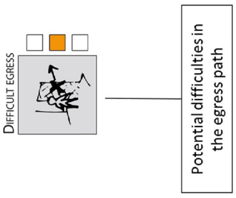


Fig. 2.34 *Ordinary use: evaluation logical tree for the 'Difficult egress' impact scenario*

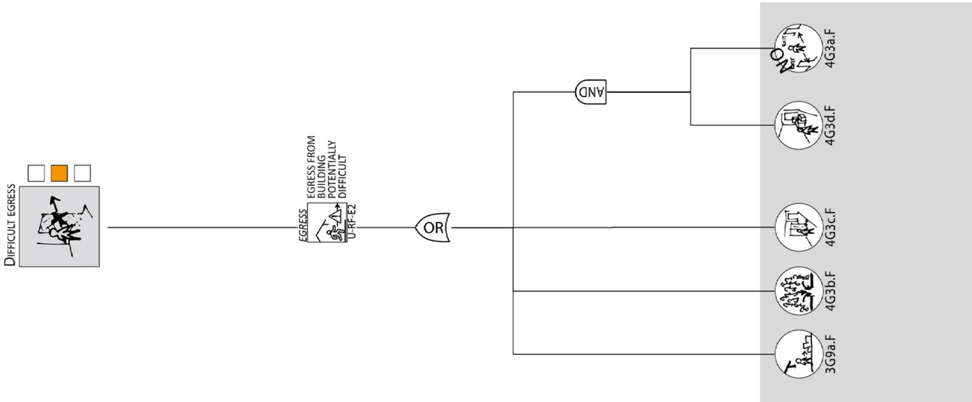


Fig. 2.35 *Ordinary use: expert logical tree for the 'Discomfort, unease' impact scenario*

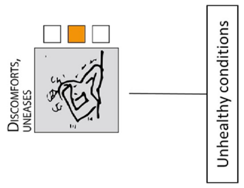
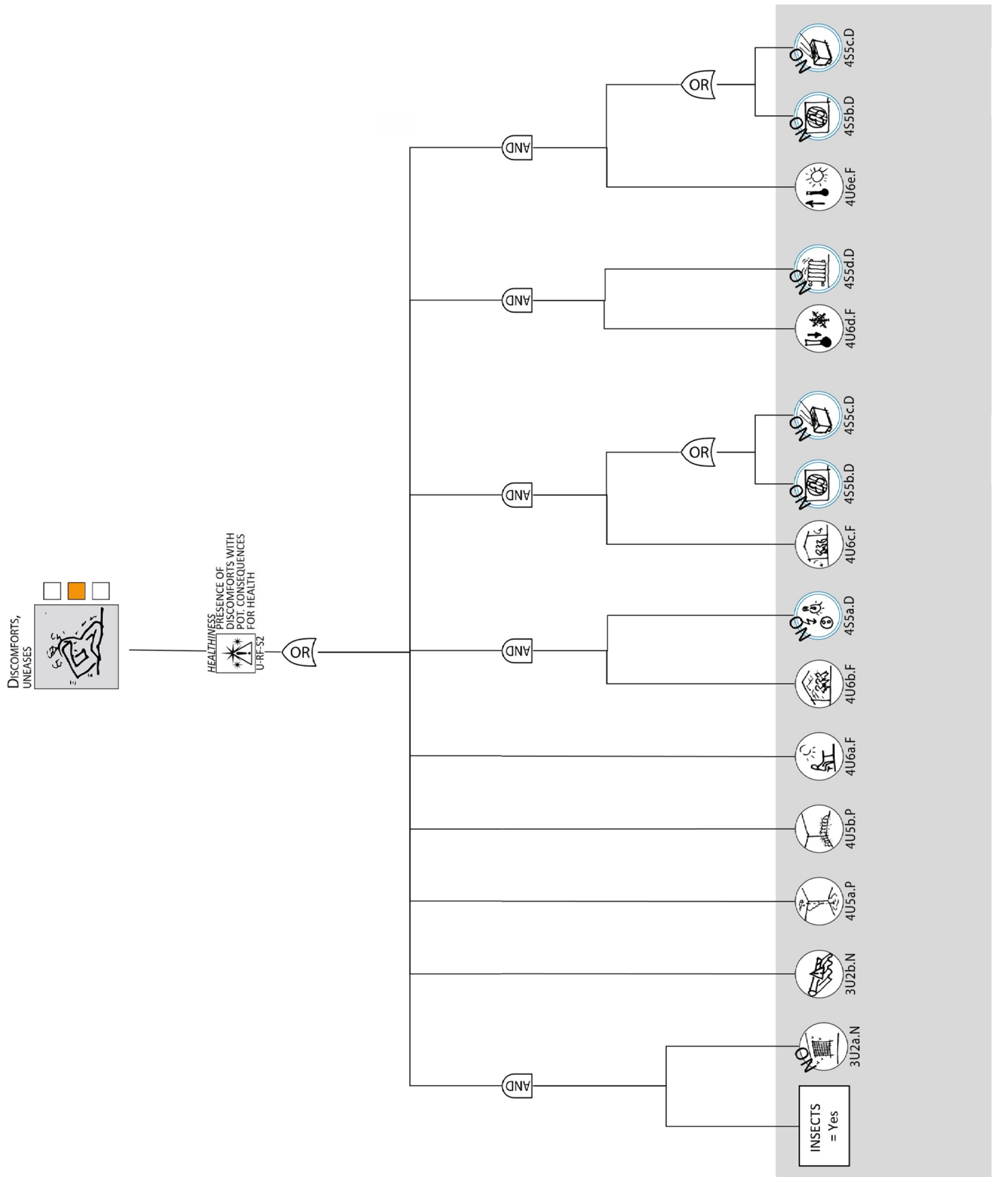


Fig. 2.36 *Ordinary use: evaluation logical tree for the 'Discomfort, unease' impact scenario*



3. REFERENCE EVENTS AND OBSERVABLES

3.1 Reference events

Table 3.1 *List of the reference events used for ordinary use evaluation*

Survey phase	Focus group	Code	Observable	Name
0	Reference event characterization – Ordinary use – Snow	No_snow	–	Predicted snow height: no snow
		Snow<0.5m	–	Predicted snow height: snow < 0.5 m
		Snow0.5–1.0m	–	Predicted snow height: snow 0.5–1.0 m
		Snow>1.0m	–	Predicted snow height: snow > 1.0 m
0	Reference event characterization – Ordinary use – Humidity	High_humidity	–	High humidity for long periods
		Dry_air	–	Dry air
		Humidity_other	–	Other
0	Reference event characterization – Ordinary use – Temperature	Temparature_min	–	Temperature: minimum value
		Temperature_max	–	Temperature: maximum value
		Temparature_C	–	Unit of measure of temperature: °C
		Temperature_F	–	Unit of measure of temperature: °F
0	Reference event characterization – Ordinary use – Insects	Insects_Yes	–	Presence of insects/bugs
		Insects_No	–	Absence of insects/bugs
0	Reference event characterization – Ordinary use – Termites	Termites_Yes	–	Presence of termites
		Termites_No	–	Absence of termites

3.2 Observables for the schoolyard

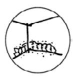
Table 3.2 *List of the observables (OBS) used for ordinary use evaluation of the schoolyard*

Survey phase	Focus group	Code	Observable	Name
1	U1 - Access to school	1U1a.L		Access via high-traffic street
		1U1b.L		Access via high-traffic street with traffic signals or lights
		1U1c.L		Unsafe transit to and from school
		1U1d.L		Access only by footpath
1	U2 - Healthiness	1U2a.F		Wetland
2	U1 - Dangers	2U1a.L		Potential falls (from, e.g., terraces, steep slopes)
		2U1b.L		Holes or potholes
		2U1c.N		Unsafely covered holes
		2U1d.N		Potential hits with protruding or sharp objects
		2U1e.N		Potential falls due to tripping hazards
		2U1f.N		Potential falls due to slippery or uneven floor
		2U1g.N		Potentially dangerous contact with live lines or high voltage elements
2	U2 - Healthiness	2U2a.N		Potentially dangerous animals
		2U2b.F		Mud
		2U2c.F		Unrestricted waste collection or noxious area
2	S1 - Accessibility	2S1a.D		Accessibility barriers to school complex
		2S1b.D		Mobility barriers in the schoolyard

3.3 Observables for school buildings

Table 3.3 *List of the observables (OBS) used for ordinary use evaluation of school buildings*

Survey phase	Focus group	Code	Observable	Name
3	G7 - Construction quality and building condition	3G7d.S		Weak for gravity loads
		3G7e.S		Poor maintenance
		3G7f.S		Poor construction quality (e.g. concrete segregation)
		3G7g.S		Evidence of existing light damage
		3G7h.S		Evidence of existing severe damage
3	G9 - Egress	3G9a.F		External obstruction to egress
3	U1 - Dangers	3U1a.N		Potential hits with protruding or sharp objects
		3U1b.N		Potential falls of people from unprotected and accessible raised areas
		3U1c.N		Potential falls of objects or elements (e.g. vases, equipment, tiles, cladding)
		3U1d.N		Potential falls due to slippery or uneven floor
		3U1e.N		Potentially dangerous contact with live lines or high voltage elements
3	U2 - Healthiness	3U2a.N		Insect screens
		3U2b.N		Asbestos
4	G3 - Egress	4G3a.F		Alternative egress paths
		4G3b.F		Single exit serving more than 50 people
		4G3c.F		Narrowed egress
		4G3d.F		Obstructed egress

Survey phase	Focus group	Code	Observable	Name
4	G7 - Quality	4G7a.S		Ineffective structural connections
		4G7b.S		Poor maintenance
4	U1 - Falls of elements or objects	4U1a.P		Potential falls of unstable structural elements
		4U1b.N		Potential falls of objects
		4U1c.N		Potential falls or overturning of portions of non-structural elements
4	U2 - Falls of people	4U2a.P		Potential injuries due to collapse of the floor
		4U2b.N		Potential falls due to flimsy railings
		4U2c.N		Potential falls due to the absence of protective measures
		4U2d.P		Potential falls due to slippery or uneven floor
4	U3 - Dangers	4U3a.P		Potential hits with protruding or sharp objects
		4U3b.N		Potential bumps with fragile doors opening onto crowded areas
4	U4 - Dangerous contacts	4U4a.N		Potentially dangerous contact with high temperature objects
		4U4b.N		Potentially dangerous contact with live lines or high voltage elements
4	U5 - Healthiness	4U5a.P		Water infiltration
		4U5b.P		Mould
4	U6 - Comfort	4U6a.F		Direct exposure to sun
		4U6b.F		Low light
		4U6c.F		Limited or no ventilation
		4U6d.F		Low temperatures in the classrooms
		4U6e.F		High temperatures in the classrooms

Survey phase	Focus group	Code	Observable	Name
4	S1 - Accessibility	4S1a.D		Limited access to the building
		4S1b.D		Limited mobility inside the building
		4S1c.D		Lift
		4S1d.D		Accessible toilet
4	S5 - Comfort	4S5a.D		Electricity and light fixtures
		4S5b.D		Fans
		4S5c.D		Coolers or air-conditioning units
		4S5d.D		Heating units or system

4. PROFILE QUALIFIERS

4.1 Profile qualifiers for the schoolyard

Table 4.1 *Definition of the profile qualifiers for ordinary use evaluation of the schoolyard*

Focus	Icon and code	Name	Evaluation logic
Suitability	U-RF-S1	Unsuitable location	1G5a.F
Reachability	U-RF-R1	Good, no problems	NOT (U-RF-R2 OR U-RF-R3)
	U-RF-R2	Potential difficulties for personal safety	1U1d.L OR [1U1a.L AND NOT (1U1b.L)]
	U-RF-R3	Unsafe path to the school	1U1c.L
Healthiness	U-RF-H1	Good, no problems	NOT U-RF-H2
	U-RF-H2	Presence of discomforts, with potential consequences for health	1U2a.F OR 2U2b.F OR 2U2c.F
Dangers	U-RN-P1	People could fall, with consequent difficulties	2U1b.L
	U-RN-P2	People could fall, with severe consequences	2U1a.L OR 2U1c.N
	U-RN-P3	People could slip, with consequent difficulties	2U1e.N OR 2U1f.N
	U-RN-P4	People could bump themselves on protruding elements, with consequent difficulties	2U1d.N
	U-RN-P7	Other – animals	2U2a.N
	U-RN-P8	People could come into contact with dangerous elements, with severe consequences	2U1g.N

4.2 Profile qualifiers for school buildings

Table 4.2 *Definition of the profile qualifiers for ordinary use evaluation of school buildings*

Focus	Icon and code	Name	Evaluation logic
Suitability	U-RF-S1	Unsuitable location	1G5a.F
Healthiness	U-RF-H1	Good, no problems	NOT(U-RF-H2)
	U-RF-H2	Presence of discomforts, with potential consequences for health	[Insects=Yes AND NOT (3U2a.N)] OR 3U2b.N OR 4U5a.P OR 4U5b.P OR 4U6a.F OR [4U6b.F AND NOT (4S5a.D)] OR [4U6c.F AND NOT (4S5b.D OR 4S5c.D)] OR [4U6d.F AND NOT (4S5d.D)]OR [4U6e.F AND NOT (4S5b.D OR 4S5c.D)]
Local critical issues	U-RL-F1	Local failures or falls	4U1a.P OR 4U2a.P
Structural critical issues	U-RB-T1	Structural weaknesses, with feeble effects – Structural strength modifier	3G7f.S OR 3G7e.S OR 3G7g.S OR 4G7a.S OR 4G7b.S
	U-RB-T2	Potential global structural failure – Structural strength modifier	3G7h.S OR 3G7d.S

Focus	Icon and code	Name	Evaluation logic
Dangers	U-RN-E1	Objects or elements could fall, with consequent difficulties	4U1b.N
	U-RN-E2	Objects or elements could fall, with severe consequences	3U1c.N OR 4U1c.N
	U-RN-P1	People could fall, with consequent difficulties	3U1b.N
	U-RN-P2	People could fall, with severe consequences	4U2a.P OR 4U2b.N OR 4U2c.N
	U-RN-P3	People could slip, with consequent difficulties	3U1d.N OR 4U2d.P
	U-RN-P4	People could bump themselves on protruding elements, with consequent difficulties	3U1a.N OR 4U3a.P OR 4U3b.N
	U-RN-P5	People could come into contact with dangerous elements, severe consequences	3U1e.N OR 4U4b.N
	U-RN-P6	People could come into contact with dangerous elements, difficulties	4U4a.N
Egress	U-RF-E1	Egress from building safe	NOT(U-RF-E2)
	U-RF-E2	Egress from building potentially difficult	3G9a.F OR 4G3b.F OR 4G3c.F OR [4G3d.F AND NOT (4G3a.F)]

5. SAFETY INDICATOR: ROSE OF WARNING LEVELS

5.1 Warning level evaluation for the schoolyard

Table U.WS.L *Ordinary use evaluation of the warning levels for the schoolyard: site/location safety issue*

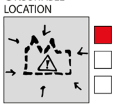
Warning level	Evaluation logic
	NOT ( OR )
	Difficult reachability 
	Unsuitable location 

Table U.WS.S *Ordinary use evaluation of the warning levels for the schoolyard: structural global safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table U.WS.P *Ordinary use evaluation of the warning levels for the schoolyard: structural local/envelope safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table U.WS.N *Ordinary use evaluation of the warning levels for the schoolyard: non-structural safety issue*

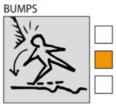
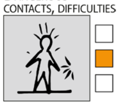
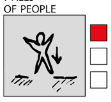
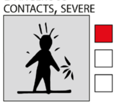
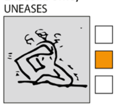
Warning level	Evaluation logic
	NOT ( OR )
	Tumbles or bumps  OR Dangerous contacts, difficulties 
	Falls of people  OR Dangerous contacts, severe 

Table U.WS.F *Ordinary use evaluation of warning levels for the schoolyard: functionality safety issue*

Warning level	Evaluation logic
	NOT ()
	Discomforts, uneases 
	No scenario

5.2 Warning level evaluation for school buildings

Table U.WB.L *Ordinary use evaluation of the warning levels for school buildings: site/location safety issue*

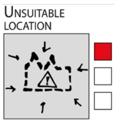
Warning level	Evaluation logic
	NOT ()
	No scenario
	

Table U.WB.S *Ordinary use evaluation of the warning levels for school buildings: structural global safety issue*

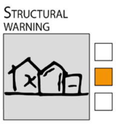
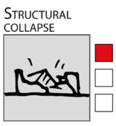
Warning level	Evaluation logic
	NOT ( OR )
	
	

Table U.WB.P *Ordinary use evaluation of the warning levels for school buildings: structural local/envelope safety issue*

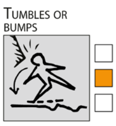
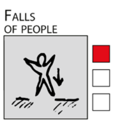
Warning level	Evaluation logic
	NOT ( OR )
	
	

Table U.WB.N *Ordinary use evaluation of the warning levels for school buildings: non-structural safety issue*

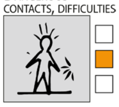
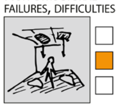
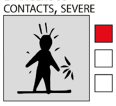
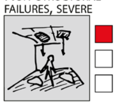
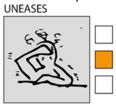
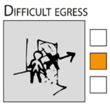
Warning level	Evaluation logic
	NOT ( OR )
	Dangerous contacts, difficulties  OR Non-structural failures, difficulties 
	Dangerous contacts, severe  OR Non-structural failures, severe 

Table U.WB.F *Ordinary use evaluation of the warning levels for school buildings: functionality safety issue*

Warning level	Evaluation logic
	NOT ()
	Discomforts, uneases  OR Difficult egress 
	No scenario

Annex to the VISUS Methodology

AM2 Evaluation Criteria: Fire Hazard

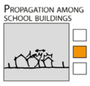
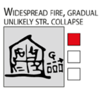
Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

1. EXPECTED IMPACT SCENARIOS

Table 1.1 lists the substantial expected impact scenarios identified for fire hazard evaluated with the Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology.

Table 1.1 *Expected impact scenarios for fire hazard*

Safety issue	Icon	Name	Where	Description
Location/site critical issues		Interdependence with the site	Schoolyard and buildings	The distance of the school buildings from facilities external to the school warns of the possibility that fire could propagate from the external facilities to the school buildings.
		Propagation among school buildings	Buildings	The distance among the buildings of the school complex and their features implies potential propagation of fire among them.
Structural global critical issues		Explosion, with structural collapse	Buildings	Presence of conditions that warn of the possibility of a significant explosion in the building, potentially causing its structural collapse.
		Widespread fire, rapid propagation – probable structural collapse	Buildings	Presence of conditions that warn of the possibility of a widespread fire in the building, with a probable rapid propagation of fire and smoke among the rooms. The structure of the building would be affected, and would probably collapse.
		Widespread fire, gradual propagation – probable structural collapse	Buildings	Presence of conditions that warn of the possibility of a widespread fire in the building, but with a gradual (relatively slow) propagation of fire and smoke among the rooms. The structure of the building would be affected, and would probably collapse.
		Widespread fire, rapid propagation – unlikely structural collapse	Buildings	Presence of conditions that warn of the possibility of a widespread fire in the building, with a probable rapid propagation of fire and smoke among the rooms. The structure of the building should not completely collapse, although it could be severely damaged.
		Widespread fire, gradual propagation – unlikely structural collapse	Buildings	Presence of conditions that warn of the possibility of a widespread fire in the building, but with a gradual (relatively slow) propagation of fire and smoke among the rooms. The structure of the building should not completely collapse, although it could be severely damaged.
		Widespread smoke, rapid propagation	Buildings	Presence of conditions that warn of the possibility of widespread smoke in the building, with a rapid propagation among the rooms.
		Widespread smoke, gradual propagation	Buildings	Presence of conditions that warn of the possibility of widespread smoke in the building, but with a gradual (relatively slow) propagation among the rooms.
		Fire limited to an area of the building	Buildings	Presence of conditions that warn of the possibility of a localized fire in the building.

Safety issue	Icon	Name	Where	Description
Structural local/ envelope critical issues		Envelope fire, widespread	Buildings	Presence of conditions that warn of the possibility of a widespread fire of the envelope of the building (internal or external). The structure of the building should not completely collapse, although it could be severely damaged.
		Envelope fire, localized	Buildings	Presence of conditions that warn of the possibility of a localized fire of the envelope of the building (internal or external).
		Dropping while burning	Buildings	Presence of conditions that warn of the possibility of the burning of the envelope. The fire causes a dropping from the envelope, with potentially severe consequences for personal safety.
Non-structural critical issues		Total loss of contents	Buildings	Potential loss of the building's entire contents because of fire.
		Local loss of contents	Buildings	Potential loss of some of the building's contents because of fire.
		Large fire in the schoolyard	Schoolyard	Potential large fire in the schoolyard that could have severe consequences for personal safety.
		Small fire in the schoolyard	Schoolyard	Potential small fire in the schoolyard that could cause difficulties for personal safety.
Functionality critical issues		Trapped people due to fire or smoke	Buildings	The characteristics of the building warn of the possibility of people being trapped in the building during a fire.
		Difficult step back from hazard	Buildings	In the case of a fire in the building, the environment (egress paths) allows people to step back from the hazard, but with some difficulties.
		Fire suppressed by prevention systems	Buildings	A potential fire in the building should be suppressed by fire protection systems, therefore the effects of the fire will be controlled and limited.

2. LOGICAL TREES

The VISUS logical trees define the substantial elements and the rules and criteria that correspond to the definition of the expected impact scenarios.

2.1 Logical trees for the schoolyard

Fig. 2.1 *Fire hazard: expert logical tree for the 'Interdependence with the context' impact scenario*

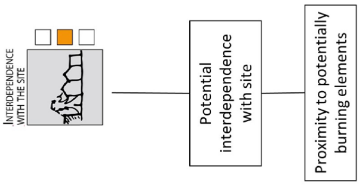


Fig. 2.2 *Fire hazard: evaluation logical tree for the 'Interdependence with the context' impact scenario*

Fig. 2.3 *Fire hazard: expert logical tree for the 'Small fire in the schoolyard' impact scenario*

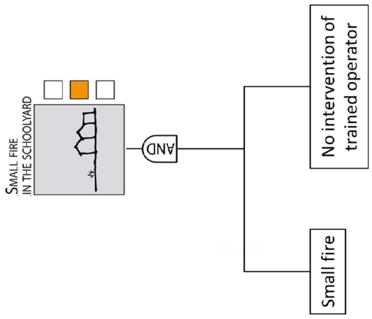


Fig. 2.4 *Fire hazard: evaluation logical tree for the 'Small fire in the schoolyard' impact scenario*

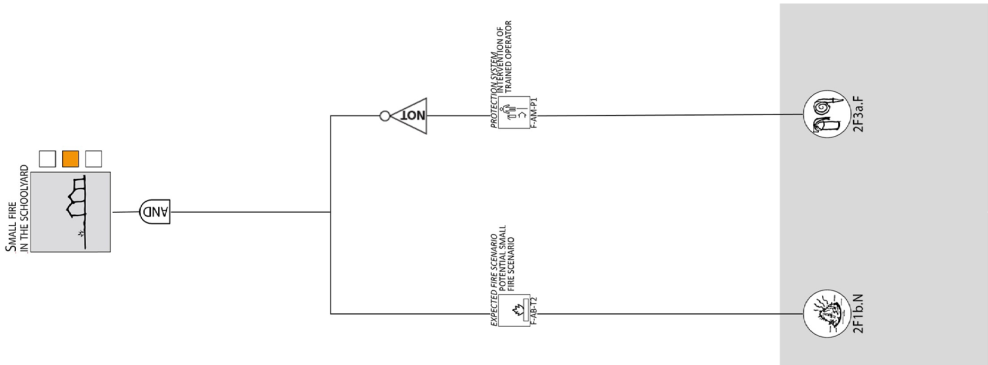


Fig. 2.5 *Fire hazard: expert logical tree for the 'Large fire in the schoolyard' impact scenario*

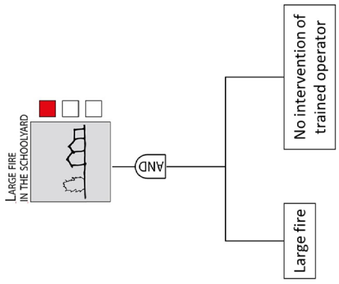
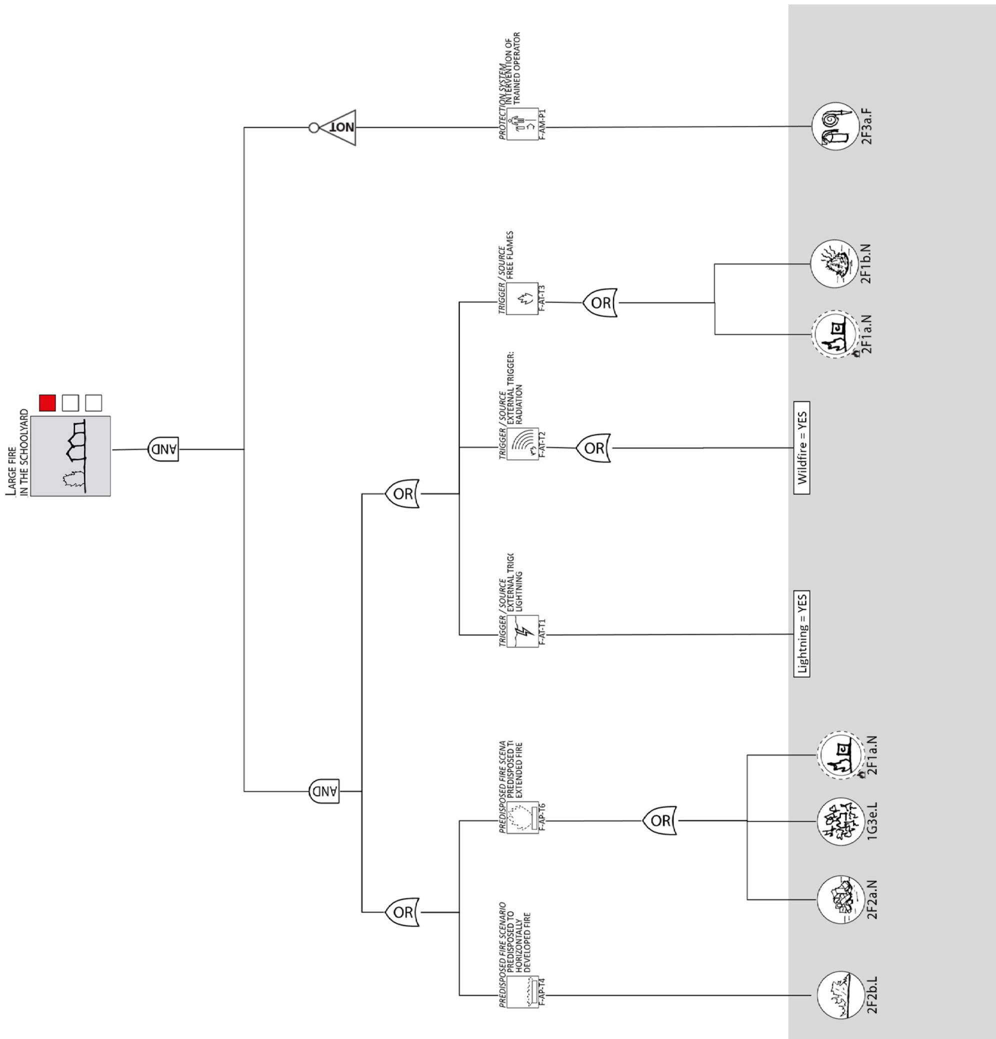


Fig. 2.6 *Fire hazard: evaluation logical tree for the 'Large fire in the schoolyard' impact scenario*



2.2 Logical trees for school buildings

Fig. 2.7 *Fire hazard: expert logical tree for the 'Interdependence with the context' impact scenario*

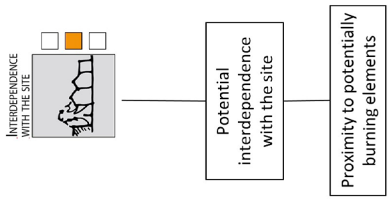


Fig. 2.8 *Fire hazard: evaluation logical tree for the 'Interdependence with the context' impact scenario*

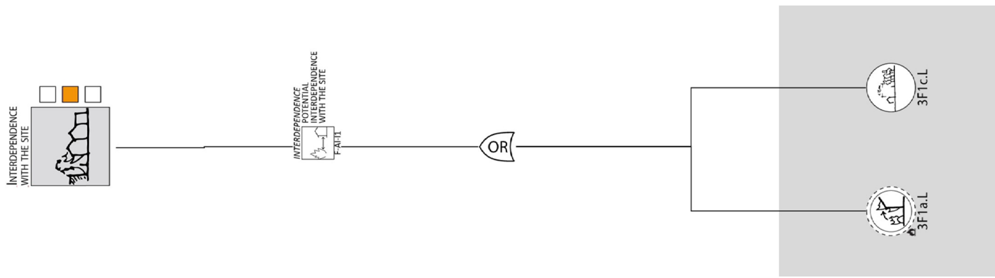


Fig. 2.9 *Fire hazard: expert logical tree for the 'Propagation among school buildings' impact scenario*

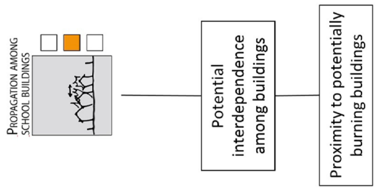


Fig. 2.10 *Fire hazard: evaluation logical tree for the 'Propagation among school buildings' impact scenario*

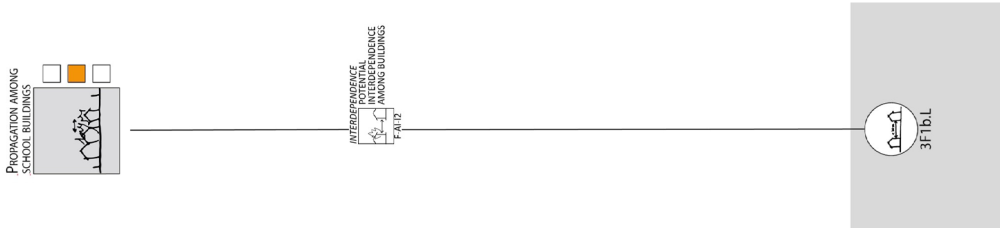


Fig. 2.11 *Fire hazard: expert logical tree for the 'Explosion, with structural collapse' impact scenario*

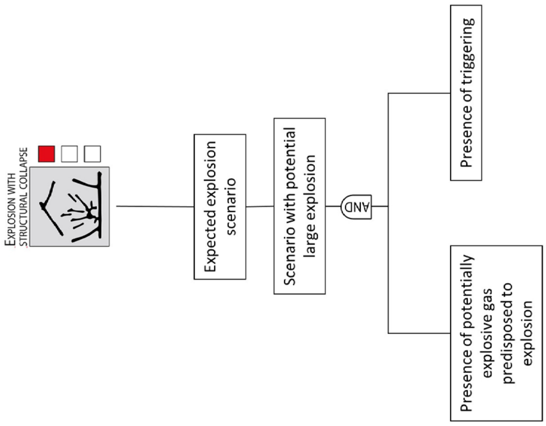


Fig. 2.12 *Fire hazard: evaluation logical tree for the 'Explosion, with structural collapse' impact scenario*

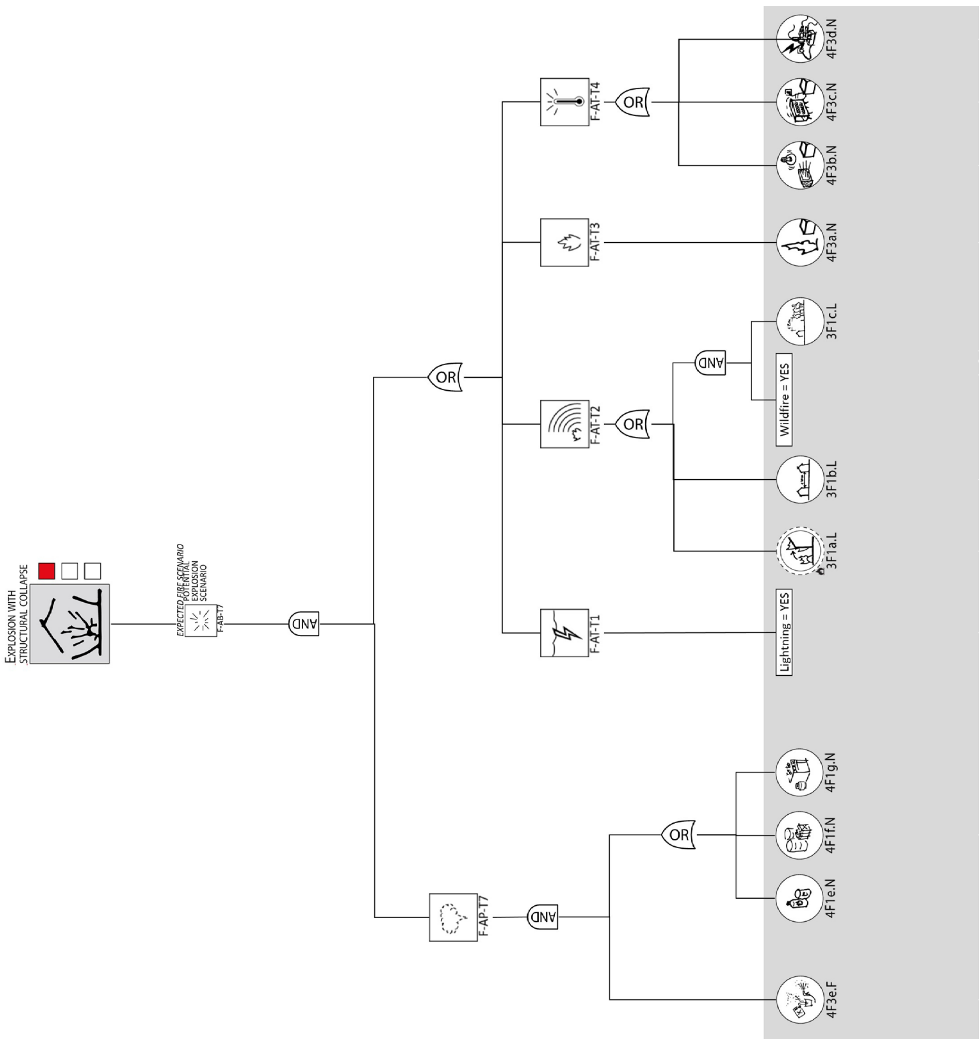


Fig. 2.13 *Fire hazard: expert logical tree for the 'Widespread fire, rapid propagation – probable structural collapse' impact scenario*

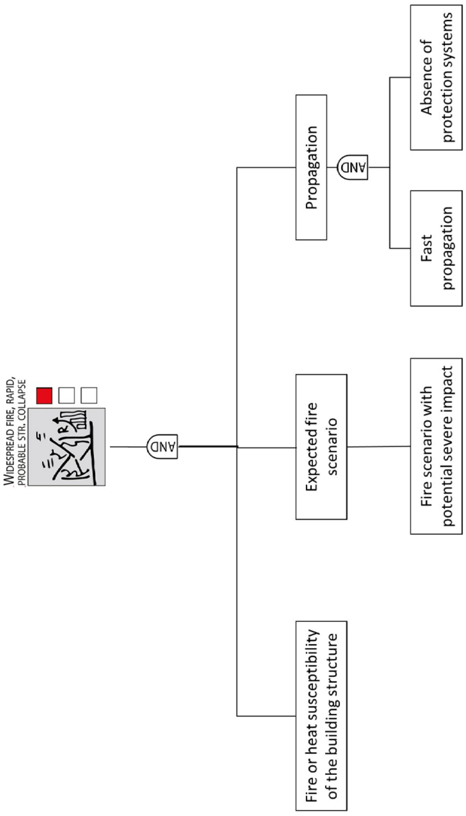


Fig. 2.14 *Fire hazard: evaluation logical tree for the ‘Widespread fire, rapid propagation – probable structural collapse’ impact scenario*

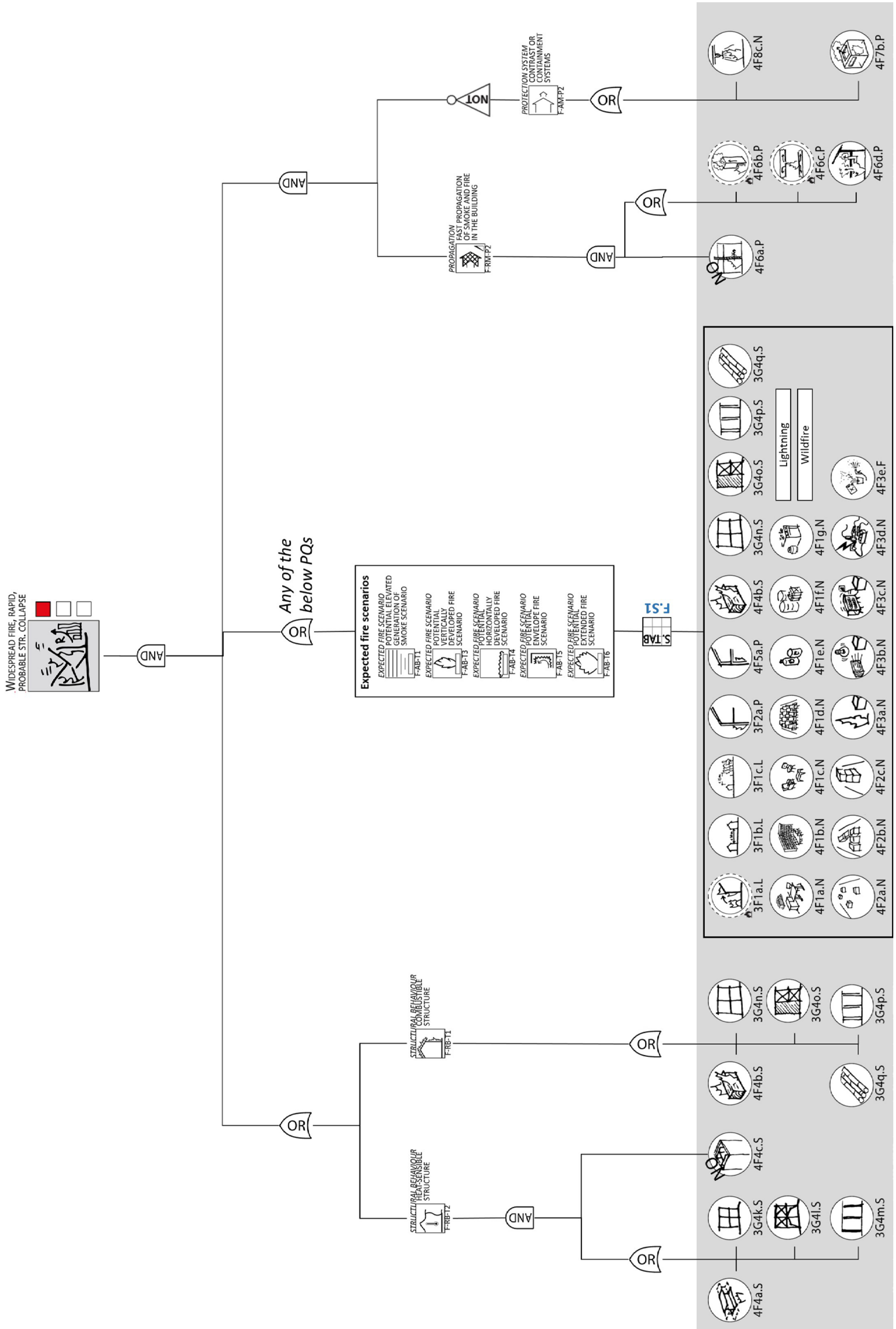


Fig. 2.15 *Fire hazard: expert logical tree for the 'Widespread fire, gradual propagation – probable structural collapse' impact scenario*

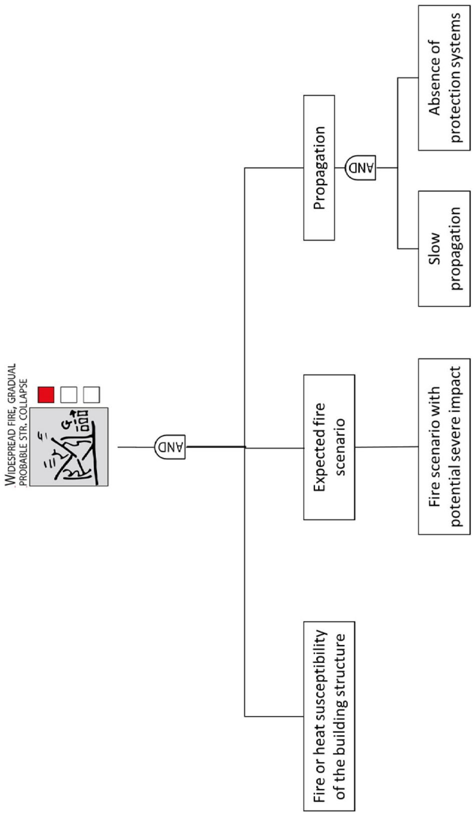


Fig. 2.16 *Fire hazard: evaluation logical tree for the 'Widespread fire, gradual propagation – probable structural collapse' impact scenario*

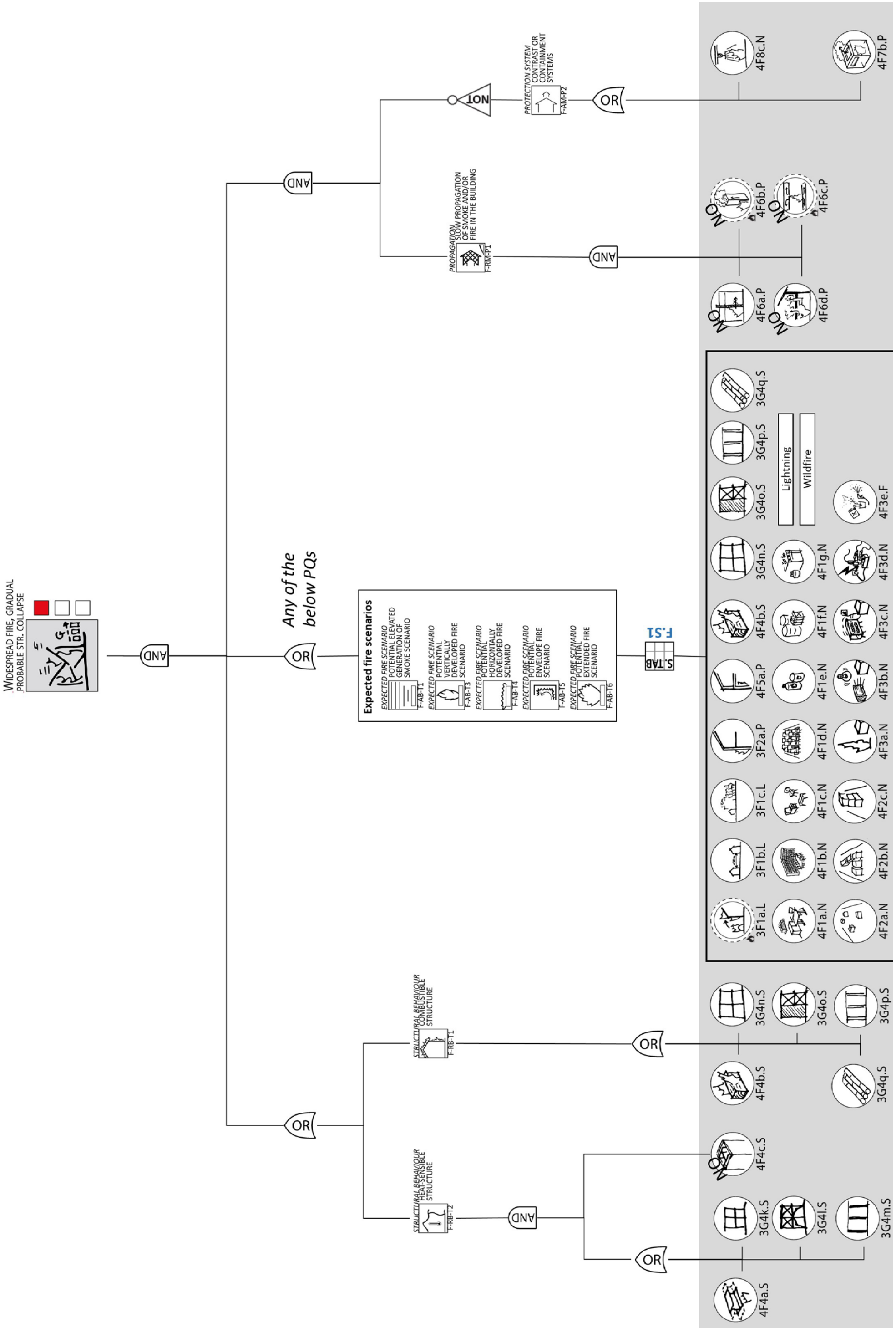


Fig. 2.17 *Fire hazard: expert logical tree for the 'Widespread fire, gradual propagation – unlikely structural collapse' impact scenario*

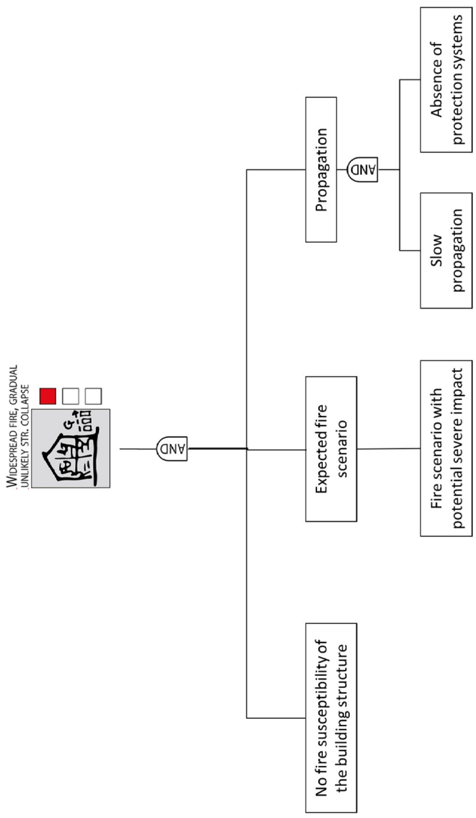


Fig. 2.18 *Fire hazard: evaluation logical tree for the 'Widespread fire, gradual propagation – unlikely structural collapse' impact scenario*

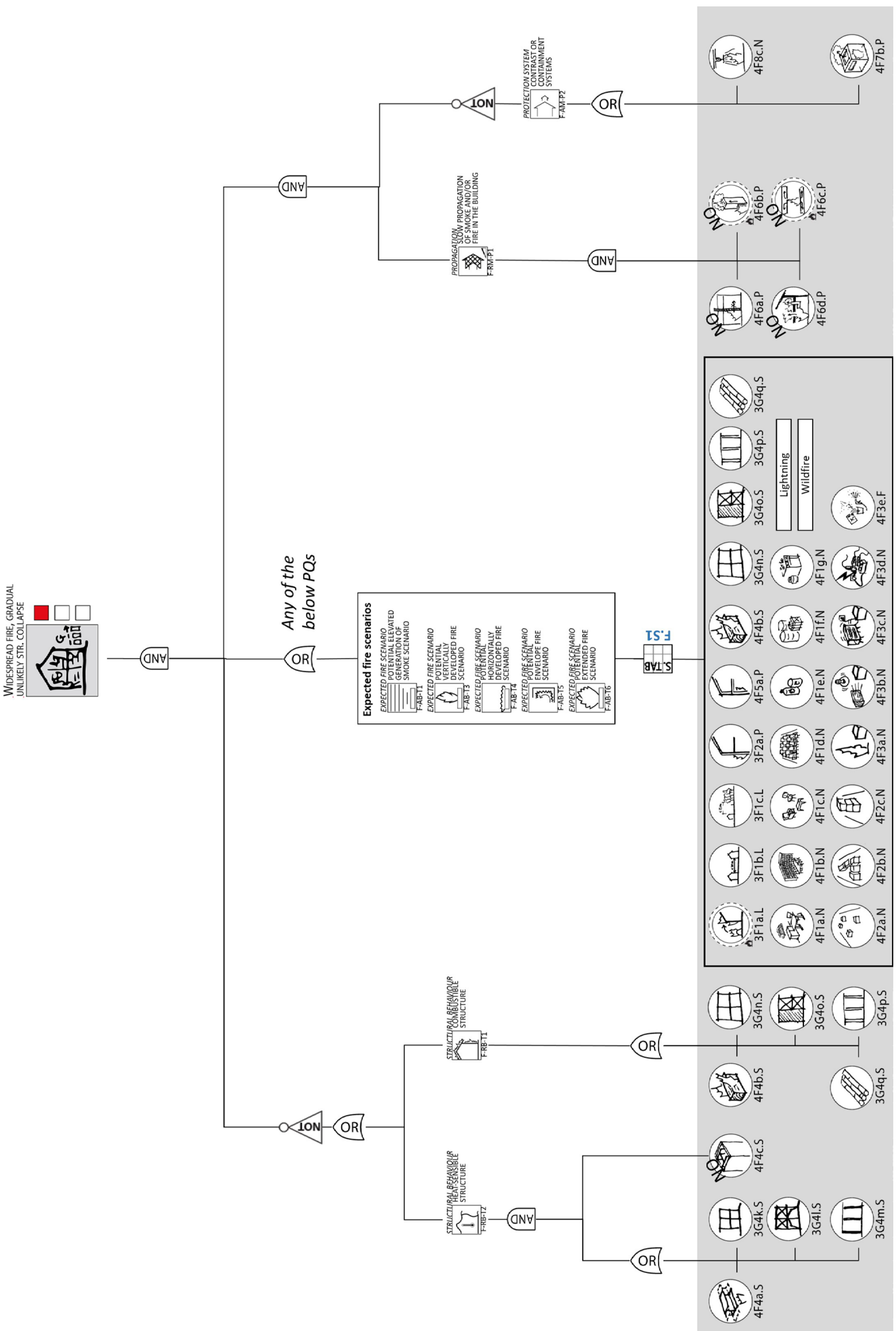


Fig. 2.19 *Fire hazard: expert logical tree for the 'Widespread fire, rapid propagation – unlikely structural collapse' impact scenario*

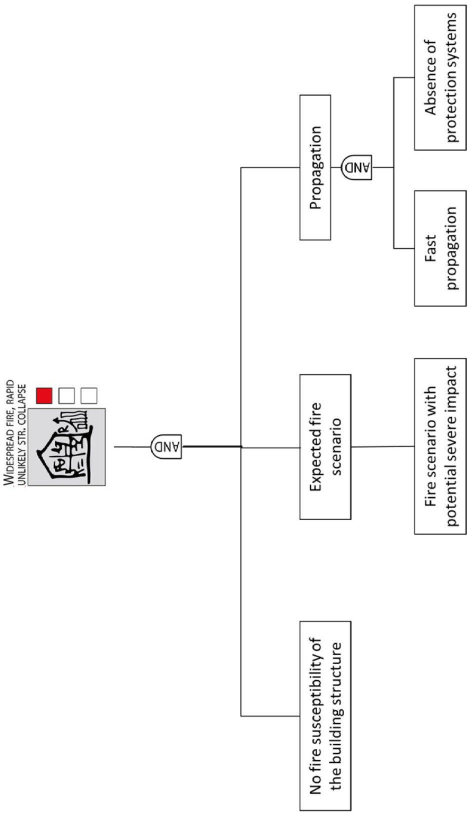


Fig. 2.20 *Fire hazard: evaluation logical tree for the 'Widespread fire, rapid propagation – unlikely structural collapse' impact scenario*

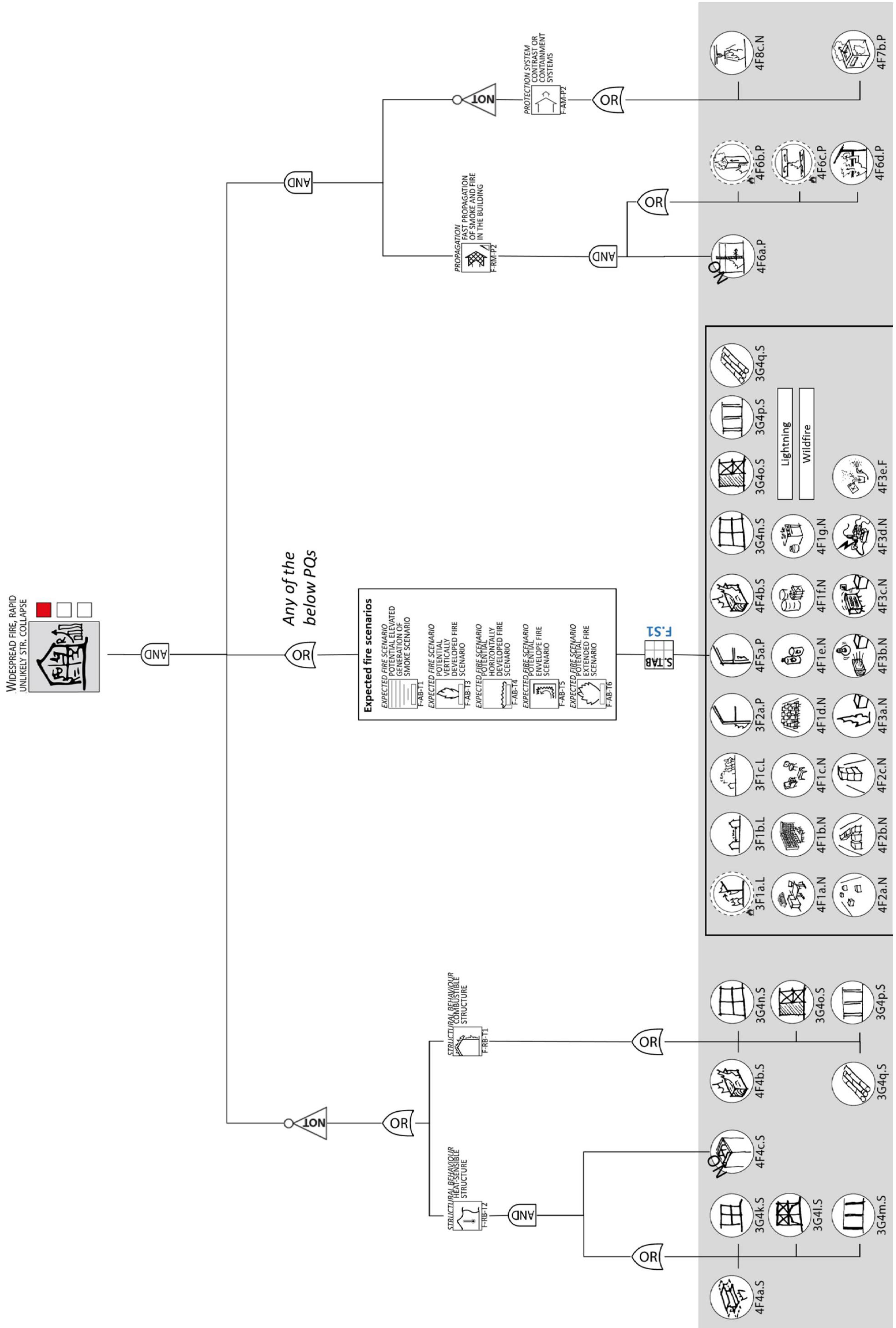


Fig. 2.21 *Fire hazard: expert logical tree for the 'Widespread smoke, rapid propagation' impact scenario*

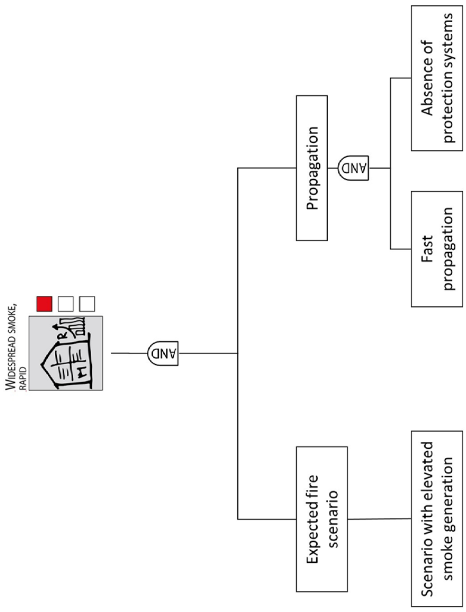


Fig. 2.22 *Fire hazard: evaluation logical tree for the 'Widespread smoke, rapid propagation' impact scenario*

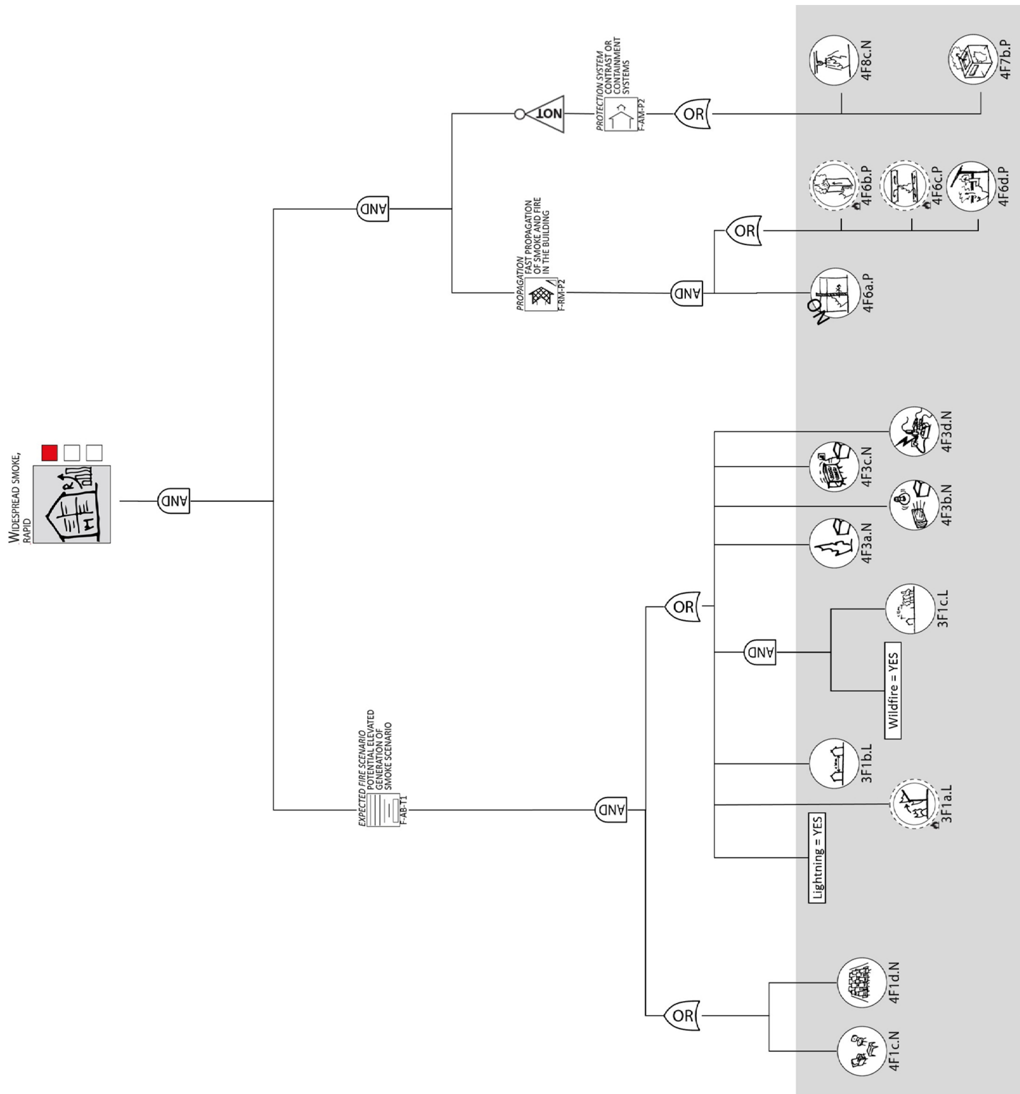


Fig. 2.23 *Fire hazard: expert logical tree for the 'Widespread smoke, gradual propagation' impact scenario*

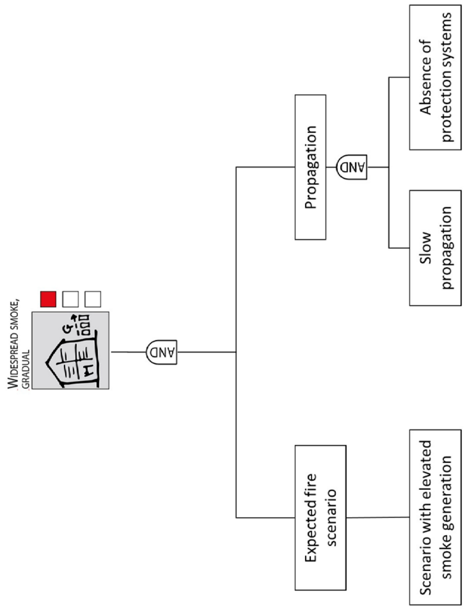
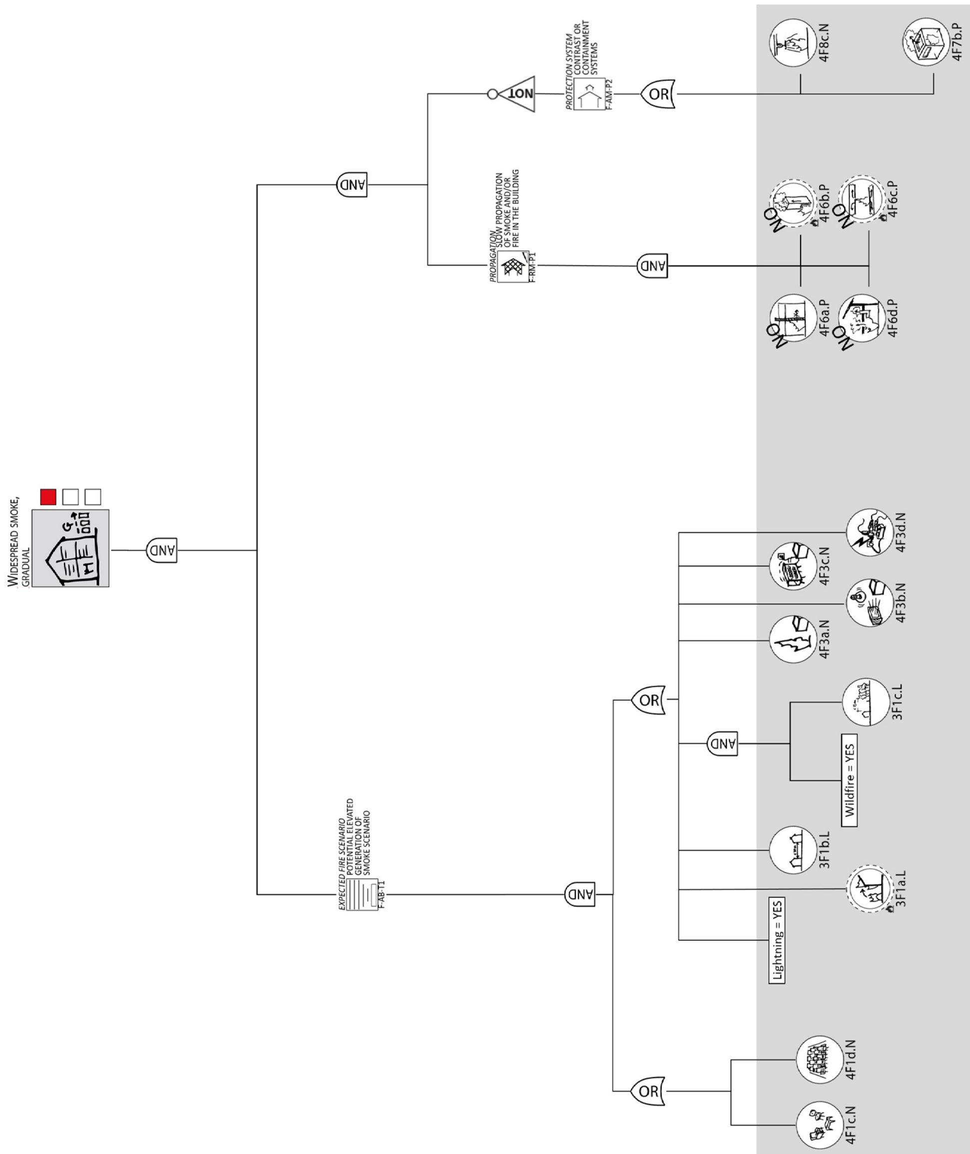


Fig. 2.24 *Fire hazard: evaluation logical tree for the 'Widespread smoke, gradual propagation' impact scenario*



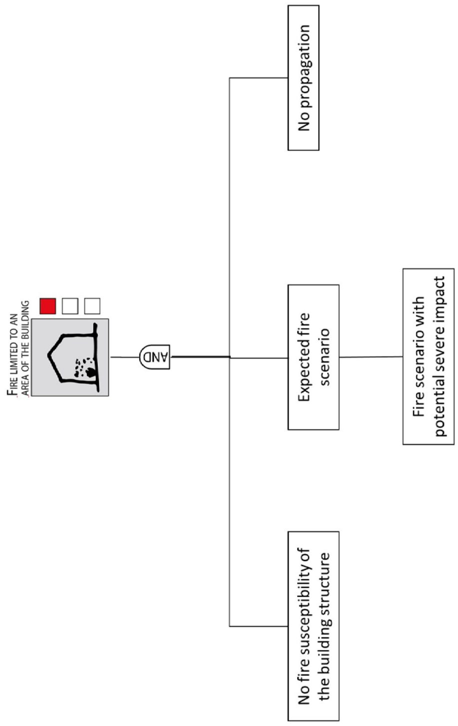


Fig. 2.25 *Fire hazard: expert logical tree for the 'Fire limited to an area of the building' impact scenario*

Fig. 2.26 *Fire hazard: evaluation logical tree for the 'Fire limited to an area of the building' impact scenario*

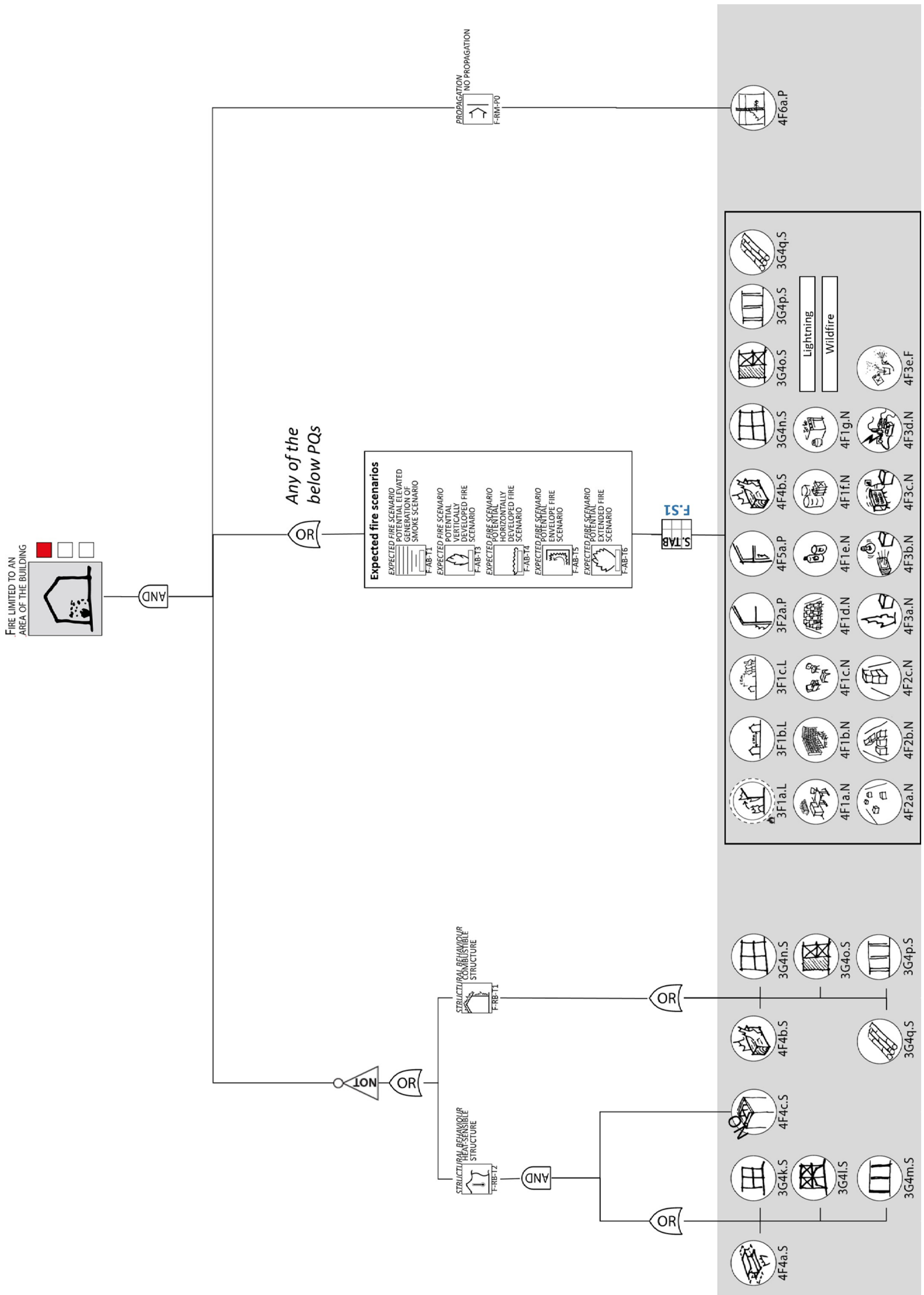


Fig. 2.27 *Fire hazard: expert logical tree for the 'Envelope fire, widespread' impact scenario*

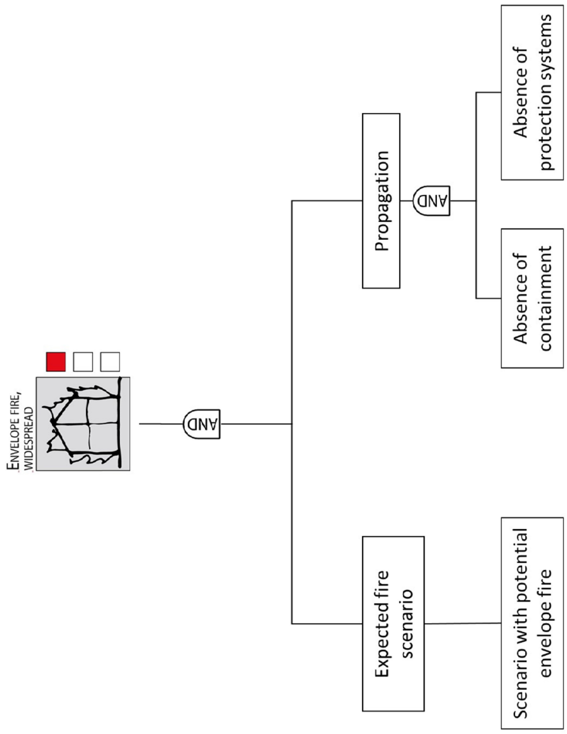


Fig. 2.28 *Fire hazard: evaluation logical tree for the 'Envelope fire, widespread' impact scenario*

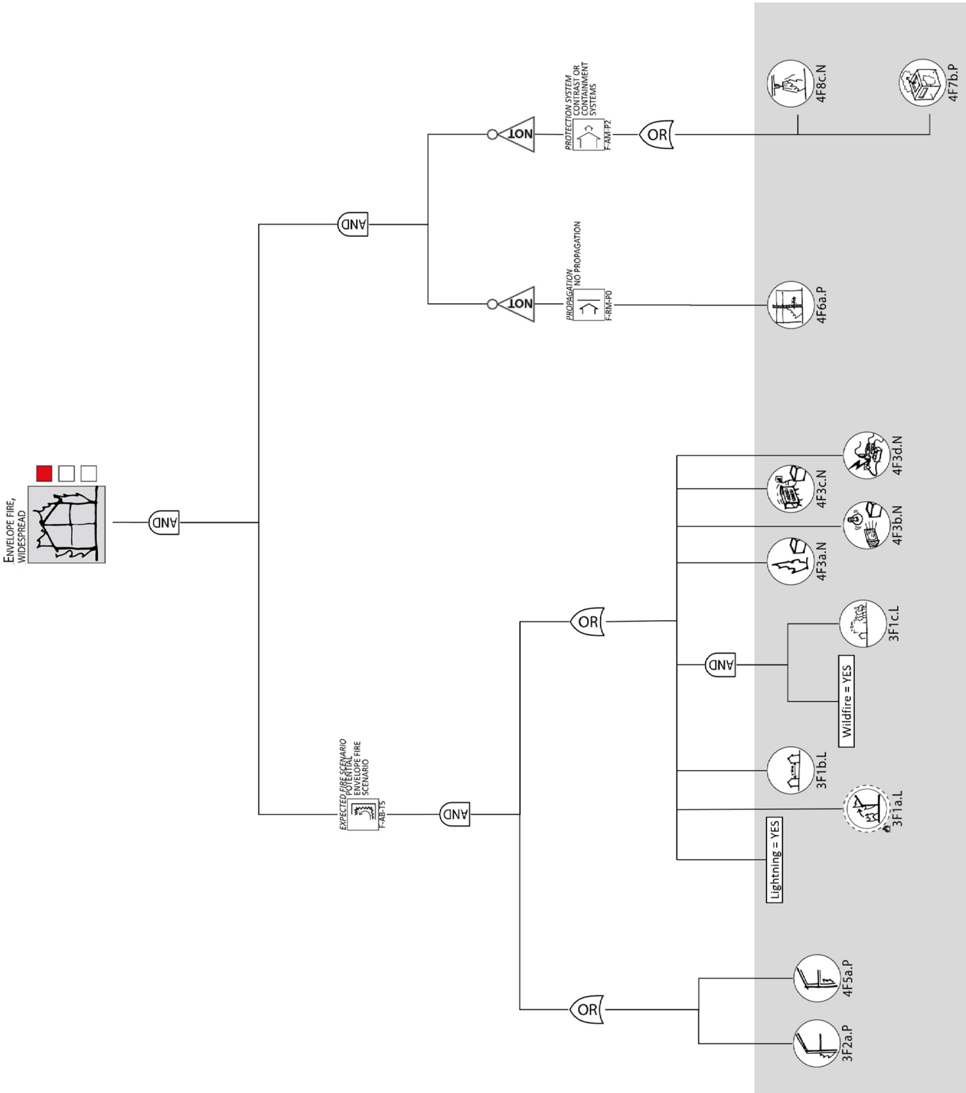


Fig. 2.29 *Fire hazard: expert logical tree for the 'Envelope fire, localized' impact scenario*

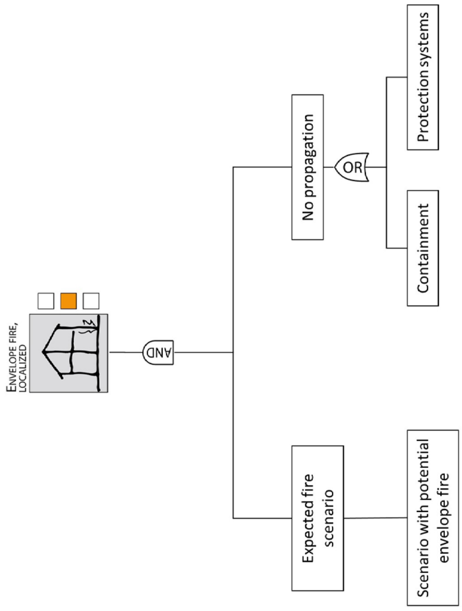


Fig. 2.30 *Fire hazard: evaluation logical tree for the 'Envelope fire, localized' impact scenario*

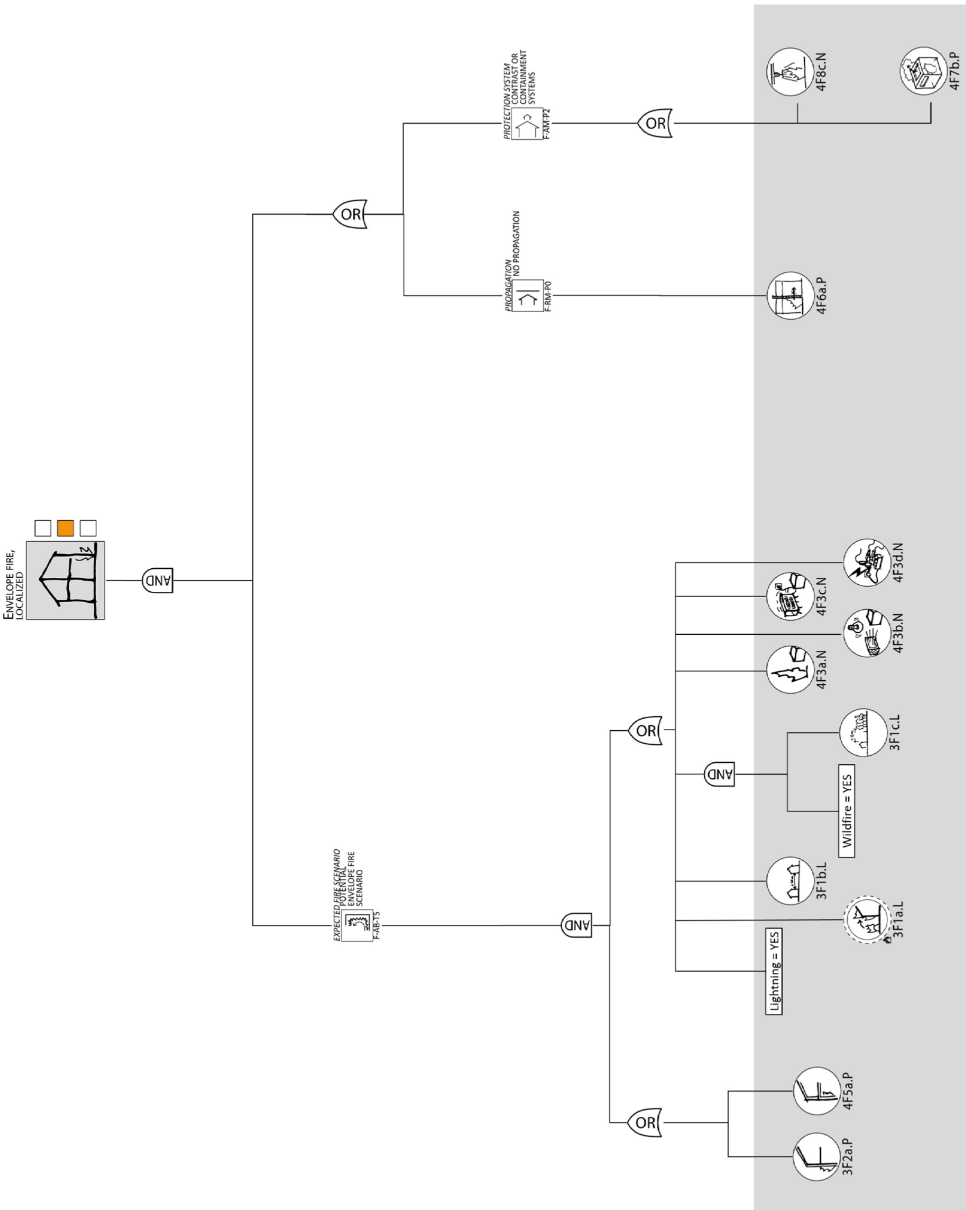


Fig. 2.31 *Fire hazard: expert logical tree for the 'Dropping while burning' impact scenario*

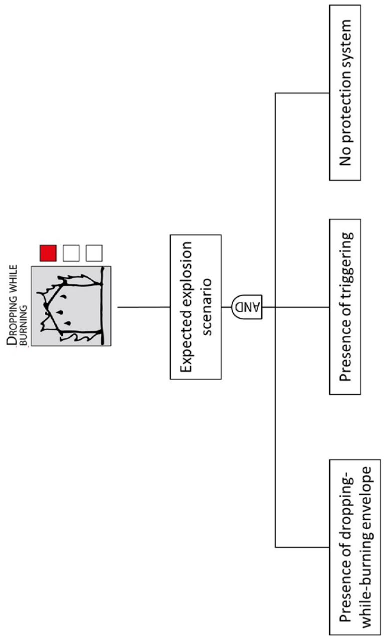


Fig. 2.32 *Fire hazard: evaluation logical tree for the 'Dropping while burning' impact scenario*

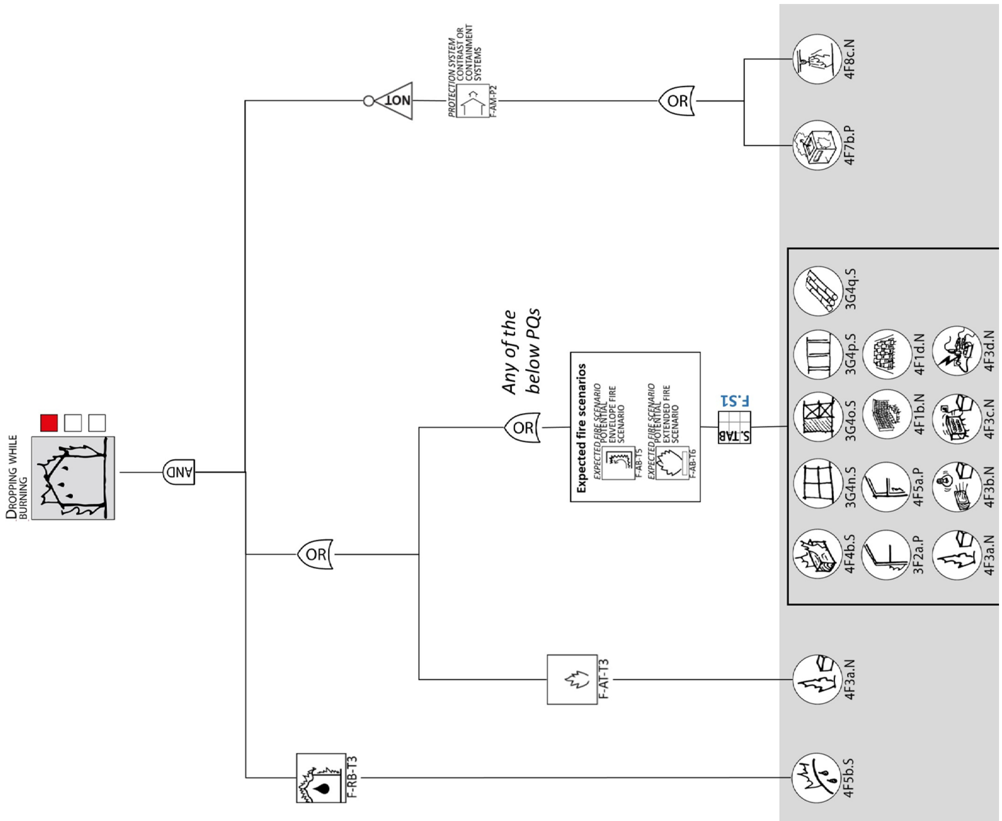


Fig. 2.33 *Fire hazard: expert logical tree for the 'Total loss of contents' impact scenario*

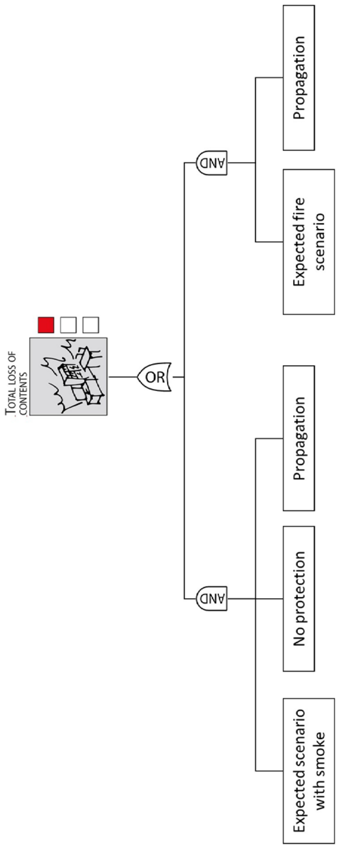


Fig. 2.34 *Fire hazard: evaluation logical tree for the 'Total loss of contents' impact scenario*

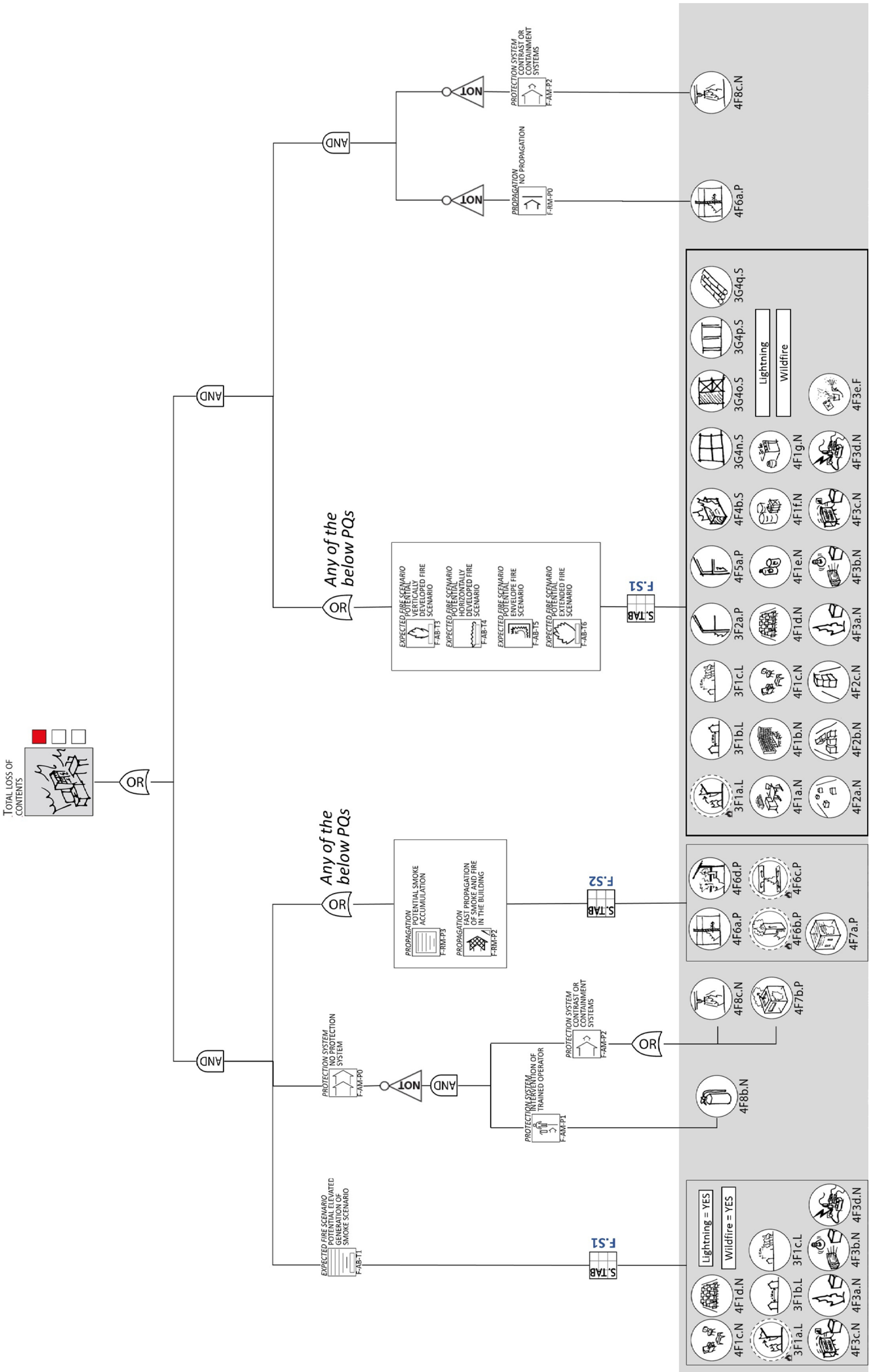


Fig. 2.35 *Fire hazard: expert logical tree for the 'Local loss of contents' impact scenario*

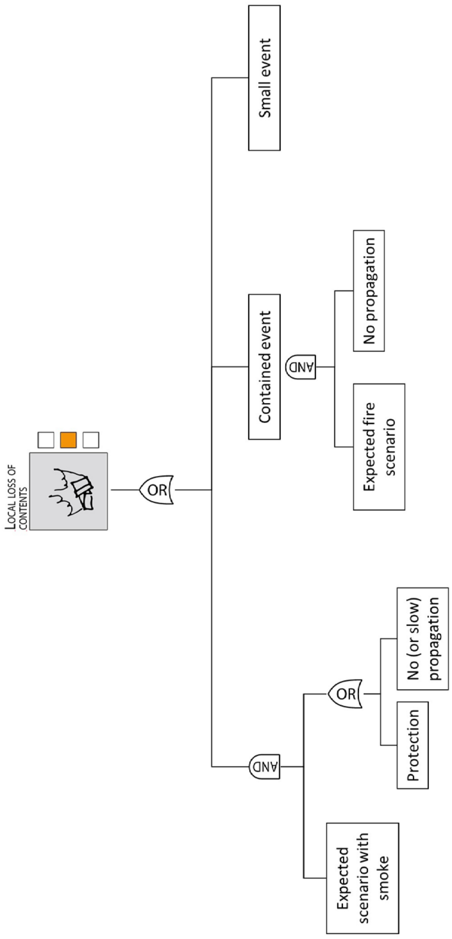


Fig. 2.36 *Fire hazard: evaluation logical tree for the 'Local loss of contents' impact scenario*

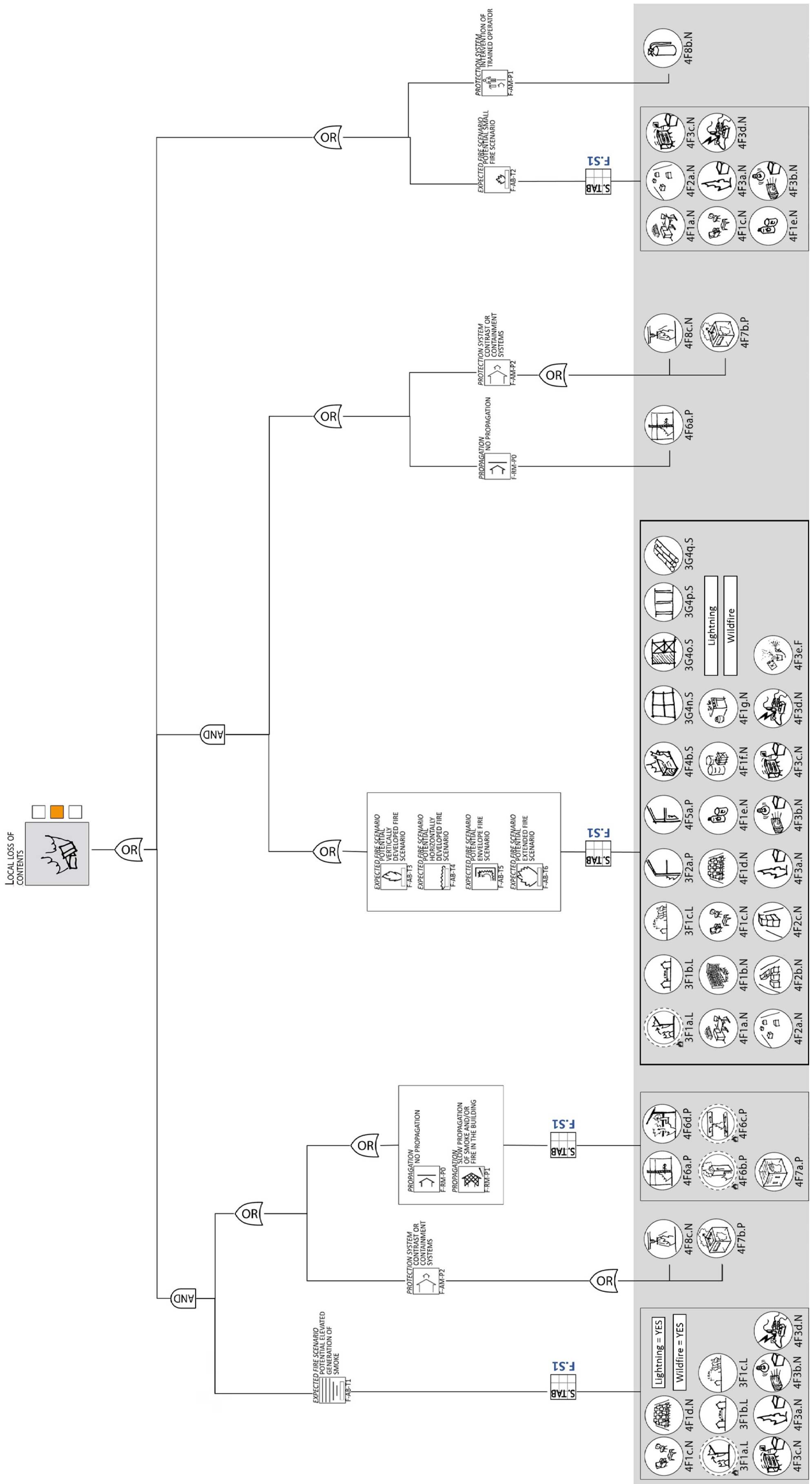


Fig. 2.37 *Fire hazard: expert logical tree for the 'Trapped people due to fire or smoke' impact scenario*

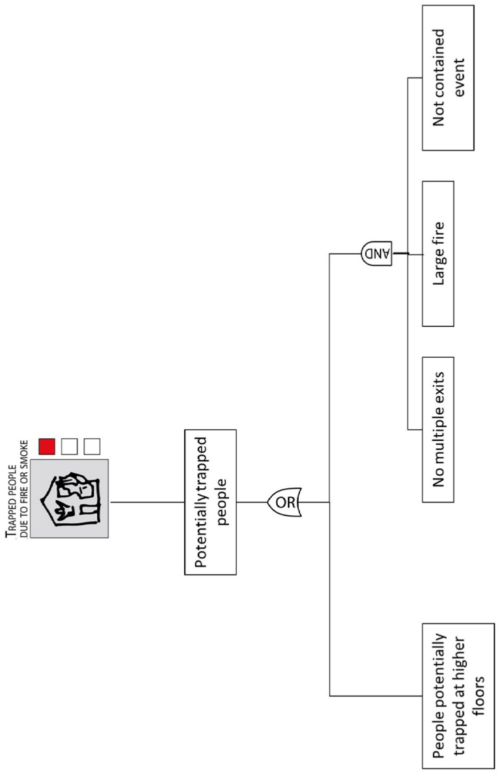


Fig. 2.38 *Fire hazard: evaluation logical tree for the 'Trapped people due to fire or smoke' impact scenario*

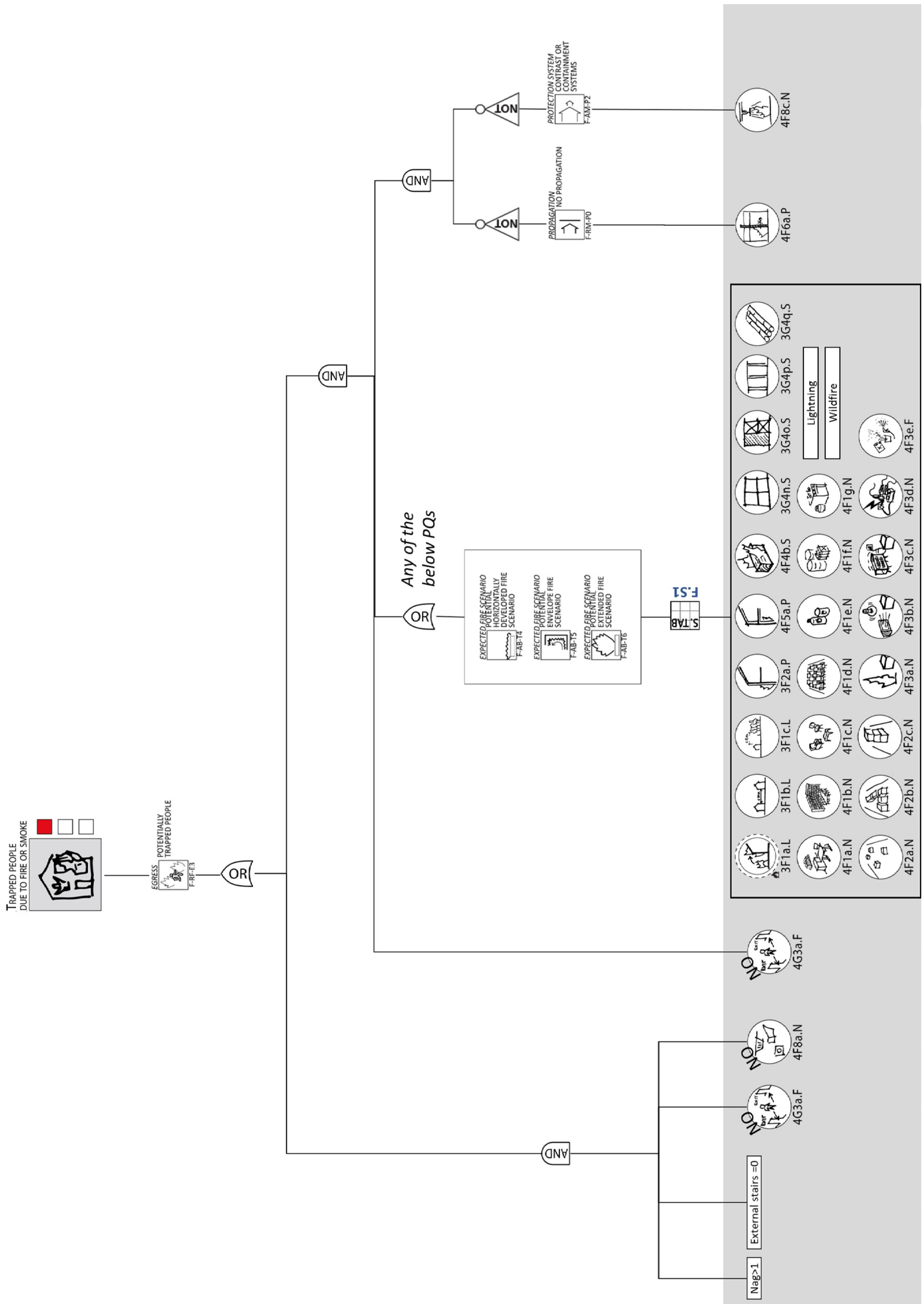


Fig. 2.39 *Fire hazard: expert logical tree for the 'Difficult step back from hazard' impact scenario*

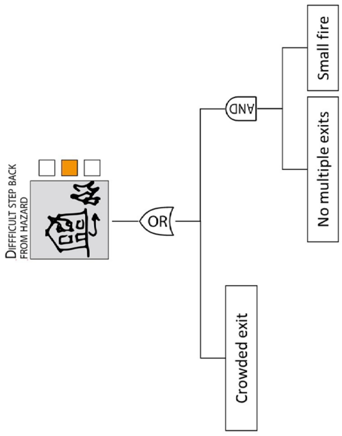


Fig. 2.40 *Fire hazard: evaluation logical tree for the 'Difficult step back from hazard' impact scenario*

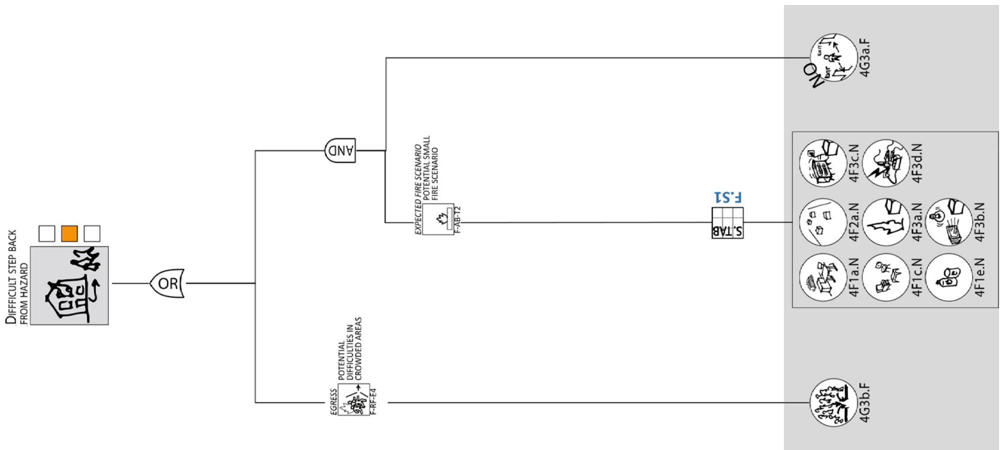


Fig. 2.41 *Fire hazard: expert logical tree for the ‘Fire suppressed by protection systems’ impact scenario*

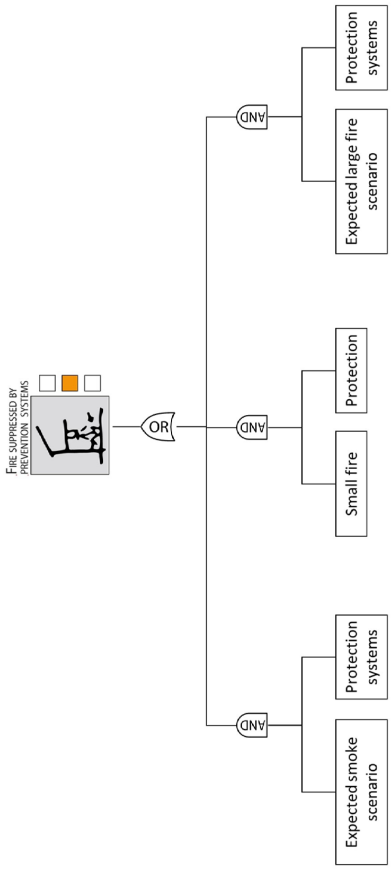
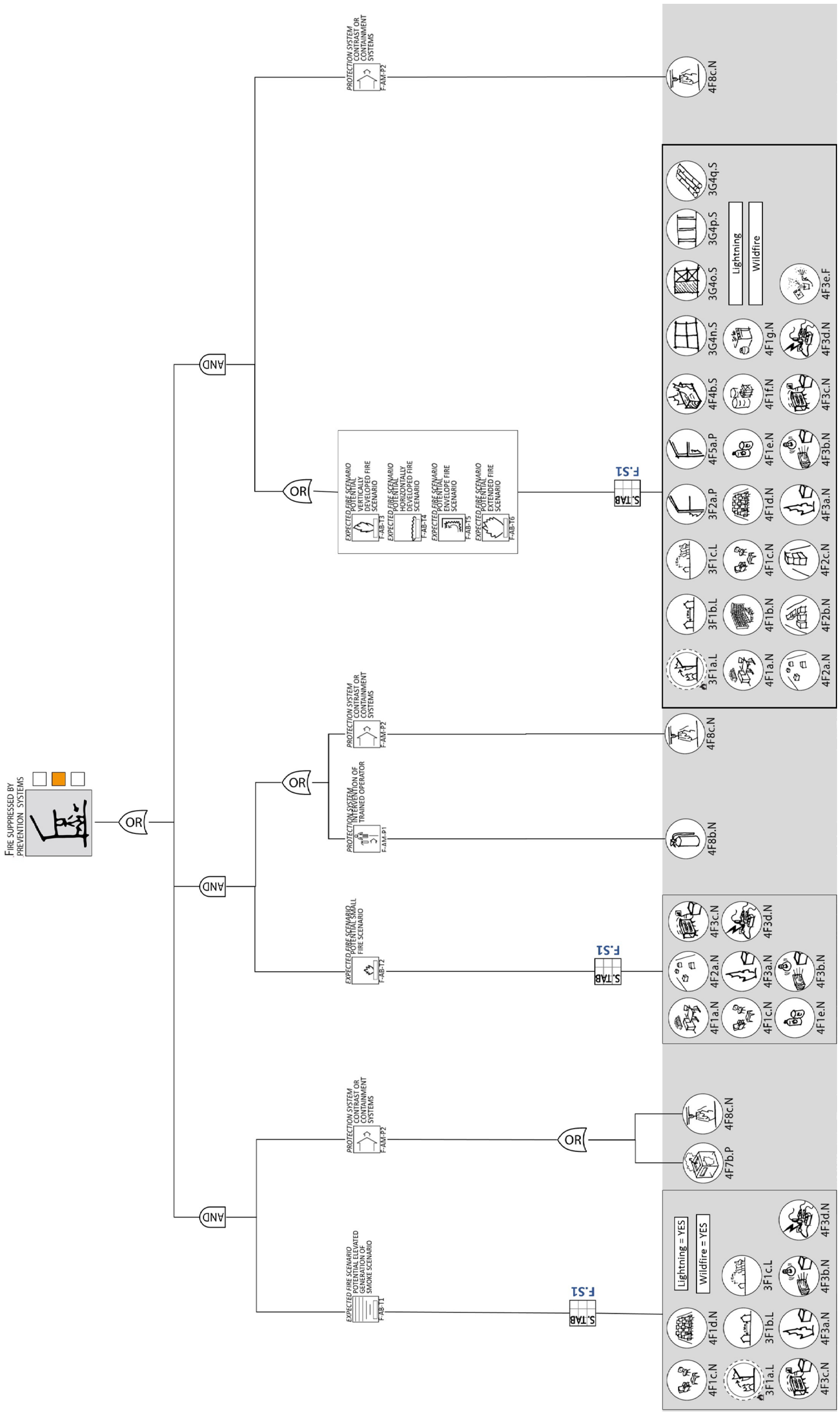


Fig. 2.42 *Fire hazard: evaluation logical tree for the 'Fire suppressed by protection systems' impact scenario*



3. REFERENCE EVENTS AND OBSERVABLES

3.1 Reference events

Table 3.1 *List of the reference events used for fire hazard evaluation*

Survey phase	Focus group	Code	Observable	Name
0	Reference event characterization – Fire – Lightning	Lightning=Yes	–	Lightning: Yes
		Lightning=No	–	Lightning: No
	Reference event characterization – Fire – Wildfire	Wildfire=Yes	–	Wildfire: Yes
		Wildfire=No	–	Wildfire: No

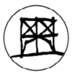
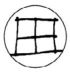
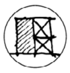
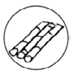
3.2 Observables for the schoolyard

Table 3.2 *List of the observables (OBS) used for fire hazard evaluation of the schoolyard*

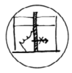
Survey phase	Focus group	Code	Observable	Name
1	G3 - Natural hazards	1G3e.L		Within a forest
2	F1 - Ignition sources	2F1a.N		Free flames near combustible material
		2F1b.N		Material with potential for autocombustion
2	F2 - Combustible material	2F2a.N		Accumulation of combustible material
		2F2b.L		Dry widespread bushes
2	F3 – Protection from fire	2F3a.F		Extinguishers

3.3 Observables for school buildings

Table 3.3 *List of the observables (OBS) used for fire hazard evaluation of school buildings*

Survey phase	Focus group	Code	Observable	Name
3	G4 - Structural system: steel	3G4k.S		Unbraced steel frame
		3G4l.S		Braced steel frame
		3G4m.S		Steel vertical piers only
3	G4 - Structural system: wood	3G4n.S		Wood frame unbraced
		3G4o.S		Wood panels or wood frame braced
		3G4p.S		Wood vertical piers only
3	G4 - Structural system: bamboo	3G4q.S		Bamboo structure
3	F1 - Interdependence	3F1a.L		Proximity to accumulation of combustible material < 5 m
		3F1b.L		Proximity to combustible building < 10 m
		3F1c.L		Proximity to a forest < 15 m
3	F2 - Combustible envelope	3F2a.P		External combustible sidings
3	F3 - Egress	3F3a.P		External stairs for fire escape
4	G3 - Egress	4G3a.F		Alternative egress paths

Survey phase	Focus group	Code	Observable	Name
4	F1 - Combustible contents	4F1a.N		Moderate amount of books or wood-based furniture
		4F1b.N		Notable amount of books or wood-based furniture
		4F1c.N		Moderate amount of upholstered or plastic-based furniture
		4F1d.N		Notable amount of upholstered or plastic-based furniture
		4F1e.N		Limited amount of flammable liquids
		4F1f.N		Notable amount of flammable liquids
		4F1g.N		Limited amount of flammable gas
4	F2 - Disposal of combustible contents	4F2a.N		Combustibles isolated from one another
		4F2b.N		Combustibles in close proximity to one another
		4F2c.N		Piles of materials or objects
4	F3 - Presence of ignition sources near combustible material	4F3a.N		Free flames near combustible material
		4F3b.N		Hot high-power lights near combustible material
		4F3c.N		Electrical or gas heaters near combustible material
		4F3d.N		Overloaded electrical outlets near combustible material
		4F3e.N		Flammable material handled with potential aero-dispersion
4	F4 - Structural fire behaviour	4F4a.S		Heat-sensitive structural material
		4F4b.S		Combustible structural material
		4F4c.S		Heat-sensitive elements have fire protection
4	F5 – Combustible interior finishes	4F5a.P		Presence of internal combustible sidings
		4F5b.S		Presence of dropping while burning material

Survey phase	Focus group	Code	Observable	Name
4	F6 - Fire and smoke propagation paths	4F6a.P		Firewalls
		4F6b.P		Vertical propagation paths
		4F6c.P		Horizontal propagation paths
		4F6d.P		Holes and/or ductwork
4	F7 - Smoke accumu-lation	4F7a.P		Rooms with small or no openings
		4F7b.P		Large top or roof openings or smoke venting system
4	F8 - Protection sys-tems	4F8a.N		Detection and alarm system
		4F8b.N		Personnel trained in the use of fire extinguishers
		4F8c.N		Automatic fire suppression system
4	F9 - Egress	4F9a.F		Presence of safe areas for people with disabilities

4. PROFILE QUALIFIERS

4.1 Profile qualifiers for the schoolyard

Table 4.1 *Definition of the profile qualifiers for fire hazard evaluation of the schoolyard*

Focus	Icon and code	Name	Evaluation logic
Trigger/source	F-AT-T0	No trigger/source	NOT (F-AT-T2 OR F-AT-T3)
	F-AT-T1	External trigger: lightning	Hazard lightning=Yes
	F-AT-T2	External trigger: radiation	Hazard wildfire=Yes
	F-AT-T3	Free flames	2F1a.N OR 2F1b.N
Interdependence	F-AI-I1	Potential interdependence with the site	1G3e.L
Predisposed fire scenario	F-AP-T0	Not predisposed to fire	NOT (F-AP-T4 OR F-AP-T6)
	F-AP-T4	Predisposed to horizontally developed fire	2F2b.L
	F-AP-T6	Predisposed to extended fire	2F2a.N OR 1G3e.L OR 2F1a.N
Expected fire scenario	F-AB-T2	Potential small fire scenario	2F1b.N
	F-AB-T4	Potential horizontally developed fire scenario	F-AP-T4 AND (F-AT-T1 OR F-AT-T2 OR F-AT-T3)
	F-AB-T6	Potential extended fire scenario	F-AP-T6 AND (F-AT-T1 OR F-AT-T2 OR F-AT-T3)
Protection	F-AM-P0	No protection system	NOT (F-AM-P1)
	F-AM-P1	Intervention of trained personnel	2F3a.F

4.2 Profile qualifiers for school buildings

Table 4.2 *Definition of the profile qualifiers for fire hazard evaluation of school buildings*

Focus	Icon and code	Name	Evaluation logic
Trigger/source	F-AT-T0	No trigger/source	NOT (F-AT-T1 OR F-AT-T2 OR F-AT-T3 OR F-AT-T4)
	F-AT-T1	External trigger: lightning	Hazard lightning=Yes
	F-AT-T2	External trigger: radiation	3F1a.L OR 3F1b.L OR (Hazard Wildfire=Yes AND 3F1c.L)
	F-AT-T3	Free flames	4F3a.N
	F-AT-T4	Internal trigger: high temperature	4F3b.N OR 4F3c.N OR 4F3d.N
Interdependence	F-AI-I1	Potential interdependence with the site	3F1a.L OR 3F1c.L
	F-AI-I2	Potential interdependence among buildings	3F1b.L

Focus	Icon and code	Name	Evaluation logic
Predisposed fire scenario	N F-AP-T0	Not predisposed to fire	NOT (F-AP-T1 OR F-AP-T2 OR F-AP-T3 OR F-AP-T4 OR F-AP-T5 OR F-AP-T6 OR F-AP-T7)
	F-AB-T1	Predisposed to elevated generation of smoke	4F1c.N OR 4F1d.N
	F-AP-T2	Predisposed to small fire	4F1a.N OR 4F1c.N OR 4F1e.N OR 4F2a.N
	F-AP-T3	Predisposed to vertically developed fire	4F2c.N
	F-AP-T4	Predisposed to horizontally developed fire	4F2b.N
	F-AP-T5	Predisposed to envelope fire	3F2a.P OR 4F5a.P
	F-AP-T6	Predisposed to extended fire	4F1b.N OR 4F1d.N OR 4F1f.N OR F-RB-T1
	F-AP-T7	Predisposed to explosive scenario	4F3e.F AND (4F1e.N OR 4F1f.N OR 4F1g.N)

Focus	Icon and code	Name	Evaluation logic
Expected fire scenario	F-AB-T1	Potential elevated generation of smoke scenario	F-AB-T1 AND (F-AT-T1 OR F-AT-T2 OR F-AT-T3 OR F-AT-T4)
	F-AB-T2	Potential small fire scenario	F-AP-T2 AND (F-AT-T3 OR F-AT-T4)
	F-AB-T3	Potential vertically developed fire scenario	F-AP-T3 AND (F-AT-T3 OR F-AT-T4)
	F-AB-T4	Potential horizontally developed fire scenario	F-AP-T4 AND (F-AT-T3 OR F-AT-T4)
	F-AB-T5	Potential envelope fire scenario	F-AP-T5 AND (F-AT-T1 OR F-AT-T2 OR F-AT-T3 OR F-AT-T4)
	F-AB-T6	Potential extended fire scenario	F-AP-T6 AND (F-AT-T3 OR F-AT-T4)
	F-AB-T7	Potential explosion scenario	F-AP-T7 AND (F-AT-T1 OR F-AT-T2 OR F-AT-T3 OR F-AT-T4)
Structural behaviour	F-RB-T0	No fire effects on structure	NOT (F-RB-T1 OR F-RB-T 2 OR F-RB-T 3)
	F-RB-T1	Combustible structure	4F4b.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S
	F-RB-T2	Heat-sensitive structure	(4F4a.S OR 3G4k.S OR 3G4l.S OR 3G4m.S) AND NOT (4F4c.S)
	F-RB-T3	Dropping while burning	4F5b.S

Focus	Icon and code	Name	Evaluation logic
Propagation	F-RM-P0	No propagation	4F6a.P
	F-RM-P1	Slow propagation of smoke and/or fire in the building	NOT (4F6a.P) AND NOT (4F6b.P) AND NOT (4F6c.P) AND NOT (4F6d.P)
	F-RM-P2	Rapid propagation of smoke and fire in the building	(4F6b.P OR 4F6c.P OR 4F6d.P) AND NOT (4F6a.P)
	F-RM-P3	Potential smoke accumulation	4F7a.P AND (F-RM-P1 OR F-RM-P2)
Protection system	F-AM-P0	No protection system	NOT (F-AM-P1 OR F-AM-P2)
	F-AM-P1	Intervention of trained operator	4F8b.N
	F-AM-P2	Contrast or containment systems	4F7b.P OR 4F8c.N
Egress	F-RF-E1	Single egress path (no alternatives)	NOT (4G3a.F)
	F-RF-E2	Multiple egress paths (alternatives)	4G3a.F
	F-RF-E3	Potentially trapped people	Nag>1 AND (External stairs=0) AND NOT (4G3a.F) AND NOT (4F8a.N) OR [NOT(4G3a.F) AND (F-AB-T4 OR F-AB-T5 OR F-AB-T6) AND [NOT(F-RM-P0) AND NOT(F-AM-P2)]]
	F-RF-E4	Potential difficulties in crowded areas	4G3b.F

5. SUPPORTING TABLES

Table F.S1 *For readability, the logical tree section that shows the definition of the expected fire scenarios is not always illustrated in the VISUS logical trees. When necessary, a link is made to the table below, which illustrates the rules and criteria for the evaluation. The evaluation logic is also represented in logical trees (the figure is linked in the last column of the table).*

Profile qualifier	Name	Evaluation logic	Figure
F-AB-T1	Potential elevated generation of smoke scenario	(4F1c.N OR 4F1d.N) AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.1**
F-AB-T2	Potential small fire scenario	(4F1a.N OR 4F1c.N OR 4F1e.N OR 4F2a.N) AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.2**
F-AB-T3	Potential vertically developed fire scenario	4F2c.N AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.3**
F-AB-T4	Potential horizontally developed fire scenario	4F2b.N AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.4**

Profile qualifier	Name	Evaluation logic	Figure
F-AB-T5	Potential envelope fire scenario	(3F2a.P OR 4F5a.P) AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.5**
F-AB-T6	Potential extended fire scenario	[4F1b.N OR 4F1d.N OR 4F1f.N OR (4F4b.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S)] AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.6**
F-AB-T7	Potential explosion scenario	[4F3e.F AND (4F1e.N OR 4F1f.N OR 4F1g.N)] AND [Hazard Lightning=Yes OR 3F1a.L OR (Hazard Wildfire=Yes AND 3F1c.L) OR 4F3a.N OR 4F3b.N OR 4F3c.N OR 4F3d.N]	**Fig. 5.7**

Table F.S2 *For readability, the logical tree section that shows the definition of the propagation profile qualifiers is not always illustrated in the VISUS logical trees. When necessary, a link is made to the table below, which illustrates the rules and criteria for the evaluation. The evaluation logic is also represented in logical trees (the figure is linked in the last column of the table).*

Profile qualifier	Name	Evaluation logic	Figure
F-RM-P0	No propagation	4F6a.P	-
F-RM-P1	Slow propagation of smoke and/or fire in the building	NOT (4F6a.P) AND NOT (4F6b.P) AND NOT (4F6c.P) AND NOT (4F6d.P)	**Fig. 5.8**
F-RM-P2	Rapid propagation of smoke and fire in the building	(4F6b.P OR 4F6c.P OR 4F6d.P) AND NOT (4F6a.P)	**Fig. 5.9**
F-RM-P3	Potential smoke accumulation	4F7a.P AND (F-RM-P1 OR F-RM-P3)	**Fig. 5.10**

Fig. 5.1 *Logical tree for defining profile qualifier F-AB-T1*

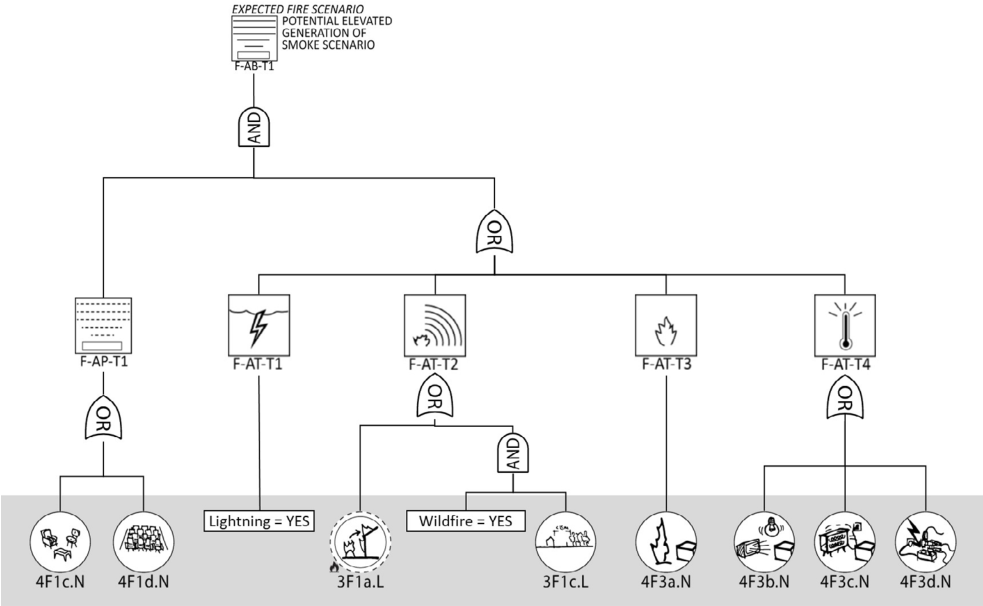


Fig. 5.2 *Logical tree for defining profile qualifier F-AB-T2*

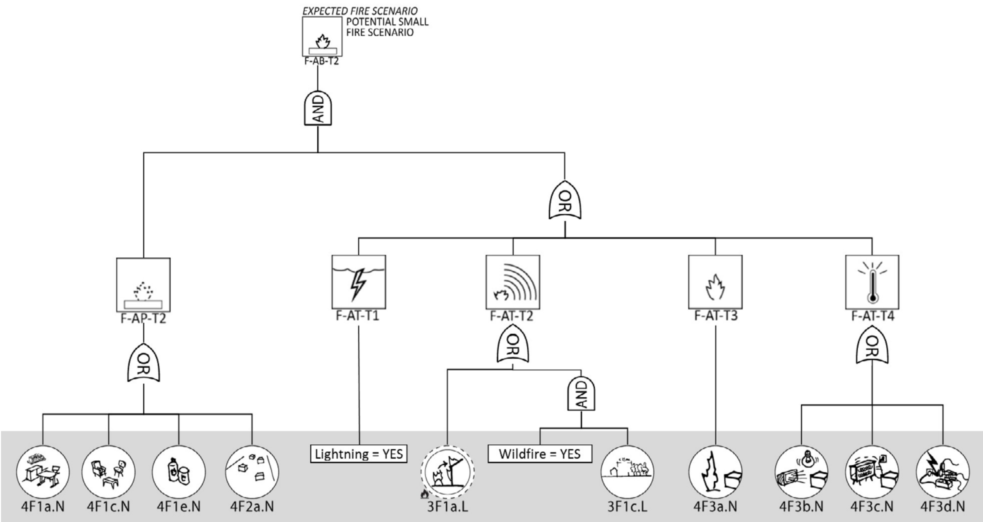


Fig. 5.3 *Logical tree for defining profile qualifier F-AB-T3*

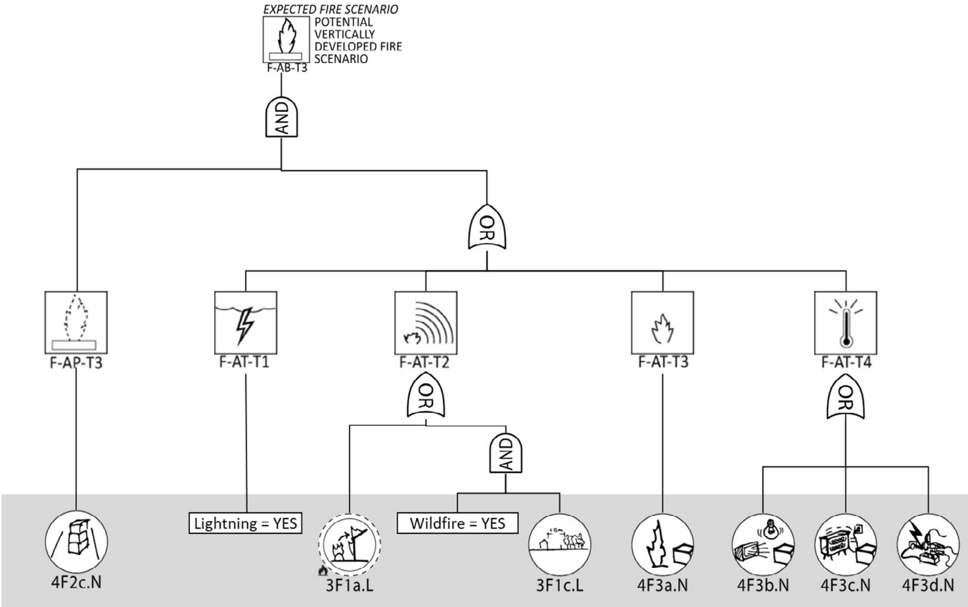


Fig. 5.4 *Logical tree for defining profile qualifier F-AB-T4*

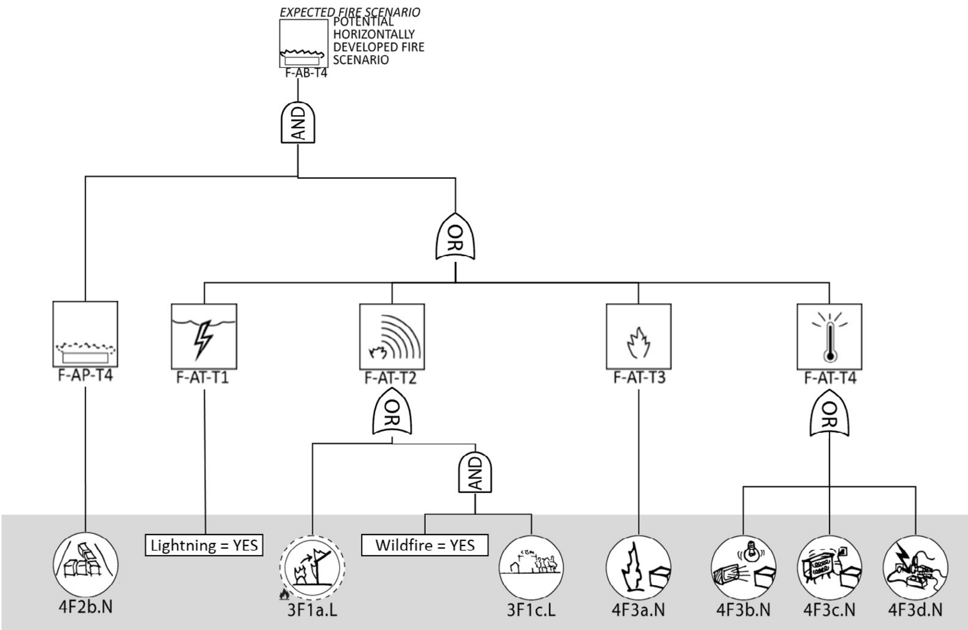


Fig. 5.5 *Logical tree for defining profile qualifier F-AB-T5*

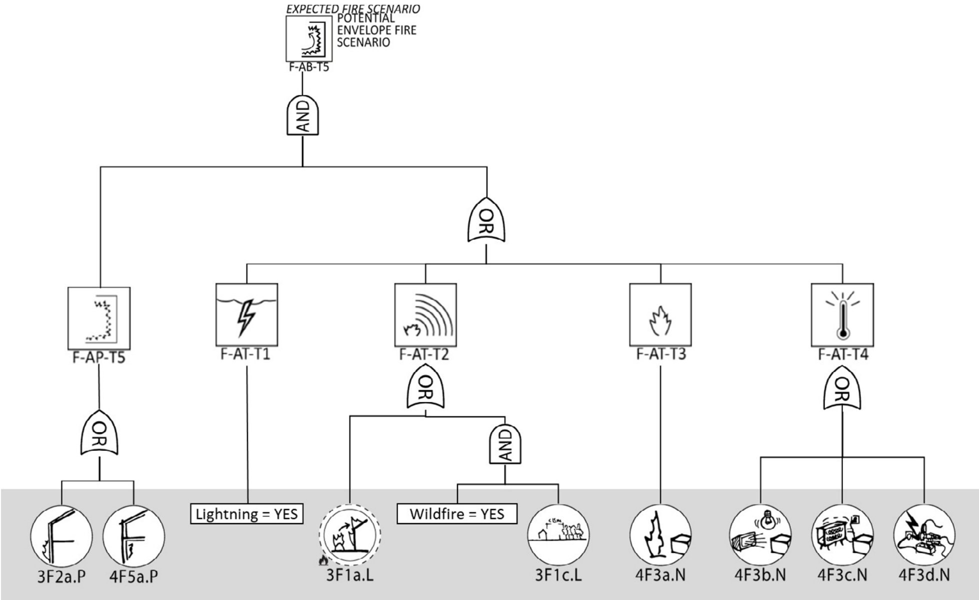


Fig. 5.6 *Logical tree for defining profile qualifier F-AB-T6*

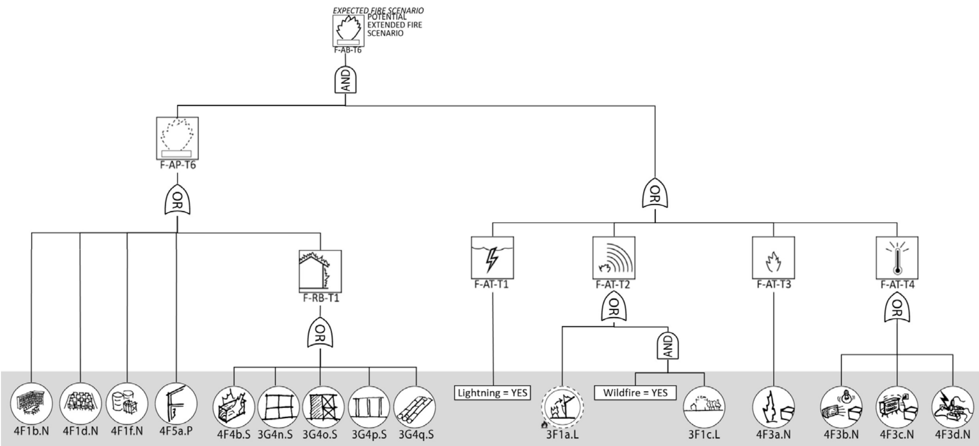


Fig. 5.7 *Logical tree for defining profile qualifier F-AB-T7*

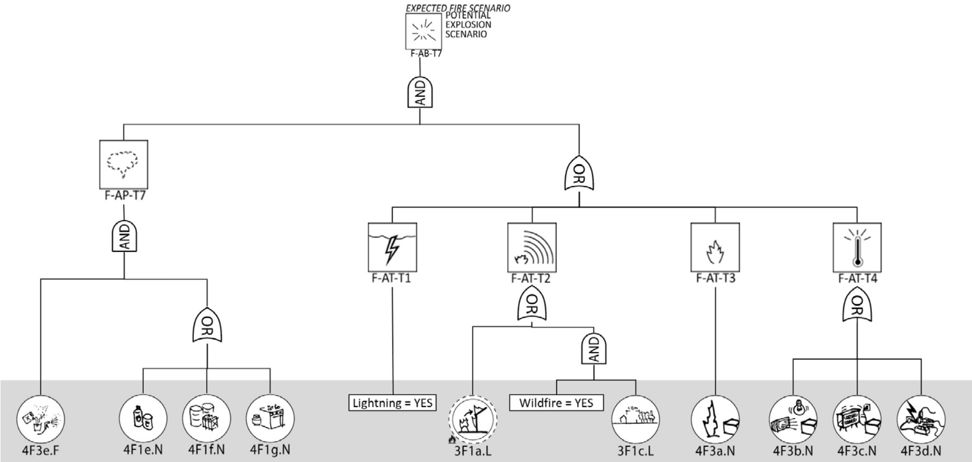


Fig. 5.8 *Logical tree for defining profile qualifier F-RM-P1*

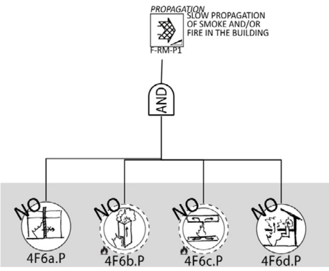


Fig. 5.9 *Logical tree for defining profile qualifier F-RM-P2*

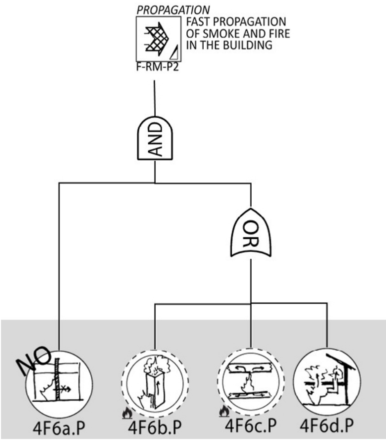
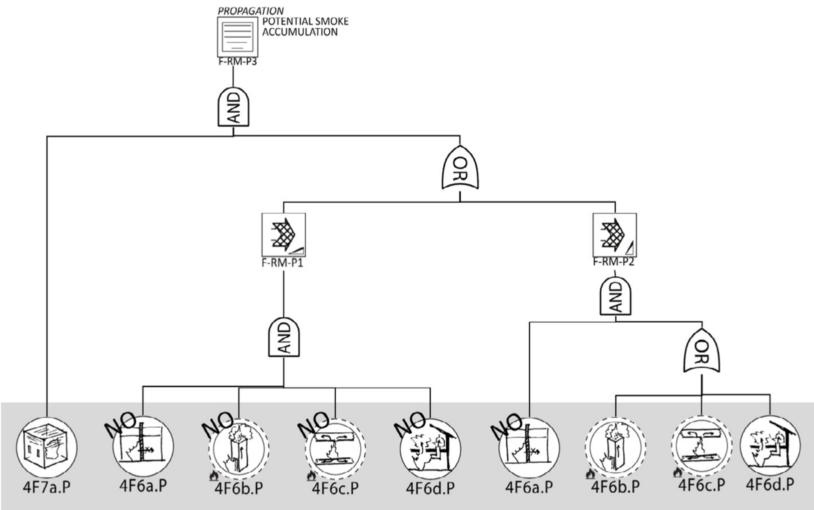


Fig. 5.10 *Logical tree for defining profile qualifier F-RM-P3*



6. SAFETY INDICATOR: ROSE OF WARNING LEVELS

6.1 Warning level evaluation for the schoolyard

Table F.WS.L *Fire hazard evaluation of the warning levels for the schoolyard: site/location safety issue*

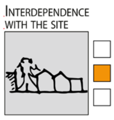
Warning level	Evaluation logic
	NOT( OR )
	
	No scenario

Table F.WS.S *Fire hazard evaluation of the warning levels for the schoolyard: structural global safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table F.WS.P *Fire hazard evaluation of the warning levels for the schoolyard: structural local/envelope safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table F.WS.N *Fire hazard evaluation of the warning levels for the schoolyard: non-structural safety issue*

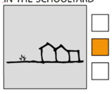
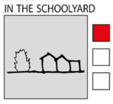
Warning level	Evaluation logic
	NOT ( OR )
	SMALL FIRE IN THE SCHOOLYARD 
	LARGE FIRE IN THE SCHOOLYARD 

Table F.WS.F *Fire hazard evaluation of the warning levels for the schoolyard: functionality safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

6.2 Warning level evaluation for school buildings

Table F.WB.L *Fire hazard evaluation of the warning levels for school buildings: site/location safety issue*

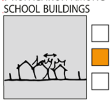
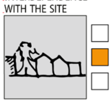
Warning level	Evaluation logic
	NOT( OR )
	PROPAGATION AMONG SCHOOL BUILDINGS  OR INTERDEPENDENCE WITH THE SITE 
	No scenario

Table F.WB.S *Fire hazard evaluation of the warning levels for school buildings: structural global safety issue*

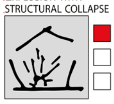
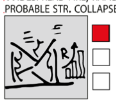
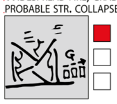
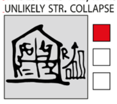
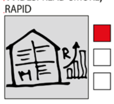
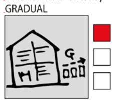
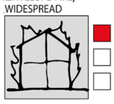
Warning level	Evaluation logic
	Not ( OR )
	Fire suppressed by prevention systems 
	Explosion with structural collapse  OR Widespread fire, rapid, probable str. collapse  OR Widespread fire, gradual probable str. collapse  OR Widespread fire, rapid unlikely str. collapse  OR Widespread fire, gradual unlikely str. collapse  OR Widespread smoke, rapid  OR Widespread smoke, gradual  OR Envelope fire, widespread 

Table F.WB.P *Fire hazard evaluation of the warning levels for school buildings: structural local/envelope safety issue*

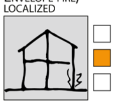
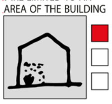
Warning level	Evaluation logic
	NOT( OR )
	Envelope fire, localized 
	Fire limited to an area of the building  OR Dropping while burning 

Table F.WB.N *Fire hazard evaluation of the warning levels for school buildings: non-structural safety issue*

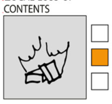
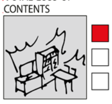
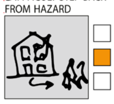
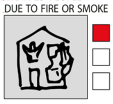
Warning level	Evaluation logic
	NOT( OR )
	Local loss of contents 
	Total loss of contents 

Table F.WB.F *Fire hazard evaluation of the warning levels for school buildings: functionality safety issue*

Warning level	Evaluation logic
	NOT( OR )
	DIFFICULT STEP BACK FROM HAZARD 
	TRAPPED PEOPLE DUE TO FIRE OR SMOKE 

Annex to the VISUS Methodology

AM3 Evaluation Criteria: Water Hazard

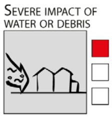
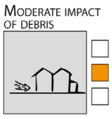
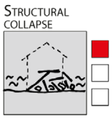
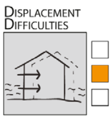
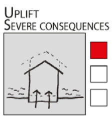
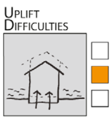
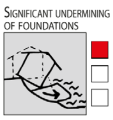
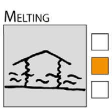
Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

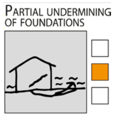
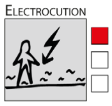
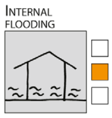
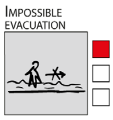
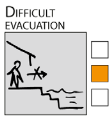
- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

1. EXPECTED IMPACT SCENARIOS

Table 1.1 lists the substantial expected impact scenarios identified for water hazard evaluated with the Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology.

Table 1.1 *Expected impact scenarios for water hazard*

Safety issue	Icon	Name	Where	Description
Location/site critical issues		Severe impact of water or debris	Schoolyard and buildings	Potentially severe impacts on the school site of very fast and deep water flow (tsunami) and/or of the presence of a large amount of debris (mud-flow).
		Moderate impact of debris	Schoolyard and buildings	Potentially moderate impacts on the school site of the presence of a significant amount of debris in floodwater.
Structural global critical issues		Structural collapse	Buildings	Potential structural collapse of the building. The structure is probably unable to withstand the water hazard (flood or tsunami) indicated in the characterization. Activation of this scenario could have severe consequences for personal safety, including injuries or deaths.
		Damage	Buildings	Presence of conditions suggesting that, in the case of the reference hazard, the structure could sustain significant damage. Activation of this scenario could result in difficulties for personal safety.
		Displacement – severe consequences	Buildings	Presence of conditions that could cause the displacement of the whole structure. This scenario could have severe consequences for personal safety.
		Displacement – difficulties	Buildings	Presence of conditions that could cause the displacement of the whole structure. This scenario could present difficulties for personal safety.
		Uplift – severe consequences	Buildings	Presence of conditions that could cause the uplift of the whole structure. This scenario could have severe consequences for personal safety.
		Uplift – difficulties	Buildings	Presence of conditions that could cause the uplift of the whole structure. This scenario could present difficulties for personal safety.
		Significant undermining of foundations	Buildings	Presence of conditions that could cause the undermining of the foundations, with potential failure of the structure. This scenario could have severe consequences for personal safety.
		Melting	Buildings	Presence of conditions that could cause the melting of the building's structural material, with potential loss of robustness in the case of prolonged contact with floodwater. This scenario would only have difficulties for personal safety.

Safety issue	Icon	Name	Where	Description
Structural local/ envelope critical issues		Local collapse– severe consequences	Buildings	Presence of local conditions that could have severe consequences for personal safety because of local collapse of structural and/or non-structural elements.
		Local collapse – difficulties	Buildings	Presence of local conditions that could cause difficulties for personal safety because of local collapse of structural and/or non-structural elements.
		Partial undermining of foundations	Buildings	Presence of conditions that could cause the undermining of the foundations, with consequent damage to the structure. This scenario could present difficulties for personal safety.
Non-structural critical issues		Electrocution	Buildings	Presence of conditions that could cause the electrocution of people in the floodwater, with potentially severe consequences for personal safety.
		Hazardous material dispersion	Schoolyard and buildings	Presence of conditions that could cause the release of hazardous material into the floodwater, resulting in potential difficulties for personal safety.
		Internal flooding	Buildings	Presence of conditions that could cause the flooding of the building, resulting in potential difficulties for personal safety.
		Loss of contents	Buildings	Potential loss of the contents of the building when there is no time for or possibility of moving valuable material to higher levels of the building.
Functionality critical issues		Trapped people in flooded areas	Buildings	Potential for people to be trapped in the building, with no possibility of escape to a safe place. Activation of this scenario could have severe consequences for personal safety.
		Impossible evacuation	Schoolyard and buildings	Potentially impossible to step away from the hazardous situation (impossible to reach a safe zone). This scenario could have severe consequences for personal safety.
		Trapped people in dry areas	Buildings	Potential for people to be trapped in the building, but with the possibility of finding a safe refuge on high levels. This scenario could present difficulties for personal safety, however, people could wait for rescuers.
		Difficult evacuation	Buildings	Potential difficulties in evacuation in the case of an adverse event.
		Absence of safe areas	Schoolyard and buildings	Absence of defined safe areas in the case of a water hazard event.

2. LOGICAL TREES

The VISUS logical trees define the substantial elements and the rules and criteria that correspond to the definition of the expected impact scenarios.

2.1 Logical trees for the schoolyard

Fig. 2.1 *Logical tree for assigning the action intensity class. This tree is used with most of the water trees to improve their readability.*

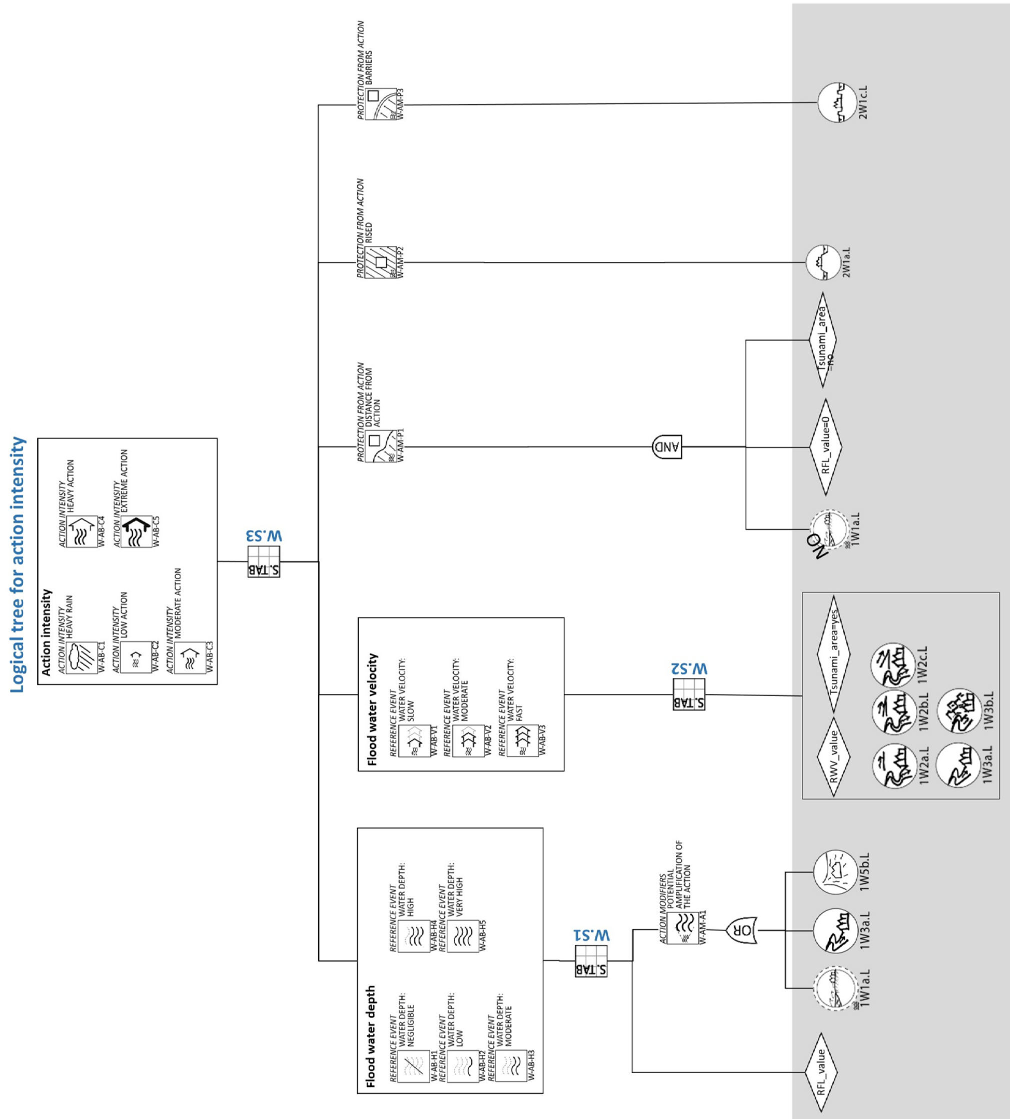


Fig. 2.2 *Water hazard: expert logical tree for the 'Severe impact of water or debris' impact scenario*

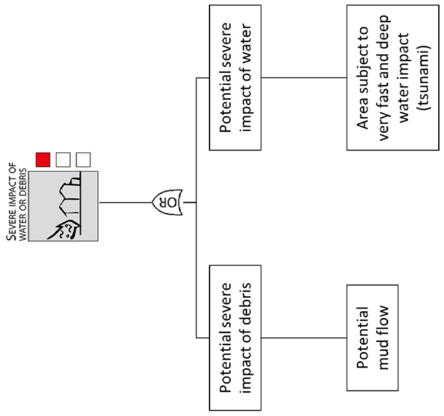


Fig. 2.3 *Water hazard: evaluation logical tree for the 'Severe impact of water or debris' impact scenario*

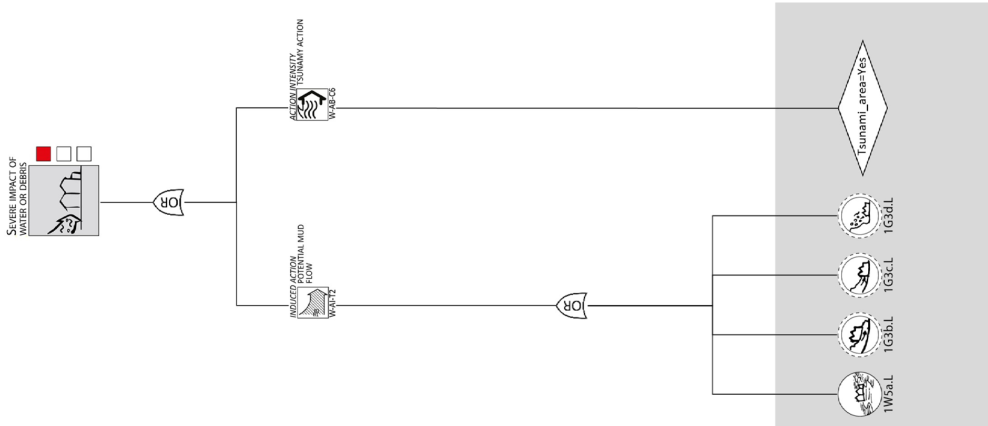


Fig. 2.4 *Water hazard: expert logical tree for the 'Moderate impact of debris' impact scenario*

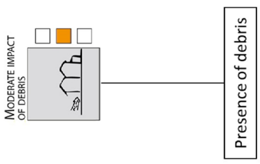


Fig. 2.5 *Water hazard: evaluation logical tree for the 'Moderate impact of debris' impact scenario*

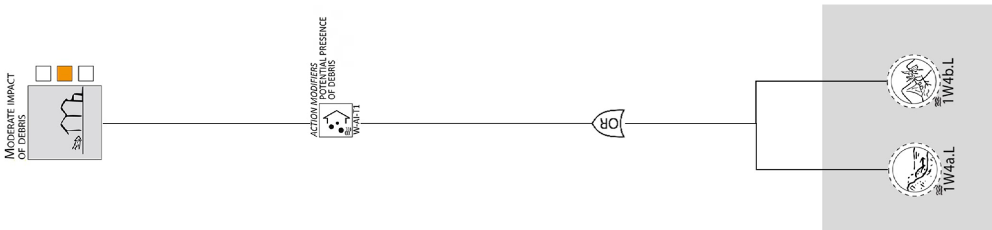


Fig. 2.6 *Water hazard: expert logical tree for the 'Hazardous material dispersion' impact scenario*

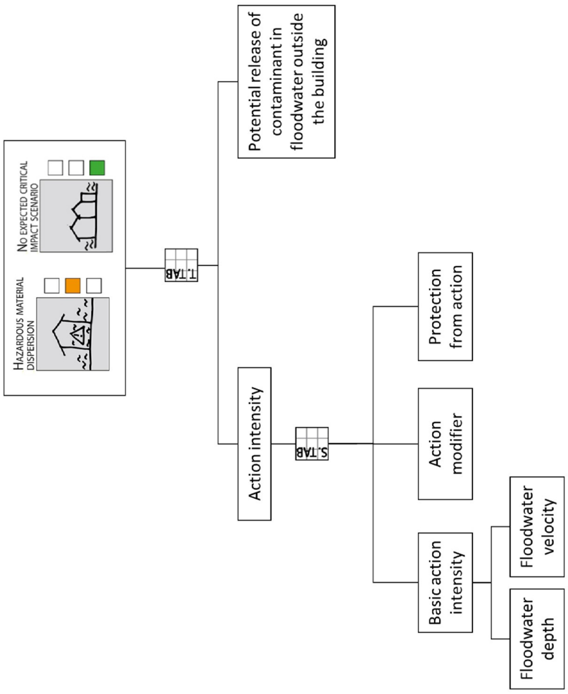


Fig. 2.7 *Water hazard: evaluation logical tree for the 'Hazardous material dispersion' impact scenario*

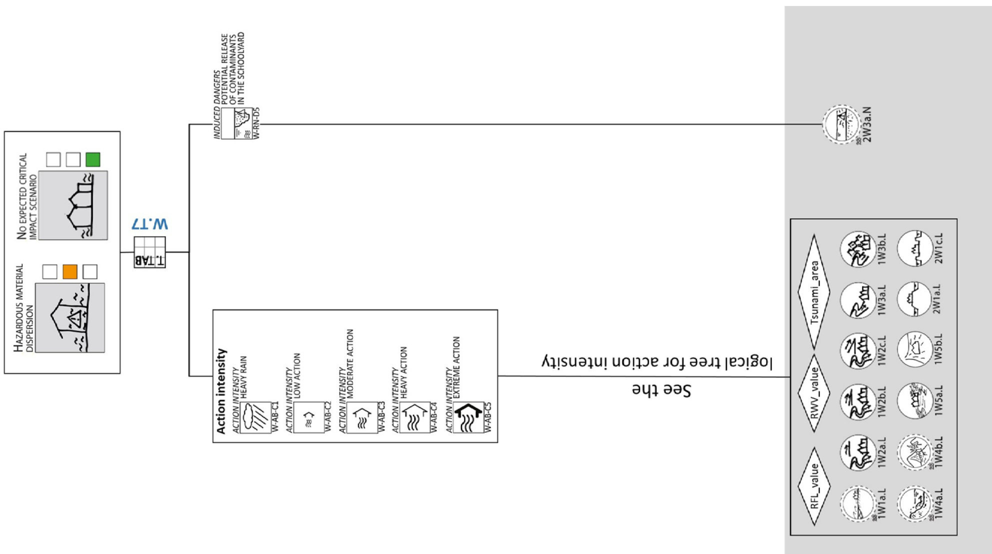


Fig. 2.8 *Water hazard: expert logical tree for the 'Absence of safe areas' impact scenario*

Fig. 2.9 *Water hazard: evaluation logical tree for the 'Absence of safe areas' impact scenario*

Fig. 2.10 *Water hazard: expert logical tree for the 'Impossible evacuation' impact scenario*

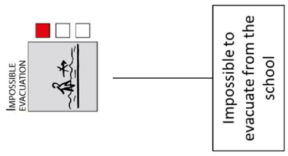
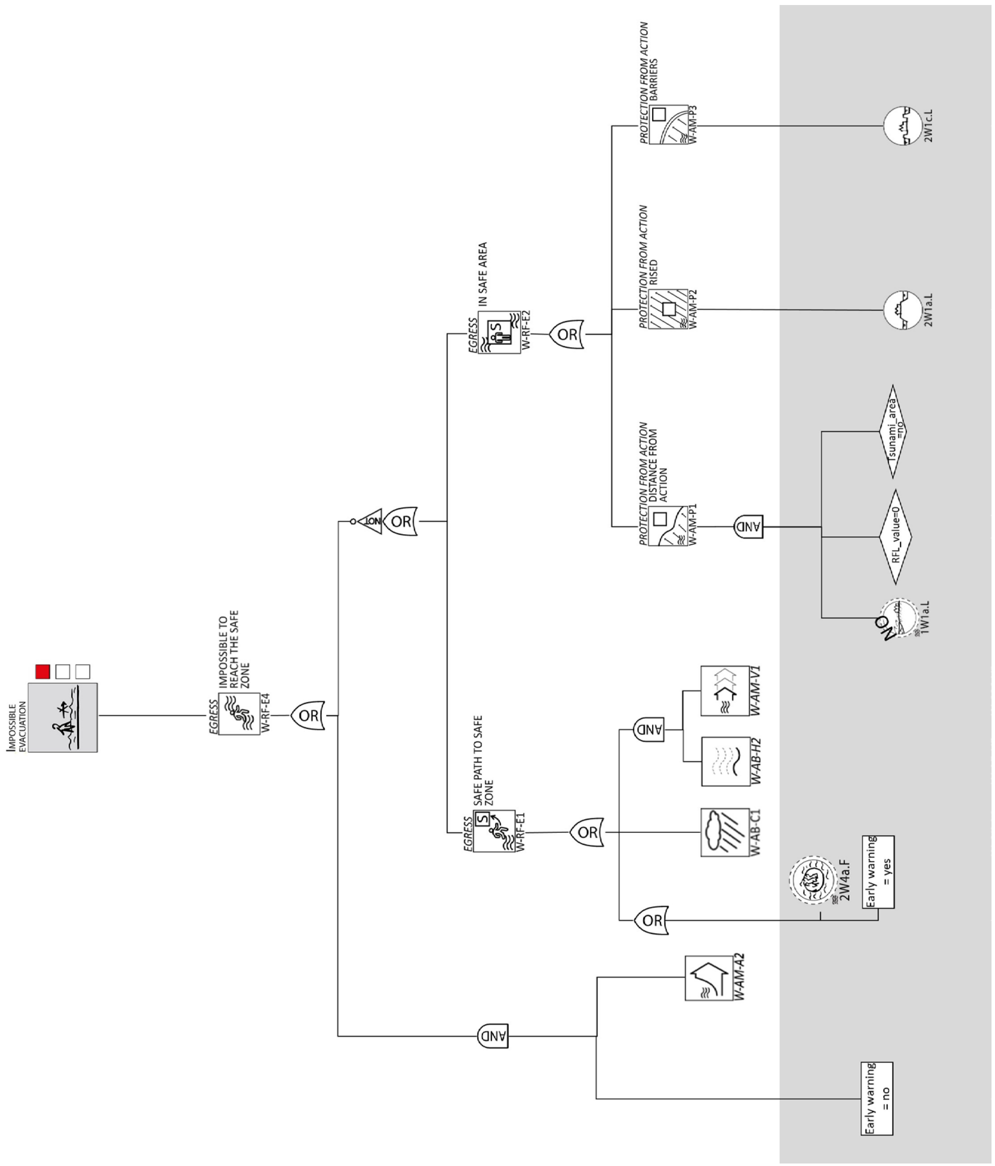


Fig. 2.11 *Water hazard: evaluation logical tree for the 'Impossible evacuation' impact scenario*



2.2 Logical trees for school buildings

Fig. 2.12 *Logical tree for assigning the hazard intensity class. This tree is used with most of the water trees to improve their readability.*

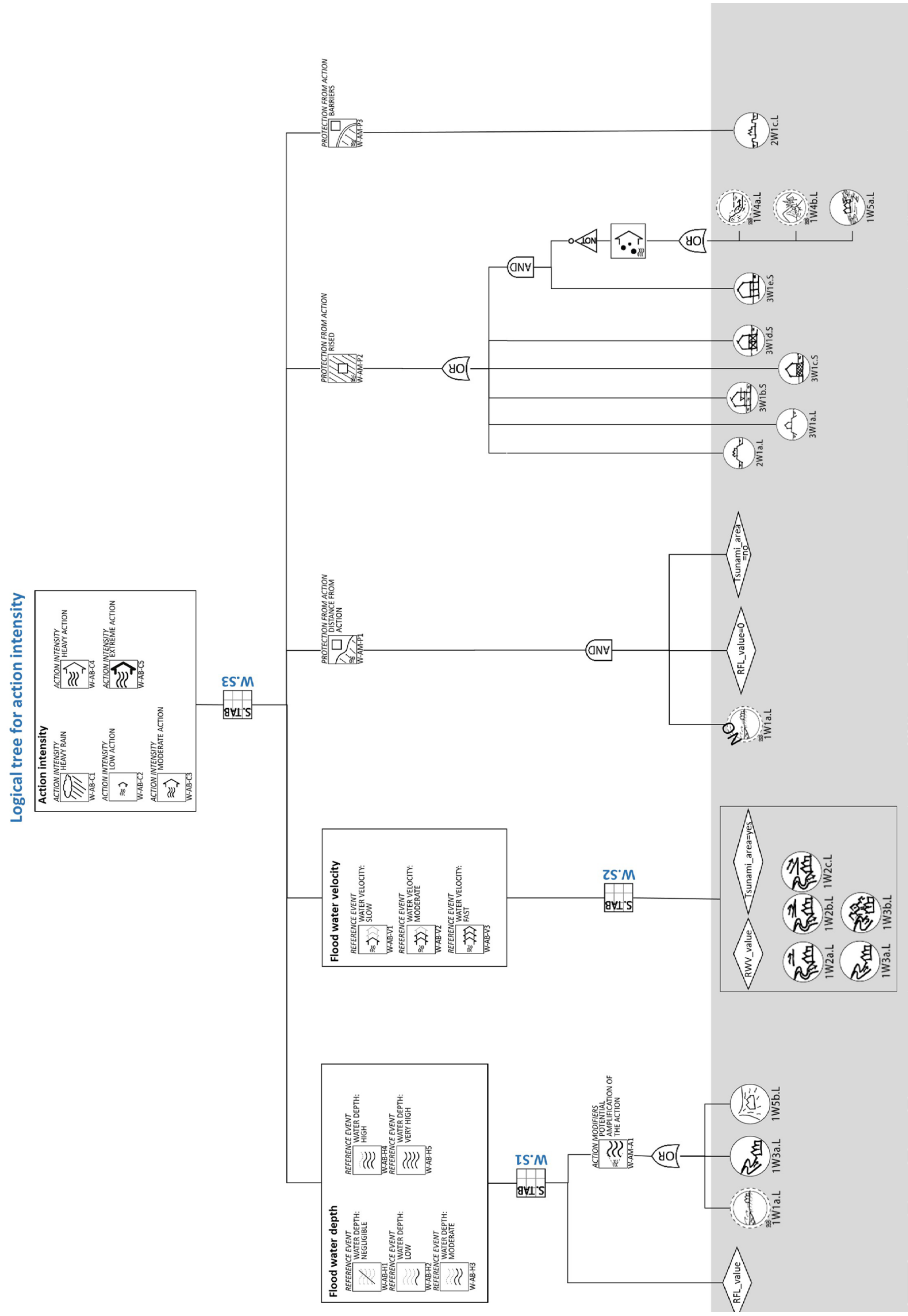


Fig. 2.13 *Water hazard: expert logical tree for the 'Severe impact of water or debris' impact scenario*

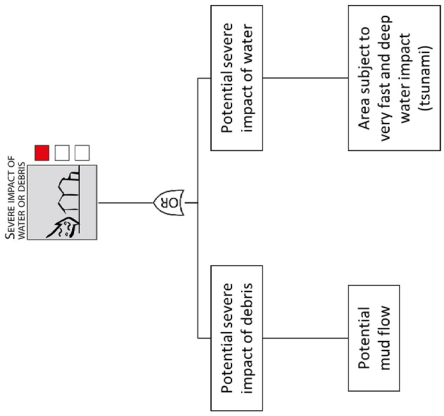


Fig. 2.14 *Water hazard: evaluation logical tree for the 'Severe impact of water or debris' impact scenario*

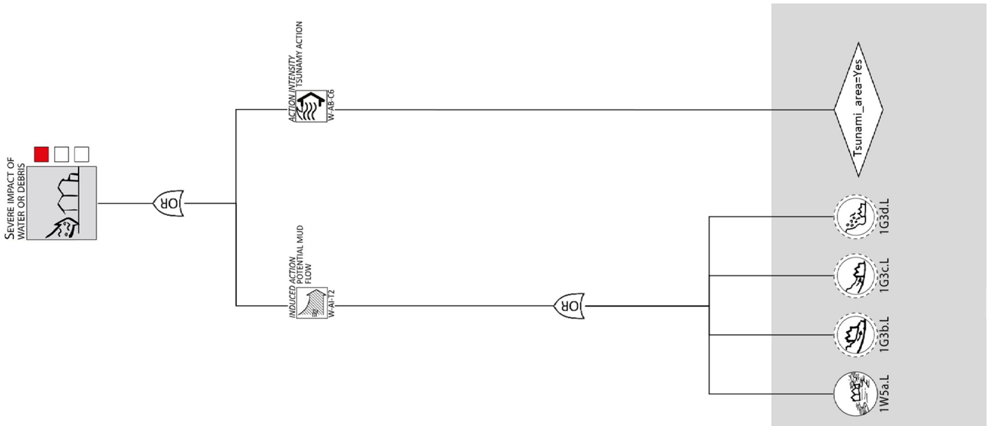


Fig. 2.15 *Water hazard: expert logical tree for the 'Moderate impact of debris' impact scenario*

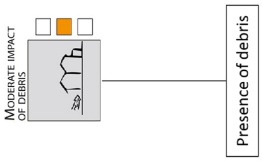


Fig. 2.16 *Water hazard: evaluation logical tree for the 'Moderate impact of debris' impact scenario*

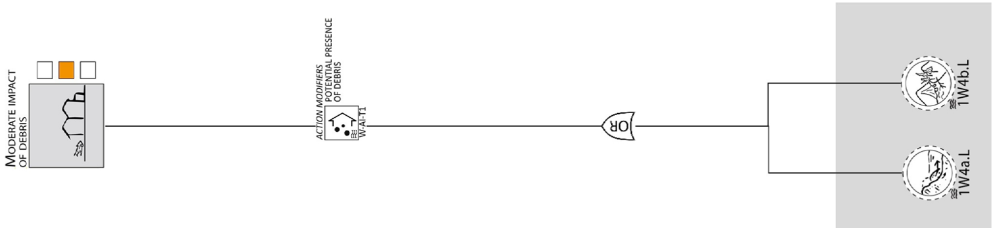


Fig. 2.17 *Water hazard: expert logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies)*

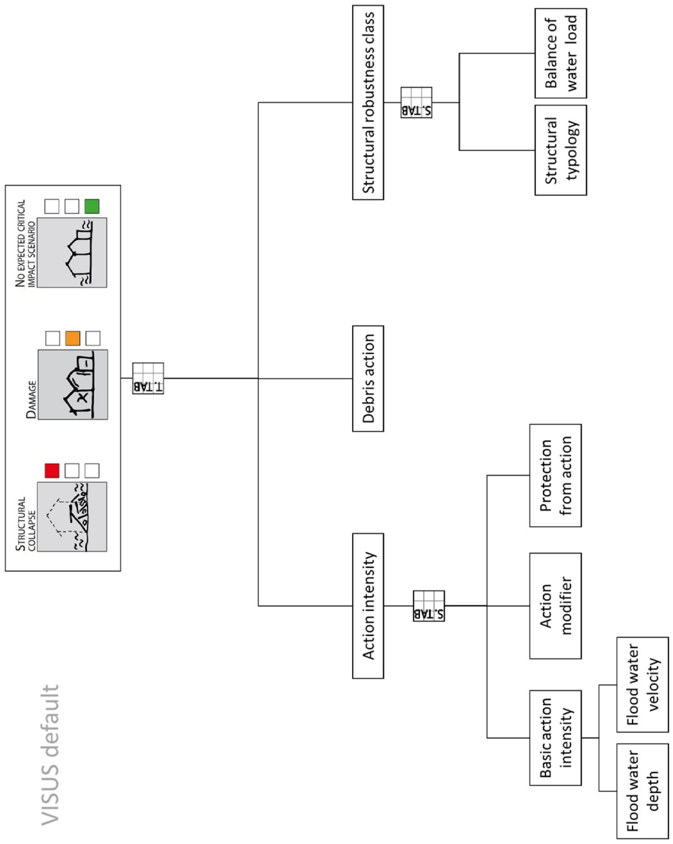
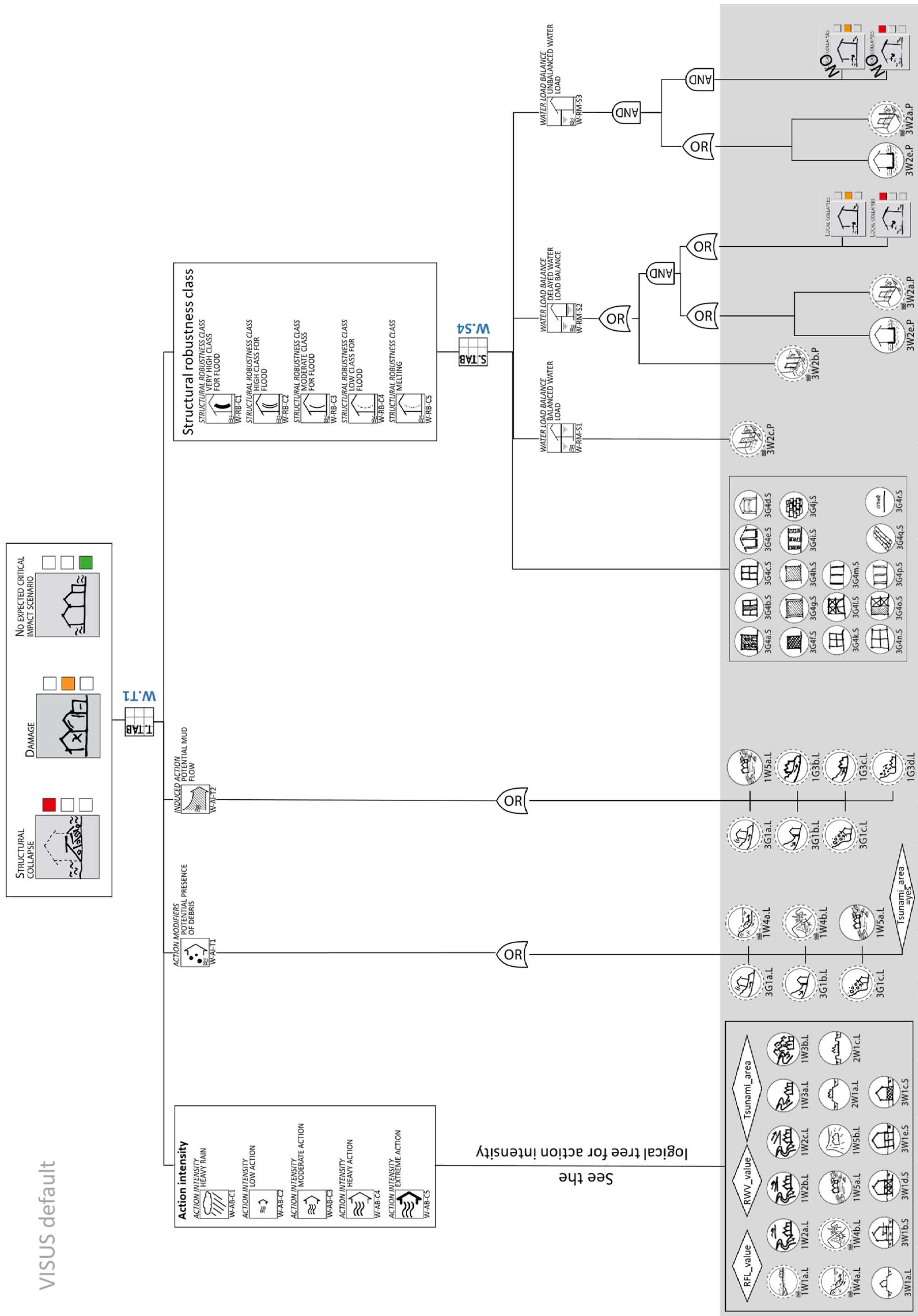


Fig. 2.18 *Water hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies)*



If, during the adaptation phase, the local committee has defined the VISUS typologies in the VISUS multi-hazard adaptation form: pre-characterized VISUS typology, the structural global critical effects are assessed with the information provided in the form, that is, the A1 and A2 values. These values are compared with the action intensity value, that is the expected 'reference event for water' (rEW). rEW is calculated by multiplying the value of reference water level (RFL) by the coefficient 'act.mod'. The 'act.mod' coefficient is calculated by multiplying the coefficients 'act.mod1' and 'act.mod2'. The coefficient 'act.mod1' represents the effect of water velocity, while 'act.mod2' represents the protection from the water action. Their values are defined in the logical trees. The results from the comparison of rEW and the values of A1 and A2 allow to assign the EIS ('Structural collapse' if rEW > A2; 'Damage' if rEW ≤ A2 and rEW > A1; or 'Action withstanding' if rEW ≤ A1).

The presence of modifiers of the building robustness should already be accounted for in the definition of the VISUS typology.

Fig. 2.19 *Water hazard: expert logical tree for the 'Structural collapse' and 'Damage' impact scenarios – approach when VISUS typologies are defined*

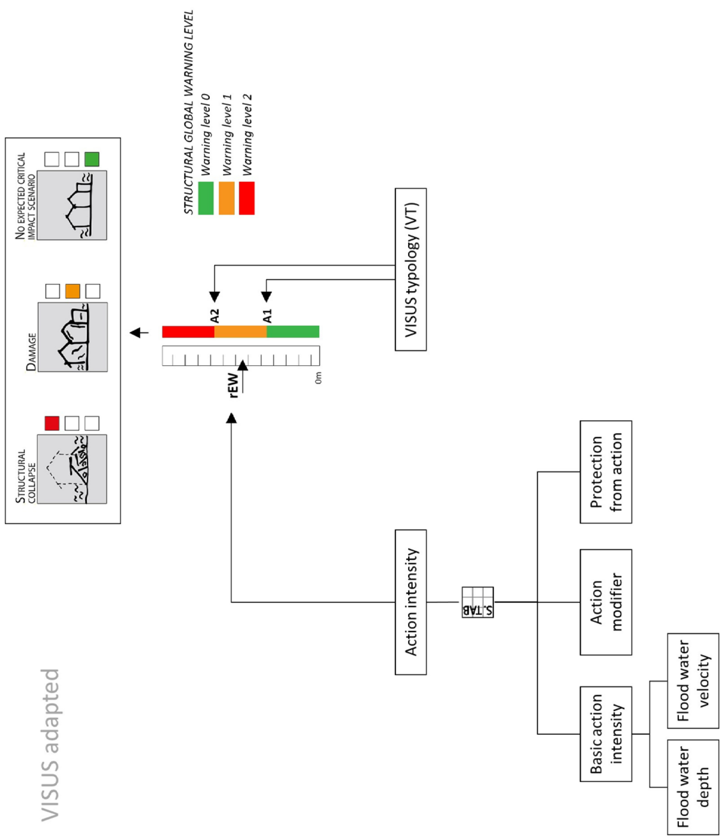
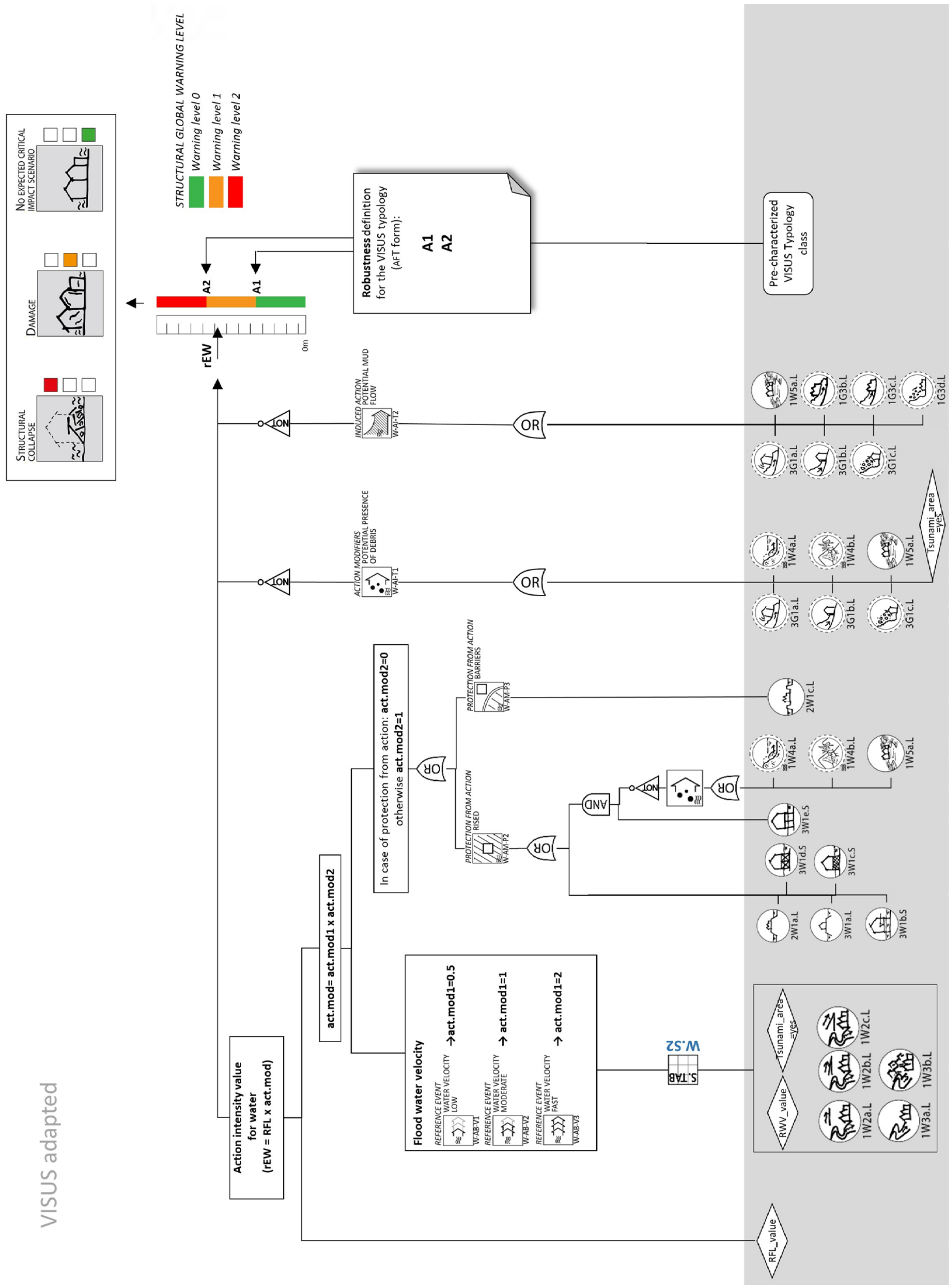


Fig. 2.20 *Water hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – approach when VISUS typologies are defined*



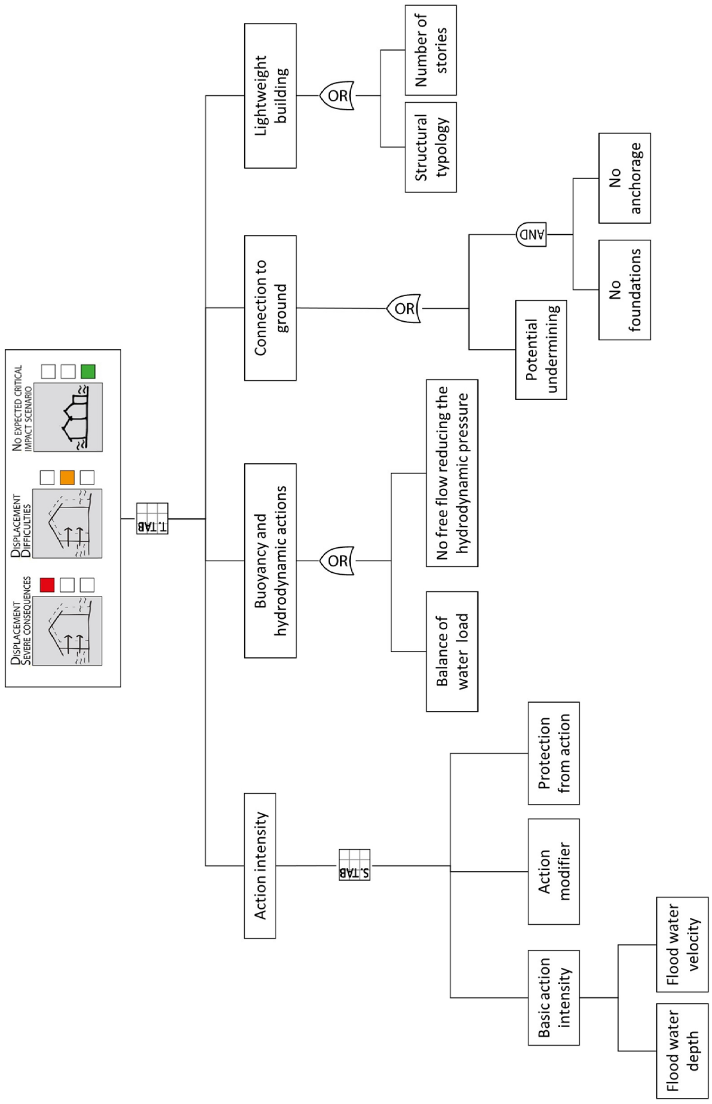


Fig. 2.21 *Water hazard: expert logical tree for the 'Uplift – severe consequences' and 'Uplift – difficulties' impact scenarios*

Fig. 2.22 *Water hazard: evaluation logical tree for the 'Uplift – severe consequences' and 'Uplift – difficulties' impact scenarios*

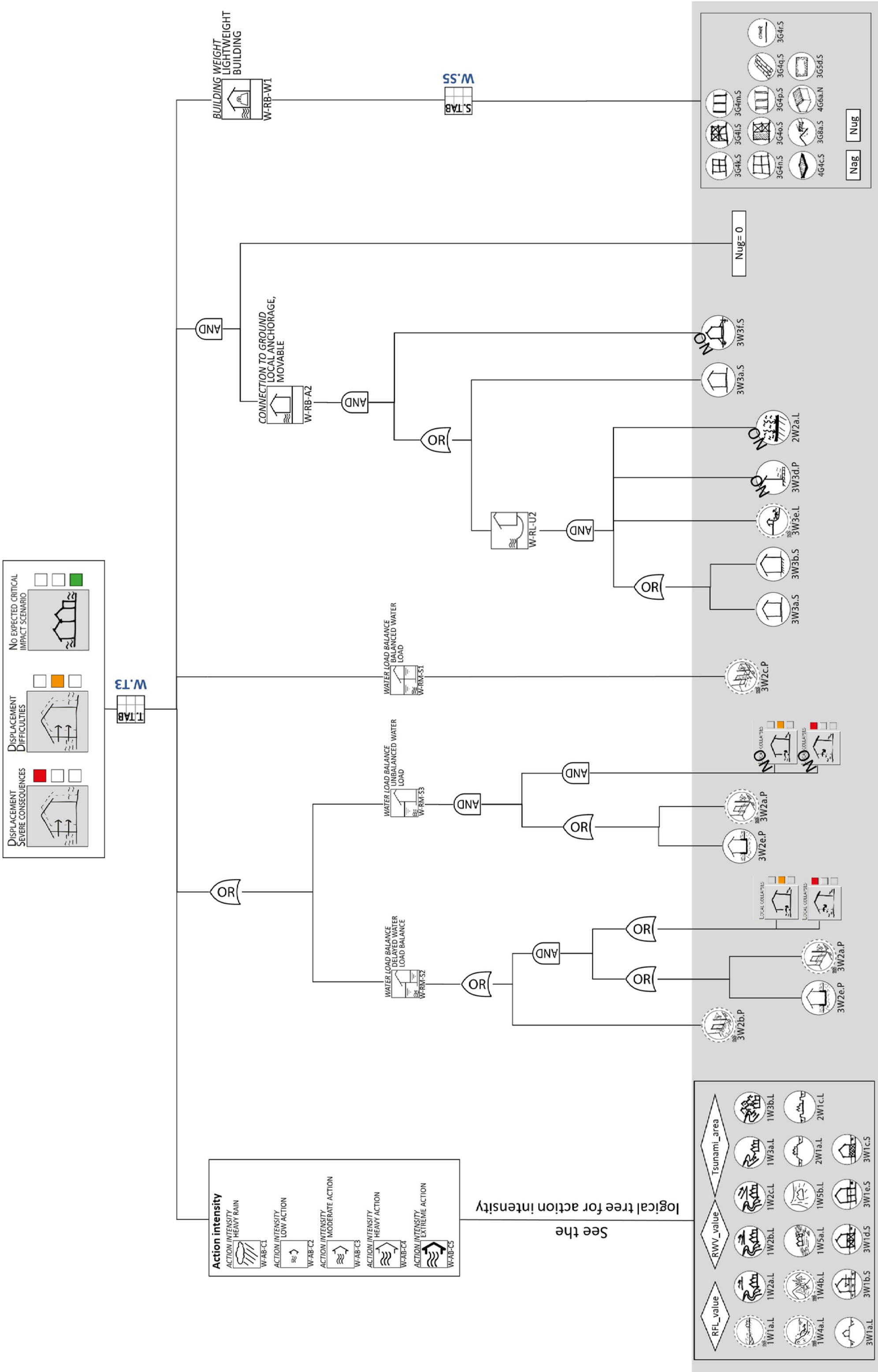


Fig. 2.23 *Water hazard: expert logical tree for the 'Displacement – severe consequences' and 'Displacement – difficulties' impact scenarios*

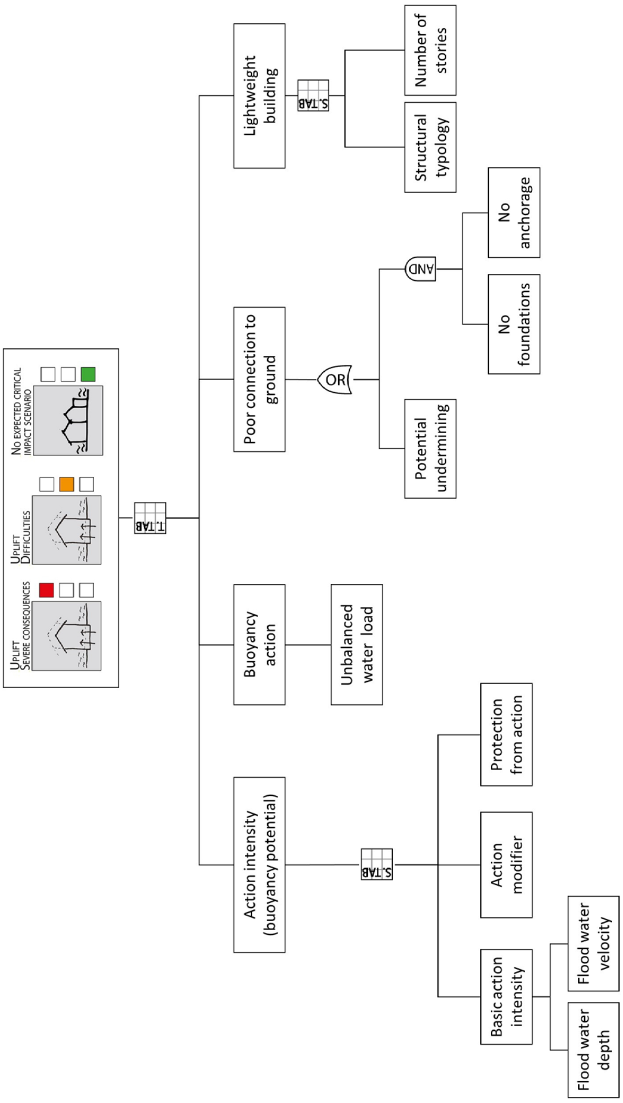


Fig. 2.24 *Water hazard: evaluation logical tree for 'Displacement – severe consequences' and 'Displacement – difficulties' impact scenarios*

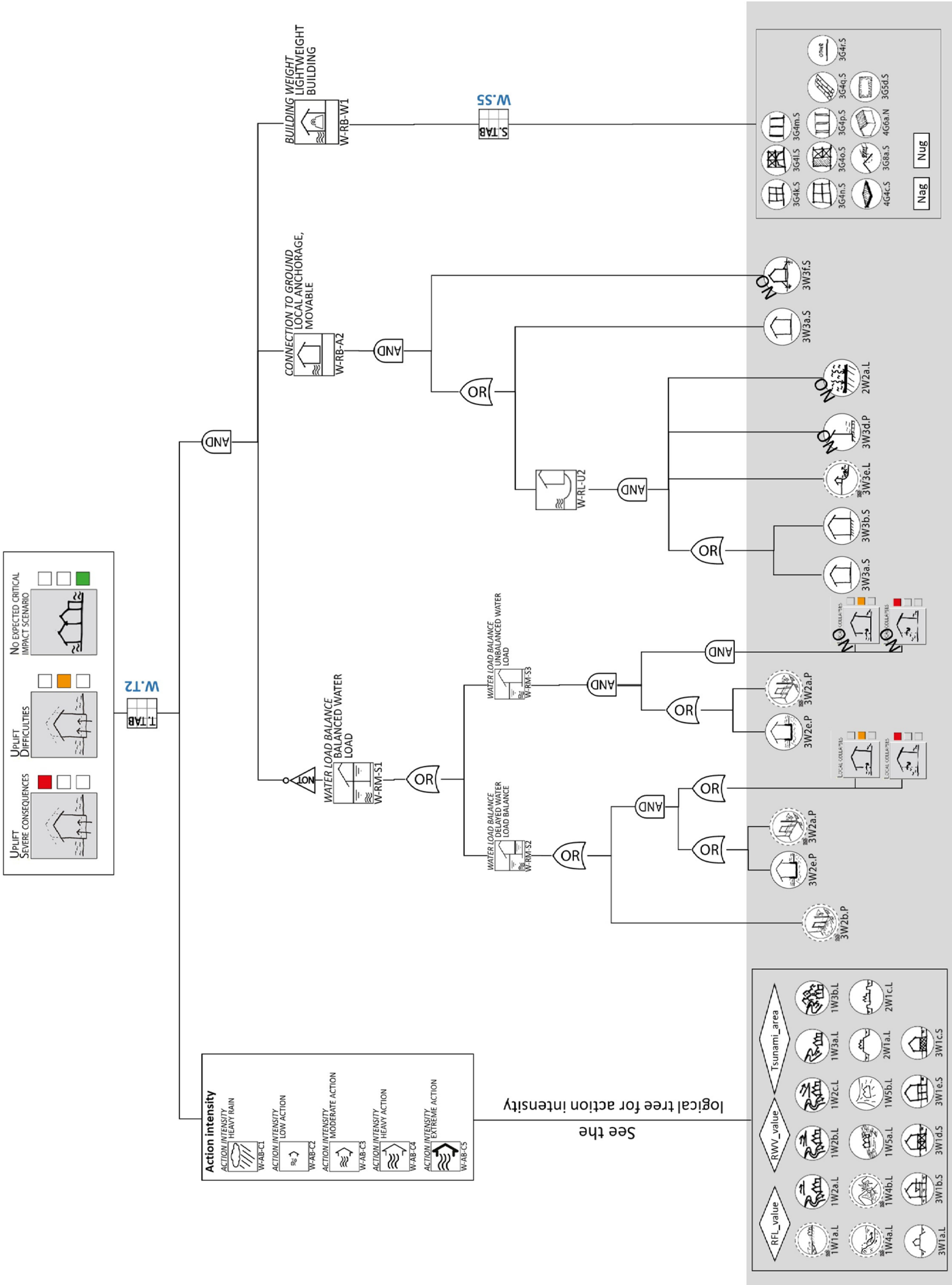
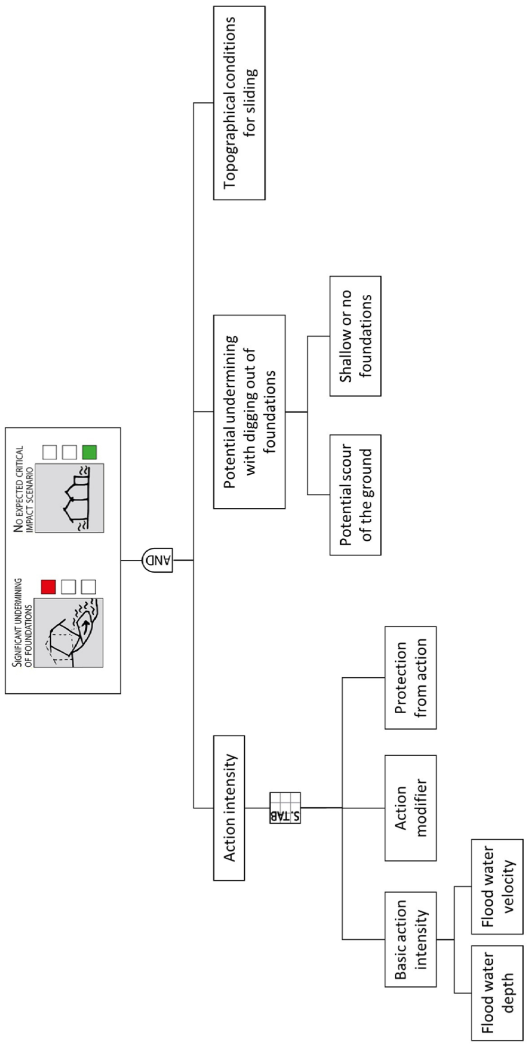


Fig. 2.25 *Water hazard: expert logical tree for the 'Significant undermining of foundations' impact scenario*



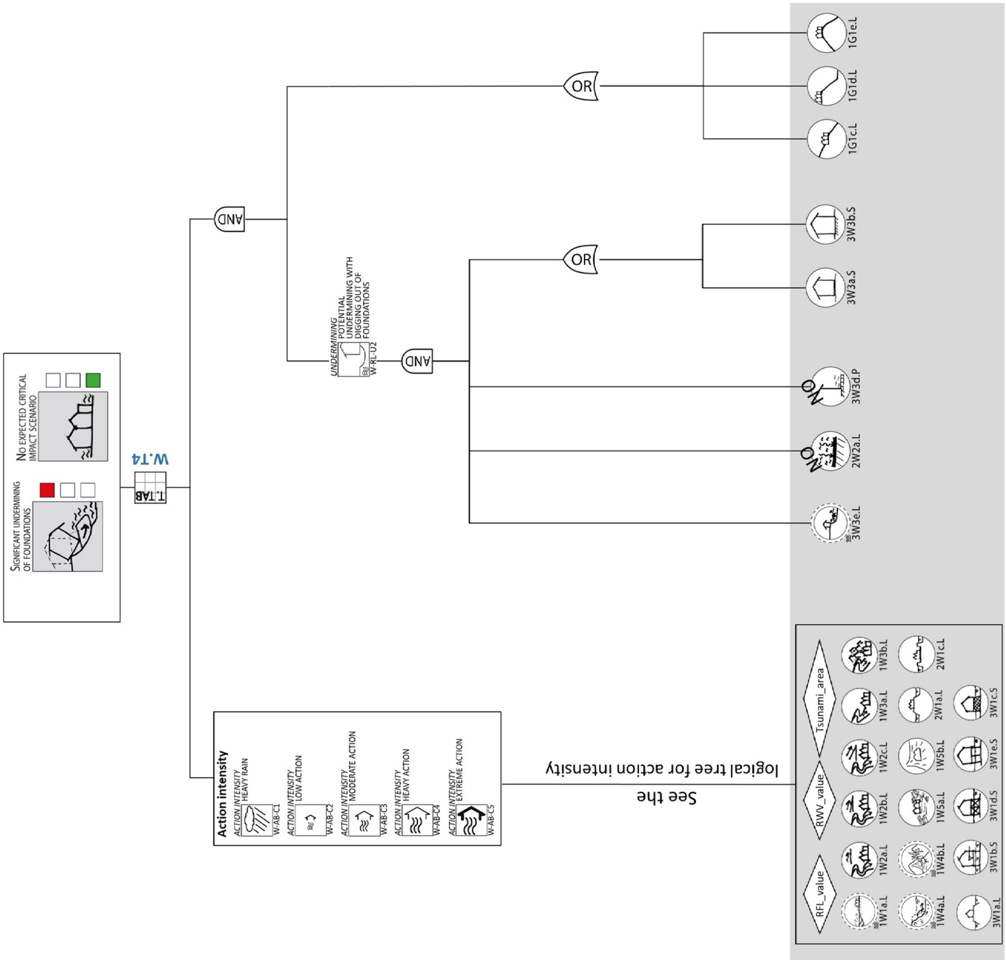


Fig. 2.26 *Water hazard: evaluation logical tree for the 'Significant undermining of foundations' impact scenario*

Fig. 2.27 *Water hazard: expert logical tree for the 'Melting' impact scenario*

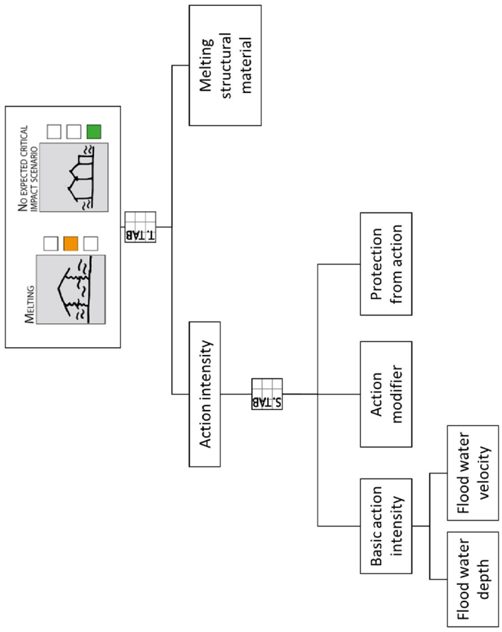


Fig. 2.28 *Water hazard: evaluation logical tree for the 'Melting' impact scenario*

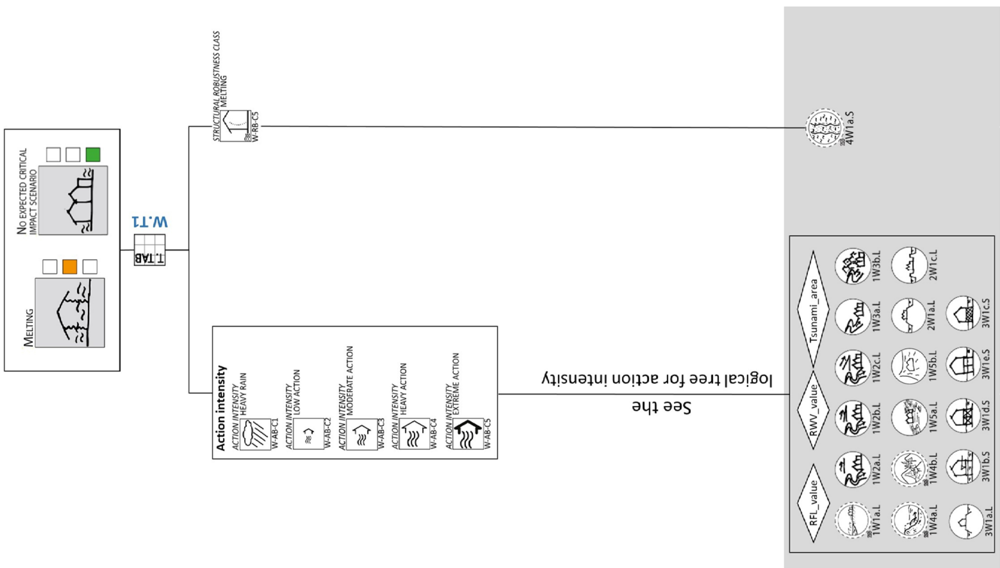


Fig. 2.29 *Water hazard: expert logical tree for the 'Local collapse' impact scenario*

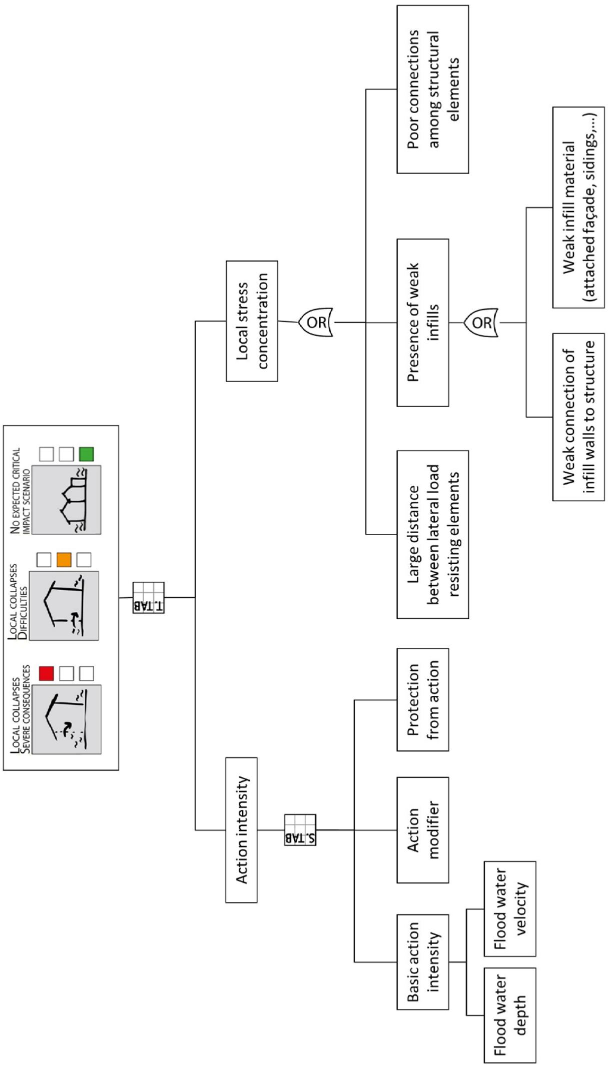


Fig. 2.30 *Water hazard: evaluation logical tree for the 'Local collapse' impact scenario*

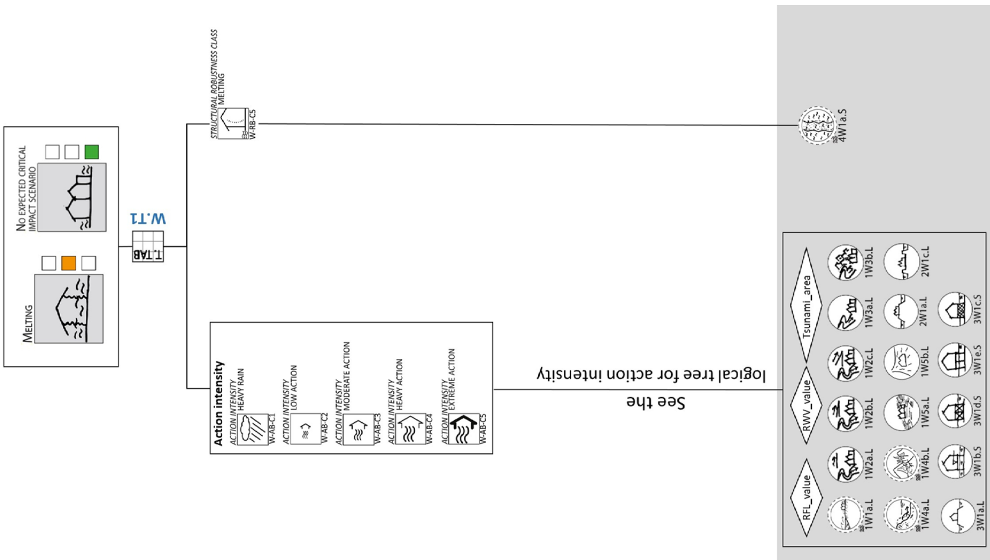


Fig. 2.31 *Water hazard: expert logical tree for the 'Partial undermining of foundations' impact scenario*

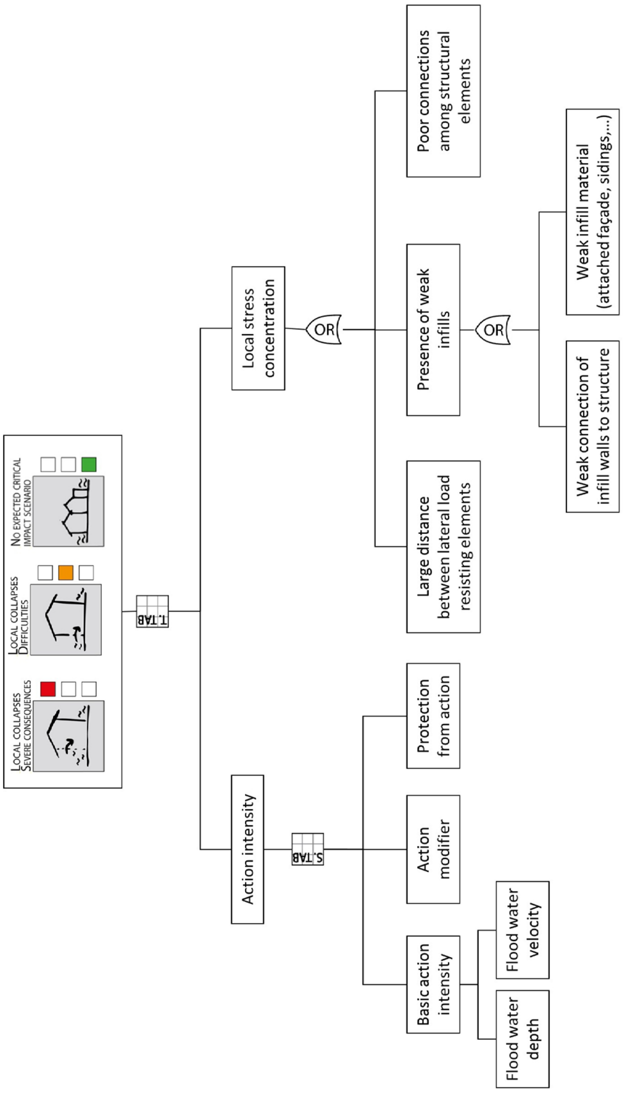


Fig. 2.32 *Water hazard: evaluation logical tree for the ‘Partial undermining of foundations’ impact scenario*

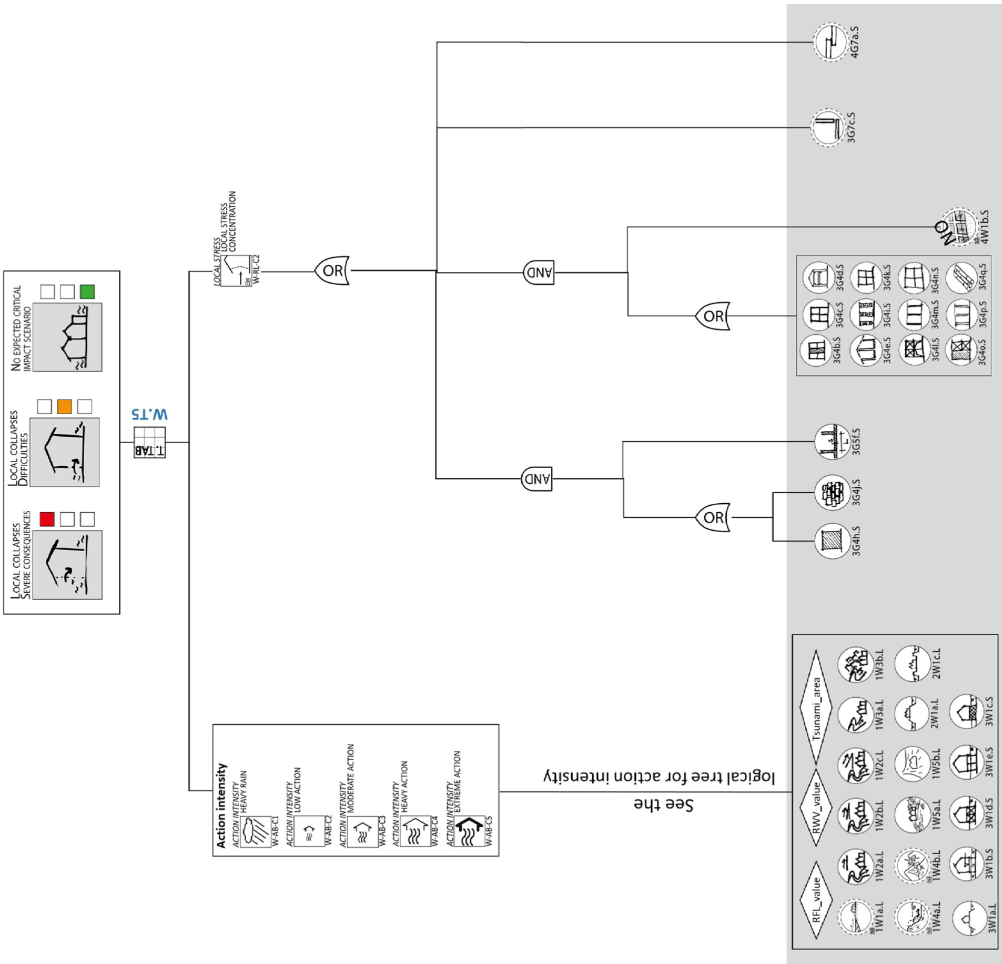


Fig. 2.33 *Water hazard: expert logical tree for the 'Internal flooding' impact scenario*

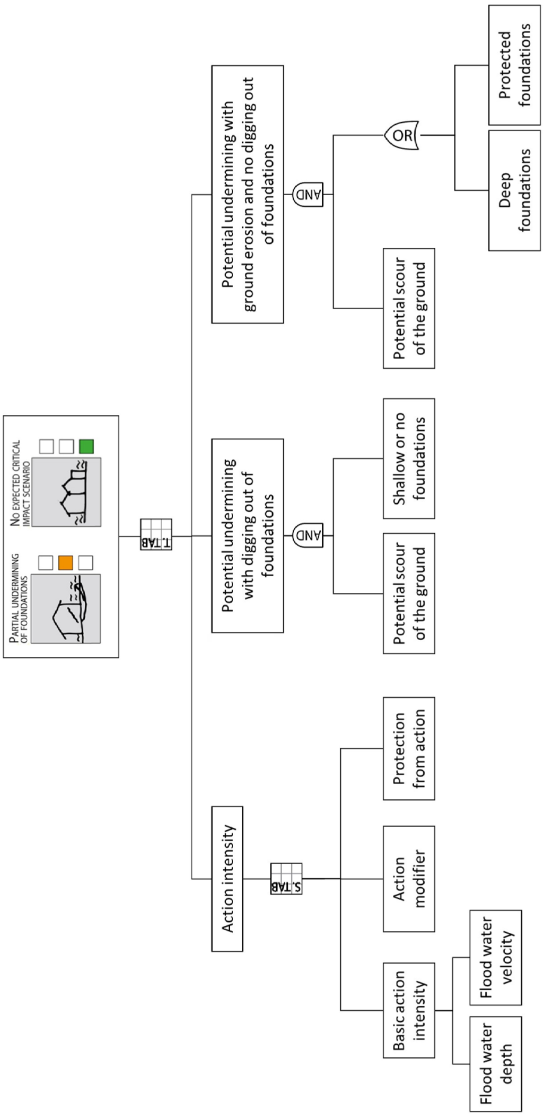


Fig. 2.34 *Water hazard: evaluation logical tree for the 'Internal flooding' impact scenario*

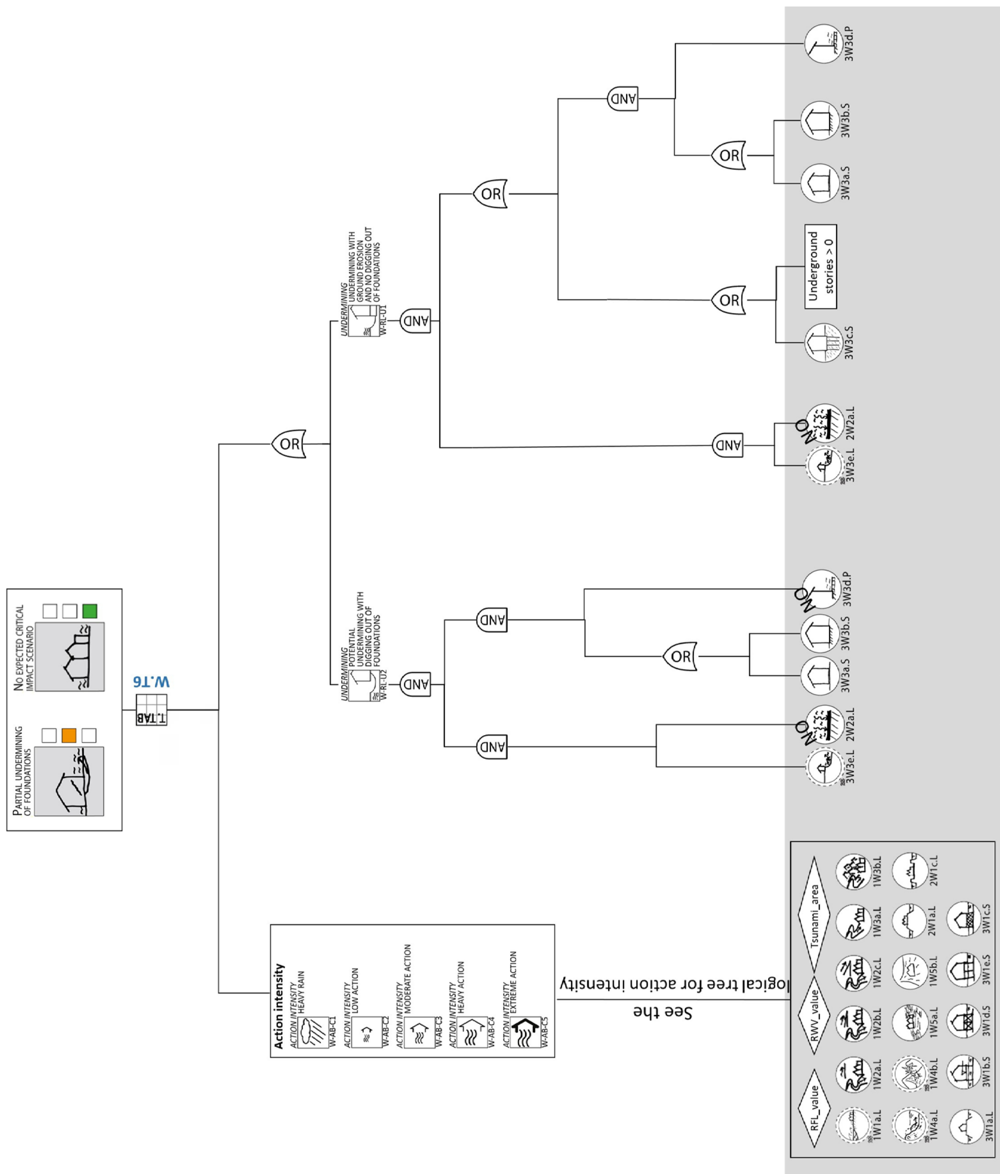


Fig. 2.35 *Water hazard: expert logical tree for the 'Loss of contents' impact scenario*

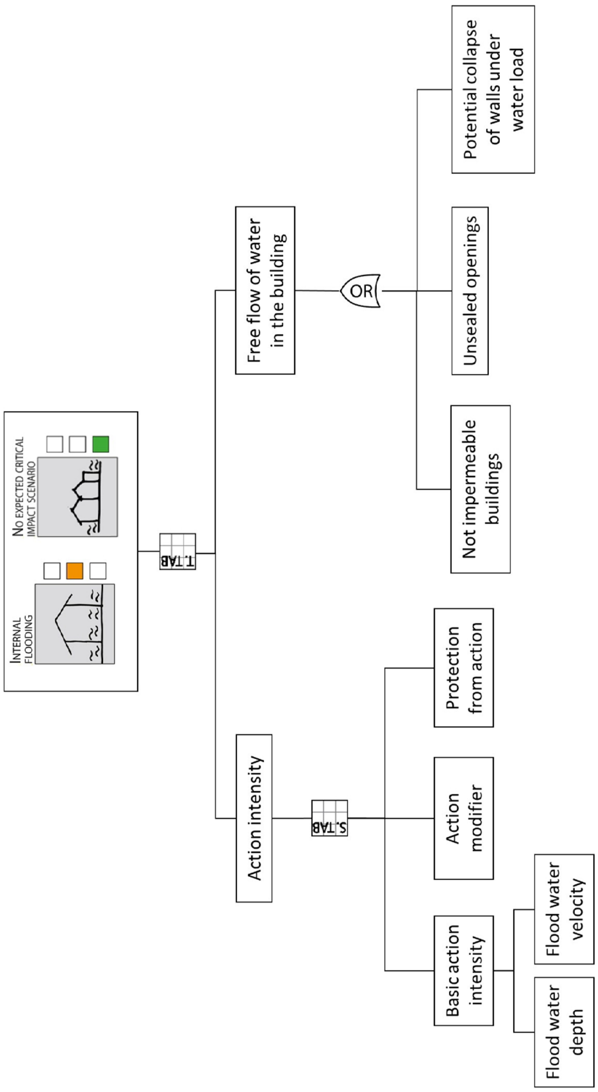


Fig. 2.36 *Water hazard: evaluation logical tree for the 'Loss of contents' impact scenario*

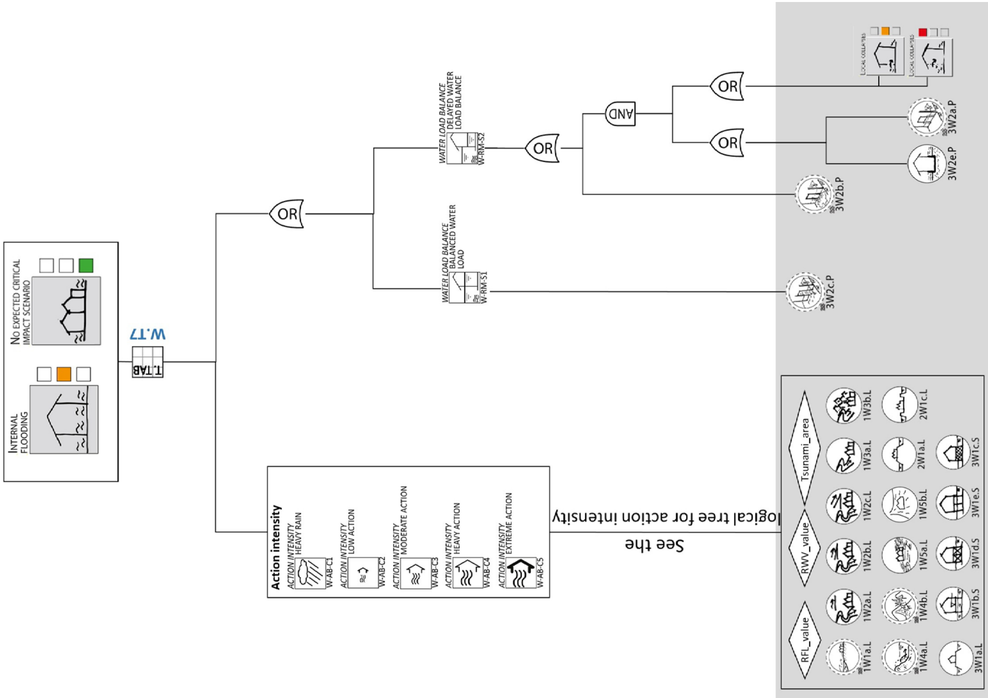


Fig. 2.37 *Water hazard: expert logical tree for the ‘Electrocution’ impact scenario*

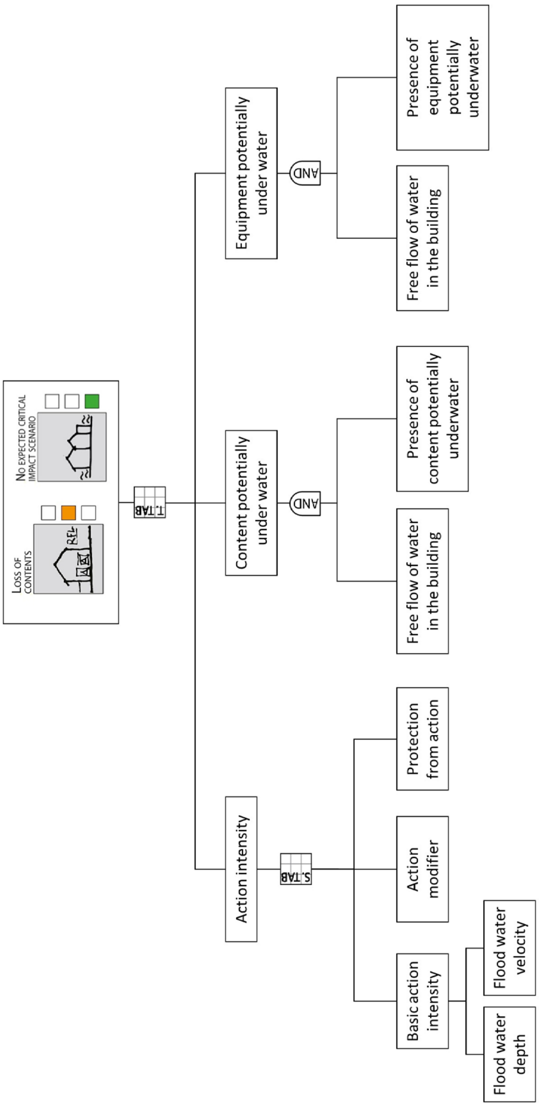


Fig. 2.38 *Water hazard: evaluation logical tree for the 'Electrocution' impact scenario*

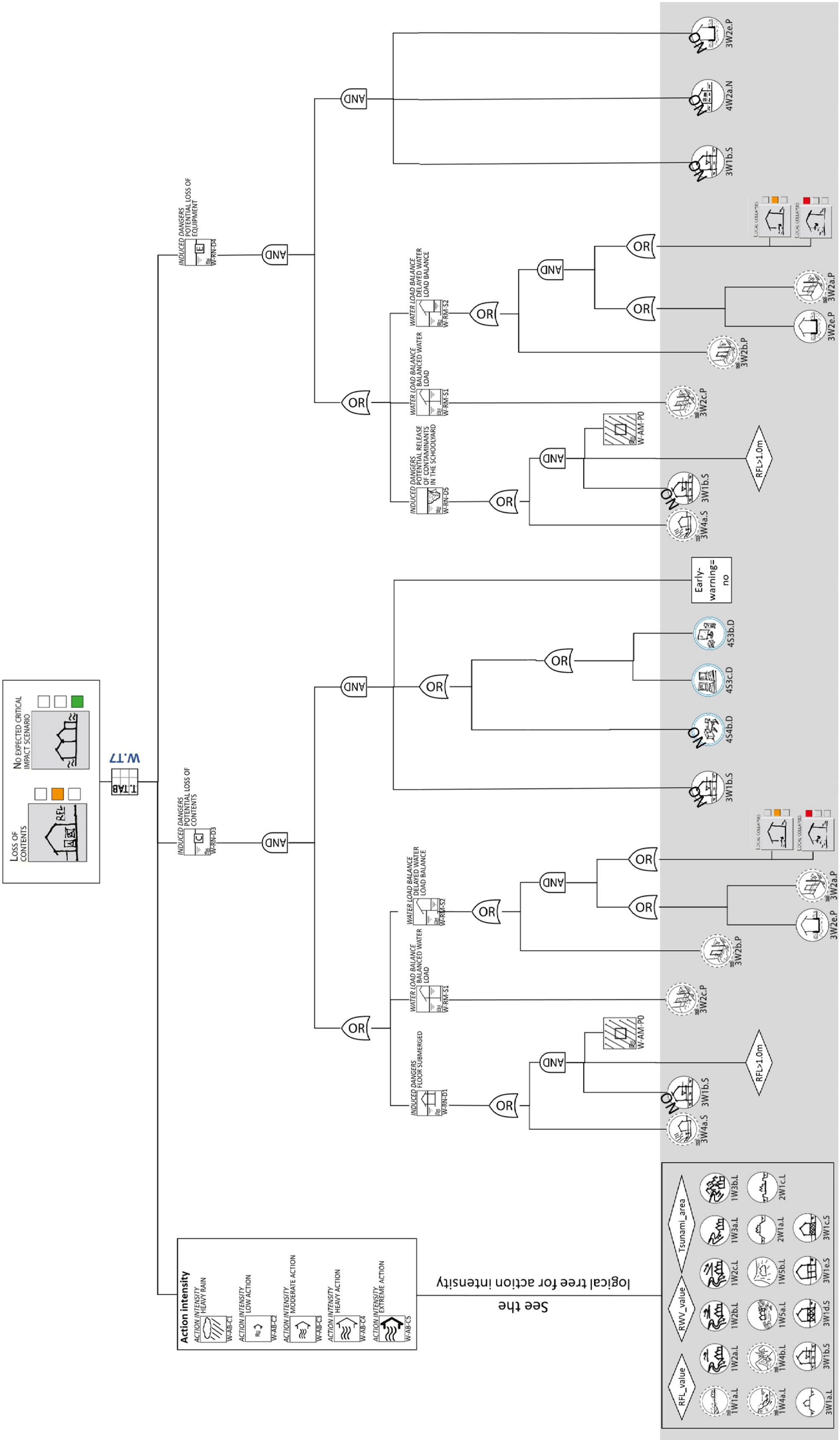


Fig. 2.39 *Water hazard: expert logical tree for the 'Hazardous material dispersion' impact scenario*

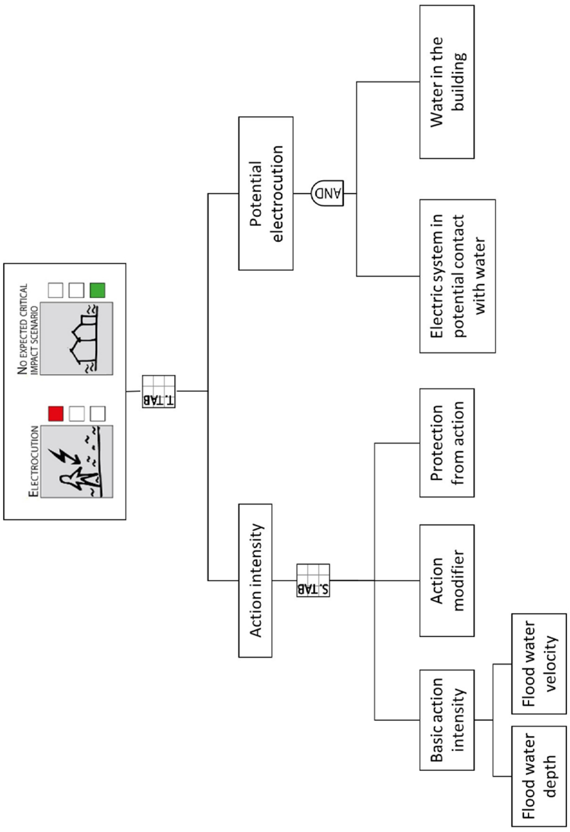


Fig. 2.40 *Water hazard: evaluation logical tree for the 'Hazardous material dispersion' impact scenario*

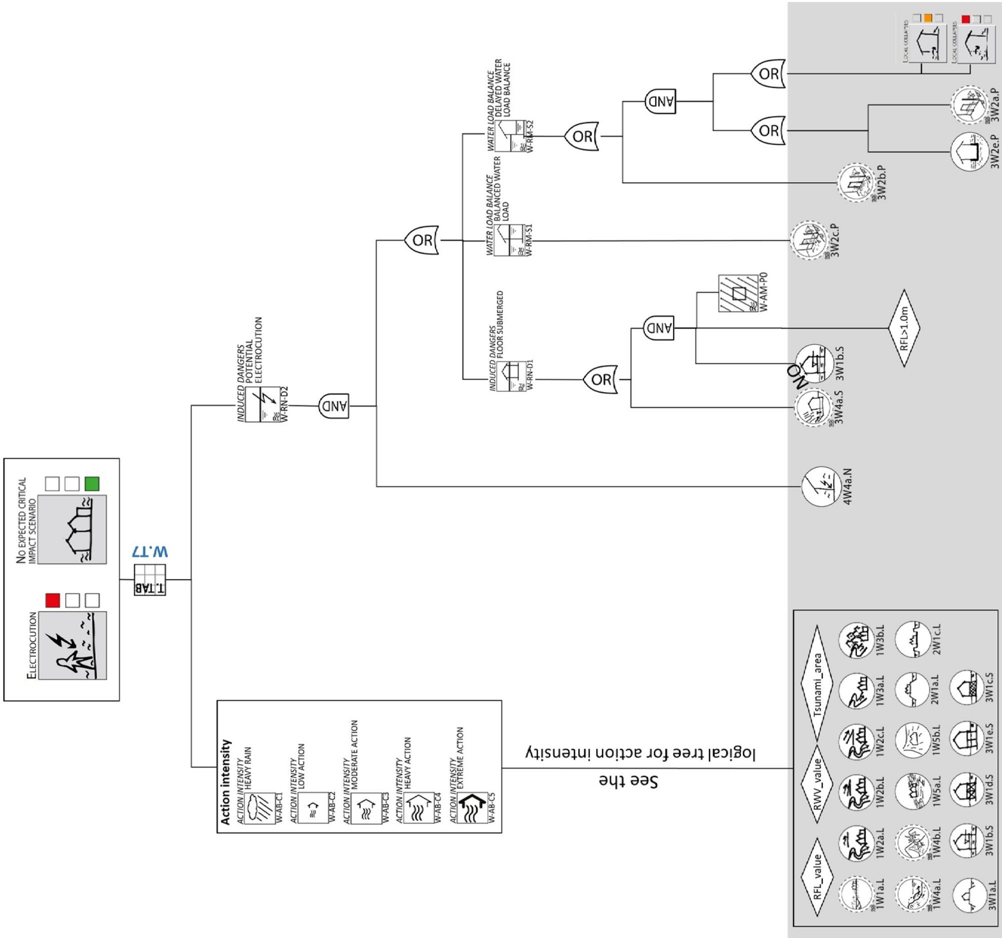


Fig. 2.41 *Water hazard: expert logical tree for the 'Trapped people in flooded areas' impact scenario*

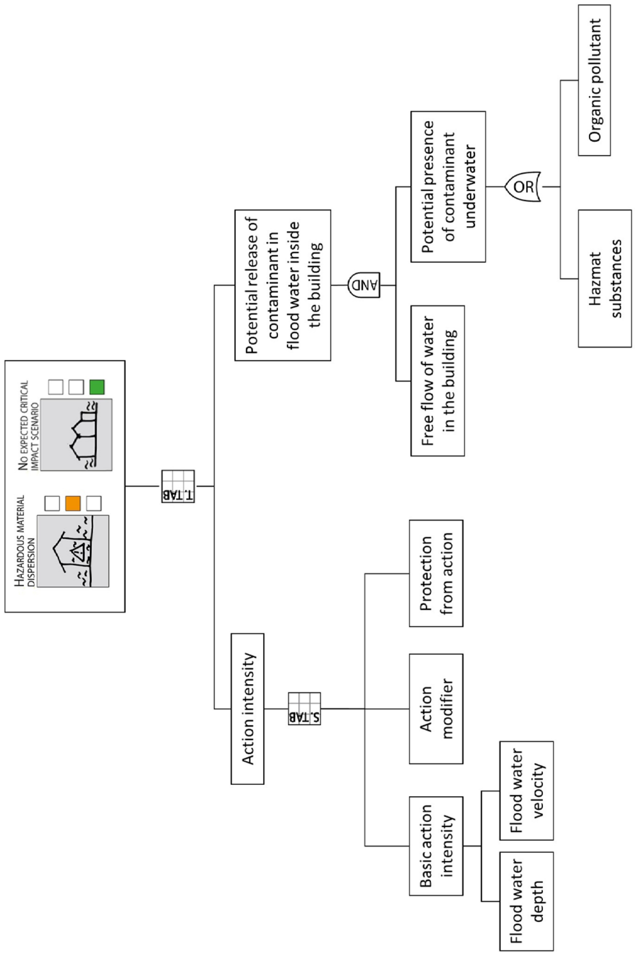


Fig. 2.42 *Water hazard: evaluation logical tree for the 'Trapped people in flooded areas' impact scenario*

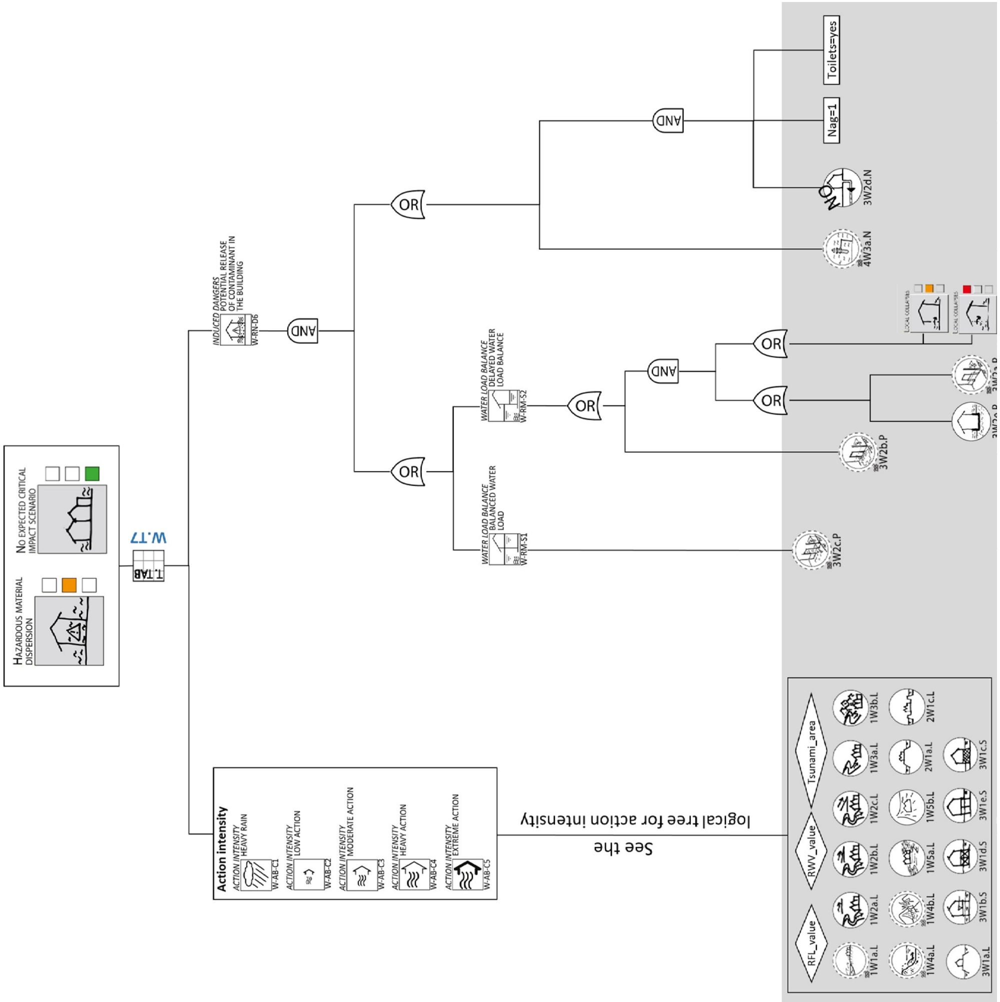


Fig. 2.43 *Water hazard: expert logical tree for the 'Trapped people in dry areas' impact scenario*

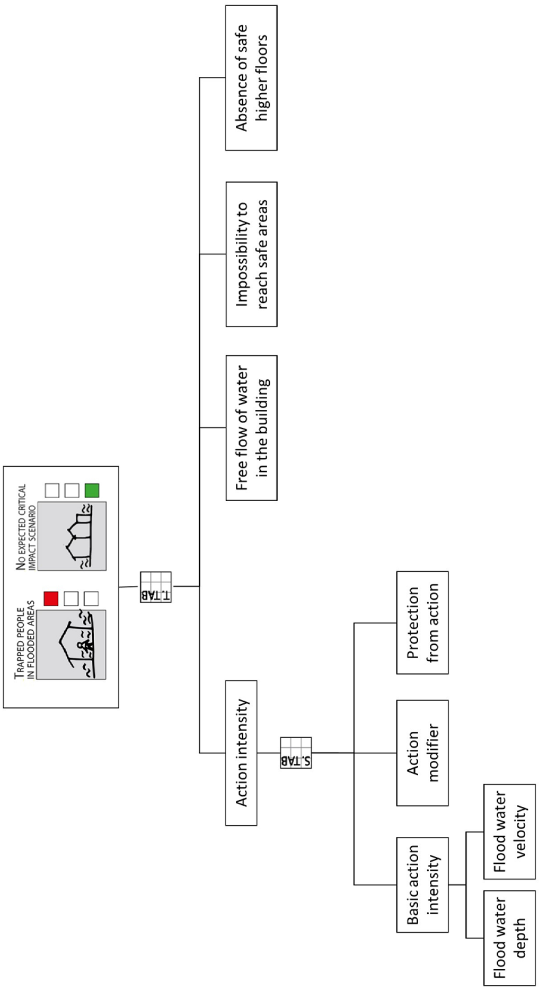


Fig. 2.44 *Water hazard: evaluation logical tree for the 'Trapped people in dry areas' impact scenario*

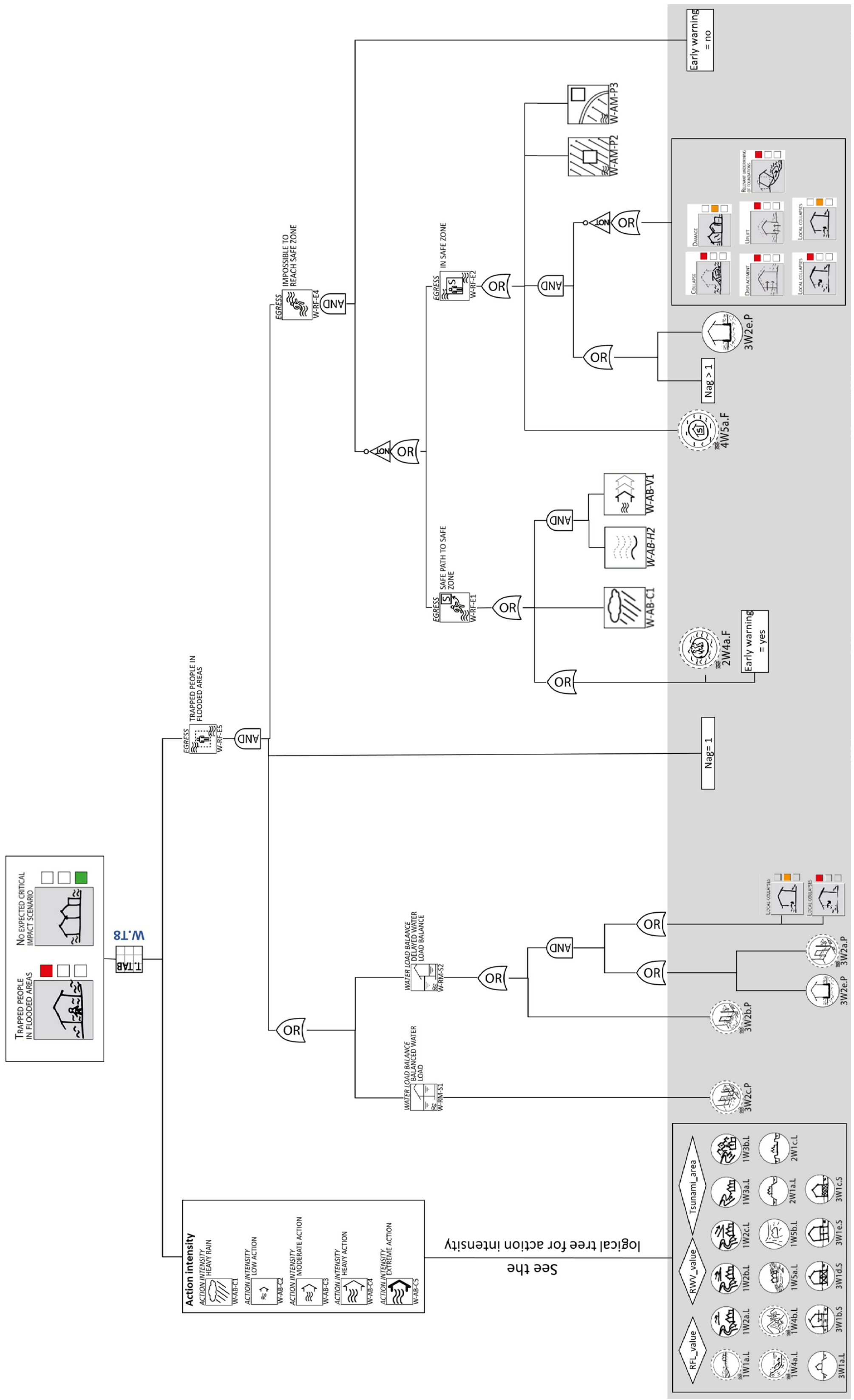


Fig. 2.45 *Water hazard: expert logical tree for the 'Difficult evacuation' impact scenario*

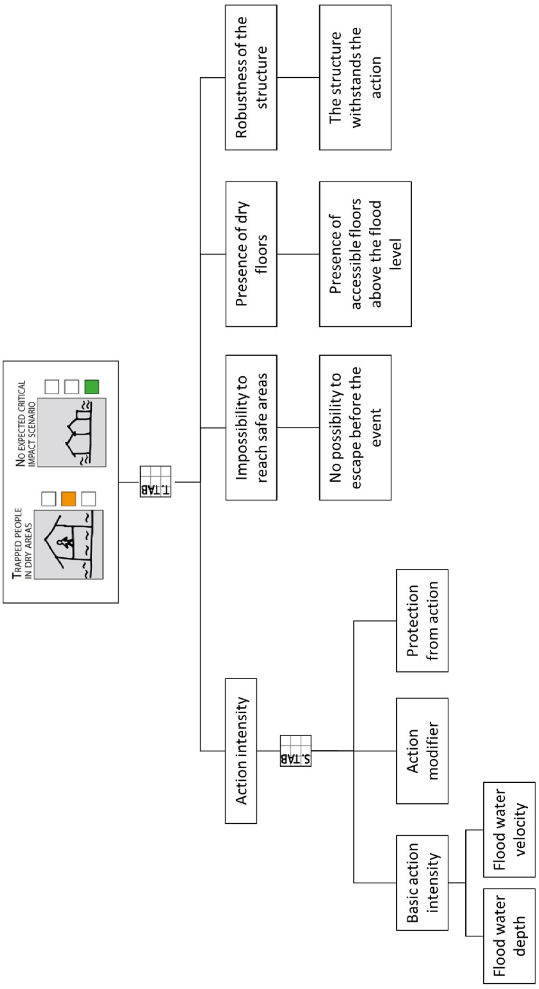


Fig. 2.46 *Water hazard: evaluation logical tree for the 'Difficult evacuation' impact scenario*

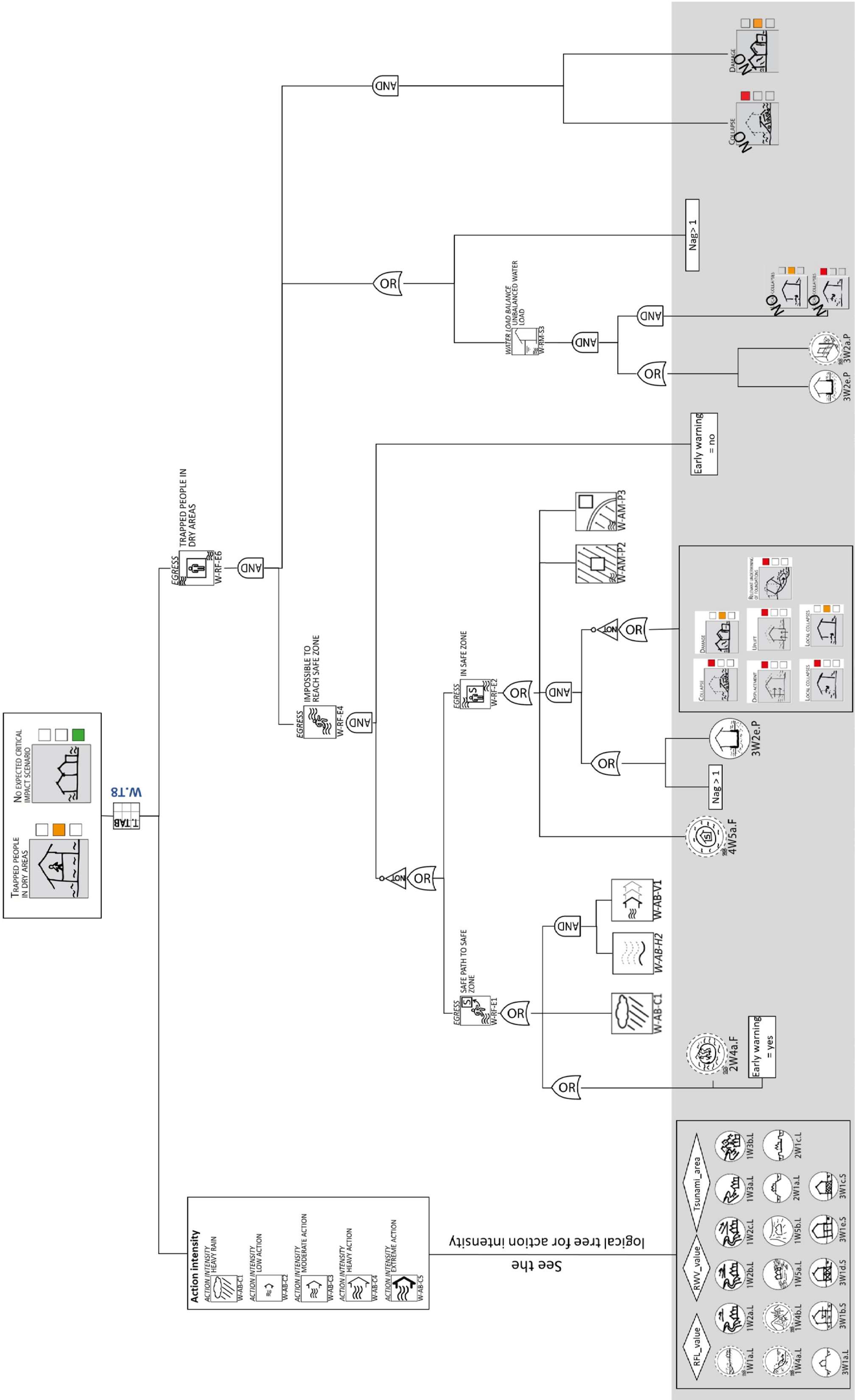


Fig. 2.47 *Water hazard: expert logical tree for the 'Absence of safe areas' impact scenario*

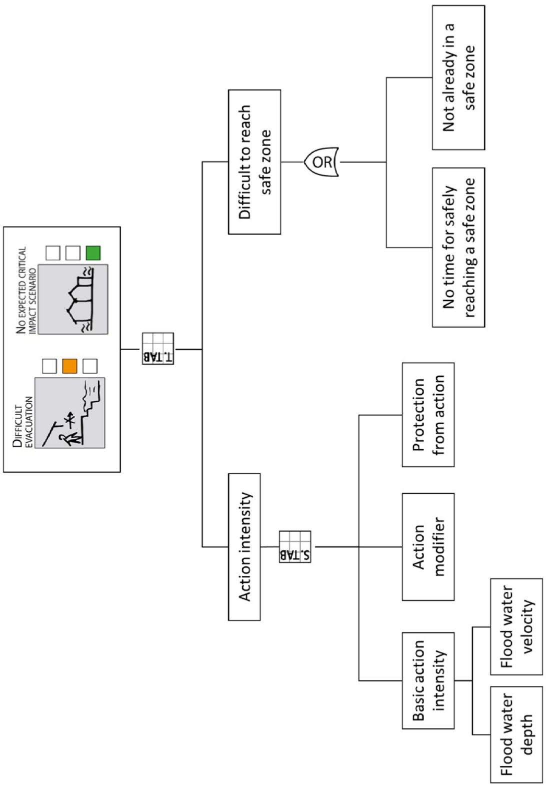


Fig. 2.48 *Water hazard: evaluation logical tree for the 'Absence of safe areas' impact scenario*

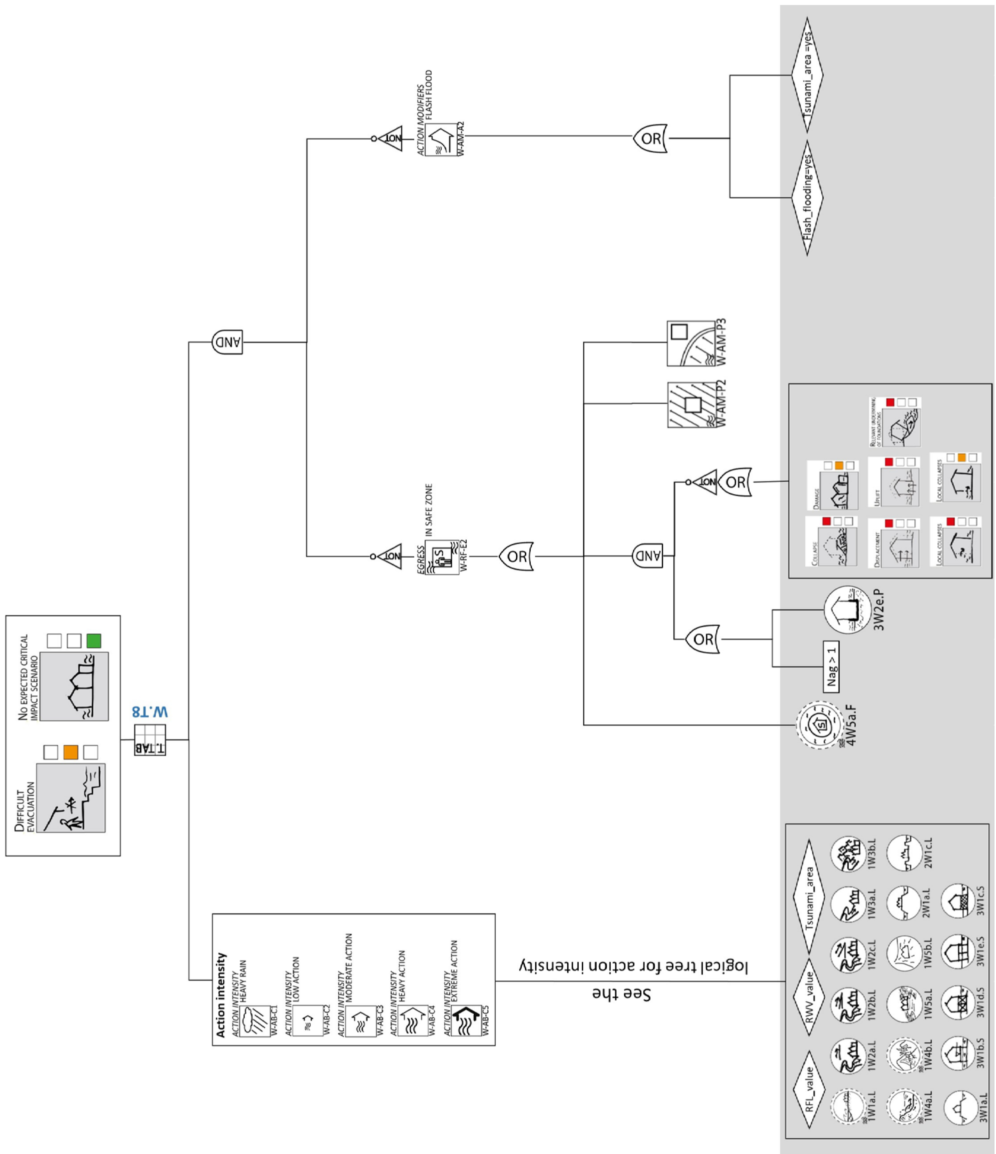


Fig. 2.49 *Water hazard: expert logical tree for the 'Impossible evacuation' impact scenario*

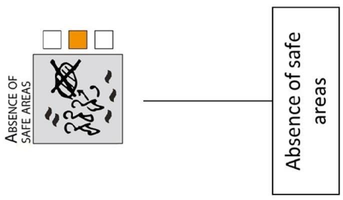
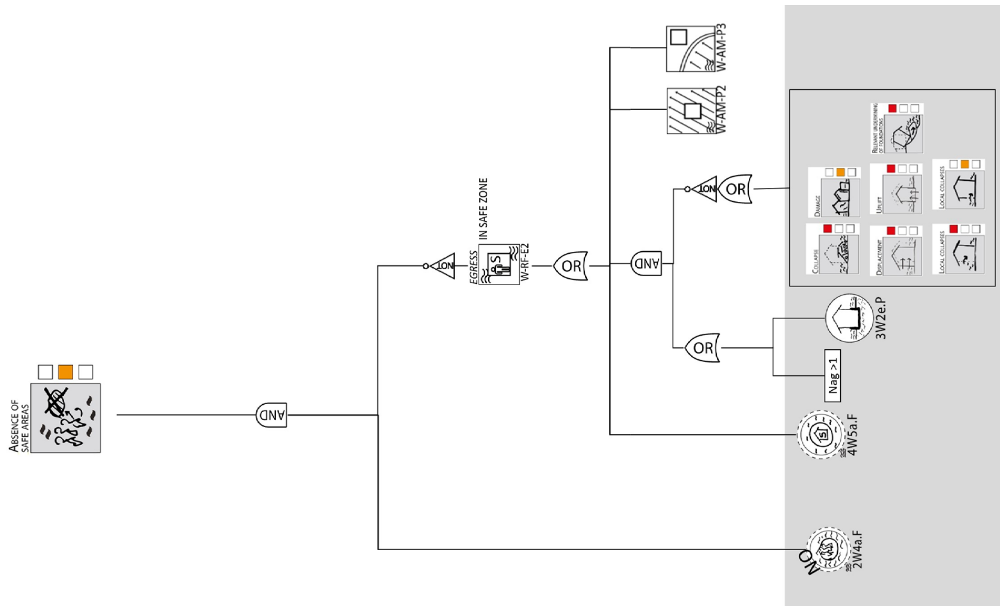


Fig. 2.50 *Water hazard: evaluation logical tree for the 'Impossible evacuation' impact scenario*



3. REFERENCE EVENTS AND OBSERVABLES

3.1 Reference events

Table 3.1 *List of the reference events used for water hazard evaluation*

Survey phase	Focus group	Code	Observable	Name
0	Reference event characterization – Water – Flood level from hazard map (FLM)	–	–	No flood
		–	–	≤0.3 m
		–	–	0.3–1.0 m
		–	–	1.0–2.0 m
		–	–	> 2.0 m
		–	–	Other (m)
0	Reference event characterization – Water – Flood level experienced (FLE)	–	–	No flood
		–	–	≤0.3 m
		–	–	0.3–1.0 m
		–	–	1.0–2.0 m
		–	–	> 2.0 m
		–	–	Other (m)
0	Reference event characterization – Water – Predicted tsunami area (PTA)	Tsunami_area=Yes	–	PTA: Yes
		Tsunami_area=No	–	PTA: No
0	Reference event characterization – Predicted or experienced tsunami level (TL)	–	–	TL: value (m)
0	Reference event characterization – Water – Reference flood level (RFL)	RFL_value	–	No flood
			–	≤0.3 m
			–	0.3–1.0 m
			–	1.0–2.0 m
			–	> 2.0 m
			–	Other (m)
0	Reference event characterization – Water – Reference water velocity (RWV)	RWV_value	–	Unknown
			–	≤0.3 m/s
			–	0.3–1.0 m/s
			–	1.0–3.0 m/s
			–	> 3.0 m/s
			–	Other (m/s)
0	Reference event characterization – Water – Flash flooding area (FFA) (< 1 hour)	Flash_flooding =Yes	–	Flash flooding area: Yes
		Flash_flooding =No	–	Flash flooding area: No

Survey phase	Focus group	Code	Observable	Name
0	Reference event characterization – Water – Heavy rain	–	–	Heavy rain: Yes
		–	–	Heavy rain: No
0	Reference event characterization – Water – Rainfall	–	–	Heavy rainfall
		–	–	Prolonged rainfall
		–	–	Potential snowmelt
0	Reference event characterization – Water – Early warning flood	Early warning =Yes	–	Early warning for flood: Yes
		Early warning =No	–	Early warning for flood: No
0	Reference event characterization – Early warning tsunami	Tsunami	–	Early warning for tsunami: Yes
		No tsunami	–	Early warning for tsunami: No

3.2 Observables for the schoolyard

Table 3.2 *List of the observables (OBS) used for water hazard evaluation of the schoolyard*

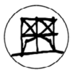
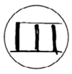
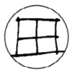
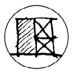
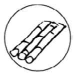
Survey phase	Focus group	Code	Observable	Name
1	G1 - Topography	1G1c.L		Slope
		1G1d.L		Scarp/cliff
		1G1e.L		Crest/top
1	G3 - Natural hazards	1G3b.L		On a landslide
		1G3c.L		Impact by a landslide
		1G3d.L		Impact by a rockfall
1	W1 - Wave action	1W1a.L		Coast, wave action
1	W2 - Upstream slope (water velocity)	1W2a.L		Gentle or no slope – upstream (mean slope < 4°)
		1W2b.L		Moderate slope – upstream (mean slope 4–15°)
		1W2c.L		Steep slope – upstream (mean slope > 15°)

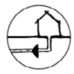
Survey phase	Focus group	Code	Observ-able	Name
1	W3 - Land roughness (water velocity)	1W3a.L		Open land – upstream
		1W3b.L		Upstream conditions reduce the water velocity
1	W4 - Debris generation	1W4a.L		Upstream highly erodible soil
		1W4b.L		Potential for debris generation upstream
1	W5 - Local characteristics	1W5a.L		School located on a previous mudflow
		1W5b.L		School located in a runoff area
2	W1 - Protection from water	2W1a.L		School complex on an elevated site (> RFL)
		2W1b.L		Potential scour could impact the school complex
		2W1c.L		Levee (on impermeable ground or with pumps)
2	W2 - Impermeability	2W2a.L		Impermeable ground
2	W3 - Releases	2W3a.N		Contaminants released into the floodwater
2	W4 - Safe areas	2W4a.F		Safe and dry area

3.3 Observables for school buildings

Table 3.3 *List of the observables (OBS) used for water hazard evaluation of school buildings*

Survey phase	Focus group	Code	Observ-able	Name
3	G3 - Building characteristics: elevation	Nag	–	Above-ground stories (number of)
		Nug	–	Underground stories (number of)
3	G4 - Structural system: reinforced concrete	3G4a.S		Reinforced concrete walls
		3G4b.S		Reinforced concrete dual frame wall system
		3G4c.S		Reinforced concrete frame
		3G4d.S		Precast
		3G4e.S		Reinforced concrete vertical piers only
3	G4 - Structural system: masonry	3G4f.S		Reinforced masonry
		3G4g.S		Confined masonry
		3G4h.S		Unreinforced masonry
		3G4i.S		Masonry vertical piers only
3	G4 - Structural system: earth or adobe	3G4j.S		Earth or adobe structure

Survey phase	Focus group	Code	Observ-able	Name
3	G4 - Structural system: steel	3G4k.S		Unbraced steel frame
		3G4l.S		Braced steel frame
		3G4m.S		Steel vertical piers only
3	G4 - Structural system: wood	3G4n.S		Wood frame unbraced
		3G4o.S		Wood panels or wood frame braced
		3G4p.S		Wood vertical piers only
3	G4 - Structural system: bamboo	3G4q.S		Bamboo structure
3	G4 - Structural system: other	3G4r.S		Other
3	G5 - Horizontal distribution and organization of lateral resistance elements	3G5d.S		Resistance distributed mainly to the perimeter
		3G5f.S		Large distance among lateral resistance systems (L/s>25)
3	G7 - Construction quality and building condition	3G7c.S		Poor connection of vertical load carrying elements
3	G8 - Roof covering and architectural features	3G8a.S		Concrete or masonry structure
3	W1 - Protection from floodwater	3W1a.L		Building on an elevated site (higher than the reference flood level)
		3W1b.S		Lowest floor higher than reference flood level
		3W1c.S		Solid perimeter foundation wall
		3W1d.S		Piers, piles or columns with braces
		3W1e.S		Piles or columns without braces

Survey phase	Focus group	Code	Observ-able	Name
3	W2 - Water permeability and flow into the building	3W2a.P		Water flow into building prevented
		3W2b.P		Water flow into building reduced
		3W2c.P		Free flow of water into building
		3W2d.N		Sewer with backflow valves
		3W2e.P		Sealed/impermeable envelope below water
3	W3 - Foundations (an-choring and/or scouring)	3W3a.S		No foundation
		3W3b.S		Shallow foundation
		3W3c.S		Deep foundation
		3W3d.P		Protected foundation (e.g. riprap)
		3W3e.L		Potential scour could impact the building
		3W3f.S		Building anchored to ground
3	W4 - Rain flooding	3W4a.S		Underground area could be inundated by rain-water
4	G4 - Floor behaviour and connection	4G4c.S		Floor: heavy
4	G6 – Roof decking	4G6a.N		Continuous roof decking
4	G7 - Quality	4G7a.S		Ineffective connections
4	W1 - Resistance to water loads	4W1a.S		Structural material weakens when exposed to water
		4W1b.S		Envelope or infills do not collapse under water load
4	W2 - Losses	4W2a.N		All equipment above the reference flood level
4	W3 - Releases	4W3a.N		Contaminants released into the floodwater

Survey phase	Focus group	Code	Observ-able	Name
4	W4 - Dangers	4W4a.N		Electrical system in contact with water
4	W5 - Shelter	4W5a.F		Building is a shelter during a flood
4	S3 - Equipment	4S3b.D		Audio-visual equipment
		4S3c.D		Computer laboratory
4	S4 - Contents	4S4b.D		Minimal or poor furniture

4. PROFILE QUALIFIERS

4.1 Profile qualifiers for the schoolyard

Table 4.1 *Definition of the profile qualifiers for water hazard evaluation of the schoolyard*

Focus	Icon and code	Name	Evaluation logic
Reference event	W-AB-H1	Water depth: negligible	Heavy rain=Yes OR No flood
	W-AB-H2	Water depth: low	Reference flood level (RFL) ≤0.3 m
	W-AB-H3	Water depth: moderate	0.3 m < RFL ≤ 1.0 m OR (RFL ≤0.3 m AND W-AM-A1)
	W-AB-H4	Water depth: high	1.0 m < RFL ≤ 2.0 m OR (0.3 m < RFL ≤ 1.0 m AND W-AM-A1)
	W-AB-H5	Water depth: very high	RFL > 2.0 m OR (1.0 m < RFL ≤ 2.0 m AND W-AM-A1)
	W-AB-V1	Water velocity: slow	Reference water velocity (RWV) ≤0.3 m/s OR (1W2a.L AND 1W3b.L)
	W-AB-V2	Water velocity: moderate	(0.3 m/s < RWV ≤ 1.0 m/s) OR (1W2a.L AND 1W3a.L) OR 1W2b.L OR (1W2c.L AND 1W3b.L) OR RWV unknown
	W-AB-V3	Water velocity: fast	RWV > 1.0 m/s OR 1W2c.L OR (1W2b.L AND 1W3a.L)

Focus	Icon and code	Name	Evaluation logic
Action intensity	W-AB-C1	Heavy rain	Table W.S3
	W-AB-C2	Low action	Table W.S3
	W-AB-C3	Moderate action	Table W.S3
	W-AB-C4	Heavy action	Table W.S3
	W-AB-C5	Extreme action	Table W.S3
	W-AB-C6	Tsunami action	Predicted tsunami area=Yes
Action modifiers	W-AM-A1	Potential amplification of the action	1W1a.L OR 1W3a.L OR 1W5b.L
	W-AM-A2	Flash flood	Flash flooding area=Yes OR W-AB-C6
Induced hazard	W-AI-T1	Potential presence of debris	1W4a.L OR 1W4b.L OR 1W5a.L OR W-AB-C6
	W-AI-T2	Potential mudflow	1W5a.L OR 1G3b.L OR 1G3c.L OR 1G3d.L
Protection from action	W-AM-P0	No protection	NOT(W-AM-P1 OR W-AM-P2 OR W-AM-P3)
	W-AM-P1	Distance from action	NOT(1W1a.L) AND RFL='No flood' AND NOT(W-AB-C6)AND NOT(W-AI-T2)
	W-AM-P2	Raised	2W1a.L
	W-AM-P3	Barriers	2W1c.L
Induced dangers	W-RN-D5	Potential release of contaminants in the schoolyard	2W3a.N

Focus	Icon and code	Name	Evaluation logic
Egress	W-RF-E1	Safe path to safe zone	(2W4a.F AND Early warning=Yes) OR [W-AB-C1 OR (W-AB-H2 AND W-AM-V1)]
	W-RF-E2	In safe area	W-AM-P1 OR W-AM-P2 OR W-AM-P3
	W-RF-E:	No safe zone	NOT (2W4a.F) AND Early warning=No
	W-RF-E4	Impossibility to reach a safe zone	(Early warning=No AND W-AM-A2) OR NOT (W-RF-E1 OR W-RF-E2)

4.2 Profile qualifiers for school buildings

Table 4.2 *Definition of the profile qualifiers for water hazard evaluation of school buildings*

Focus	Icon and code	Name	Evaluation logic
Reference event	W-AB-H1	Water depth: negligible	Heavy rain=Yes OR No flood
	W-AB-H2	Water depth: low	Reference flood level (RFL) ≤0.3 m
	W-AB-H3	Water depth: moderate	0.3 m < RFL ≤ 1.0 m OR (RFL ≤0.3 m AND W-AM-A1)
	W-AB-H4	Water depth: high	1.0 m < RFL ≤ 2.0 m OR (0.3 m < RFL ≤ 1.0 m AND W-AM-A1)
	W-AB-H5	Water depth: very high	RFL > 2.0 m OR (1.0 m < RFL ≤ 2.0 m AND W-AM-A1)
	W-AB-V1	Water velocity: slow	Reference water velocity (RWV) ≤0.3 m/s OR (1W2a.L AND 1W3b.L)
	W-AB-V2	Water velocity: moderate	(0.3 m/s < RWV ≤ 1.0 m/s) OR (1W2a.L AND 1W3a.L) OR 1W2b.L OR (1W2c.L AND 1W3b.L) OR NOT (W-AB-V1 OR W-AB-V3)
	W-AB-V3	Water velocity: fast	RWV > 1.0 m/s OR 1W2c.L OR (1W2b.L AND 1W3a.L) OR 1W4a.L OR 1W4b.L OR 1W5a.L

Action intensity	W-AB-C1	Heavy rain	**Table W.S3**
	W-AB-C2	Low action	**Table W.S3**
	W-AB-C3	Moderate action	**Table W.S3**
	W-AB-C4	Heavy action	**Table W.S3**
	W-AB-C5	Extreme action	**Table W.S3**
	W-AB-C6	Tsunami action	Predicted tsunami area=Yes
Action modifiers	W-AM-A1	Potential amplification of the action	1W1a.L OR 1W3a.L OR 1W5b.L
	W-AM-A2	Flash flood	Flash flooding area=Yes OR W-AB-C6
Induced hazard	W-AI-T1	Potential presence of debris	1W4a.L OR 1W4b.L OR 1W5a.L OR 3G1a.L OR 3G1b.L OR 3G1c.L OR W-AB-C6
	W-AI-T2	Potential mudflow	1W5a.L OR 1G3b.L OR 1G3c.L OR 1G3d.L
Protection from hazard	W-AM-P0	No protection	NOT (W-AM-P1 OR W-AM-P2 OR W-AM-P3)
	W-AM-P1	Action protection: distance from hazard (the evaluation will be done only for rain)	NOT(1W1a.L) AND RFL='No flood' AND NOT(W-AB-C6)AND NOT(W-AI-T2)
	W-AM-P2	Action protection: raised	2W1a.L OR 3W1a.L OR 3W1b.S OR 3W1c.S OR 3W1d.S OR [3W1e.S AND NOT (W-AI-T1)]
	W-AM-P3	Action protection: barriers	2W1c.L

Water load balance	W-RM-S1	Balanced water load	3W2c.P
	W-RM-S2	Delayed water load balance	3W2b.P OR [(3W2a.P OR 3W2e.P) AND (LOCAL COLLAPSES OR LOCAL COLLAPSES)]
	W-RM-S3	Unbalanced water load	{(3W2a.P OR 3W2e.P) AND [NOT (LOCAL COLLAPSES) AND NOT (LOCAL COLLAPSES)]}
Undermining	W-RL-U0	Undermining not credible	NOT (W-RL-U1) AND NOT (W-RL-U2)
	W-RL-U1	Potential undermining with ground erosion and no digging out of foundations	3W3e.L AND [NOT (2W2a.L)] AND {(3W3c.S OR Nug>0) OR [(3W3a.S OR 3W3b.S) AND 3W3d.P]}
	W-RL-U2	Potential undermining with digging out of foundations	3W3e.L AND (3W3a.S OR 3W3b.S) AND NOT (3W3d.P) AND NOT (2W2a.L)
Connection to ground	W-RB-A1	Local anchorage, fixed	NOT (W-RB-A2)
	W-RB-A2	Local anchorage, movable	(W-RL-U2 OR 3W3a.S) AND NOT (3W3f.S)

Structural ro-bustness class	W-RB-C1	Very high class for flood	**Table W.S4**
	W-RB-C2	High class for flood	**Table W.S4**
	W-RB-C3	Moderate class for flood	**Table W.S4**
	W-RB-C4	Low class for flood	**Table W.S4** OR 3G6a.S OR 3G7h.S
	W-RB-C5	Melting	4W1a.S
	VT*n*	VISUS typology	If the VISUS typology “n” is assigned
Building weight	W-RB-W1	Lightweight building	{(Nag+Nug=1) AND [3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)]} OR {(Nag+Nug=2) AND {[3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)] AND NOT (4G4c.S AND 3G8a.S AND 4G6a.N)}} OR {(Nag+Nug=3) AND [3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S] AND NOT (4G4c.S)}
	W-RB-W2	Heavy building	NOT (W-RB-W1)

Local stress	W-RL-C1	Distribution of stresses	NOT (W-RL-C2)
	W-RL-C2	Local stress concentration	[(3G4h.S OR 3G4j.S) AND 3G5f.S] OR [(3G4b.S OR 3G4c.S OR 3G4d.S OR 3G4e.S OR 3G4i.S OR 3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S) AND NOT (4W1b.S)] OR 3G7c.S OR 4G7a.S
Induced dangers	W-RN-D1	Floor submerged	3W4a.S OR [NOT (3W1b.S) AND RFL > 1.0m AND W-AM-P0]
	W-RN-D2	Potential electrocution	4W4a.N AND (W-RN-D1 OR W-RM-S1 OR W-RM-S2)
	W-RN-D3	Potential loss of contents	(W-RN-D1 OR W-RM-S1 OR W-RM-S2) AND {NOT (3W1b.S) AND [NOT 4S4b.D OR(4S3b.D OR 4S3c.D)] AND NOT (Early warning)}
	W-RN-D4	Potential loss of equipment	(W-RN-D1 OR W-RM-S1 OR W-RM-S2) AND [NOT (3W1b.S) AND NOT (4W2a.N) AND NOT (3W2e.P)]
	W-RN-D6	Potential release of contaminants in the building	(W-RM-S1 OR W-RM-S2) AND { 4W3a.N OR [Toilets=Yes AND Nag=1 AND NOT (3W2d.N)]}

Egress	W-RF-E1	Safe path to safe zone	2W4a.F OR Early warning=Yes OR W-AB-C1 OR (W-AB-H2 AND W-AM-V1)
	W-RF-E2	In safe area	4W5a.F OR [(Nag>1 OR 3W2e.P) AND NOT (COLLAPSE OR DAMAGE OR RELEVANT UNDERMINING OF FOUNDATIONS OR DISPLACEMENT OR UPLIFT OR LOCAL COLLAPSES OR LOCAL COLLAPSES)] OR W-AM-P2 OR W-AM-P3
	W-RF-E3	No safe zone	NOT (4W5a.F) AND NOT (W-RF-E1) AND Early warning=No
	W-RF-E4	Impossibility to reach a safe zone	NOT (W-RF-E1 OR W-RF-E2) AND Early warning=No
	W-RF-E5	Trapped people in flooded areas	(W-RM-S1 OR W-RM-S2) AND W-RF-E4 AND (Nag=1)
	W-RF-E6	Trapped people in dry areas	W-RF-E4 AND (W-RM-S3 OR Nag>1) AND [NOT (COLLAPSE) AND NOT (DAMAGE)]

5. SUPPORTING TABLES

Table W.S1 *Flood hazard: criteria for assigning the water depth class*

Reference flood level (RFL) value	Floodwater depth	
	NOT (W-AM-A1)	W-AM-A1
Heavy rain = Yes	W-AB-H1	W-AB-H1
RFL = 0	W-AB-H1	W-AB-H1
RFL ≤0.3 m	W-AB-H2	W-AB-H3
0.3 m < RFL ≤ 1.0 m	W-AB-H3	W-AB-H4
1.0 m < RFL ≤ 2.0 m	W-AB-H4	W-AB-H5
RFL > 2.0 m	W-AB-H5	W-AB-H5

Table W.S2 *Flood hazard: criteria for assigning the water velocity class*

Reference water velocity (RWV)	Water velocity class
RWV ≤0.3 m/s	W-AB-V1
0.3 m/s < RWV ≤ 1.0 m/s	W-AB-V2
RWV > 1.0 m/s	W-AB-V3
If RWV is not assigned, use the criteria below to assign the water velocity class	
Logical criteria	Water velocity class

Reference water velocity (RWV)	Water velocity class
(1W2a.L AND 1W3b.L)	W-AB-V1
(1W2a.L AND 1W3a.L) OR 1W2b.L OR (1W2c.L AND 1W3b.L)	W-AB-V2
1W2c.L OR (1W2b.L AND 1W3a.L) OR Tsunami_area=Yes	W-AB-V3

Table W.S3 *Flood hazard: criteria for assigning the water action class, starting from the reference flood level, the reference water velocity and the protection from hazard (if any profile qualifiers concerning the protection from hazard exist [except if 'no protection' is active, the water action class becomes 'heavy rain']).*

Protection from hazard	Floodwater velocity	Floodwater depth				
		W-AB-H1	W-AB-H2	W-AB-H3	W-AB-H4	W-AB-H5
NOT (W-AM-P1 OR W-AM-P2 OR W-AM-P3)	W-AB-V1	ACTION INTENSITY HEAVY RAIN W-AB-C1	ACTION INTENSITY LOW ACTION W-AB-C2	ACTION INTENSITY LOW ACTION W-AB-C2	ACTION INTENSITY MODERATE ACTION W-AB-C3	ACTION INTENSITY HEAVY ACTION W-AB-C4
	W-AB-V2	ACTION INTENSITY HEAVY RAIN W-AB-C1	ACTION INTENSITY LOW ACTION W-AB-C2	ACTION INTENSITY MODERATE ACTION W-AB-C3	ACTION INTENSITY HEAVY ACTION W-AB-C4	ACTION INTENSITY EXTREME ACTION W-AB-C5
	W-AB-V3	ACTION INTENSITY HEAVY RAIN W-AB-C1	ACTION INTENSITY MODERATE ACTION W-AB-C3	ACTION INTENSITY HEAVY ACTION W-AB-C4	ACTION INTENSITY EXTREME ACTION W-AB-C5	ACTION INTENSITY EXTREME ACTION W-AB-C5
W-AM-P1	–	ACTION INTENSITY HEAVY RAIN W-AB-C1				
W-AM-P2	–					
W-AM-P3	–					

Table W.S4 *Flood hazard: criteria for assigning the robustness class for flood, depending on W-RM-S1,2,3 (water load balance). Note that the case of 'delayed balance' is treated as 'unbalanced' (conservative definition).*

Observable (OBS)	OBS description	Water load balance	
		WATER LOAD BALANCE BALANCED WATER LOAD W-RM-S1	WATER LOAD BALANCE DELAYED WATER LOAD BALANCE W-RM-S2 OR WATER LOAD BALANCE UNBALANCED WATER LOAD W-RM-S3 OR other
3G4a.S	Reinforced concrete walls	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR FLOOD W-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR FLOOD W-RB-C1
3G4b.S	Reinforced concrete dual frame wall system	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2
3G4c.S	Reinforced concrete frame	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2
3G4d.S	Precast	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2
3G4e.S	Reinforced concrete vertical piers only	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4f.S	Reinforced masonry	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4g.S	Confined masonry	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4h.S	Unreinforced masonry	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4i.S	Masonry vertical piers only	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4j.S	Earth or adobe structure	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4k.S	Unbraced steel frame	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4l.S	Braced steel frame	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4m.S	Steel vertical piers only	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4n.S	Wood frame unbraced	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4o.S	Wood panels or wood frame braced	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR FLOOD W-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3
3G4p.S	Wood vertical piers only	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4
3G4q.S	Bamboo structure	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR FLOOD W-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4

Observable (OBS)	OBS description	Water load balance	
		WATER LOAD BALANCE BALANCED WATER LOAD W-RM-S1	WATER LOAD BALANCE DELAYED WATER LOAD BALANCE W-RM-S2 OR WATER LOAD BALANCE UNBALANCED WATER LOAD W-RM-S3 OR other
OTHER 3G4r.S	Other	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR FLOOD W-RB-C4

Table W.S5 *Flood hazard: criteria for assigning the lightweight building profile qualifiers (PQs)*

PQ	Name	Evaluation logic
W-RB-W1	Lightweight building	{(Nag+Nug=1) AND [3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)]} OR {(Nag+Nug=2) AND {[3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)] AND NOT (4G4c.S AND 3G8a.S AND 4G6a.N)}} OR {(Nag+Nug=3) AND [3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S] AND NOT (4G4c.S)}

6. TRIGGERING TABLES

Table W.T1 *Triggering table for the 'Collapse' and 'Damage' impact scenarios (structural global critical issues).*

Action	Robustness class				
	W-RB-C1	W-RB-C2	W-RB-C3	W-RB-C4	W-RB-C5
W-AB-C1	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Damage
W-AB-C2 AND NOT (W-AI-T1 OR W-AI-T2)	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Damage	Damage
W-AB-C2 AND (W-AI-T1 OR W-AI-T2)	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse	Structural collapse
W-AB-C3 AND NOT (W-AI-T1 OR W-AI-T2)	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse	Structural collapse
W-AB-C3 AND (W-AI-T1 OR W-AI-T2)	No expected critical impact scenario	Damage	Structural collapse	Structural collapse	Structural collapse
W-AB-C4 AND NOT (W-AI-T1 OR W-AI-T2)	No expected critical impact scenario	Damage	Structural collapse	Structural collapse	Structural collapse
W-AB-C4 AND (W-AI-T1 OR W-AI-T2)	Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
W-AB-C5 AND NOT (W-AI-T1 OR W-AI-T2)	Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
W-AB-C5 AND (W-AI-T1 OR W-AI-T2)	Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
W-AB-C6	Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse

Table W.T2 *Triggering table for the 'Uplift' impact scenario (structural global critical issue)*

Criteria for the predisposition to uplift	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
NOT(W-RM-S1) AND W-RB-A2 AND W-RB-W1	No expected critical impact scenario	Uplift difficulties	Uplift severe consequences	Uplift severe consequences	Uplift severe consequences

Table W.T3 *Triggering table for the 'Displacement' impact scenario (structural global critical issue)*

Criteria for the predisposition to displacement	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
W-RM-S1 AND W-RB-W1 AND W-RB-A2 AND Nug=0	No expected critical impact scenario	No expected critical impact scenario	Displacement difficulties	Displacement severe consequences	Displacement severe consequences
(W-RM-S2 OR W-RM-S3) AND W-RB-W1 AND W-RB-A2 AND Nug=0	No expected critical impact scenario	Displacement difficulties	Displacement severe consequences	Displacement severe consequences	Displacement severe consequences

Table W.T4 *Triggering table for the 'Significant undermining of foundations' impact scenario (structural global critical issue)*

Criteria for the predisposition to the significant undermining of foundations	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
W-RL-U2 AND (1G1c.L OR 1G1d.L OR 1G1e.L)	No expected critical impact scenario	No expected critical impact scenario	Significant undermining of foundations	Significant undermining of foundations	Significant undermining of foundations

Table W.T5 *Triggering table for the 'Local collapse' impact scenario (structural local/envelope critical issue)*

Predisposition to local collapse	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
W-RL-C2	No expected critical impact scenario	Local collapses difficulties	Local collapses severe consequences	Local collapses severe consequences	Local collapses severe consequences

Table W.T6 *Triggering table for the 'Partial undermining of foundations' impact scenario (structural local/envelope critical issue)*

Criteria for the predisposition to partial undermining of foundations	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
W-RL-U1	No expected critical impact scenario	No expected critical impact scenario	Partial undermining of foundations	Partial undermining of foundations	Partial undermining of foundations
W-RL-U2	No expected critical impact scenario	No expected critical impact scenario	Partial undermining of foundations	Partial undermining of foundations	Partial undermining of foundations

Table W.T7 *Triggering table for the non-structural critical issue impact scenarios*

Criteria	Action intensity				
	W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
(W-RM-S1 OR W-RM-S2)	No expected critical impact scenario	Internal flooding	Internal flooding	Internal flooding	Internal flooding
W-RN-D2	No expected critical impact scenario	Electrocution	Electrocution	Electrocution	Electrocution
W-RN-D3	No expected critical impact scenario	No expected critical impact scenario	Loss of contents	Loss of contents	Loss of contents
W-RN-D4	No expected critical impact scenario	Loss of contents	Loss of contents	Loss of contents	Loss of contents
W-RN-D5	No expected critical impact scenario	Hazardous material dispersion	Hazardous material dispersion	Hazardous material dispersion	Hazardous material dispersion
W-RN-D6	No expected critical impact scenario	No expected critical impact scenario	Hazardous material dispersion	Hazardous material dispersion	Hazardous material dispersion

Table W.T8 *Triggering table for the functionality critical issue impact scenarios*

Criteria	Action intensity W-AB-C1	W-AB-C2	W-AB-C3	W-AB-C4	W-AB-C5
NOT W-RF-E2 AND NOT W-AM-A2	No expected critical impact scenario	Difficult evacuation	Difficult evacuation	Difficult evacuation	Difficult evacuation
W-RF-E5	No expected critical impact scenario	No expected critical impact scenario	Trapped people in flooded areas	Trapped people in flooded areas	Trapped people in flooded areas
W-RF-E6	No expected critical impact scenario	No expected critical impact scenario	Trapped people in dry areas	Trapped people in dry areas	Trapped people in dry areas

7. SAFETY INDICATOR: ROSE OF WARNING LEVELS

7.1 Warning level evaluation for the schoolyard

Table W.WS.L *Water hazard evaluation of the warning levels for the schoolyard: location/site safety issue*

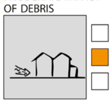
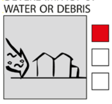
Warning level	Evaluation logic
	NOT( OR )
	MODERATE IMPACT OF DEBRIS 
	SEVERE IMPACT OF WATER OR DEBRIS 

Table W.WS.S *Water hazard evaluation of the warning levels for the schoolyard: structural global safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table W.WS.P *Water hazard evaluation of the warning levels for the schoolyard: structural local/envelope safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table W.WS.N *Water hazard evaluation of the warning levels for the schoolyard: non-structural safety issue*

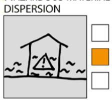
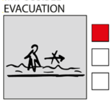
Warning level	Evaluation logic
	NOT ()
	HAZARDOUS MATERIAL DISPERSION 
	No scenario

Table W.WS.F *Water hazard evaluation of the warning levels for the schoolyard: functionality safety issue*

Warning level	Evaluation logic
	NOT ()
	ABSENCE OF SAFE AREAS 
	IMPOSSIBLE EVACUATION 

7.2 Warning level evaluation for school buildings

Table W.WB.L *Water hazard evaluation of the warning levels for school buildings: location/site safety issue*

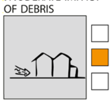
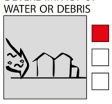
Warning level	Evaluation logic
	NOT( OR )
	Moderate impact of debris 
	Severe impact of water or debris 

Table W.WB.S *Water hazard evaluation of the warning levels for school buildings: structural global safety issue*

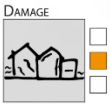
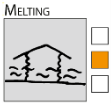
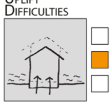
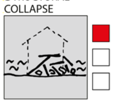
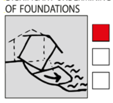
Warning level	Evaluation logic
	NOT( OR )
	Damage  OR Melting  OR Displacement difficulties  OR Uplift difficulties 
	Structural collapse  OR Displacement severe consequences  OR Uplift severe consequences  OR Significant undermining of foundations 

Table W.WB.P *Water hazard evaluation of the warning levels for the school buildings: structural local/envelope safety issue*

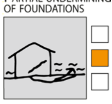
Warning level	Evaluation logic
	NOT( OR )
	Local collapses difficulties  OR Partial undermining of foundations 
	Local collapses severe consequences 

Table W.WB.N *Water hazard evaluation of the warning levels for the school buildings: non-structural safety issue*

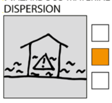
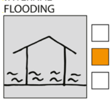
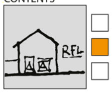
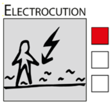
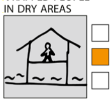
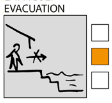
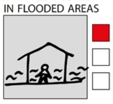
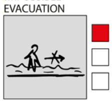
Warning level	Evaluation logic
	NOT( OR )
	Hazardous material dispersion  OR Internal flooding  OR Loss of contents 
	Electrocution 

Table W.WB.F *Water hazard evaluation of the warning levels for the school buildings: functional safety issue*

Warning level	Evaluation logic
	NOT( OR )
	Trapped people in dry areas  OR Difficult evacuation  OR Absence of safe areas 
	Trapped people in flooded areas  OR Impossible evacuation 

Annex to the VISUS Methodology

| AM4 Evaluation Criteria: Earthquake Hazard

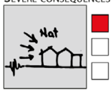
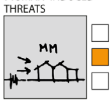
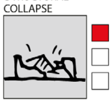
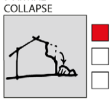
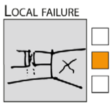
Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

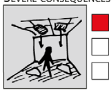
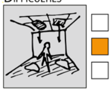
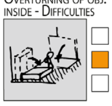
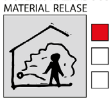
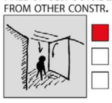
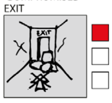
- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

1. EXPECTED IMPACT SCENARIOS

Table 1.1 lists the substantial impact scenarios identified for earthquake hazard evaluated with the Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology.

Table 1.1 *Expected impact scenarios for earthquake hazard*

Safety issue	Icon	Name	Where	Description
Location/site critical issues	Natural threats Severe consequences 	Natural threats – severe consequences	Schoolyard and buildings	Presence of conditions that suggest there could be induced natural hazards to the school triggered by the earthquake, such as landslides and tsunamis, with severe consequences for personal safety.
	Natural threats Difficulties 	Natural threats – difficulties	Schoolyard and buildings	Presence of conditions that suggest there could be induced natural hazards to the school triggered by the earthquake, such as liquefaction, causing difficulties for personal safety.
	Human-induced threats 	Human-induced threats	Schoolyard and buildings	Presence of conditions that suggest there could be human-induced hazards to the school triggered by the earthquake, such as technological accidents or flooding caused by the failure of an upstream dam, causing difficulties for personal safety.
Structural global critical issues	Structural collapse 	Structural collapse	Buildings	Presence of conditions that suggest the structure of the building is probably unable to withstand the reference earthquake hazard. Activation of this scenario could have severe consequences for personal safety, including injuries or deaths.
	Damage 	Damage	Buildings	Presence of conditions suggesting that, in the case of the reference earthquake hazard, the whole structure could sustain significant damage. Activation of this scenario could result in difficulties for personal safety.
Structural local/envelope critical issues	Partial collapse 	Partial collapse	Buildings	Presence of conditions suggesting that, in the case of the reference earthquake hazard, there could be local collapse of the structure. Activation of this scenario could have severe consequences for personal safety.
	Local failure 	Local failures	Buildings	Presence of conditions suggesting that, in the case of the reference earthquake hazard, there could be local failures of and damage to the structure, but not collapse. Activation of this scenario could result in difficulties for personal safety.

Safety issue	Icon	Name	Where	Description
Non-structural critical issues	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES 	Fall of objects inside – severe consequences	Buildings	Potential falls of non-structural elements inside the building. The falls could have severe consequences for personal safety depending on size and/or location of the falling elements.
	FALL OF OBJECTS INSIDE DIFFICULTIES 	Fall of objects inside – difficulties	Buildings	Potential falls of non-structural elements inside the building. The falls could cause difficulties for personal safety because of the dimensions and/or the location of the falling elements.
	OVERTURNING OF OBJ. INSIDE - SEVERE CONSEQ. 	Overturning of objects inside – severe consequences	Buildings	Potential overturning or slipping of non-structural elements inside the building. Activation of this scenario could have severe consequences for personal safety because of the dimensions and/or the location of the falling elements.
	OVERTURNING OF OBJ. INSIDE - DIFFICULTIES 	Overturning of objects inside – difficulties	Buildings	Potential overturning or slipping of non-structural elements inside the building. Activation of this scenario could result in difficulties for personal safety because of the dimensions and/or the location of the falling elements.
	POTENT. HAZARDOUS MATERIAL RELASE 	Potential hazardous material release	Buildings	Potential release of hazardous material inside the school buildings. The releases could originate from unsafely stored containers or from pipes that crack because of the earthquake.
	FALL OF OBJ. OUTSIDE, FROM BLD - SEVERE CONS. 	Fall of objects outside, from the building – severe consequences	Buildings	Potential falls of non-structural elements outside the building. The falls could have severe consequences for personal safety because of the dimensions and/or the location of the falling elements.
	FALL OF OBJ. OUTSIDE, FROM BLD - DIFFICULTIES 	Fall of objects outside, from the building -difficulties	Buildings	Potential falls of non-structural elements outside the building. The falls could cause difficulties for personal safety because of the dimensions and/or the location of the falling elements.
	FALL OF OBJ. OUTSIDE FROM OTHER CONSTR. 	Fall of objects outside, from other constructions	Schoolyard and buildings	Potential falls of non-structural elements outside the building originating from buildings that are not school buildings (external buildings). The falls could have severe consequences for personal safety because of the dimensions and/or the location of the falling elements.
Functionality critical issues	COMPROMISED EXIT 	Compromised exit	Buildings	Presence of conditions that could compromise or obstruct the egress path of the building in the case of an earthquake. Activation of this scenario could have severe consequences for personal safety.
	DIFFICULT EGRESS 	Difficult egress	Buildings	Presence of conditions that could cause difficulties to people when leaving the school because of obstacles or difficulties in the egress path.
	ABSENCE OF SAFE AREAS 	Absence of safe areas	Schoolyard and buildings	Absence of defined safe areas in the case of an earthquake. This scenario could present difficulties for personal safety.

2. LOGICAL TREES

The VISUS logical trees define the substantial elements and the rules and criteria that correspond to the definition of the expected impact scenarios.

2.1 Logical trees for the schoolyard

Fig. 2.1 *Earthquake hazard: expert logical tree for the 'Natural threats' impact scenario*

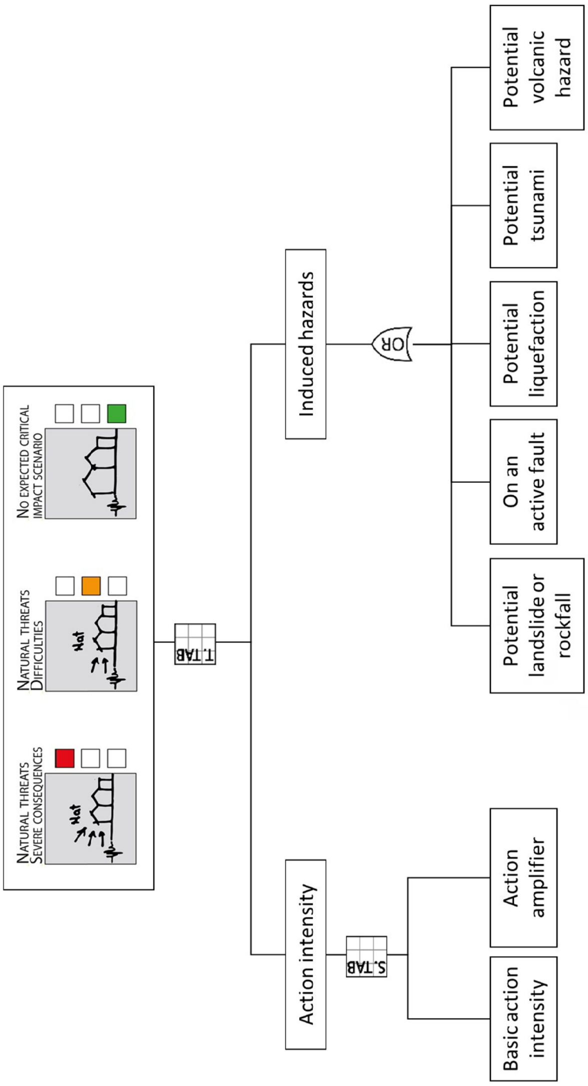


Fig. 2.2 *Earthquake hazard: evaluation logical tree for the 'Natural threats' impact scenario*

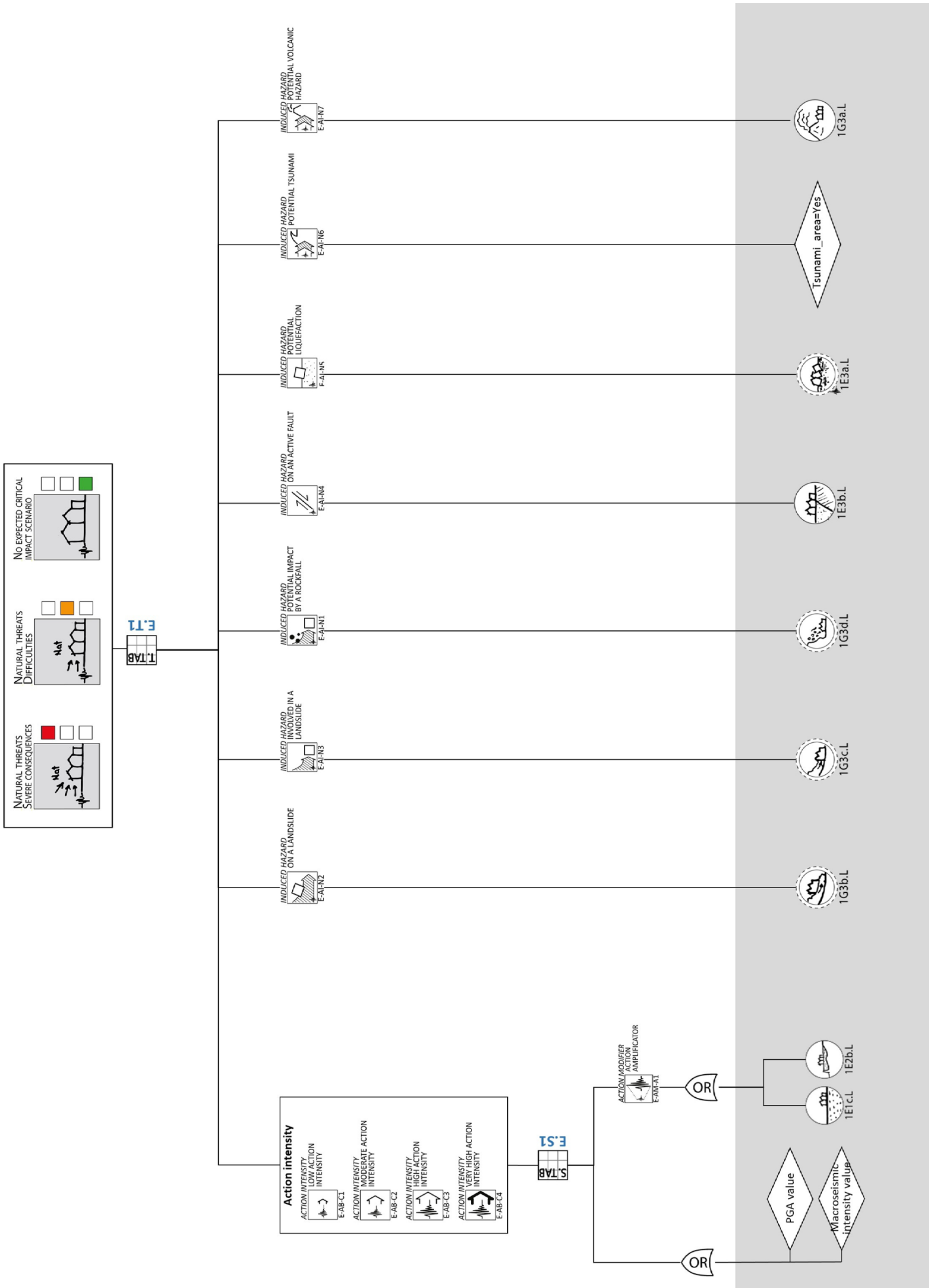


Fig. 2.3 *Earthquake hazard: expert logical tree for the 'Human-induced threats' impact scenario*

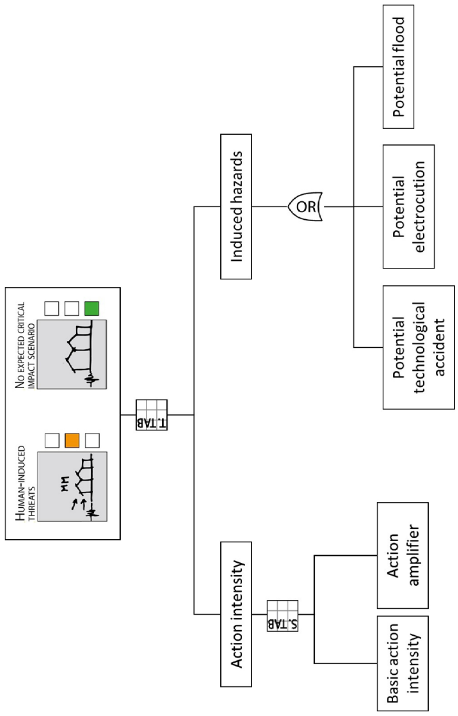


Fig. 2.4 *Earthquake hazard: evaluation logical tree for the 'Human-induced threats' impact scenario*

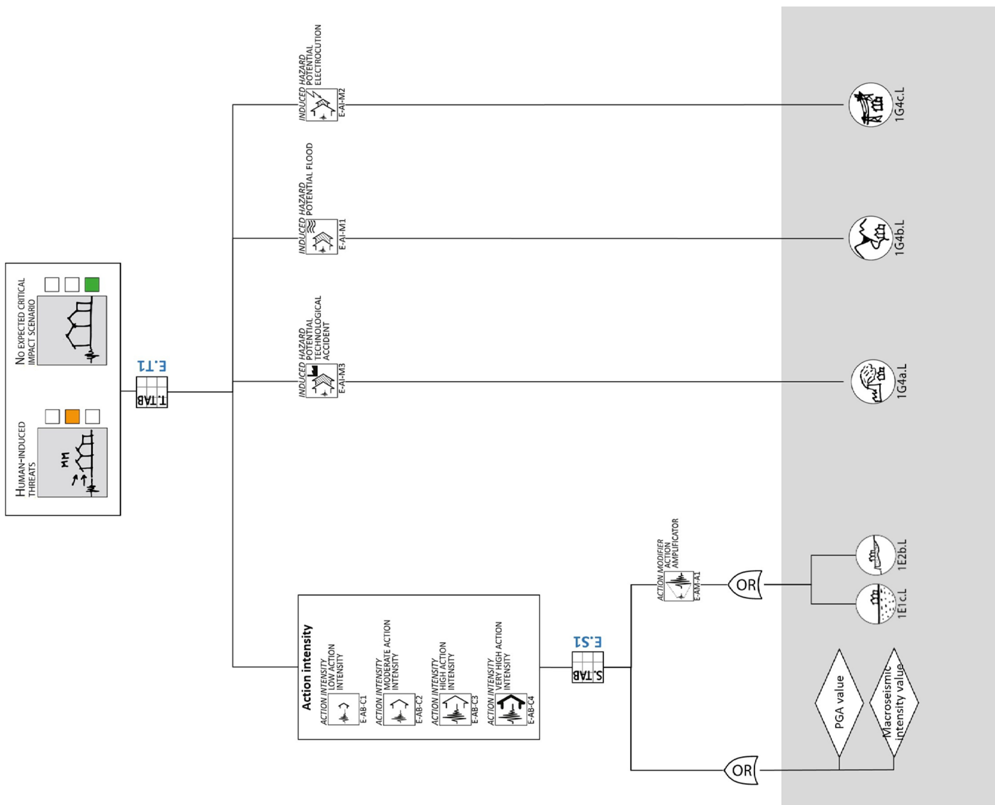


Fig. 2.5 *Earthquake hazard: expert logical tree for the 'Fall of objects outside, from other constructions' impact scenaio*

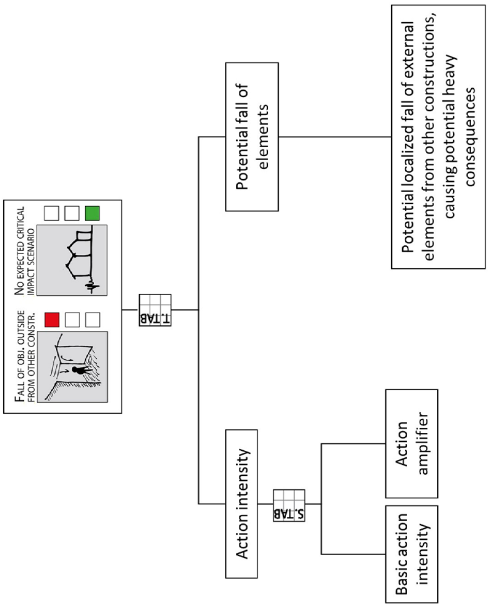


Fig. 2.6 *Earthquake hazard: evaluation logical tree for the 'Fall of objects outside, from other constructions impact scenario*

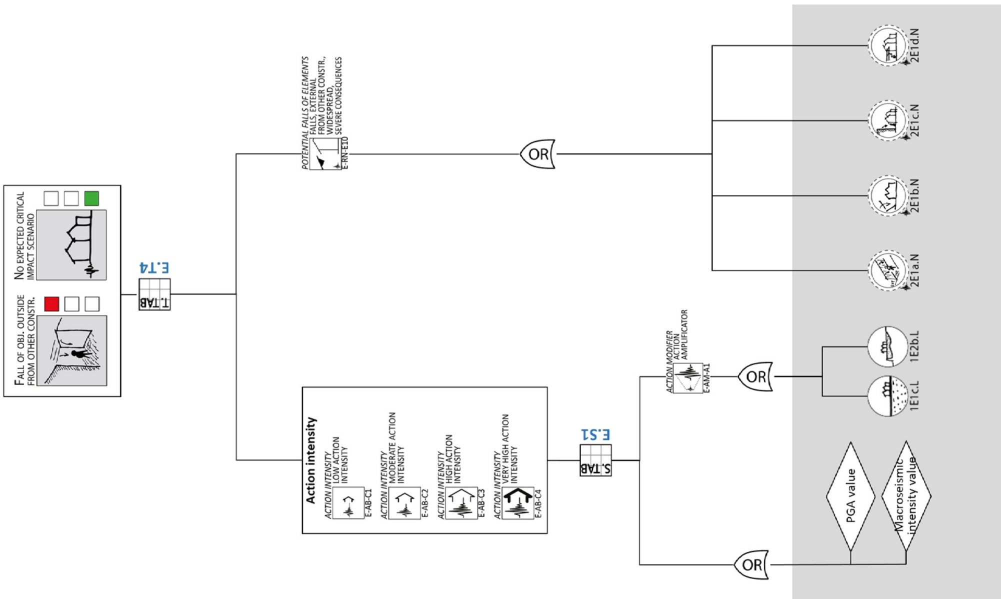


Fig. 2.7 *Earthquake hazard: expert logical tree for the 'Absence of safe areas' impact scenario*

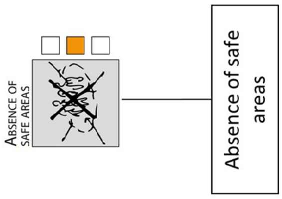
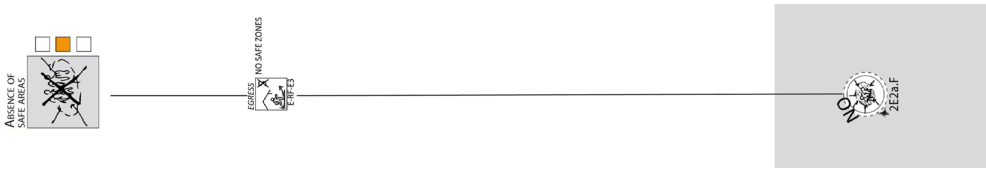


Fig. 2.8 *Earthquake hazard: evaluation logical tree for the 'Absence of safe areas' impact scenario*



2.2 Logical trees for school buildings

Fig. 2.9 *Earthquake hazard: expert logical tree for the ''Natural threats' impact scenario*

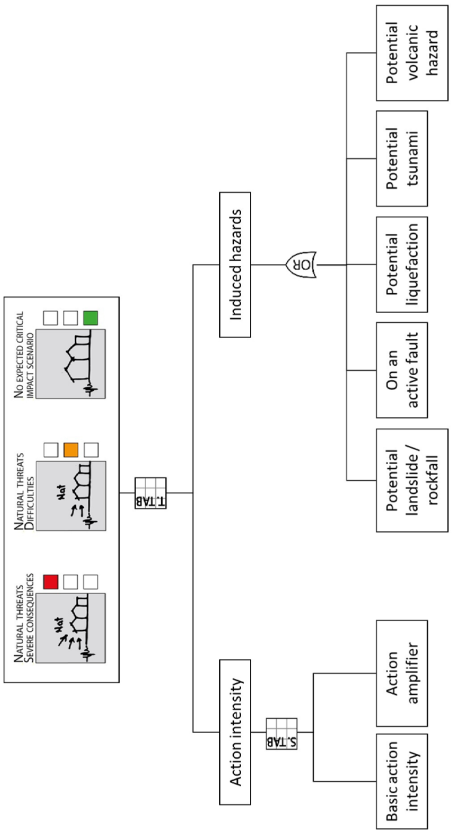


Fig. 2.10 *Earthquake hazard: evaluation logical tree for the ‘Natural threats’ impact scenario*

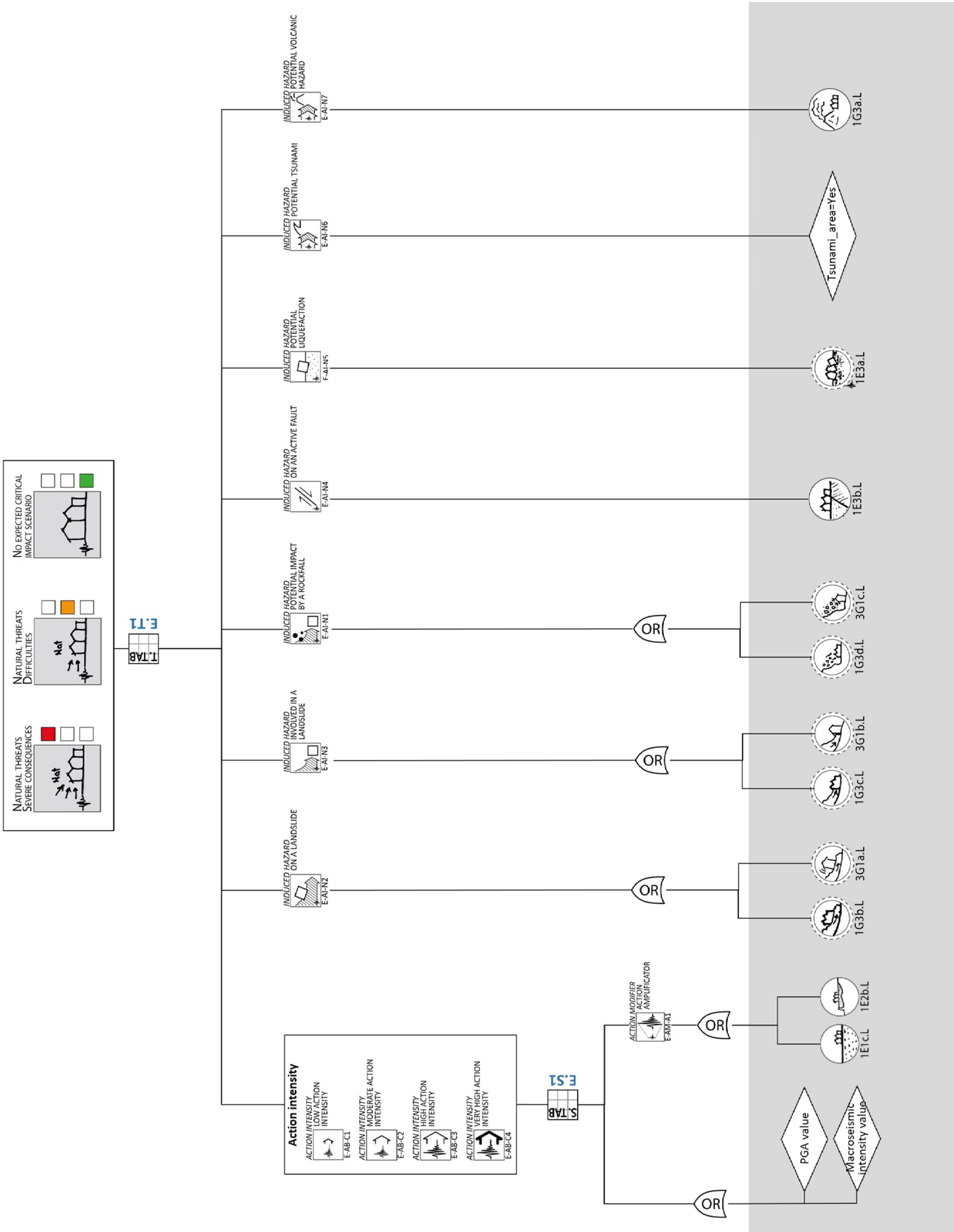


Fig. 2.11 *Earthquake hazard: expert logical tree for the 'Human-induced threats' impact scenario*

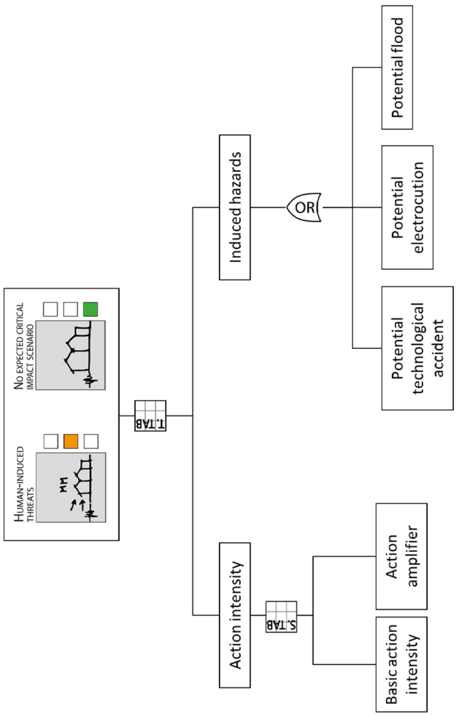


Fig. 2.12 *Earthquake hazard: evaluation logical tree for the 'Human-induced threats' impact scenario*

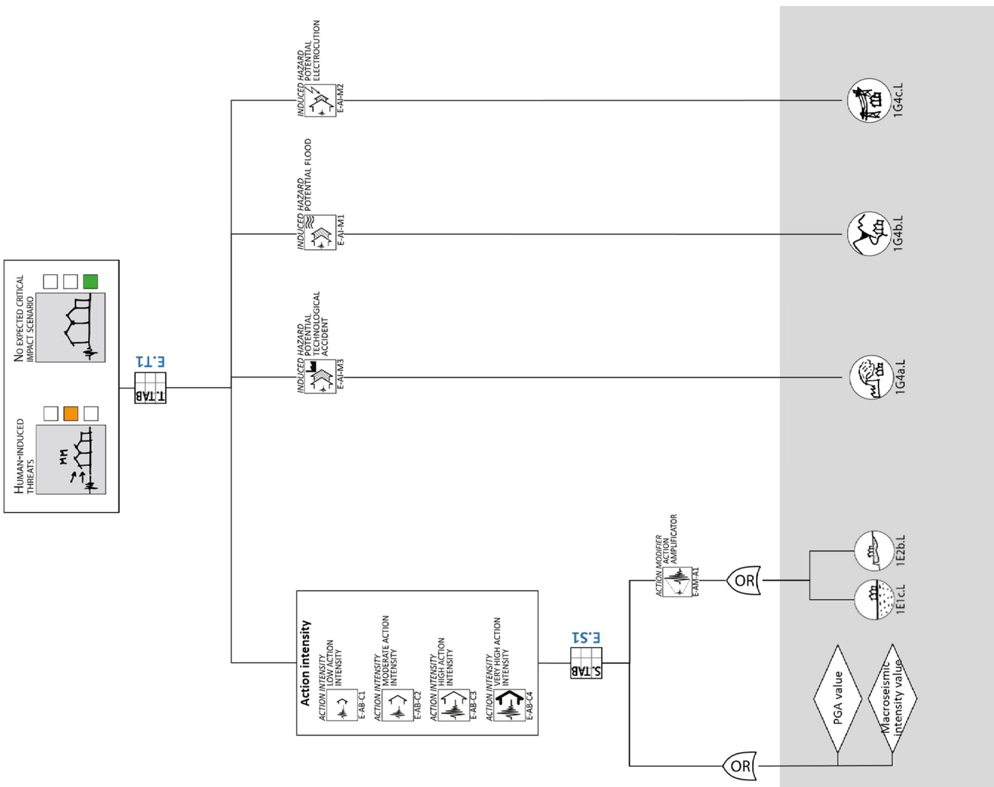


Fig. 2.13 *Earthquake hazard: expert logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies).*

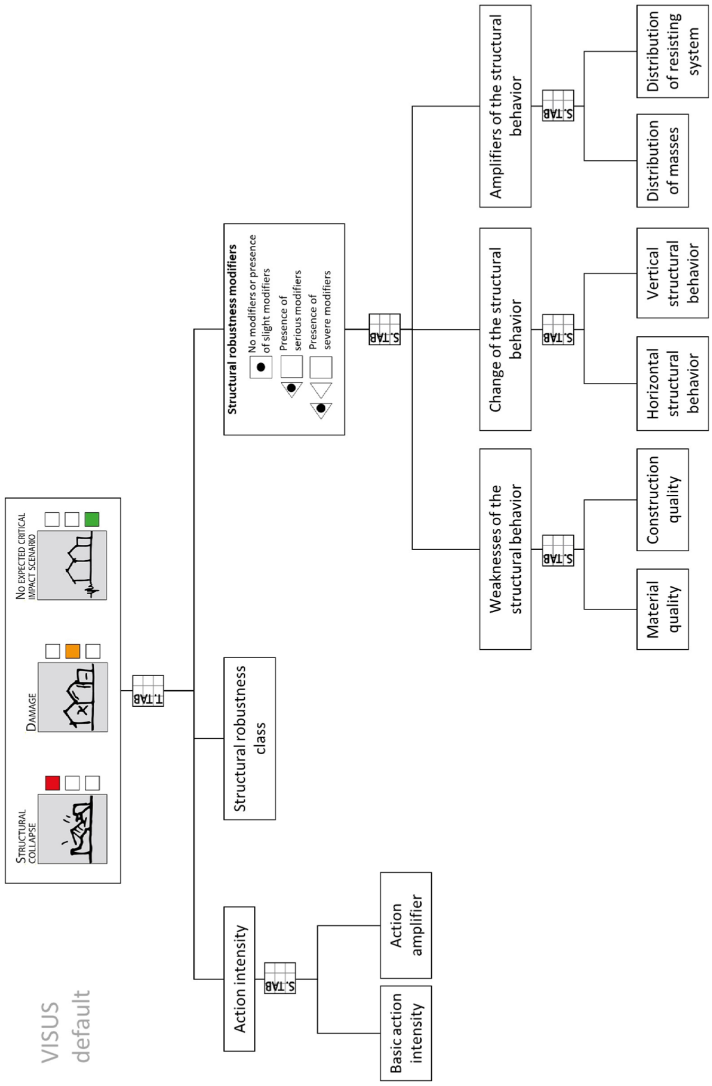
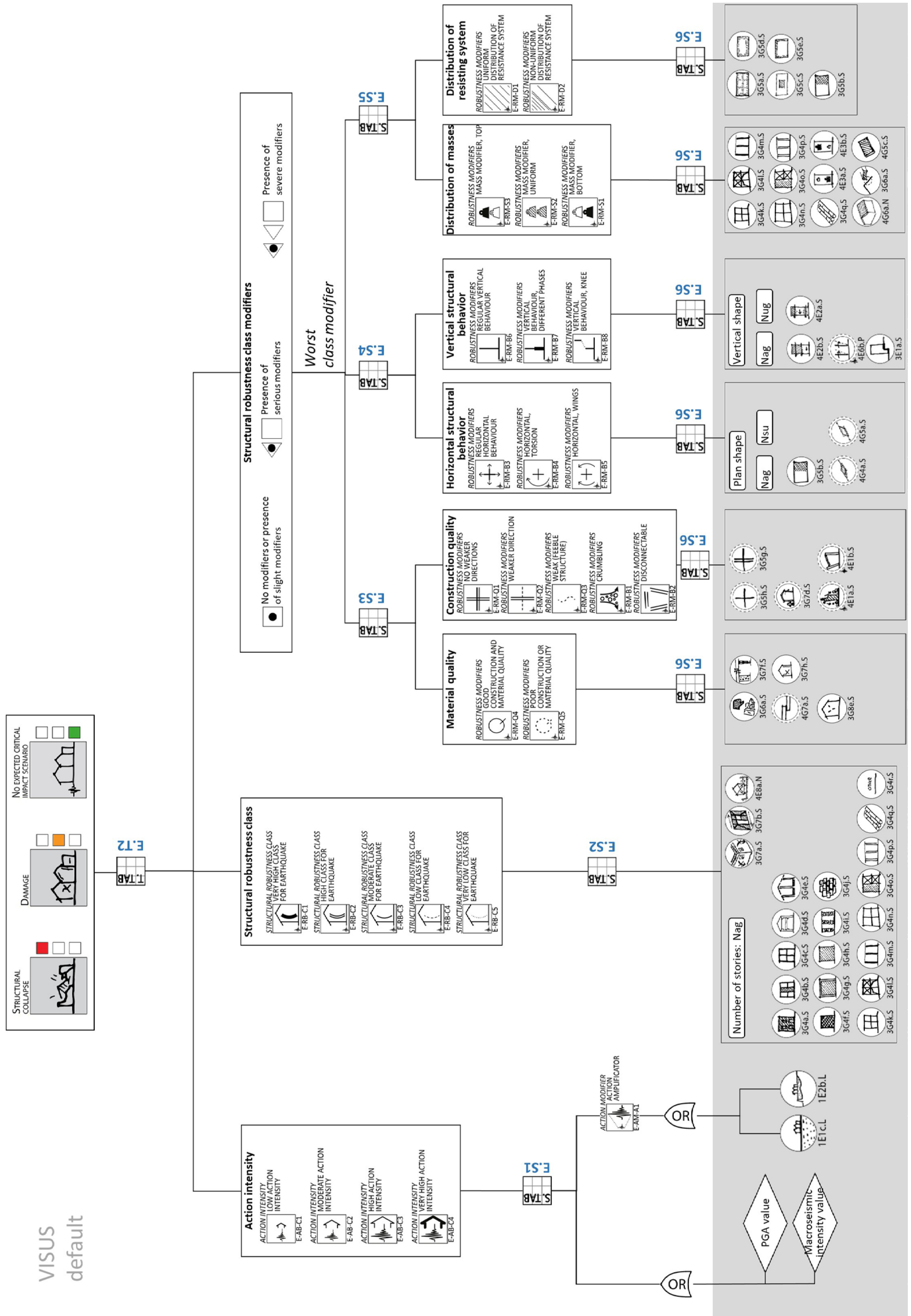


Fig. 2.14 *Earthquake hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies)*



If, during the adaptation phase, the local committee defined the VISUS typologies in the VISUS multi-hazard adaptation form: pre-characterized VISUS typology, the structural global critical effects are assessed with the information provided in the form, that is the A1 and A2 values. These values are compared with the action intensity value, that is the expected 'reference event for earthquake' (rEE). rEE is calculated by multiplying the peak ground acceleration (PGA) value by the coefficient 'act.mod' (that is equal to 1.6 in case of seismic amplification, 1 otherwise). The results from the comparison of rEE and the values of A1 and A2 allow to assign the EIS ('Structural collapse' if rEE > A2; 'Damage' if rEE ≤ A2 and rEE > A1; or 'Action withstanding' if rEE ≤ A1).

The presence of modifiers of the building robustness should be already accounted in the definition of the VISUS typology.

Fig. 2.15 *Earthquake hazard: expert logical tree for the 'Structural collapse', 'Damage' and 'Action withstanding' impact scenarios – approach when VISUS typologies are defined*

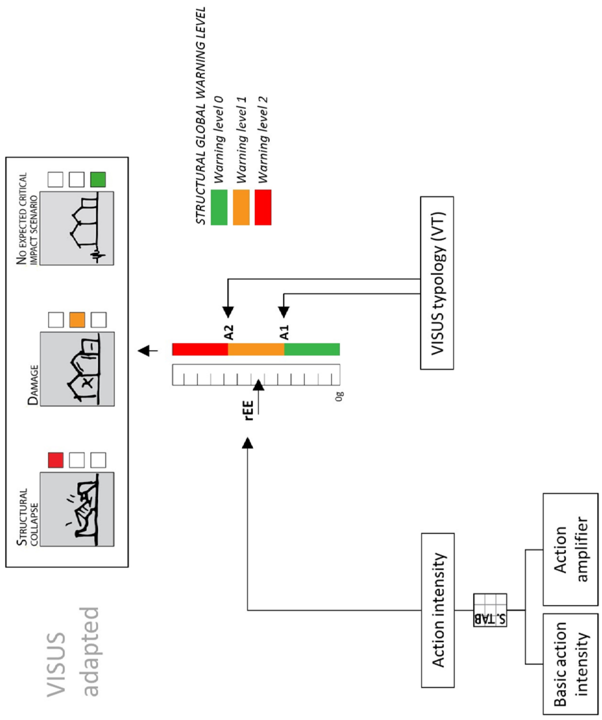


Fig. 2.16 *Earthquake hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – approach when VISUS typologies are defined*

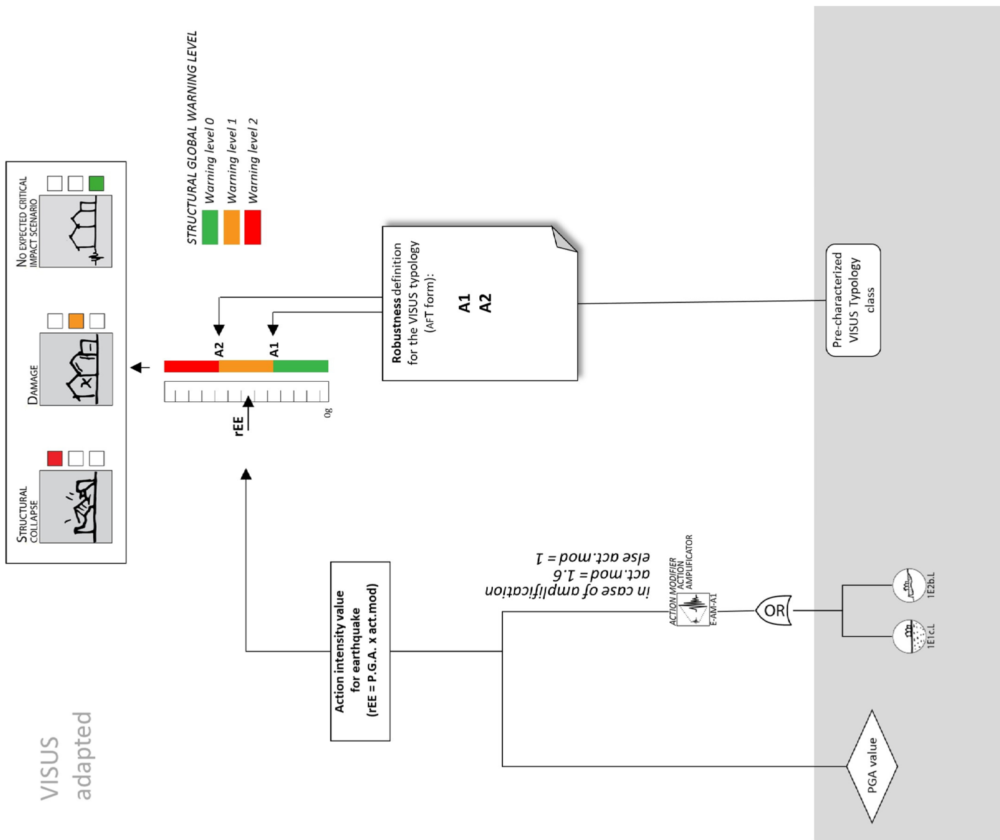


Fig. 2.17 *Earthquake hazard: expert logical tree for the 'Partial collapse' and 'Local failures' impact scenarios*

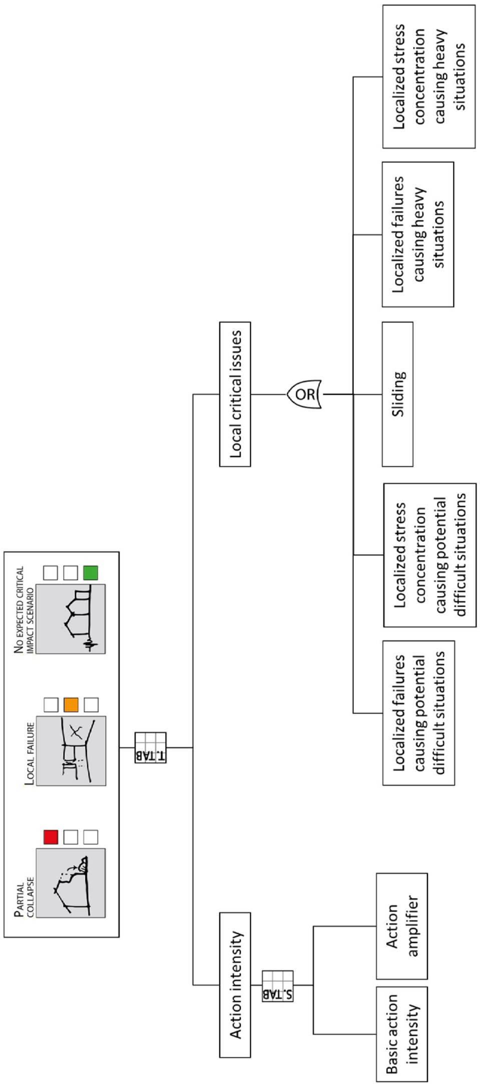


Fig. 2.18 *Earthquake hazard: evaluation logical tree for the 'Partial collapse' and 'Local failures' impact scenarios*

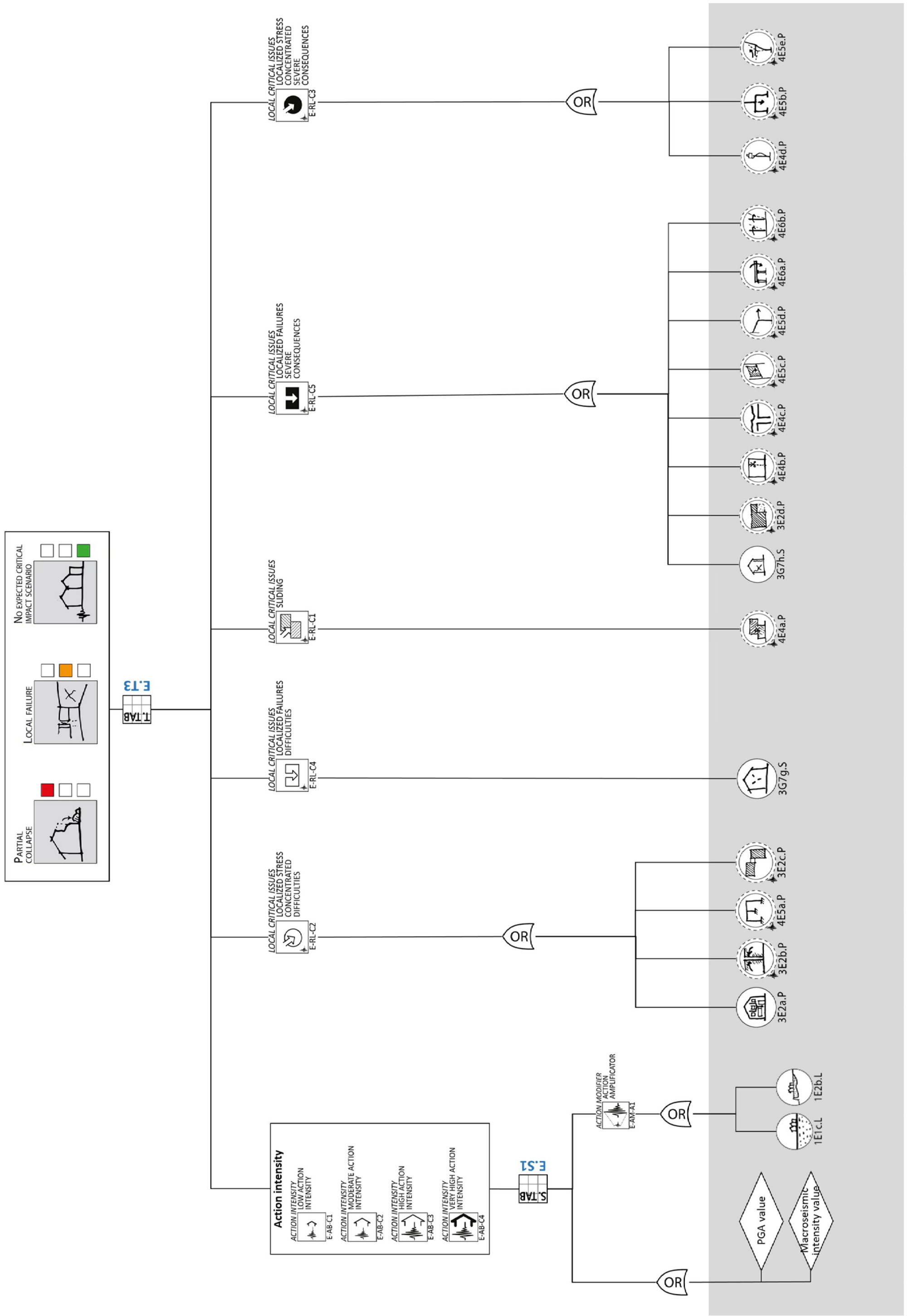


Fig. 2.19 *Earthquake hazard: expert logical tree for the 'Fall of objects inside' impact scenario*

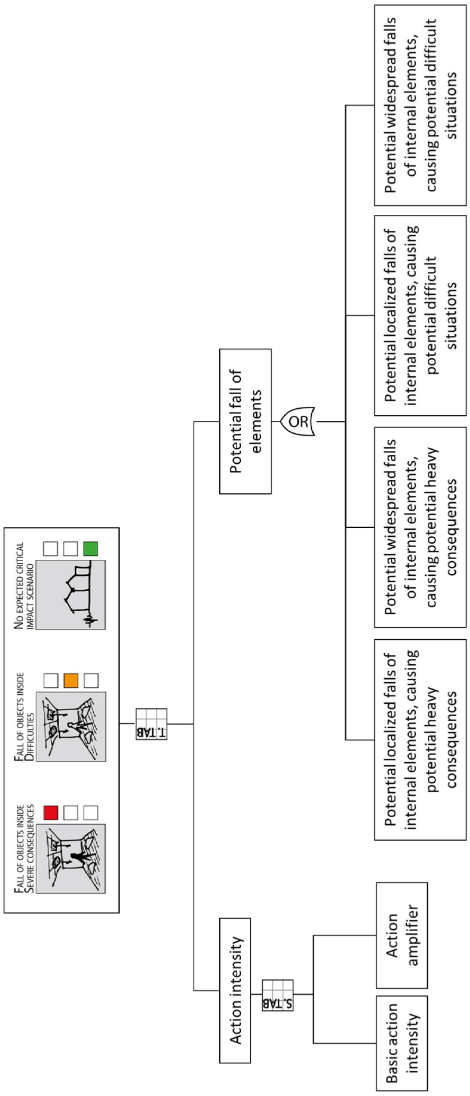


Fig. 2.20 *Earthquake hazard: evaluation logical tree for the 'Fall of objects inside' impact scenario*

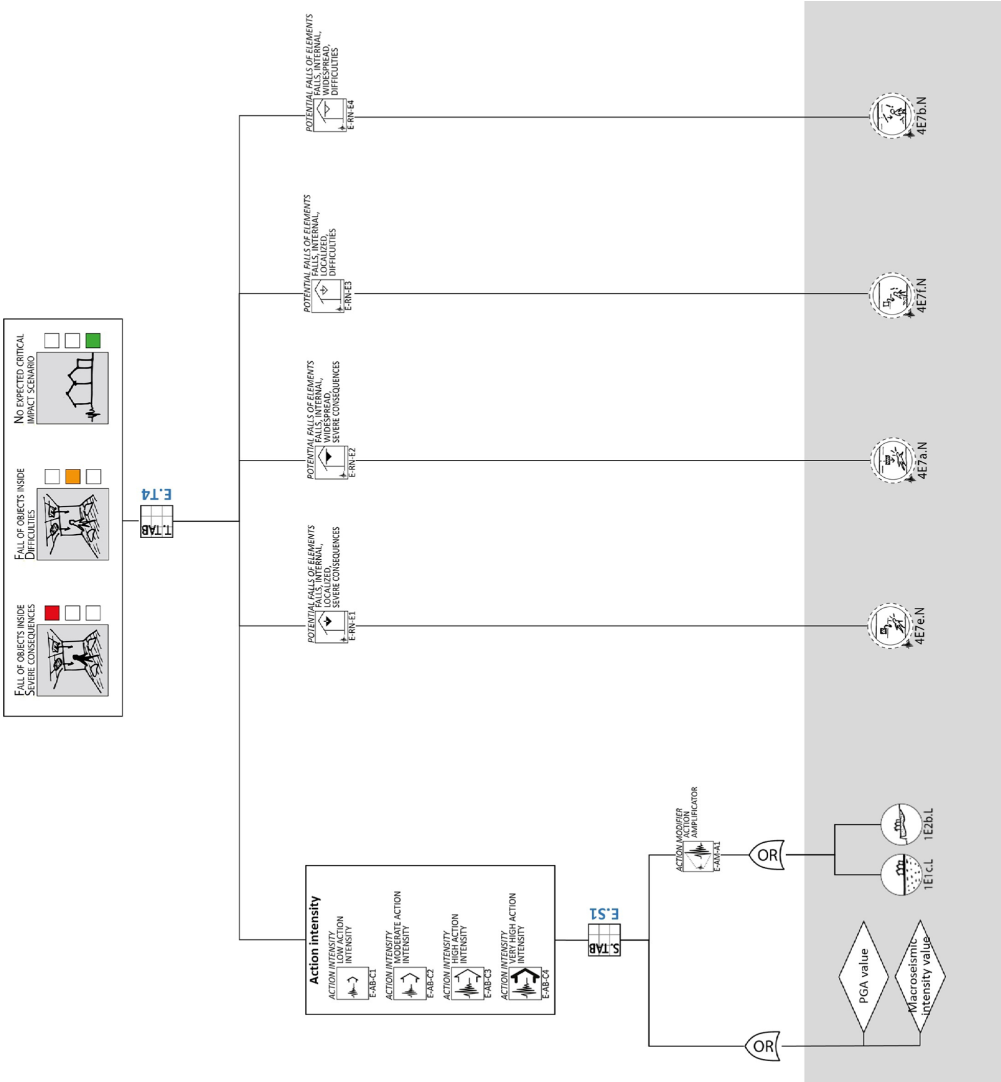


Fig. 2.21 *Earthquake hazard: expert logical tree for the 'Overturning of objects inside' impact scenario*

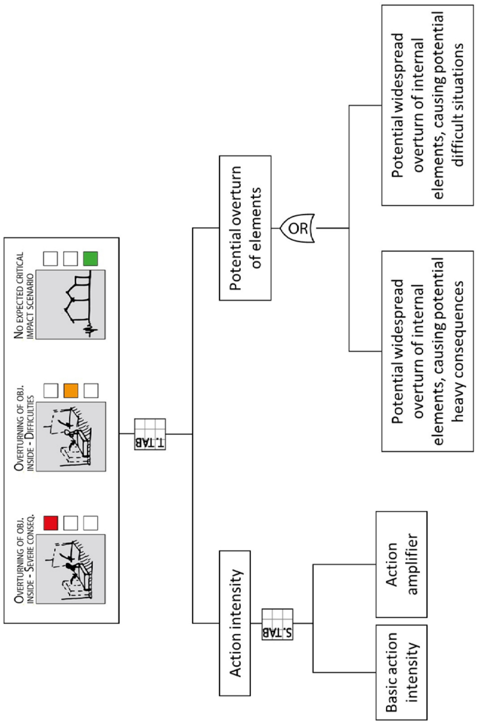


Fig. 2.22 *Earthquake hazard: evaluation logical tree for the 'Overturning of objects inside' impact scenario*

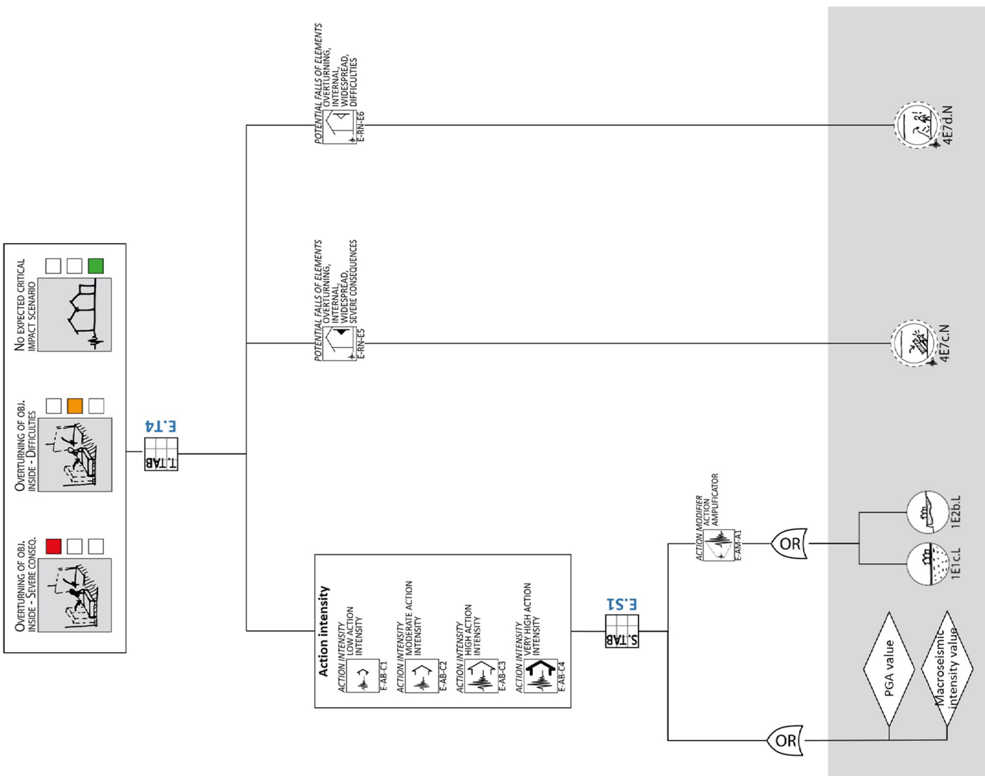


Fig. 2.23 *Earthquake hazard: expert logical tree for the 'Potential hazardous material release' impact scenario*

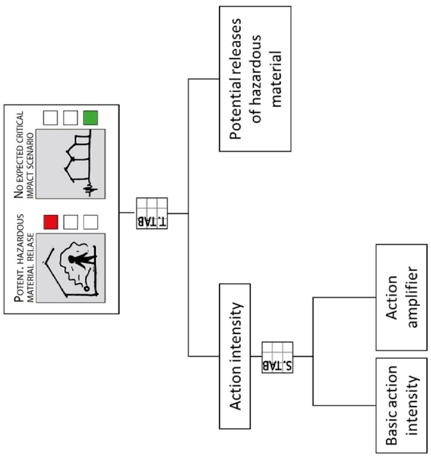


Fig. 2.24 *Earthquake hazard: evaluation logical tree for the 'Potential hazardous material release' impact scenario*

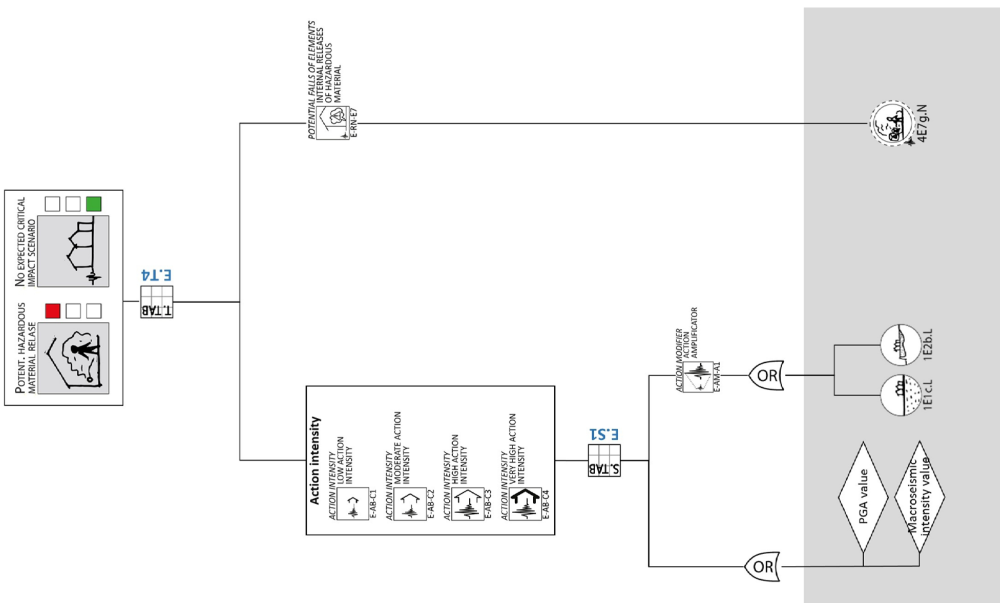


Fig. 2.25 *Earthquake hazard: expert logical tree for the 'Fall of objects outside, from the building' impact scenario*

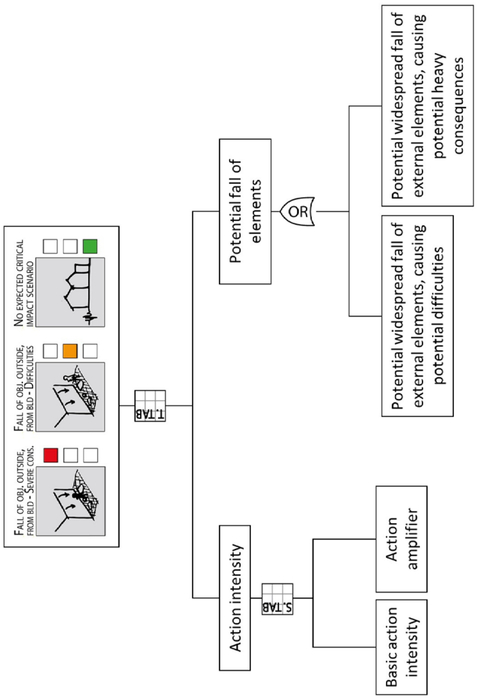


Fig. 2.26 *Earthquake hazard: evaluation logical tree for the 'Fall of objects outside, from the building impact scenario*

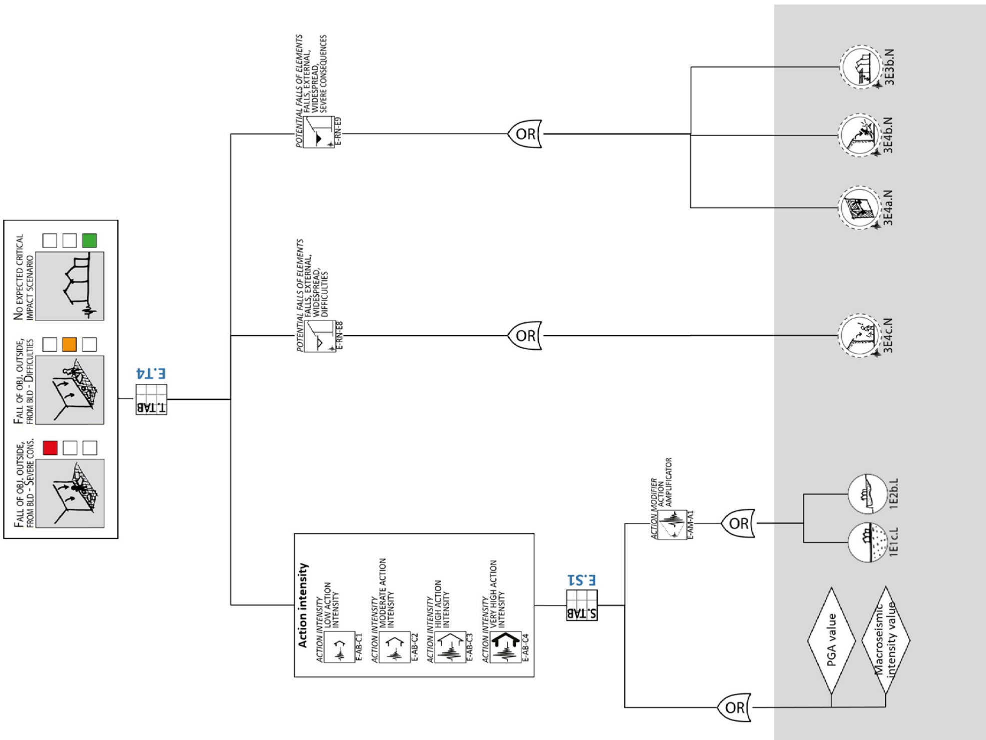


Fig. 2.27 *Earthquake hazard: expert logical tree for the "Fall of objects outside, from other constructions' impact scenario*

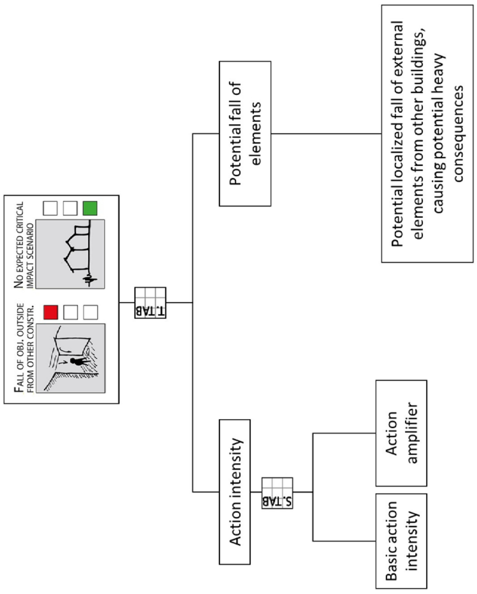


Fig. 2.28 *Earthquake hazard: evaluation logical tree for the 'Fall of objects outside, from other constructions' impact scenario*

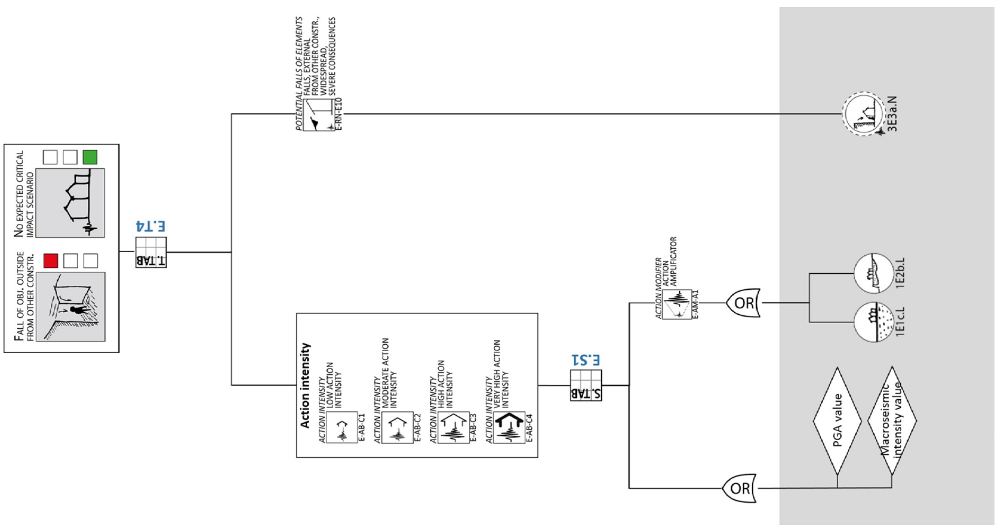


Fig. 2.29 *Earthquake hazard: expert logical tree for the 'Compromised exit' impact scenario*

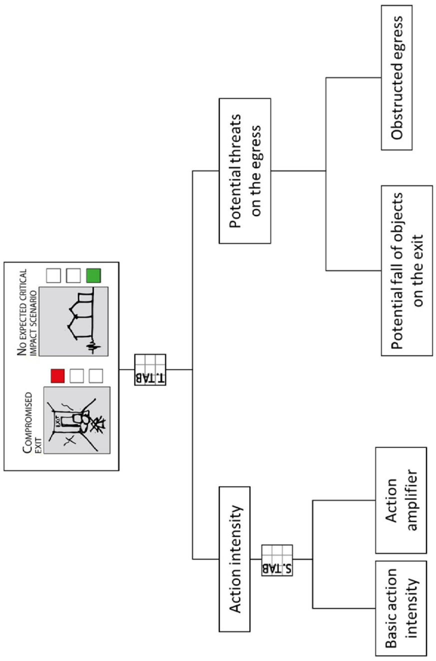


Fig. 2.30 *Earthquake hazard: evaluation logical tree for the 'Compromised exit' impact scenario*

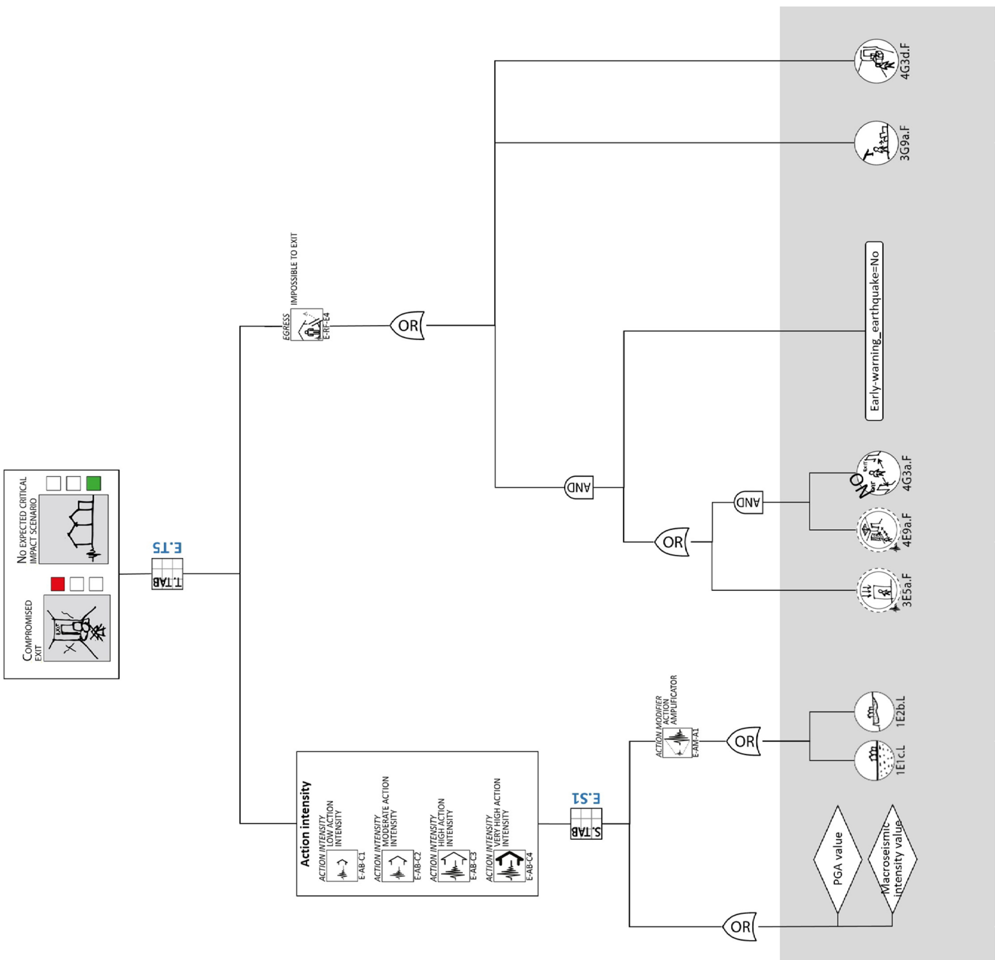


Fig. 2.31 *Earthquake hazard: expert logical tree for the 'Difficult egress' impact scenario*

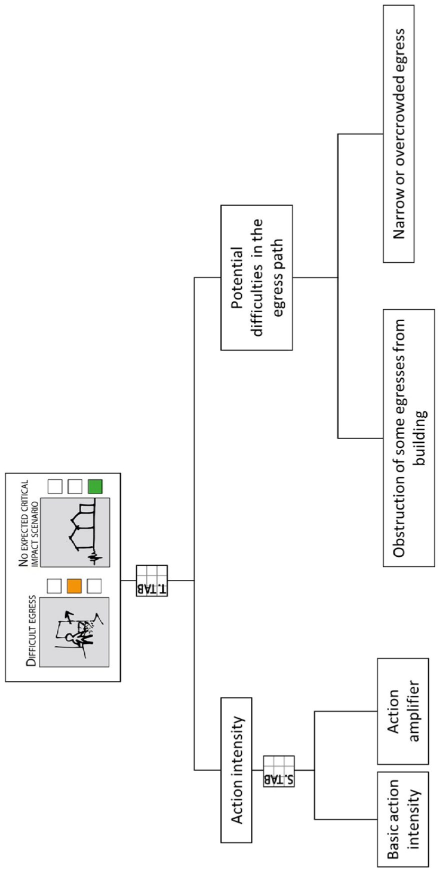


Fig. 2.32 *Earthquake hazard: evaluation logical tree for the 'Difficult egress' impact scenario*

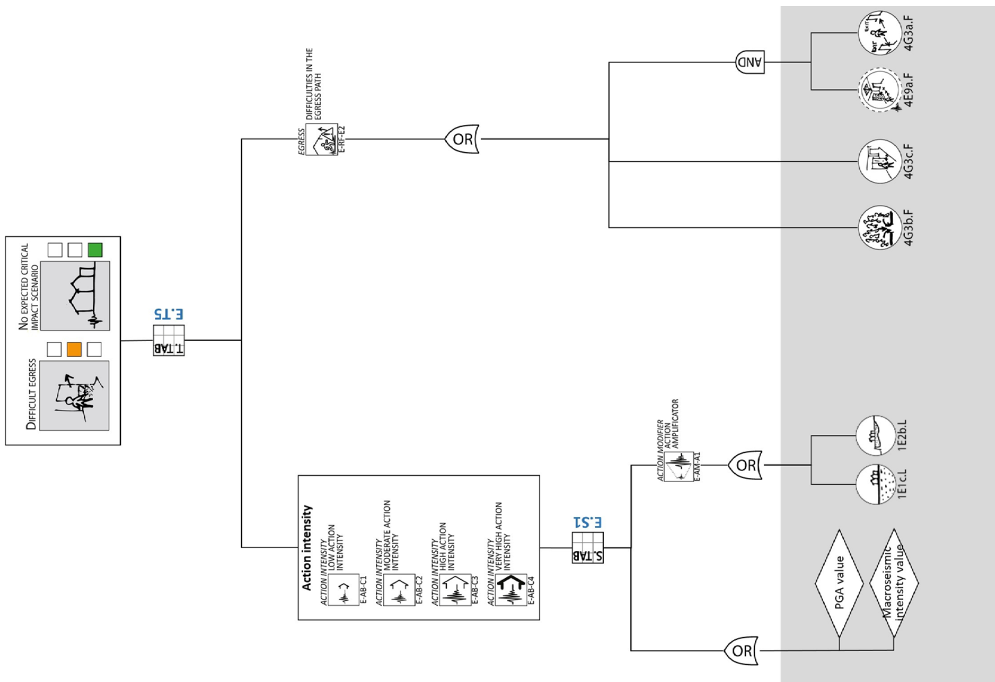


Fig. 2.33 *Earthquake hazard: expert logical tree for the 'Absence of safe areas' impact scenario*

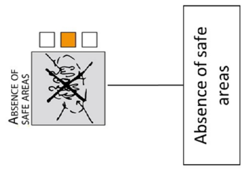
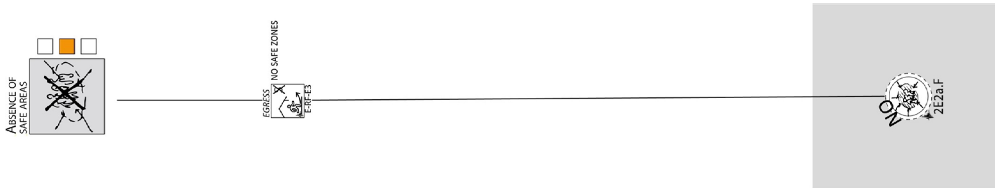


Fig. 2.34 *Earthquake hazard: evaluation logical tree for the 'Absence of safe areas' impact scenario*



3. REFERENCE EVENTS AND OBSERVABLES

3.1 Reference events

Table 3.1 *List of the reference events used for earthquake hazard evaluation*

Survey phase	Focus group	Code	Observ-able	Name
0	Reference event characterization – Earthquake – Peak ground acceleration (PGA) value	PGA<0.05g	–	PGA value < 0.05 g
		PGA_0.05_0.09g	–	0.05 g < PGA value < 0.09 g
		PGA_0.10_0.14	–	0.10 g < PGA value < 0.14 g
		PGA_0.15_0.19	–	0.15 g < PGA value < 0.19 g
		PGA_0.20_0.24	–	0.20 g < PGA value < 0.24 g
		PGA_0.25_0.29	–	0.25 g < PGA value < 0.29 g
		PGA_0.30_0.39	–	0.30 g < PGA value < 0.39 g
		PGA_0.40_0.49	–	0.40 g < PGA value < 0.49 g
		PGA_0.49-0.59	–	0.50 g < PGA value < 0.59 g
		PGA>=0.60	–	PGA value ≥ 0.60 g
0	Reference event characterization – Earthquake – Macroseismic intensity scale	MCS	–	Mercalli–Cancani–Sieberg (MCS) scale
		MSK	–	Medvedev–Sponheuer–Karník (MSK) scale
		MM	–	Modified Mercalli (MM) scale
		JMA	–	Japanese Meteorological Agency (JMA) scale
		EMS	–	European Macroseismic Scale (EMS) scale
		CSIS	–	China Seismic Intensity Scale (CSIS) scale
0	Earthquake – Macroseismic intensity degree	Int_I_V	–	Earthquake intensity: I–V degree
		Int_VI	–	Earthquake intensity: VI degree
		Int_VII	–	Earthquake intensity: VII degree
		Int_VIII	–	Earthquake intensity: VIII degree
		Int_IX	–	Earthquake intensity: IX degree
		Int_X_XII	–	Earthquake intensity: X–XII degree
0	Earthquake – Early warning	Early_warning_earthquake=Yes	–	Early warning for earthquake: Yes
		Early_warning_earthquake=No	–	Early warning for earthquake: No

3.2 Observables for the schoolyard

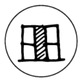
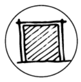
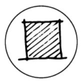
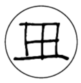
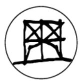
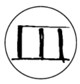
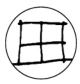
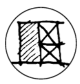
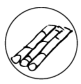
Table 3.2 *List of the observables (OBS) used for earthquake hazard evaluation of the schoolyard*

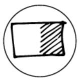
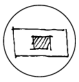
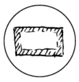
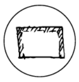
Survey phase	Focus group	Code	Observ-able	Name
1	G3 - Natural haz-ards	1G3a.L		Volcano
		1G3b.L		On a landslide
		1G3c.L		Impact by a landslide
		1G3d.L		Impact by a rockfall
1	G4 – Human-in-duced hazards	1G4a.L		Nearby activity may cause technological accident
		1G4b.L		Dam – upstream
		1G4c.L		Under electrical power-transmission line
1	E1 - Soil stiffness (action modifier)	1E1a.L		Very stiff soil or hard rock (NEHRP: A or B)
		1E1b.L		Intermediate class soil (NEHRP: C, D or unknown)
		1E1c.L		Very soft soil (NEHRP: E)
1	E2 - Geomorphol-ogy (action mod-ifier)	1E2a.L		Foothill zone
		1E2b.L		Landfill
1	E3 - Local charac-teristics	1E3a.L		Liquefaction
		1E3b.L		On or near a fault
2	E1 - Falls of ele-ments	2E1a.N		Potential overturning of fences
		2E1b.N		Falls of elements in the schoolyard
		2E1c.N		Hazards from nearby buildings
		2E1d.N		Potential falls of suspended live lines (e.g. electrical)
2	E2 - Safe areas	2E2a.F		Sufficient safe areas

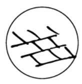
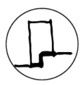
3.3 Observables for school buildings

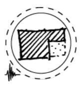
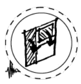
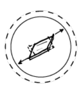
Table 3.3 *List of the observables (OBS) used for earthquake hazard evaluation of school buildings*

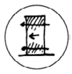
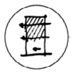
Survey phase	Focus group	Code	Observable	Name
3	G1 - Natural hazard impacts on building	3G1a.L		On a landslide
		3G1b.L		Impact by a landslide
		3G1c.L		Impact by a rockfall
3	G2 - Type of function, class of building and VISUS typology	3G2a.D		Main building
		3G2b.D		Ancillary building
		3G2c.S		Permanent building
		3G2d.S		Semi-permanent building
		3G2e.S		Temporary building
		VT	–	VISUS typology number
3	G3 - Building characteristics: plan shape	–	–	Simple
		–	–	Complex
		–	–	Compact
		–	–	Elongated
		–	–	Winged
3	G3 - Building characteristics: elevation shape	–	–	Simple
		–	–	Complex
3	G3 - Building characteristics	N.units	–	Structural units (number of)
		Nag	–	Above-ground stories (number of)
		Nug	–	Underground stories (number of)
		–	–	Construction date/period
		–	–	Building code/s (standards/regulations)

Survey phase	Focus group	Code	Observable	Name
3	G4 - Structural system: reinforced concrete	3G4a.S		Reinforced concrete walls
		3G4b.S		Reinforced concrete dual frame wall system
		3G4c.S		Reinforced concrete frame
		3G4d.S		Precast
		3G4e.S		Reinforced concrete vertical piers only
3	G4 - Structural system: masonry	3G4f.S		Reinforced masonry
		3G4g.S		Confined masonry
		3G4h.S		Unreinforced masonry
		3G4i.S		Masonry vertical piers only
3	G4 - Structural system: earth or adobe	3G4j.S		Earth or adobe structure
3	G4 - Structural system: steel	3G4k.S		Unbraced steel frame
		3G4l.S		Braced steel frame
		3G4m.S		Steel vertical piers only
3	G4 - Structural system: wood	3G4n.S		Wood frame unbraced
		3G4o.S		Wood panels or wood frame braced
		3G4p.S		Wood vertical piers only
3	G4 - Structural system: bamboo	3G4q.S		Bamboo structure
3	G4 - Structural system: other	3G4r.S		Other

Survey phase	Focus group	Code	Observable	Name
3	G5 - Horizontal distribution and organization of lateral resistance elements	3G5a.S		Regular cell distribution of resistance
		3G5b.S		Resistance distributed mainly to an extremity
		3G5c.S		Resistance distributed mainly to the centre
		3G5d.S		Resistance distributed mainly to the perimeter
		3G5e.S		'C-shape' distribution of resistance (one weaker side)
		3G5f.S		Large distance among lateral resistance systems (L/s > 25)
		3G5g.S		Inadequate resistance in one direction
		3G5h.S		Inadequate resistance in both directions

Survey phase	Focus group	Code	Observable	Name
3	G6 - Material resistance	3G6a.S		Poor material resistance (lower than ordinary)
3	G7 - Construction quality and building condition	3G7a.S		Countermeasures for out-of-plane behaviour
		3G7b.S		In-plane reinforcement of lateral load resistance
		3G7c.S		Poor connection of vertical load-carrying elements
		3G7d.S		Weak for gravity loads
		3G7e.S		Poor maintenance
		3G7f.S		Poor construction quality (e.g. concrete segregation)
		3G7g.S		Evidence of existing light damage
		3G7h.S		Evidence of existing severe damage
3	G8 - Roof covering and architectural features	3G8a.S		Concrete or masonry structure
		3G8b.S		Wood structure
		3G8c.S		Steel structure
		3G8d.N		Tiles/pieces heavy
		3G8e.N		Tiles/pieces sharp
		3G8f.N		Tiles/pieces light
		3G8g.N		Sheets
3	G9 - Egress	3G9a.F		External obstruction to egress
3	E1 - Foundations	3E1a.S		Stepped foundation

Survey phase	Focus group	Code	Observable	Name
3	E2 - Stress focus	3E2a.P		Discontinuous load path
		3E2b.P		Pounding
		3E2c.P		Weak connection
		3E2d.P		Weak small portion of the building
3	E3 - Falls from nearby buildings	3E3a.N		Hazards from nearby buildings
3	E4 - Falls from building	3E4a.N		Unsecured infills or sidings
		3E4b.N		Falls of unsafe elements – severe consequences
		3E4c.N		Falls of unsafe elements – difficulties
3	E5 - Egress	3E5a.F		Exit exposed to potential threats
4	G3 - Egress	4G3a.F		Alternative egress paths
		4G3b.F		Single exit serving more than 50 people
		4G3c.F		Narrowed egress
		4G3d.F		Obstructed egress
4	G4 - Floor behaviour and connection	4G4a.S		Floor: non-rigid
		4G4b.S		Floor: poorly or not connected to vertical structure
		4G4c.S		Floor: heavy
4	G5 - Roof behaviour and connection	4G5a.S		Roof: non-rigid
		4G5b.S		Roof: poorly or not connected to vertical structure
		4G5c.S		Roof: heavy

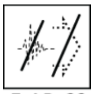
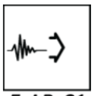
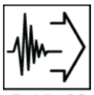
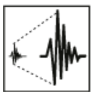
Survey phase	Focus group	Code	Observable	Name
4	G6 - Roof decking	4G6a.N		Continuous roof decking
		4G6b.N		Not continuous or fragile decking
4	G7 - Quality	4G7a.S		Ineffective connections
		4G7b.S		Poor maintenance
4	E1 – Structural behaviour not as a whole	4E1a.S		Crumbling
		4E1b.S		Detachable elements
4	E2 - Soft floor	4E2a.S		Soft intermediate floor
		4E2b.S		Soft ground floor
4	E3 - Irregular vertical mass distribution	4E3a.S		Large mass on the bottom
		4E3b.S		Large mass on the top
4	E4 - Weaknesses	4E4a.P		Horizontal sliding
		4E4b.P		Disjunction
		4E4c.P		Critical weakness
		4E4d.P		Buckling failure
4	E5 - Increased stresses and/or displacements	4E5a.P		Short column
		4E5b.P		Unsupported load
		4E5c.P		Out of plane
		4E5d.P		Unconstrained thrust
		4E5e.P		Amplified lateral displacement

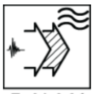
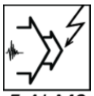
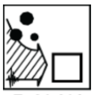
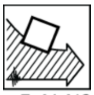
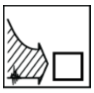
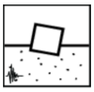
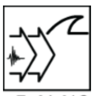
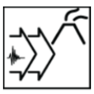
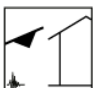
Survey phase	Focus group	Code	Observable	Name
4	E6 - Failure hazards	4E6a.P		Precarious balance
		4E6b.P		Overturning domino effect
4	E7 - Falls of elements or objects and releases	4E7a.N		Fall of unsafe elements – severe consequences
		4E7b.N		Fall of unsafe elements – difficulties
		4E7c.N		Overturning of unsafe elements – severe consequences
		4E7d.N		Overturning of unsafe elements – difficulties
		4E7e.N		Falls of unsafe objects – severe consequences
		4E7f.N		Falls of unsafe objects – difficulties
		4E7g.N		Release of hazardous material
4	E8 - Anti-seismic devices	4E8a.N		Anti-seismic devices (e.g. insulators, dissipators)
4	E9 - Egress	4E9a.F		Obstructed egress
		4E9b.F		Presence of safe areas for people with disabilities

4. PROFILE QUALIFIERS

4.1 Profile qualifiers for the schoolyard

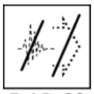
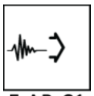
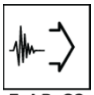
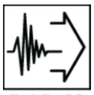
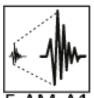
Table 4.1 *Definition of the profile qualifiers for earthquake hazard evaluation of the schoolyard*

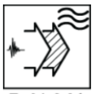
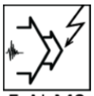
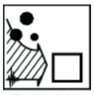
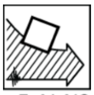
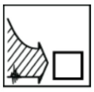
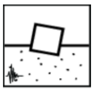
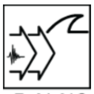
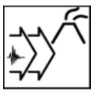
Focus	Icon and code	Name	Evaluation logic
Action intensity	 E-AB-C0	No action	The 'earthquake hazard' is not selected
	 E-AB-C1	Low action	**Table E.S1**
	 E-AB-C2	Moderate action	**Table E.S1**
	 E-AB-C3	High action	**Table E.S1**
	 E-AB-C4	Very high action	**Table E.S1**
Action modifier	 E-AM-A1	Action amplification	 1E1c.L OR  1E2b.L

Focus	Icon and code	Name	Evaluation logic
Induced hazard	 E-AI-M1	Potential flood	 1G4b.L
	 E-AI-M2	Potential electrocu-tion	 1G4c.L
	 E-AI-M3	Potential technologi-cal accident	 1G4a.L
	 E-AI-N1	Potential impact by a rockfall	 1G3d.L
	 E-AI-N2	On a landslide	 1G3b.L
	 E-AI-N3	Involved in a land-slide	 1G3c.L
	 E-AI-N4	On an active fault	 1E3b.L
	 E-AI-N5	Potential liquefaction	 1E3a.L
	 E-AI-N6	Potential tsunami	Tsunami_area=Yes
	 E-AI-N7	Potential volcanic hazard	 1G3a.L
Potential falls of elements	 E-RN-E10	Potential falls of ele-ments, external from other constructions, widespread, severe	 2E1a.N OR  2E1b.N OR  2E1c.N OR  2E1d.N
Egress	 E-RF-E1	Safe path to safe zone	 2E2a.F
	 E-RF-E3	No safe zone	NOT ( 2E2a.F)

4.2 Profile qualifiers for school buildings

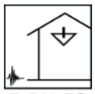
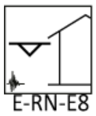
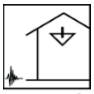
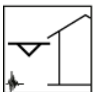
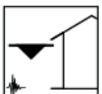
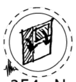
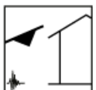
Table 4.2 *Definition of the profile qualifiers for earthquake hazard evaluation of school buildings*

Focus	Icon and code	Name	Evaluation logic
Action intensity	 E-AB-C0	No action	The 'earthquake hazard' is not selected
	 E-AB-C1	Low action	**Table E.S1**
	 E-AB-C2	Moderate action	**Table E.S1**
	 E-AB-C3	High action	**Table E.S1**
	 E-AB-C4	Very high action	**Table E.S1**
Action modifier	 E-AM-A1	Action amplifier	 1E1c.L OR  1E2b.L

Focus	Icon and code	Name	Evaluation logic
Induced hazard	 E-AI-M1	Potential flood	 1G4b.L
	 E-AI-M2	Potential electrocution	 1G4c.L
	 E-AI-M3	Potential technological accident	 1G4a.L
	 E-AI-N1	Potential impact by a rockfall	 1G3d.L OR  3G1c.L
	 E-AI-N2	On a landslide	 1G3b.L OR  3G1a.L
	 E-AI-N3	Involved in a landslide	 1G3c.L OR  3G1b.L
	 E-AI-N4	On an active fault	 1E3b.L
	 E-AI-N5	Potential liquefaction	 1E3a.L
	 E-AI-N6	Potential tsunami	Tsunami_area=Yes
	 E-AI-N7	Potential volcanic hazard	 1G3a.L

Focus	Icon and code	Name	Evaluation logic
Robustness modifiers	E-RM-B1	Crumbling	4E1a.S
	E-RM-B2	Disconnectable	4E1b.S
	E-RM-B3	Regular horizontal behaviour	N.units>1 OR (Plan_shape=simple AND Plan_shape=compact)
	E-RM-B4	Horizontal, torsion	N.units =1 AND NOT[(Nag>1 AND 4G4a.S) OR (Nag=1 AND 4G5a.S)] AND {[Plan_shape=complex AND NOT(Plan_shape=compact)] OR 3G5b.S }
	E-RM-B5	Horizontal, wings	N.units =1 AND NOT [(Nag>1 AND 4G4a.S) OR (Nag=1 AND 4G5a.S)] AND (Plan_shape=with wings)
	E-RM-B6	Regular vertical behaviour	NOT (E-RM-B7) AND NOT (E-RM-B8)
	E-RM-B7	Vertical, different phases	(Elevation_shape=complex OR 3E1a.S) AND (Nag+Nug)>1
	E-RM-B8	Vertical, knee	(4E2a.S OR 4E2b.S OR 4E6b.P) AND (Nag+Nug)>1
	E-RM-S1	Mass modifier, bottom	4E3a.S
	E-RM-S2	Mass modifier, uniform	NOT (E-RM-S1) AND NOT (E-RM-S3)
	E-RM-S3	Mass modifier, top	4E3b.S OR {[4G5c.S OR (3G8a.S AND 4G6a.N)] AND (3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S) }

Focus	Icon and code	Name	Evaluation logic
Robustness modifiers	E-RM-Q1	No weaker direction	NOT (E-RM-Q2) AND NOT (E-RM-Q3)
	E-RM-Q2	Weaker direction	3G5g.S
	E-RM-Q3	Weak (feeble structure)	3G5h.S OR 3G8g.S
	E-RM-Q4	Good construction and material quality	NOT (E-RM-Q5) AND NOT (3G8e.S)
	E-RM-Q5	Poor construction or material quality	3G6a.S OR 3G7f.S OR 4G7a.S OR 3G7h.S
	E-RM-D1	Uniform distribution of resistance system	3G5a.S OR 3G5d.S
	E-RM-D2	Non-uniform distribution of resistance system	3G5b.S OR 3G5c.S OR 3G5e.S
Local critical issues	E-RL-N0	No local critical issues	NOT(E-RL-C1 OR E-RL-C2 OR E-RL-C3 OR E-RL-C4 OR E-RL-C5)
	E-RL-C1	Sliding	4E4a.P
	E-RL-C2	Localized stress, concentrated – difficulties	3E2a.P OR 3E2b.P OR 3E2c.P OR 4E5a.P
	E-RL-C3	Localized stress, concentrated – severe consequences	4E5b.P OR 4E5e.P OR 4E4d.P
	E-RL-C4	Localized failures – difficulties	3G7g.S
	E-RL-C5	Localized failures – severe consequences	3G7h.S OR 3E2d.P OR 4E5c.P OR 4E5d.P OR 4E4b.P OR 4E4c.P OR 4E6a.P OR 4E6b.P

Focus	Icon and code	Name	Evaluation logic
Potential falls of elements	 E-RN-E0	No problems	NOT( E-RN-E1 OR  E-RN-E2 OR  E-RN-E3 OR  E-RN-E4 OR  E-RN-E5 OR  E-RN-E6 OR  E-RN-E7 OR  E-RN-E8 OR  E-RN-E9 OR  E-RN-E10)
	 E-RN-E1	Potential falls of elements, internal, localized – severe consequences	 4E7e.N
	 E-RN-E2	Potential falls of elements, internal, widespread – severe consequences	 4E7a.N
	 E-RN-E3	Potential falls of elements, internal, localized – difficulties	 4E7f.N
	 E-RN-E4	Potential falls of elements, internal, widespread –difficulties	 4E7b.N
	 E-RN-E5	Potential overturning of elements, internal, widespread – severe consequences	 4E7c.N
	 E-RN-E6	Potential overturning of elements, internal, widespread – difficulties	 4E7d.N
	 E-RN-E7	Potential falls of elements, internal, releases of hazardous material	 4E7g.N
	 E-RN-E8	Potential falls of elements, external, widespread – difficulties	 3E4c.N
	 E-RN-E9	Potential falls of elements external, widespread – severe consequences	 3E4a.N OR  3E4b.N
	 E-RN-E10	Potential falls of elements, external, from other constructions, widespread – severe consequences	 3E3a.N

Focus	Icon and code	Name	Evaluation logic
Egress	 E-RF-E1	Safe path to safe zones	2E2a.F AND NOT(4G3b.F OR 4G3c.F OR 4G3d.F) AND [NOT(3E5a.F OR 4E9a.F) OR 'Early warning for earth-quake'=Yes]
	 E-RF-E2	Difficulties in the egress path	4G3b.F OR 4G3c.F OR (4E9a.F AND 4G3a.F)
	 E-RF-E3	No safe zone	NOT (2E2a.F OR 4E9b.F)
	 E-RF-E4	Impossible to exit	{[3E5a.F OR (4E9a.F AND NOT(4G3a.F))] AND 'Early warning for earthquake'=No} OR 3G9a.F OR 4G3d.F

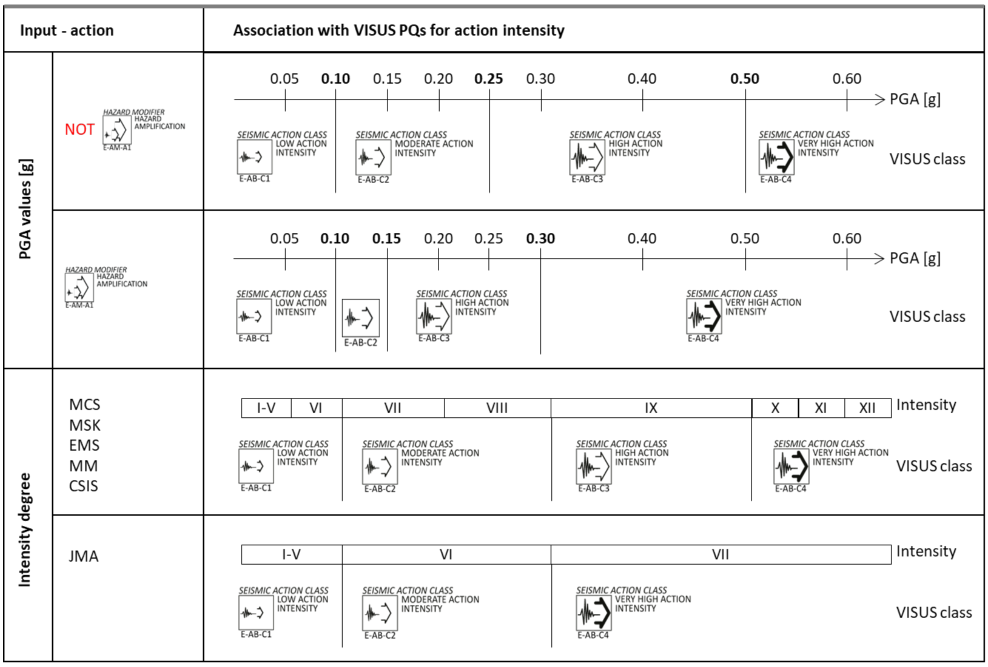
5. SUPPORTING TABLES

Table E.S1 *Seismic hazard intensity attribution in the VISUS methodology (in the case of multiple definitions of input hazards, the value of peak ground acceleration (PGA) is used). Action values (PGA or macroseismic intensity) are entered in the rows. The columns 3 and 4 distinguish the cases 'without hazard amplification' and 'with hazard amplification'. The output of the table is the VISUS class for hazard intensity.*

		NOT(*ACTION MODIFIER* ACTION AMPLIFICATOR E-AM-A1)	*ACTION MODIFIER* ACTION AMPLIFICATOR E-AM-A1
PGA values	PGA<0.05g	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1
	PGA_0.05–0.09 g	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1
	PGA_0.10–0.14 g	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2
	PGA_0.15–0.19 g	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3
	PGA_0.20–0.24 g	*SEISMIC ACTION CLASS* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3
	PGA_0.25–0.29 g	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3
	PGA_0.30–0.39 g	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
	PGA_0.40–0.49 g	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
	PGA_0.50–0.59 g	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
	PGA > 0.60 g	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4

		ACTION MODIFIER ACTION AMPLIFICATOR NOT(E-AM-A1)	*ACTION MODIFIER* ACTION AMPLIFICATOR E-AM-A1
Macroseismic intensity: MCS, MSK, EMS, MM, CSIS scales	Degree_I–V	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1
	Degree_VI	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* LOW ACTION INTENSITY E-AB-C1
	Degree_VII	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2
	Degree_VIII	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2
	Degree_IX	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3
	Degree_X–XII	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
Macroseismic intensity: JMA scale	Degree_I–V	*SEISMIC ACTION CLASS* LOW ACTION INTENSITY E-AB-C1	*SEISMIC ACTION CLASS* LOW ACTION INTENSITY E-AB-C1
	Degree_VI	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2
	Degree_VII	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3

Fig. 5.1 *Graphical representation of Table E.S1*



* In case of multiple definitions of input action, the value obtained through PGA is used.

Table E.S2 *Robustness class for earthquake hazard, which depends on the number of floors in the building (which corresponds to the number of above-ground stories [Nag])*

Observable (OBS)	OBS description	Number of floors			
		One	Two	Three	Four+
4E8a.N	Anti-seismic devices	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1
3G4a.S	Reinforced concrete walls	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2
3G4b.S	Reinforced concrete dual frame wall system	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2
3G4c.S	Reinforced concrete frame	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
3G4d.S	Precast	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
3G4e.S	Reinforced concrete vertical piers only	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	Should not exist	Should not exist
3G4f.S	Reinforced masonry	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
3G4g.S	Confined masonry	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
3G4h.S AND NOT (3G7a.S OR 3G7b.S)	Unreinforced masonry AND NOT(Countermeasures for out-of-plane behaviour OR In-plane reinforcement of lateral load resistance)	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4
3G4h.S AND (3G7a.S OR 3G7b.S)	Unreinforced masonry AND (Countermeasures for out-of-plane behaviour OR In-plane reinforcement of lateral load resistance)	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
3G4i.S	Masonry vertical piers only	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	Should not exist
3G4j.S	Earth or adobe structure	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	Should not exist	Should not exist
3G4k.S	Unbraced steel frame	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4

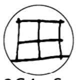
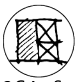
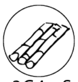
Observable (OBS)	OBS description	Number of floors			
		One	Two	Three	Four+
 3G4l.S	Braced steel frame	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
 3G4m.S	Steel vertical piers only	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	*Should not exist*	*Should not exist*
 3G4n.S	Wood frame unbraced	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4
 3G4o.S	Wood panels or wood frame braced	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR EARTHQUAKE E-RB-C1	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
 3G4p.S	Wood vertical piers only	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	*Should not exist*	*Should not exist*
 3G4q.S	Bamboo structure	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR EARTHQUAKE E-RB-C2	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3
 3G4r.S	Other	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR EARTHQUAKE E-RB-C3	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR EARTHQUAKE E-RB-C4

Table E.S3 *Structural robustness modifiers: weaknesses of structural behaviour*

	ROBUSTNESS MODIFIERS NO WEAKER DIRECTIONS E-RM-Q1	*ROBUSTNESS MODIFIERS* WEAKER DIRECTION E-RM-Q2	*ROBUSTNESS MODIFIERS* WEAK (FEEBLE STRUCTURE) E-RM-Q3	*ROBUSTNESS MODIFIERS* CRUMBLING E-RM-B1 OR *ROBUSTNESS MODIFIERS* DISCONNECTABLE E-RM-B2
ROBUSTNESS MODIFIERS GOOD CONSTRUCTION AND MATERIAL QUALITY E-RM-Q4	⊡	◀ □	◀ □	◀ ◁ □
ROBUSTNESS MODIFIERS POOR CONSTRUCTION OR MATERIAL QUALITY E-RM-Q5	◀ □	◀ □	◀ ◁ □	◀ ◁ □

Table E.S4 *Structural robustness modifiers: changes in structural behaviour*

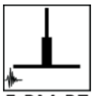
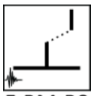
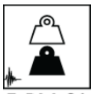
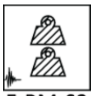
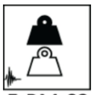
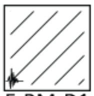
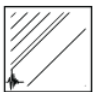
	ROBUSTNESS MODIFIERS REGULAR VERTICAL BEHAVIOUR E-RM-B6	*ROBUSTNESS MODIFIERS* VERTICAL BEHAVIOUR, DIFFERENT PHASES E-RM-B7	*ROBUSTNESS MODIFIERS* VERTICAL BEHAVIOUR, KNEE E-RM-B8
ROBUSTNESS MODIFIERS REGULAR HORIZONTAL BEHAVIOUR E-RM-B3	⊡	⊡	◀ □
ROBUSTNESS MODIFIERS HORIZONTAL, TORSION E-RM-B4	⊡	⊡	◀ □
ROBUSTNESS MODIFIERS HORIZONTAL, WINGS E-RM-B5	⊡	◀ □	◀ ◁ □

Table E.S5 *Structural robustness modifiers: amplifiers of structural behaviour*

	ROBUSTNESS MODIFIERS UNIFORM DISTRIBUTION OF RESISTANCE SYSTEM E-RM-D1	*ROBUSTNESS MODIFIERS* NON-UNIFORM DISTRIBUTION OF RESISTANCE SYSTEM E-RM-D2
ROBUSTNESS MODIFIERS MASS MODIFIER, BOTTOM E-RM-S1	⊡	⊡
ROBUSTNESS MODIFIERS MASS MODIFIER, UNIFORM E-RM-S2	⊡	⊡
ROBUSTNESS MODIFIERS MASS MODIFIER, TOP E-RM-S3	⊡	◀ □

Table E.S6 *Definition of the profile qualifiers (PQs) for the structural robustness modifiers*

PQ	Name	Logical rules for assignment		
E-RM-Q4	Good construction and material quality	NOT (E-RM-Q5) AND NOT (3G8e.S)		
E-RM-Q5	Poor construction or material quality	3G8a.S OR 3G8b.S OR 4G7a.S OR 3G8f.S		
E-RM-Q1	No weaker direction	NOT (E-RM-Q2) AND NOT (E-RM-Q3)		
E-RM-Q2	Weaker direction	3G5g.S		
E-RM-Q3	Weak (feeble structure)	3G5h.S OR 3G8g.S		
E-RM-B1	Crumbling	4E1a.S		
E-RM-B2	Disconnectable	4E1b.S		
E-RM-B3	Regular horizontal behaviour	N.units > 1 OR (Plan_shape=simple AND Plan_shape=compact)		
E-RM-B4	Horizontal, torsion	N.units = 1 AND NOT[(Nag>1 AND 4G4a.S) OR (Nag=1 AND 4G5a.S)] AND {[Plan_shape=complex AND NOT(Plan_shape=compact) OR 3G5b.S]}		
E-RM-B5	Horizontal, wings	N.units =1 AND NOT [(Nag>1 AND 4G4a.S) OR (Nag=1 AND 4G5a.S)] AND (Plan_shape=with wings)		
E-RM-B6	Regular vertical behaviour	NOT (E-RM-B7) AND NOT (E-RM-B8)		

PQ	Name	Logical rules for assignment
 E-RM-B7	Vertical, different phases	(Elevation_shape= complex OR 3E1a.S) AND (Nag+Nug)>1
 E-RM-B8	Vertical, knee	(4E2a.S OR 4E2b.S OR 4E6b.P) AND (Nag+Nug)>1
 E-RM-S1	Mass modifier, bottom	4E3a.S
 E-RM-S2	Mass modifier, uniform	NOT (E-RM-S1) AND NOT (E-RM-S3)
 E-RM-S3	Mass modifier, top	4E3b.S OR {[4G5c.S OR (3G6a.S AND 4G6a.N)] AND (3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S) }
 E-RM-D1	Uniform distribution of resistance system	3G5a.S OR 3G5d.S
 E-RM-D2	Non-uniform distribution of resistance system	3G5b.S OR 3G5c.S OR 3G5e.S

6. TRIGGERING TABLES

Table E.T1 *Triggering table for the location/site critical issue impact scenarios*

Profile qualifier	Action intensity			
	Action intensity Low action intensity E-AB-C1	*Action intensity* Moderate action intensity E-AB-C2	*Action intensity* High action intensity E-AB-C3	*Action intensity* Very high action intensity E-AB-C4
Induced hazard Potential impact by a rockfall E-AI-N1	No expected critical impact scenario	Natural threats Severe consequences	Natural threats Severe consequences	Natural threats Severe consequences
Induced hazard On a landslide E-AI-N2	No expected critical impact scenario	Natural threats Severe consequences	Natural threats Severe consequences	Natural threats Severe consequences
Induced hazard Involved in a landslide E-AI-N3	No expected critical impact scenario	Natural threats Severe consequences	Natural threats Severe consequences	Natural threats Severe consequences
Induced hazard On an active fault E-AI-N4	*Not credible*	Natural threats Severe consequences	Natural threats Severe consequences	Natural threats Severe consequences
Induced hazard Potential liquefaction E-AI-N5	No expected critical impact scenario	Natural threats Difficulties	Natural threats Difficulties	Natural threats Difficulties
Induced hazard Potential tsunami E-AI-N6	No expected critical impact scenario	No expected critical impact scenario	Natural threats Severe consequences	Natural threats Severe consequences
Induced hazard Potential volcanic hazard E-AI-N7	No expected critical impact scenario	Natural threats Difficulties	Natural threats Difficulties	Natural threats Difficulties
Induced hazard Potential flood E-AI-M1	No expected critical impact scenario	No expected critical impact scenario	Human-induced threats	Human-induced threats

Profile qualifier	Action intensity			
	ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	ACTION INTENSITY MODERATE ACTION INTENSITY E-AB-C2	ACTION INTENSITY HIGH ACTION INTENSITY E-AB-C3	ACTION INTENSITY VERY HIGH ACTION INTENSITY E-AB-C4
INDUCED HAZARD POTENTIAL ELECTROCUTION E-AI-M2	NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	HUMAN-INDUCED THREATS	HUMAN-INDUCED THREATS
INDUCED HAZARD POTENTIAL TECHNOLOGICAL ACCIDENT E-AI-M3	NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	HUMAN-INDUCED THREATS	HUMAN-INDUCED THREATS

Table E.T2 *Triggering table for the structural global critical issue impact scenarios.*

Profile qualifier	Modifier (Table)	Action intensity			
		ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	ACTION INTENSITY MODERATE ACTION INTENSITY E-AB-C2	ACTION INTENSITY HIGH ACTION INTENSITY E-AB-C3	ACTION INTENSITY VERY HIGH ACTION INTENSITY E-AB-C4
E-RB-C1		NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	DAMAGE
		NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	DAMAGE	STRUCTURAL COLLAPSE
		NO EXPECTED CRITICAL IMPACT SCENARIO	DAMAGE	STRUCTURAL COLLAPSE	STRUCTURAL COLLAPSE
E-RB-C2		NO EXPECTED CRITICAL IMPACT SCENARIO	NO EXPECTED CRITICAL IMPACT SCENARIO	DAMAGE	STRUCTURAL COLLAPSE
		NO EXPECTED CRITICAL IMPACT SCENARIO	DAMAGE	STRUCTURAL COLLAPSE	STRUCTURAL COLLAPSE
		DAMAGE	STRUCTURAL COLLAPSE	STRUCTURAL COLLAPSE	STRUCTURAL COLLAPSE

Profile qualifier	Modifier (Table)	Action intensity			
		ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
E-RB-C3		No expected critical impact scenario	Damage	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse
E-RB-C4		Damage	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse
		Structural collapse	Structural collapse	Structural collapse	Structural collapse
E-RB-C5		Damage	Structural collapse	Structural collapse	Structural collapse
		Structural collapse	Structural collapse	Structural collapse	Structural collapse
		Structural collapse	Structural collapse	Structural collapse	Structural collapse

Table E.T3 *Triggering table for the structural local/envelope critical issue impact scenarios*

Profile qualifier	Action intensity			
	ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
LOCAL CRITICAL ISSUES SLIDING E-RL-C1	NO EXPECTED CRITICAL IMPACT SCENARIO	PARTIAL COLLAPSE	PARTIAL COLLAPSE	PARTIAL COLLAPSE
LOCAL CRITICAL ISSUES LOCALIZED STRESS CONCENTRATED DIFFICULTIES E-RL-C2	NO EXPECTED CRITICAL IMPACT SCENARIO	LOCAL FAILURE	LOCAL FAILURE	LOCAL FAILURE
LOCAL CRITICAL ISSUES LOCALIZED STRESS CONCENTRATED SEVERE CONSEQUENCES E-RL-C3	NO EXPECTED CRITICAL IMPACT SCENARIO	PARTIAL COLLAPSE	PARTIAL COLLAPSE	PARTIAL COLLAPSE
LOCAL CRITICAL ISSUES LOCALIZED FAILURES DIFFICULTIES E-RL-C4	NO EXPECTED CRITICAL IMPACT SCENARIO	LOCAL FAILURE	LOCAL FAILURE	LOCAL FAILURE
LOCAL CRITICAL ISSUES LOCALIZED FAILURES SEVERE CONSEQUENCES E-RL-C5	NO EXPECTED CRITICAL IMPACT SCENARIO	PARTIAL COLLAPSE	PARTIAL COLLAPSE	PARTIAL COLLAPSE

Table E.T4 *Triggering table for the non-structural critical issue impact scenarios*

Profile qualifier	Action intensity			
	ACTION INTENSITY LOW ACTION INTENSITY E-AB-C1	*ACTION INTENSITY* MODERATE ACTION INTENSITY E-AB-C2	*ACTION INTENSITY* HIGH ACTION INTENSITY E-AB-C3	*ACTION INTENSITY* VERY HIGH ACTION INTENSITY E-AB-C4
POTENTIAL FALLS OF ELEMENTS FALLS, INTERNAL, LOCALIZED, SEVERE CONSEQUENCES E-RN-E1	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES
POTENTIAL FALLS OF ELEMENTS FALLS, INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES E-RN-E2	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES
POTENTIAL FALLS OF ELEMENTS FALLS, INTERNAL, LOCALIZED, DIFFICULTIES E-RN-E3	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJECTS INSIDE DIFFICULTIES	FALL OF OBJECTS INSIDE DIFFICULTIES	FALL OF OBJECTS INSIDE DIFFICULTIES
POTENTIAL FALLS OF ELEMENTS FALLS, INTERNAL, WIDESPREAD, DIFFICULTIES E-RN-E4	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJECTS INSIDE DIFFICULTIES	FALL OF OBJECTS INSIDE DIFFICULTIES	FALL OF OBJECTS INSIDE DIFFICULTIES
POTENTIAL FALLS OF ELEMENTS OVERTURNING, INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES E-RN-E5	NO EXPECTED CRITICAL IMPACT SCENARIO	OVERTURNING OF OBJ. INSIDE - SEVERE CONSEQ.	OVERTURNING OF OBJ. INSIDE - SEVERE CONSEQ.	OVERTURNING OF OBJ. INSIDE - SEVERE CONSEQ.
POTENTIAL FALLS OF ELEMENTS OVERTURNING, INTERNAL, WIDESPREAD, DIFFICULTIES E-RN-E6	NO EXPECTED CRITICAL IMPACT SCENARIO	OVERTURNING OF OBJ. INSIDE - DIFFICULTIES	OVERTURNING OF OBJ. INSIDE - DIFFICULTIES	OVERTURNING OF OBJ. INSIDE - DIFFICULTIES
POTENTIAL FALLS OF ELEMENTS INTERNAL RELEASES OF HAZARDOUS MATERIAL E-RN-E7	NO EXPECTED CRITICAL IMPACT SCENARIO	POTENT. HAZARDOUS MATERIAL RELEASE	POTENT. HAZARDOUS MATERIAL RELEASE	POTENT. HAZARDOUS MATERIAL RELEASE
POTENTIAL FALLS OF ELEMENTS FALLS, EXTERNAL, WIDESPREAD, DIFFICULTIES E-RN-E8	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJ. OUTSIDE, FROM BLD - DIFFICULTIES	FALL OF OBJ. OUTSIDE, FROM BLD - DIFFICULTIES	FALL OF OBJ. OUTSIDE, FROM BLD - DIFFICULTIES
POTENTIAL FALLS OF ELEMENTS FALLS, EXTERNAL, WIDESPREAD, SEVERE CONSEQUENCES E-RN-E9	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJ. OUTSIDE, FROM BLD - SEVERE CONS.	FALL OF OBJ. OUTSIDE, FROM BLD - SEVERE CONS.	FALL OF OBJ. OUTSIDE, FROM BLD - SEVERE CONS.
POTENTIAL FALLS OF ELEMENTS FALLS, EXTERNAL FROM OTHER CONSTR., WIDESPREAD, SEVERE CONSEQUENCES E-RN-E10	NO EXPECTED CRITICAL IMPACT SCENARIO	FALL OF OBJ. OUTSIDE FROM OTHER CONSTR.	FALL OF OBJ. OUTSIDE FROM OTHER CONSTR.	FALL OF OBJ. OUTSIDE FROM OTHER CONSTR.

Table E.T5 *Triggering table for the functionality critical issue impact scenarios*

Profile qualifier	Hazard			
	HAZARD INTENSITY LOW HAZARD E-AB-C1	*HAZARD INTENSITY* MODERATE HAZARD E-AB-C2	*HAZARD INTENSITY* HIGH HAZARD E-AB-C3	*HAZARD INTENSITY* VERY HIGH HAZARD E-AB-C4
EGRESS DIFFICULTIES IN THE EGRESS PATH E-RF-E2	NO EXPECTED CRITICAL IMPACT SCENARIO	DIFFICULT EGRESS	DIFFICULT EGRESS	DIFFICULT EGRESS
EGRESS NO SAFE ZONES E-RF-E3	ABSENCE OF SAFE AREAS	ABSENCE OF SAFE AREAS	ABSENCE OF SAFE AREAS	ABSENCE OF SAFE AREAS
EGRESS IMPOSSIBLE TO EXIT E-RF-E4	NO EXPECTED CRITICAL IMPACT SCENARIO	COMPROMISED EXIT	COMPROMISED EXIT	COMPROMISED EXIT

7. SAFETY INDICATOR: ROSE OF WARNING LEVELS

7.1 Warning level evaluation for the schoolyard

Table E.WS.L *Earthquake hazard evaluation of the warning levels for the schoolyard: site/location safety issue*

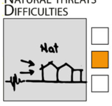
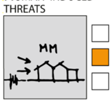
Warning level	Evaluation logic
	NOT( OR )
	NATURAL THREATS DIFFICULTIES  OR HUMAN-INDUCED THREATS 
	NATURAL THREATS SEVERE CONSEQUENCES 

Table E.WS.S *Earthquake hazard evaluation of the warning levels for the schoolyard: structural global safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table E.WS.P *Earthquake hazard evaluation of the warning levels for the schoolyard: structural local/envelope safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table E.WS.N *Earthquake hazard evaluation of the warning levels for the schoolyard: non-structural safety issue*

Warning level	Evaluation logic
	NOT ()
	No scenario
	

Table E.WS.F *Earthquake hazard evaluation of the warning levels for the schoolyard: functionality safety issue*

Warning level	Evaluation logic
	NOT ()
	
	No scenario

7.2 Warning level evaluation for school buildings

Table E.WB.L *Earthquake hazard evaluation of the warning levels for school buildings: site/location safety issue*

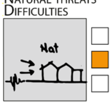
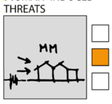
Warning level	Evaluation logic
	NOT( OR )
	Natural threats Difficulties  OR Human-induced threats 
	Natural threats Severe consequences 

Table E.WB.S *Earthquake hazard evaluation of the warning levels for school buildings: structural global safety issue*

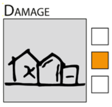
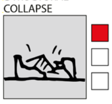
Warning level	Evaluation logic
	NOT( OR )
	Damage 
	Structural collapse 

Table E.WB.P *Earthquake hazard evaluation of the warning levels for school buildings: structural local/envelope safety issue*

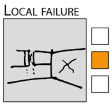
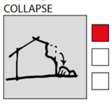
Warning level	Evaluation logic
	NOT( OR )
	Local failure 
	Partial collapse 

Table E.WB.N *Earthquake hazard evaluation of the warning levels for school buildings: non-structural safety issue*

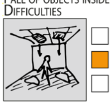
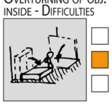
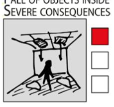
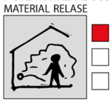
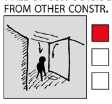
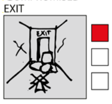
Warning level	Evaluation logic
	NOT( OR )
	FALL OF OBJECTS INSIDE DIFFICULTIES  OR OVERTURNING OF OBJ. INSIDE - DIFFICULTIES  OR FALL OF OBJ. OUTSIDE, FROM BLD - DIFFICULTIES 
	FALL OF OBJECTS INSIDE SEVERE CONSEQUENCES  OR OVERTURNING OF OBJ. INSIDE - SEVERE CONSEQ.  OR POTENT. HAZARDOUS MATERIAL RELASE  OR FALL OF OBJ. OUTSIDE, FROM BLD - SEVERE CONS.  OR FALL OF OBJ. OUTSIDE FROM OTHER CONSTR. 

Table E.WB.F *Earthquake hazard evaluation of the warning levels for school buildings: functionality safety issue*

Warning level	Evaluation logic
	NOT( OR )
	ABSENCE OF SAFE AREAS  OR DIFFICULT EGRESS 
	COMPROMISED EXIT 

Annex to the VISUS Methodology

AM5 Evaluation Criteria: Air Hazard

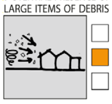
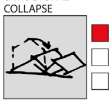
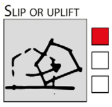
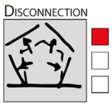
Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

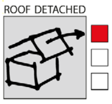
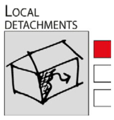
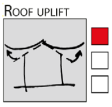
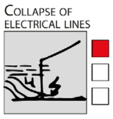
- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

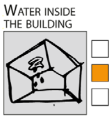
1. EXPECTED IMPACT SCENARIOS

Table 1.1 lists the substantial expected impact scenarios identified for air hazard evaluated with the Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology.

Table 1.1 *Expected impact scenarios for air hazard*

Safety issue	Icon	Name	Where	Description
Location/site critical issues	POTENTIAL PRESENCE OF LARGE ITEMS OF DEBRIS 	Potential presence of large items of debris	Schoolyard and buildings	Potential presence of large items of debris uplifted by air action. The debris can both impact the school buildings and hit people. Assuming that people are not outside during an event, this scenario presents potential difficulties.
Structural global critical issues	STRUCTURAL COLLAPSE 	Structural collapse	Buildings	Potential structural collapse of the building. The structure is probably unable to withstand the reference hazard. Activation of this scenario could have severe consequences for personal safety, including injuries or deaths.
	DAMAGE 	Damage	Buildings	Presence of conditions suggesting that in the case of the reference hazard, the structure could sustain significant damage. Activation of this scenario could result in difficulties for personal safety.
	SLIP OR UPLIFT 	Slip or uplift	Buildings	Presence of conditions suggesting that the building could be moved by wind, with severe consequences for personal safety.
	DISCONNECTION 	Disconnection	Buildings	Presence of conditions suggesting that the structure could collapse (or suffer local collapse) because of the detachment of structural elements.

Safety issue	Icon	Name	Where	Description
Structural local/ envelope critical issues		Local collapse	Buildings	Presence of conditions suggesting that there could be local collapse of the building, with severe consequences for personal safety.
		Roof detached	Buildings	Presence of conditions suggesting that the roof could be detached from the building in the case of the reference air hazard. Activation of this scenario could have severe consequences for personal safety.
		Local detachments	Buildings	Presence of conditions suggesting that portions of the building envelope could be detached from the building by wind. This scenario could have severe consequences for personal safety.
		Roof uplift	Buildings	Potential uplift of portions of the roof, especially roof extensions. This scenario could have severe consequences for personal safety.
		Roof scrape – severe consequences	Buildings	Potential scrape of the roof covering. This scenario could have severe consequences for personal safety.
		Roof scrape – difficulties	Buildings	Potential scrape of the roof covering. This scenario could present difficulties for personal safety.
Non-structural critical issues		Flying or falling objects, inside – severe consequences	Buildings	Presence of conditions suggesting that wind could enter the building and cause the fall of non-structural elements inside. This scenario could have severe consequences for personal safety depending on size and/or location of the falling elements.
		Flying or falling objects, inside – difficulties	Buildings	Presence of conditions suggesting that wind could enter the building and cause the fall of non-structural elements inside. This scenario could present difficulties for personal safety depending on size and/or location of the falling elements.
		Flying or falling objects, outside – severe consequences	Schoolyard and buildings	Presence of conditions suggesting that wind could cause the fall of non-structural elements outside the school buildings. This scenario could have severe consequences for personal safety depending on size and/or location of the falling elements.
		Flying or falling objects, outside – difficulties	Schoolyard and buildings	Presence of conditions suggesting that wind could cause the fall of non-structural elements outside the school buildings. This scenario could present difficulties for personal safety depending on size and/or location of the falling elements.
		Collapse of electrical lines	Schoolyard and buildings	Presence of conditions warning of the probable fall or collapse of electrical lines. This scenario could have severe consequences for personal safety.
		External threats	Schoolyard and buildings	Presence of conditions warning of the probable fall of external elements on the school buildings, with potentially severe consequences for personal safety.

Safety issue	Icon	Name	Where	Description
Functionality critical issues		Water inside the building	Buildings	Presence of conditions warning of the possibility of water infiltrations from the roof (or the envelope). This scenario could present difficulties for personal safety.
		Wind inside the building – severe consequences	Buildings	Presence of conditions suggesting that wind could enter the building, with potentially severe consequences for personal safety.
		Wind inside the building – difficulties	Buildings	Presence of conditions suggesting that wind could enter the building, causing potential difficulties for personal safety.
		Impossible to reach a safe zone	Schoolyard and buildings	Presence of conditions warning that it could be impossible, during a hazardous air event, to reach a safe zone. This scenario could have severe consequences for personal safety.
		Difficulties in the path to a safe zone	Schoolyard and buildings	Presence of conditions warning that, during a hazardous air event, people could encounter difficulties on the path to a safe zone.

2. LOGICAL TREES

The VISUS logical trees define the substantial elements and the rules and criteria that correspond to the definition of the expected impact scenarios.

2.1 Logical trees for the schoolyard

Fig. 2.1 *Air hazard: expert logical tree for the 'Potential presence of large items of debris' impact scenario*

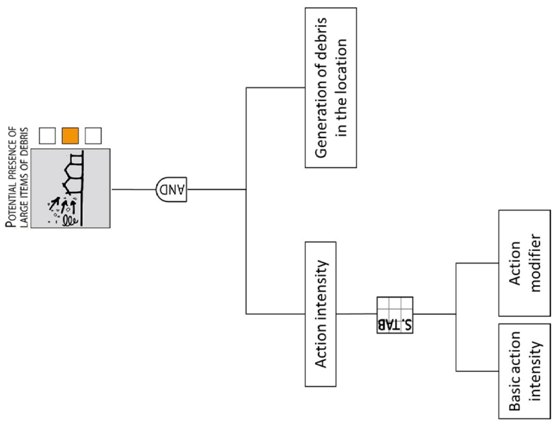


Fig. 2.2 *Air hazard: evaluation logical tree for the 'Potential presence of large items of debris' impact scenario*

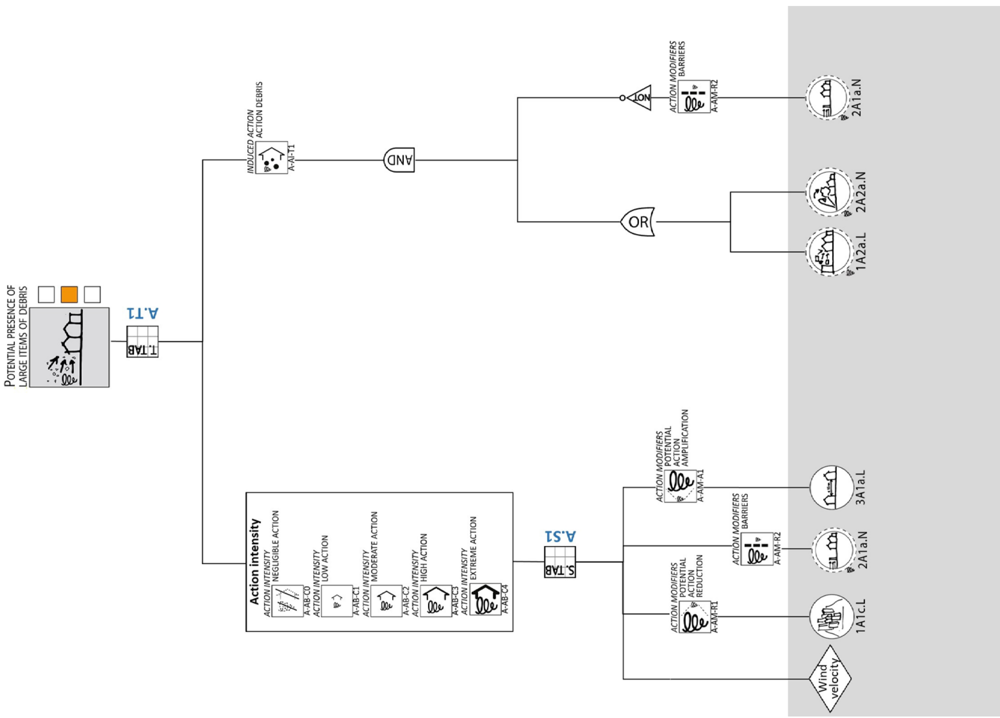


Fig. 2.3 *Air hazard: expert logical tree for the 'Flying or falling objects, outside' impact scenario*

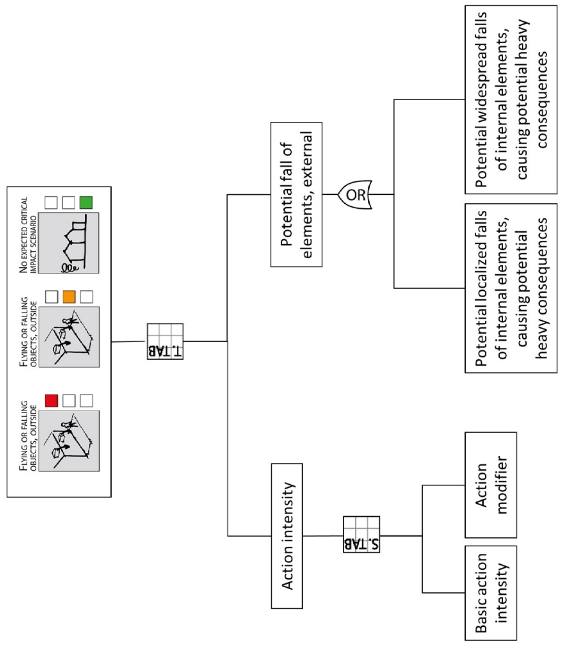


Fig. 2.4 *Air hazard: evaluation logical tree for the 'Flying or falling objects, outside' impact scenario*

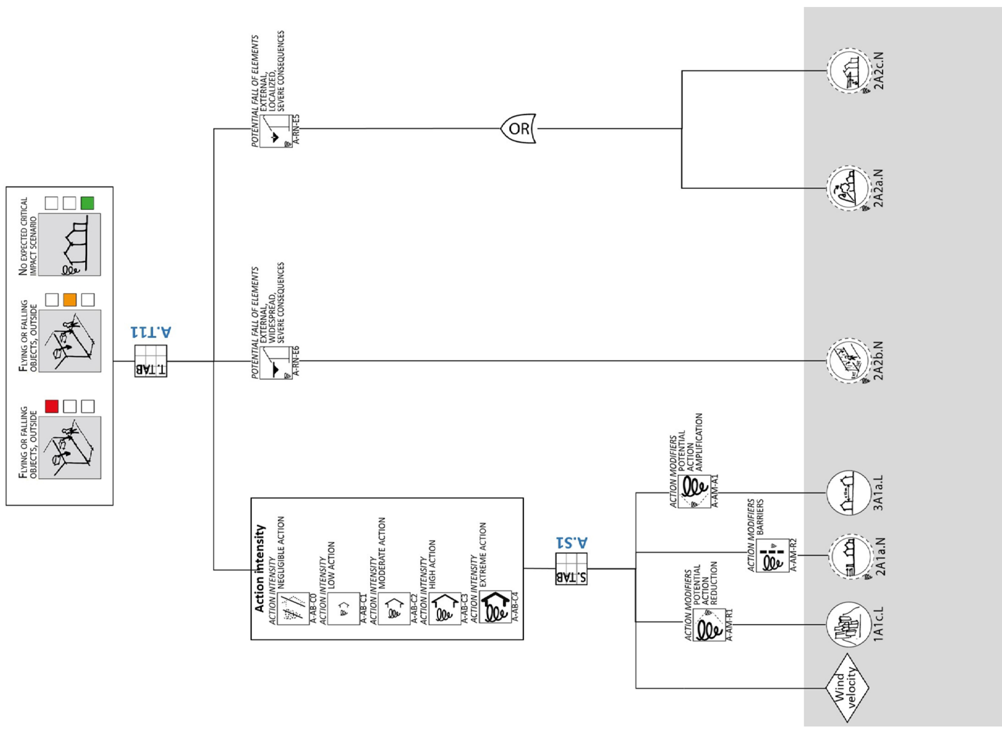


Fig. 2.5 *Air hazard: expert logical tree for the 'Collapse of electrical lines' impact scenario*

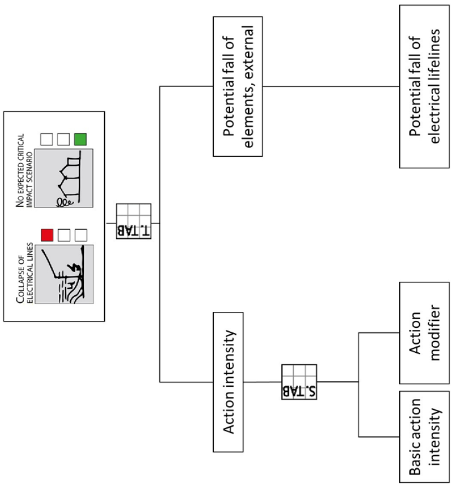


Fig. 2.6 *Air hazard: evaluation logical tree for the 'Collapse of electrical lines' impact scenario*

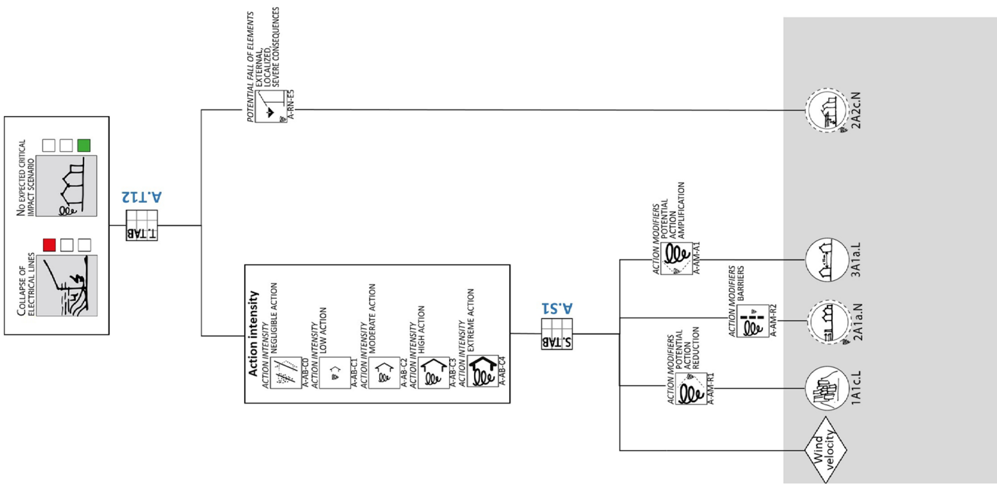


Fig. 2.7 *Air hazard: expert logical tree for the 'External threats' impact scenario*

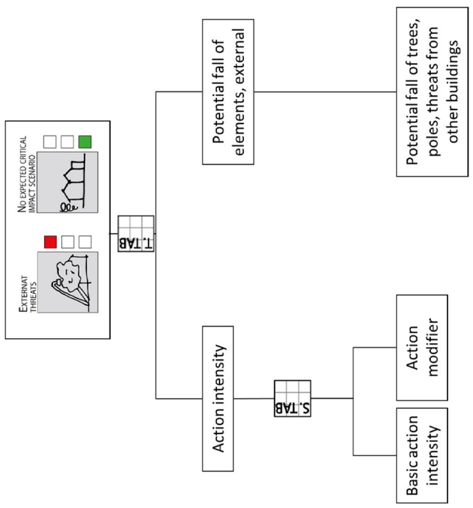


Fig. 2.8 *Air hazard: evaluation logical tree for the 'External threats' impact scenario*

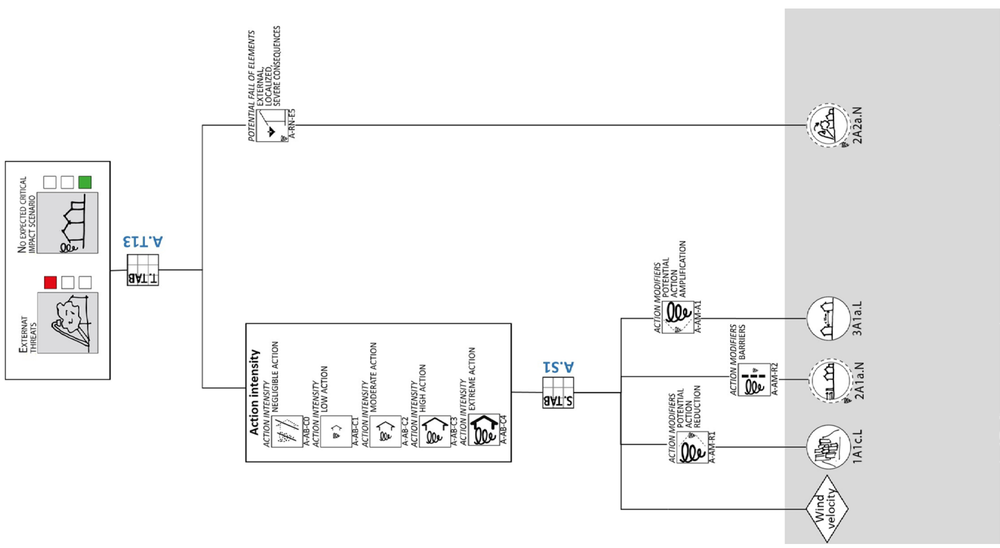


Fig. 2.9 *Air hazard: expert logical tree for the 'Impossible to reach a safe zone' impact scenario*

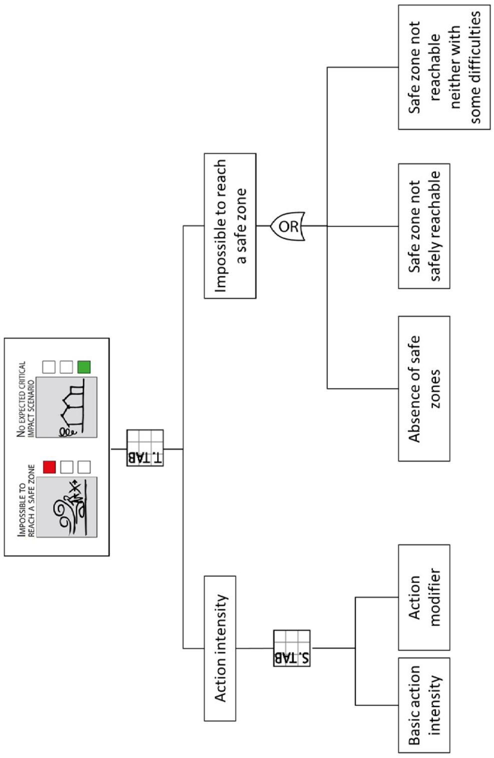


Fig. 2.10 *Air hazard: evaluation logical tree for the 'Impossible to reach a safe zone' impact scenario*

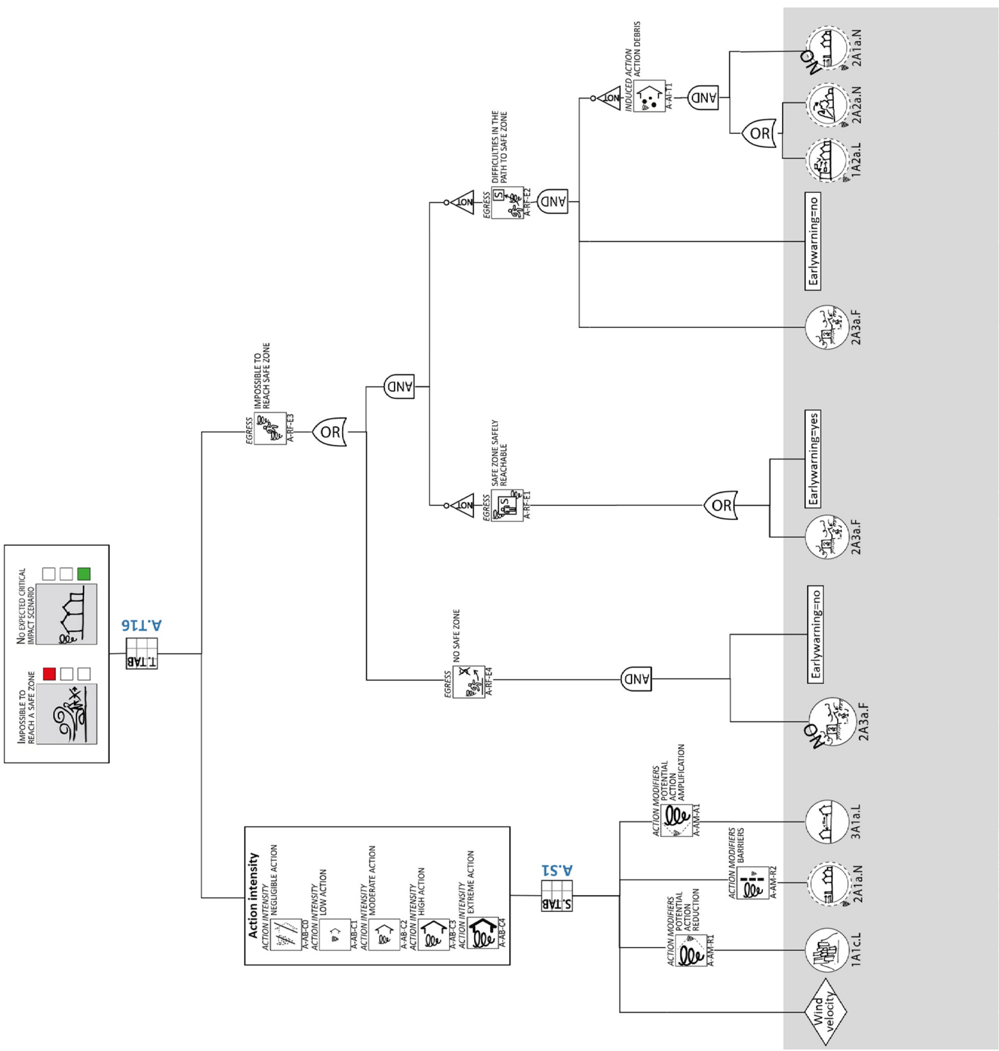


Fig. 2.11 *Air hazard: expert logical tree for the 'Difficulties in the path to a safe zone' impact scenario*

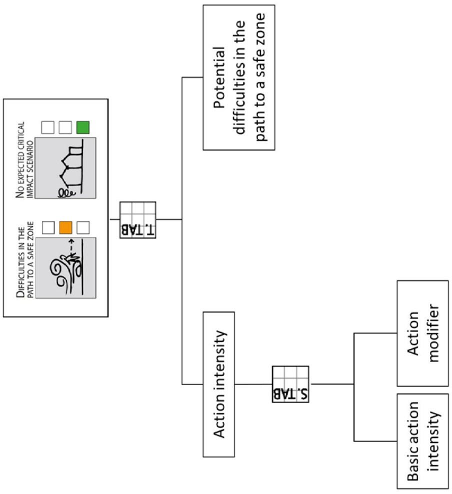
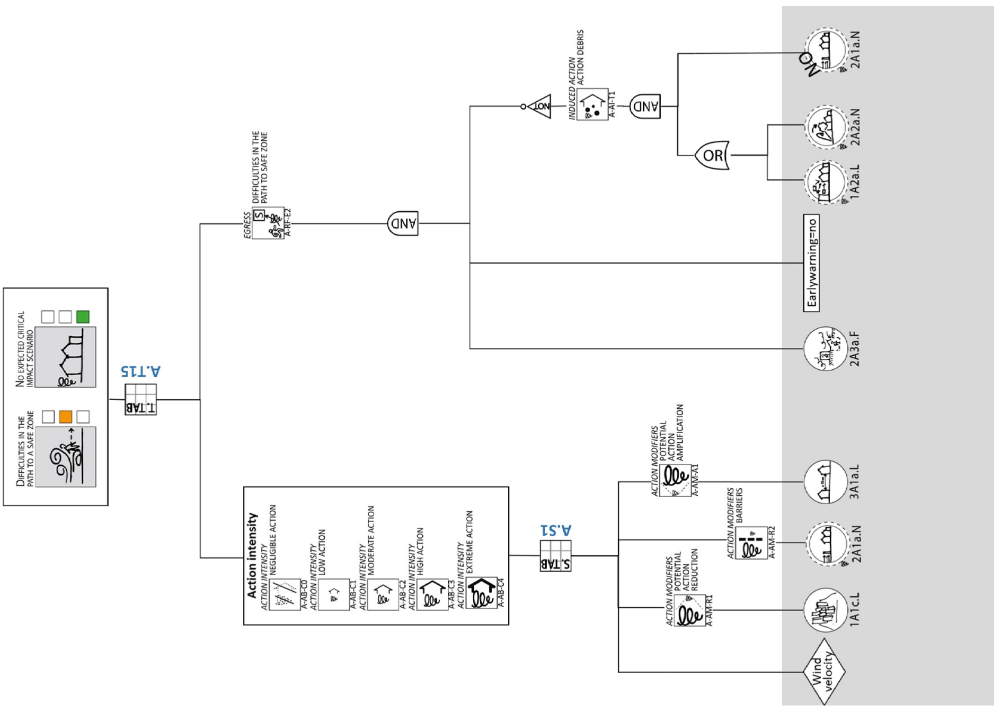


Fig. 2.12 *Air hazard: evaluation logical tree for the 'Difficulties in the path to a safe zone' impact scenario*



2.2 Logical trees for school buildings

Fig. 2.13 *Air hazard: expert logical tree for the 'Potential presence of large items of debris' impact scenario*

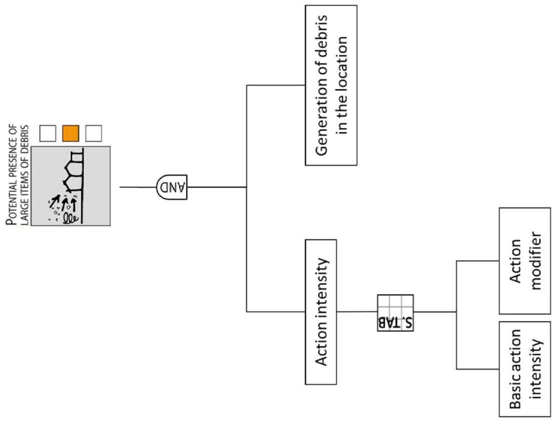


Fig. 2.14 *Air hazard: evaluation logical tree for the 'Potential presence of large items of debris' impact scenario*

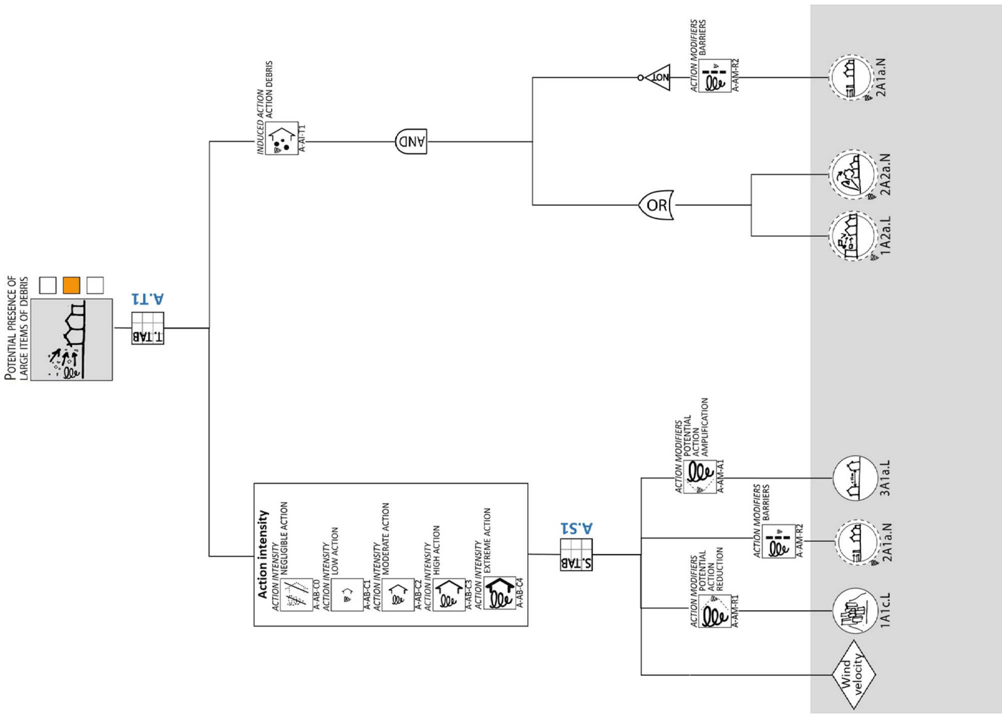


Fig. 2.15 *Air hazard: expert logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies)*

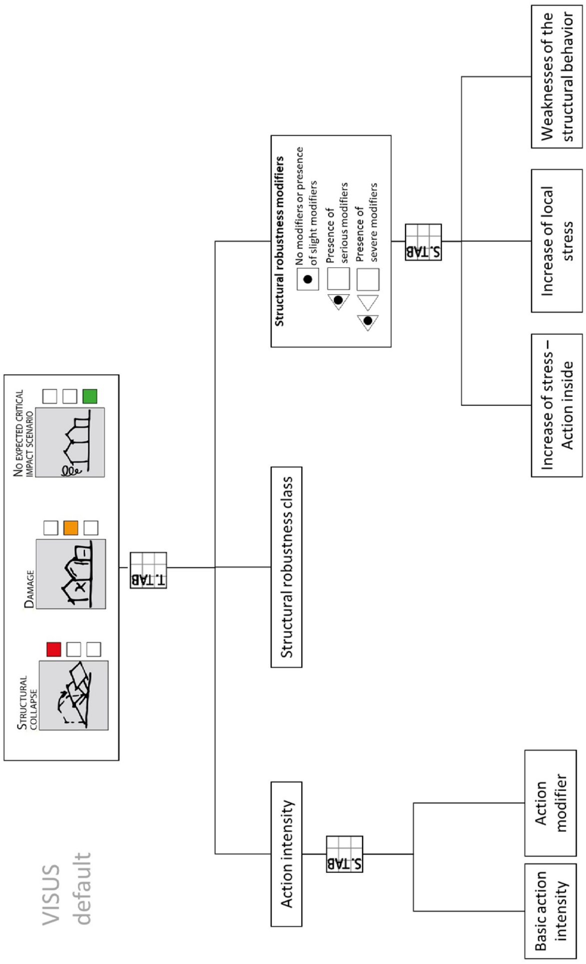
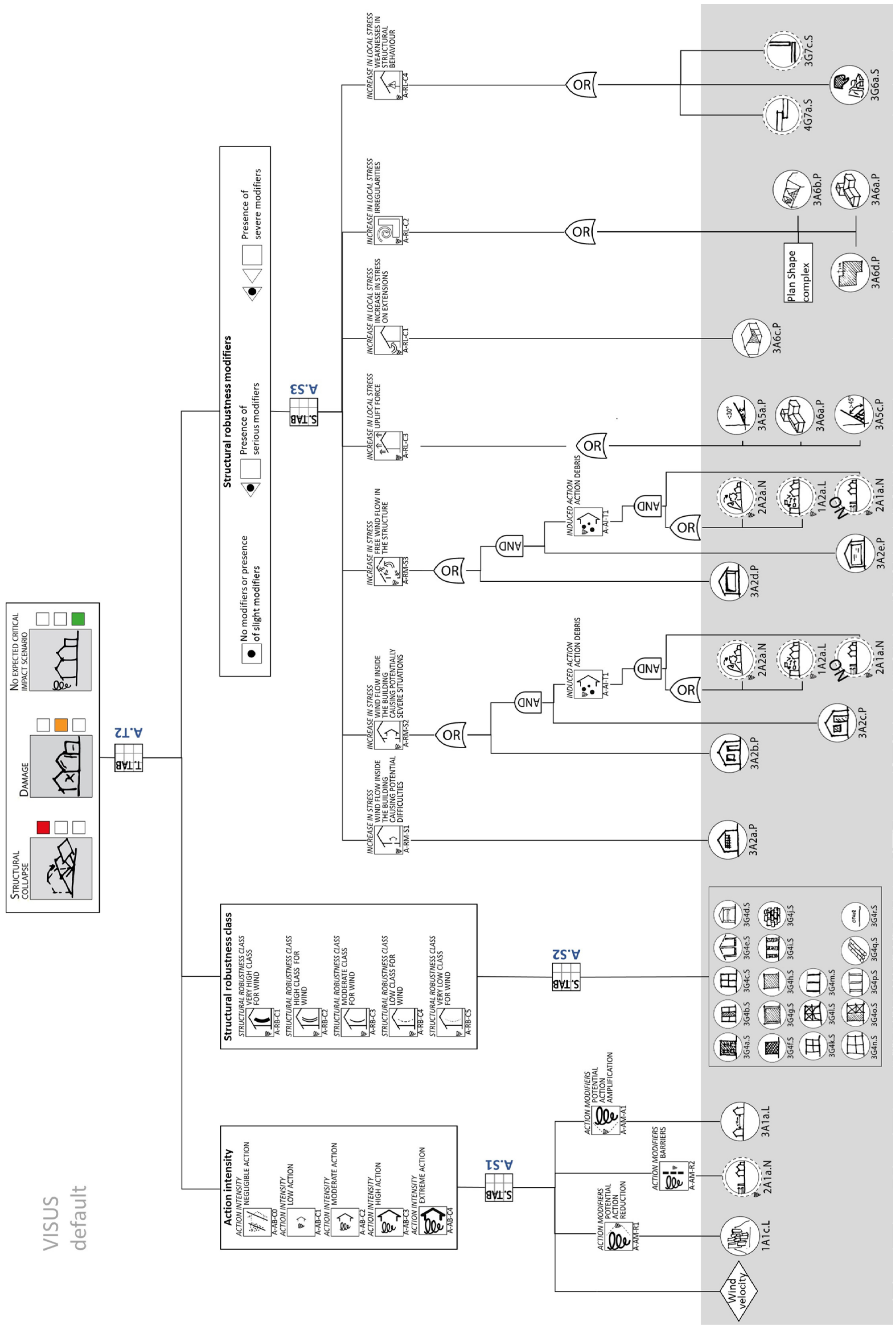


Fig. 2.16 *Air hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – default approach (the building is not characterized using the VISUS typologies)*



If, during the adaptation phase, the local committee defined the VISUS typologies in the VISUS multi-hazard adaptation form: pre-characterized VISUS typology, the structural global critical effects are assessed with the information provided in the form, that is the A1 and A2 values. These values are compared with the action intensity value, that is the expected 'reference event for air' (rEA). rEA is calculated by multiplying the value of wind air velocity (vA) by the coefficient 'act.mod' (that is equal to 0.75 in the case of air action reduction, 1 otherwise). The results from the comparison of rEA and the values of A1 and A2 allow to assign the EIS ('Structural collapse' if rEA > A2; 'Damage' if rEA ≤ A2 and rEA > A1; or 'Action withstanding' if rEA ≤ A1).

The presence of modifiers of the building robustness should be already accounted in the definition of the VISUS typologies.

Fig. 2.17 *Air hazard: expert logical tree for the 'Structural collapse' and 'Damage' impact scenarios – approach when VISUS typologies are defined*

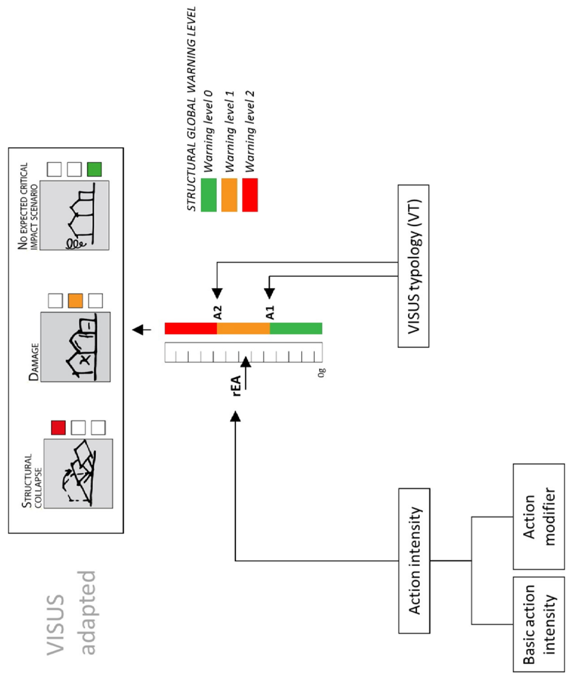


Fig. 2.18 *Air hazard: evaluation logical tree for the 'Structural collapse' and 'Damage' impact scenarios – approach when VISUS typologies are defined*

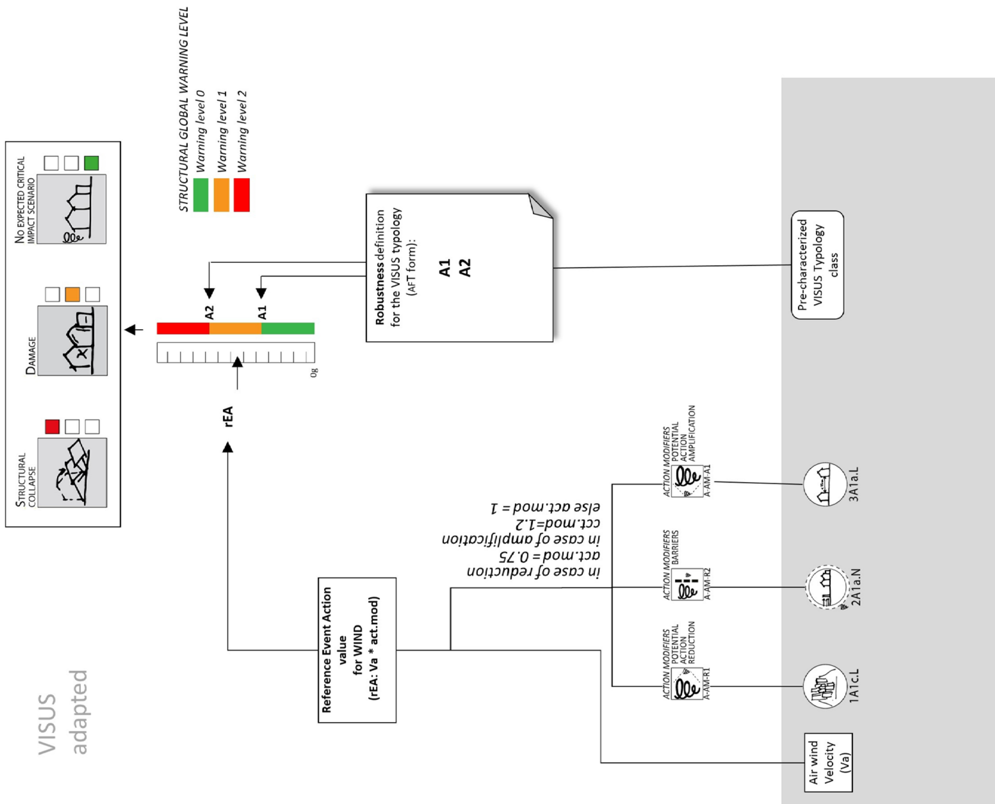


Fig. 2.19 *Air hazard: expert logical tree for the 'Slip or uplift' impact scenario*

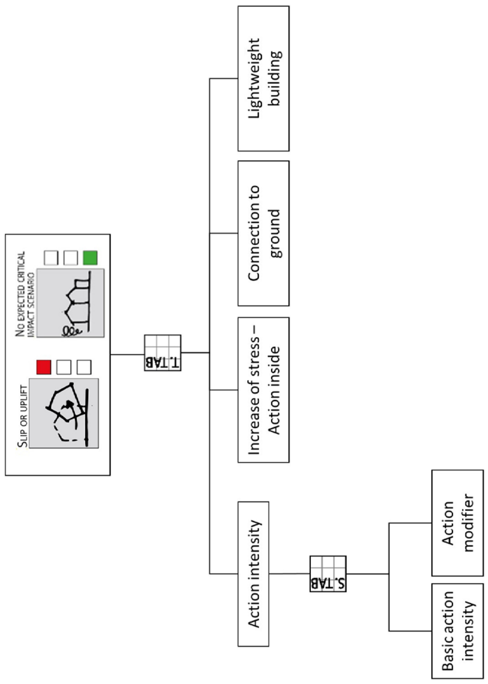


Fig. 2.20 *Air hazard: evaluation logical tree for the 'Slip or uplift' impact scenario*

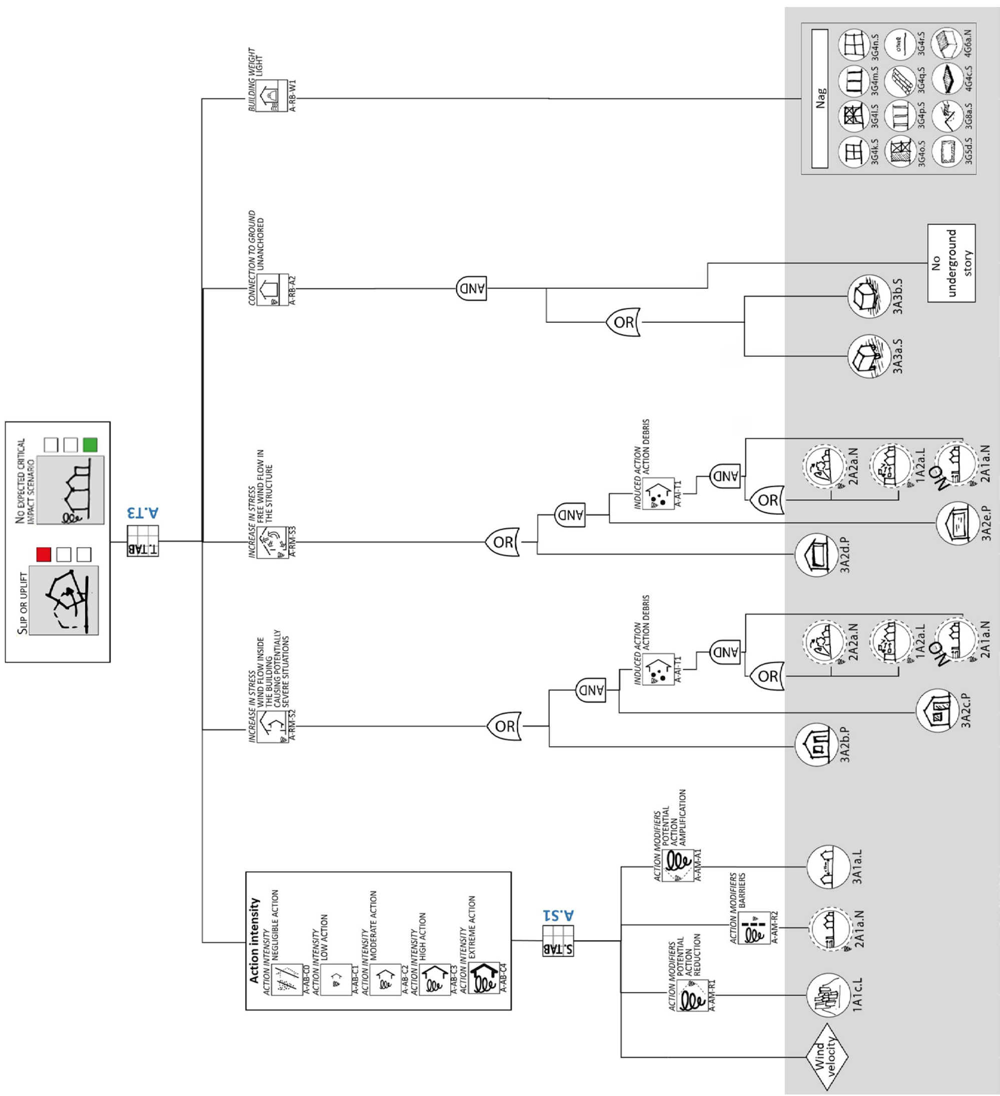


Fig. 2.21 *Air hazard: expert logical tree for the 'Disconnection' impact scenario*

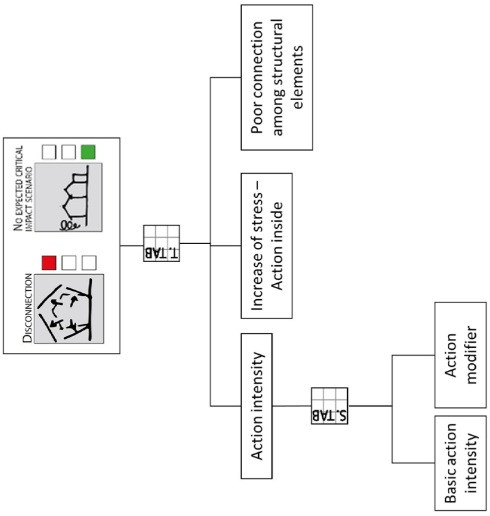


Fig. 2.22 *Air hazard: evaluation logical tree for the 'Disconnection' impact scenario*

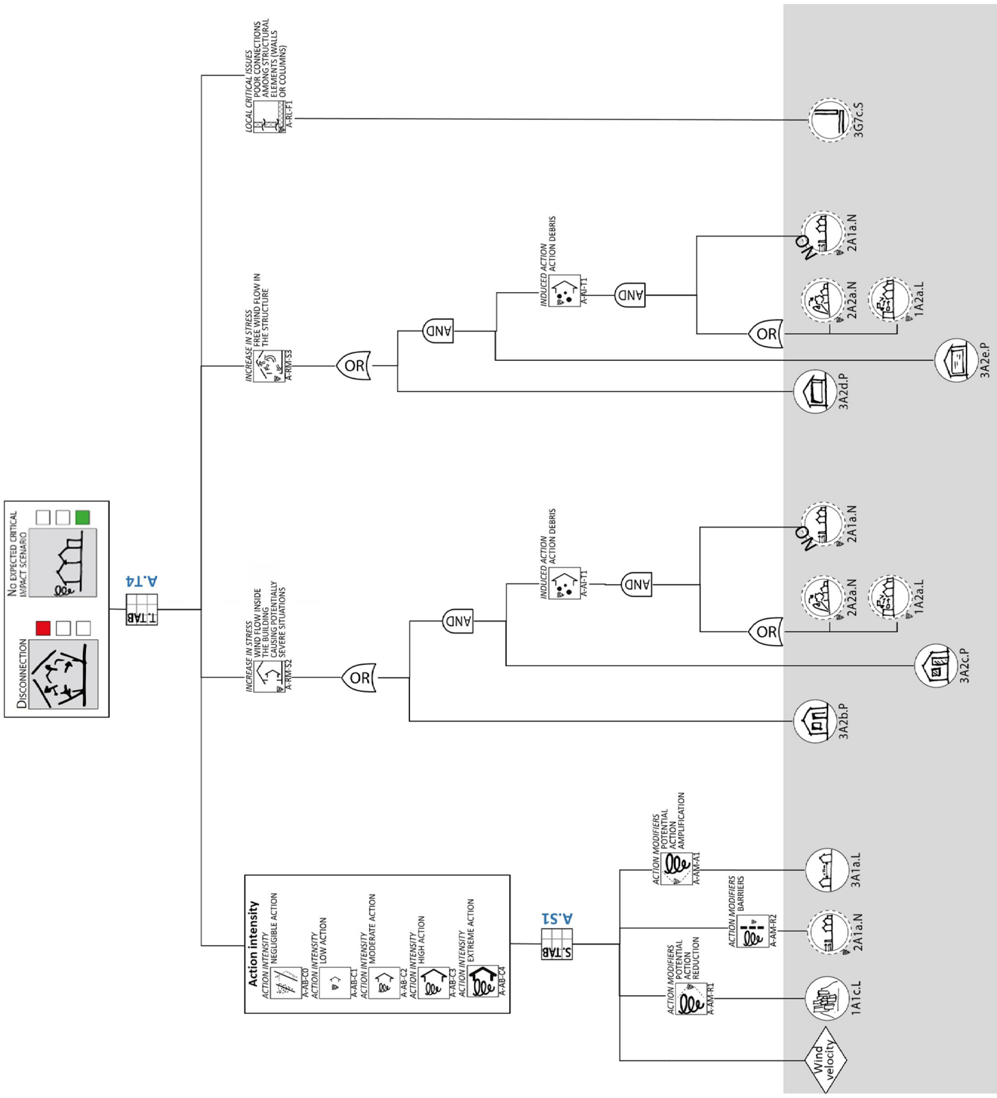


Fig. 2.23 *Air hazard: expert logical tree for the 'Local collapse' impact scenario*

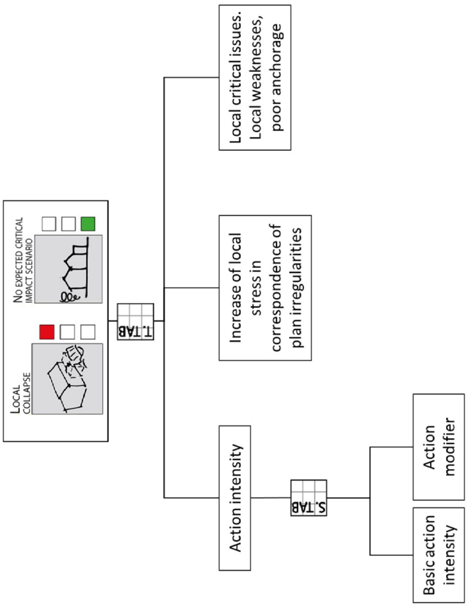


Fig. 2.24 *Air hazard: evaluation logical tree for the 'Local collapse' impact scenario*

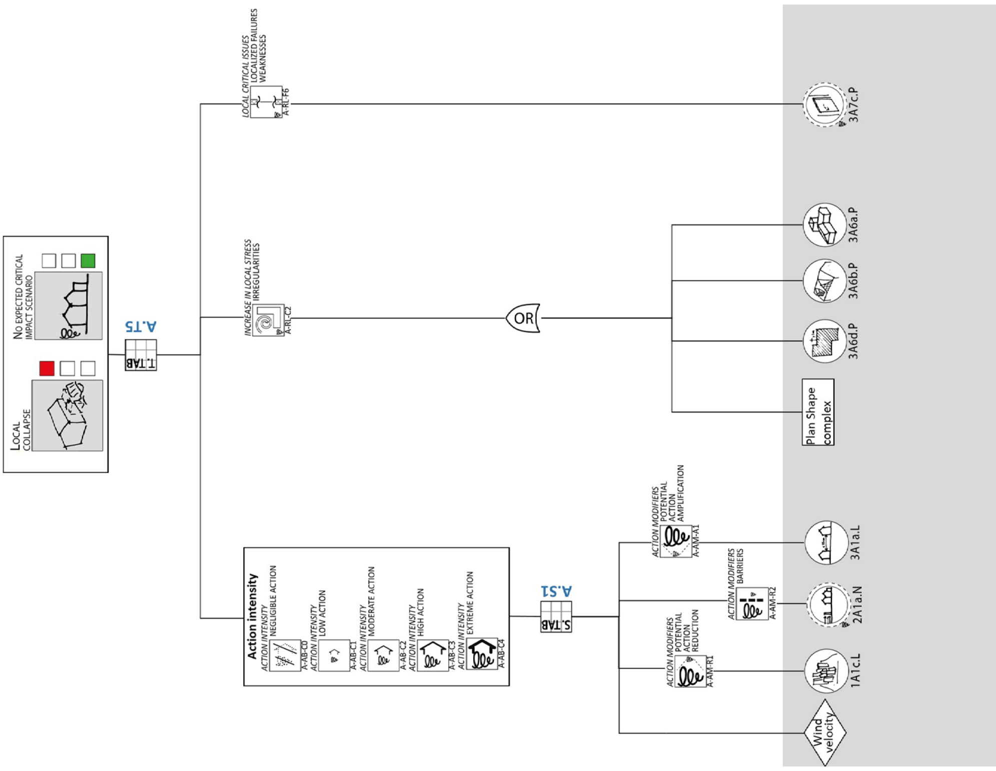


Fig. 2.25 *Air hazard: expert logical tree for the 'Roof detached' impact scenario*

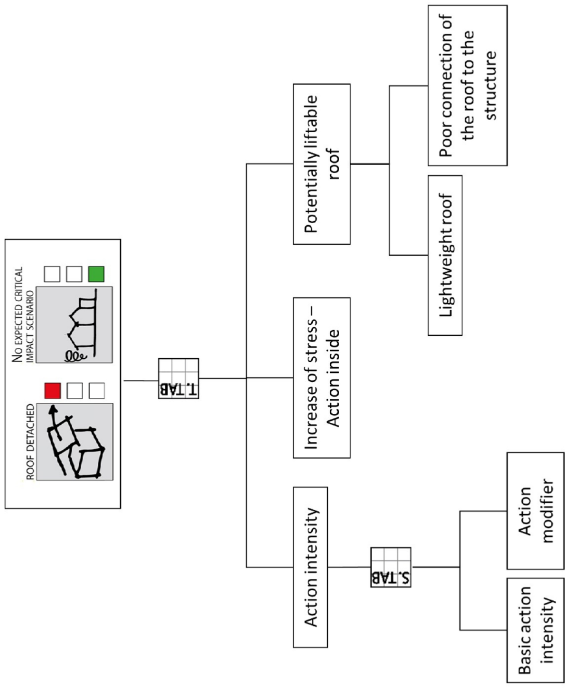


Fig. 2.26 *Air hazard: evaluation logical tree for the 'Roof detached' impact scenario*

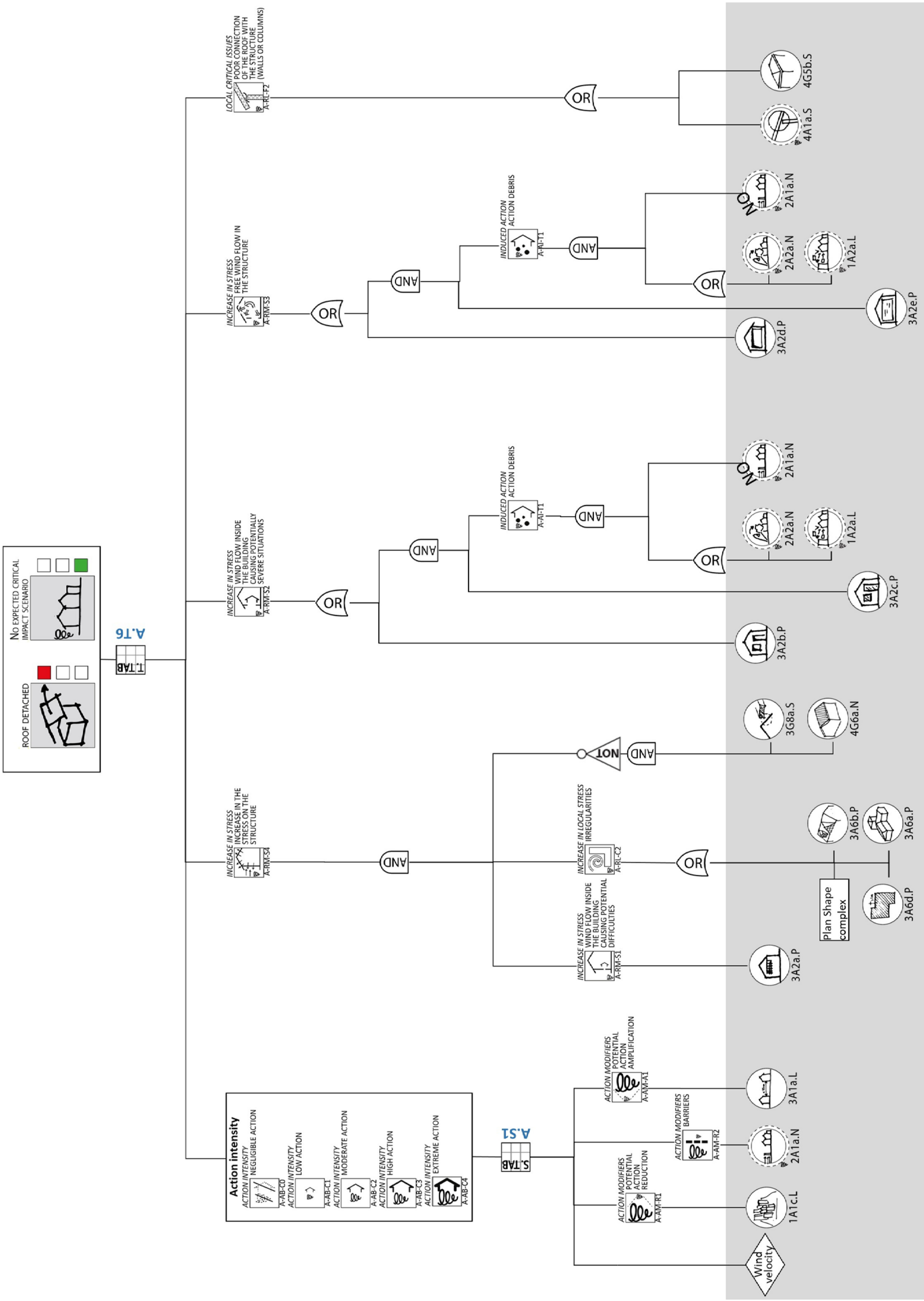


Fig. 2.27 *Air hazard: expert logical tree for the ‘Local detachments’ impact scenario*

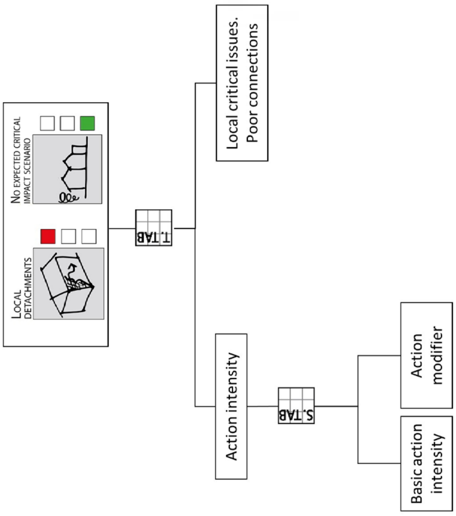


Fig. 2.28 *Air hazard: evaluation logical tree for the ‘Local detachments’ impact scenario*

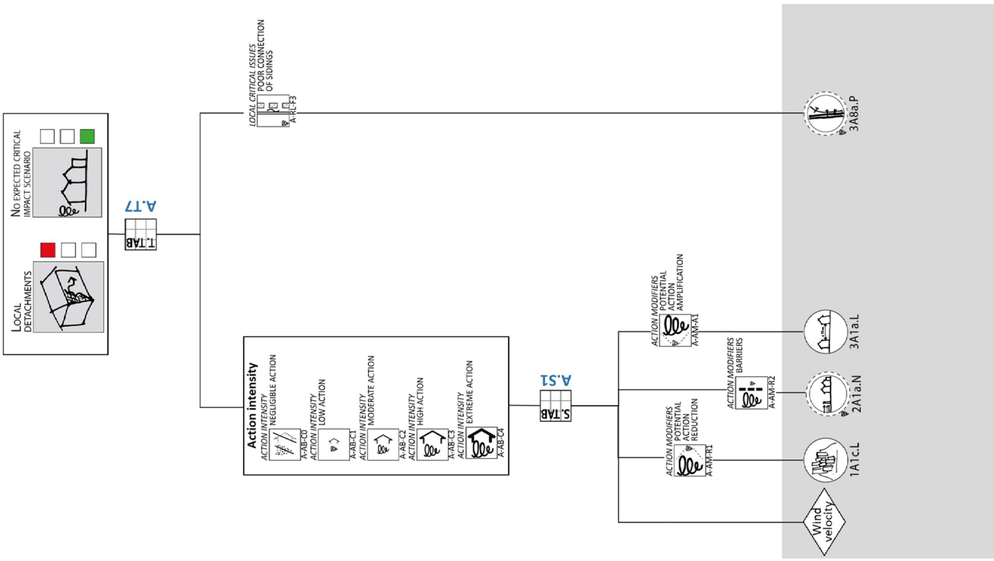


Fig. 2.29 *Air hazard: expert logical tree for the 'Roof uplift' impact scenario*

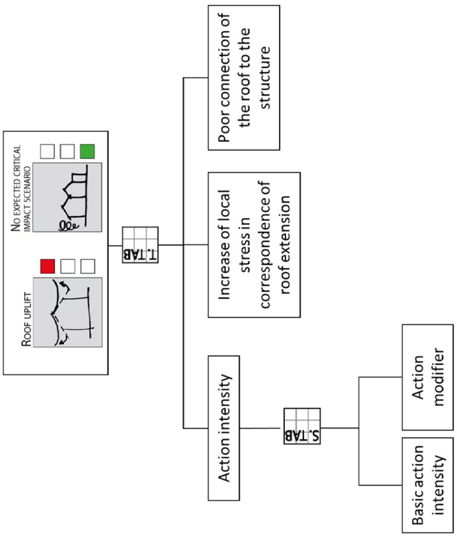


Fig. 2.30 *Air hazard: evaluation logical tree for the 'Roof uplift' impact scenario*

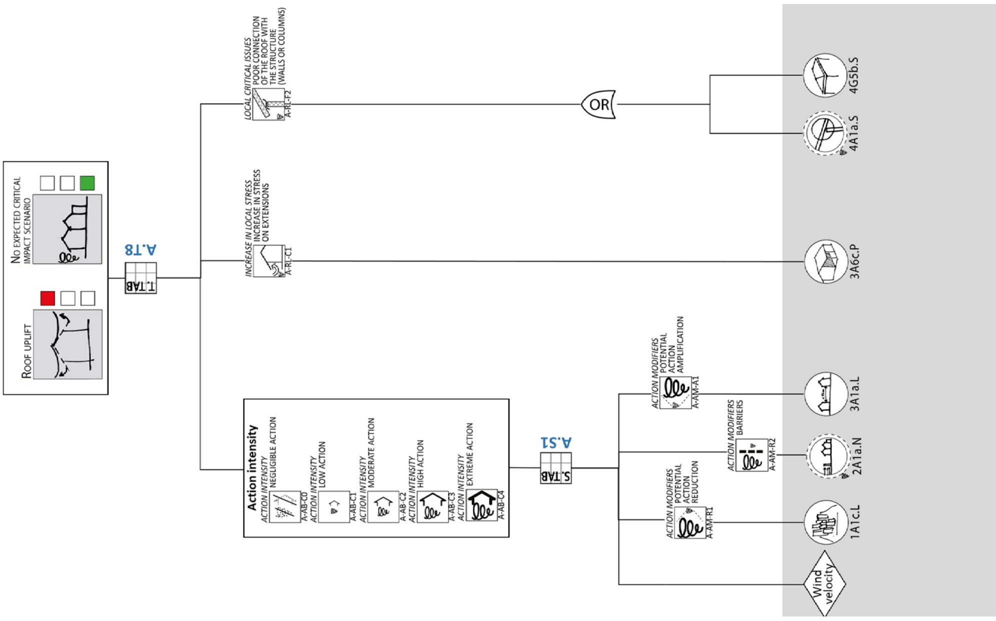


Fig. 2.31 *Air hazard: expert logical tree for the 'Roof scrape' impact scenario*

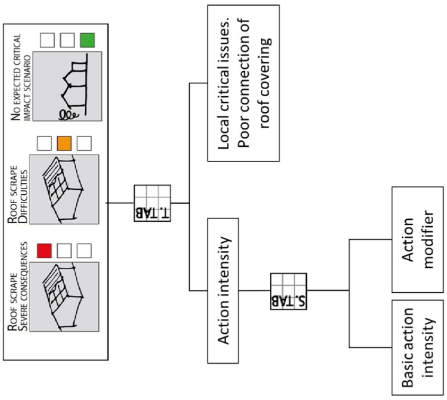


Fig. 2.32 *Air hazard: evaluation logical tree for the 'Roof scrape' impact scenario*

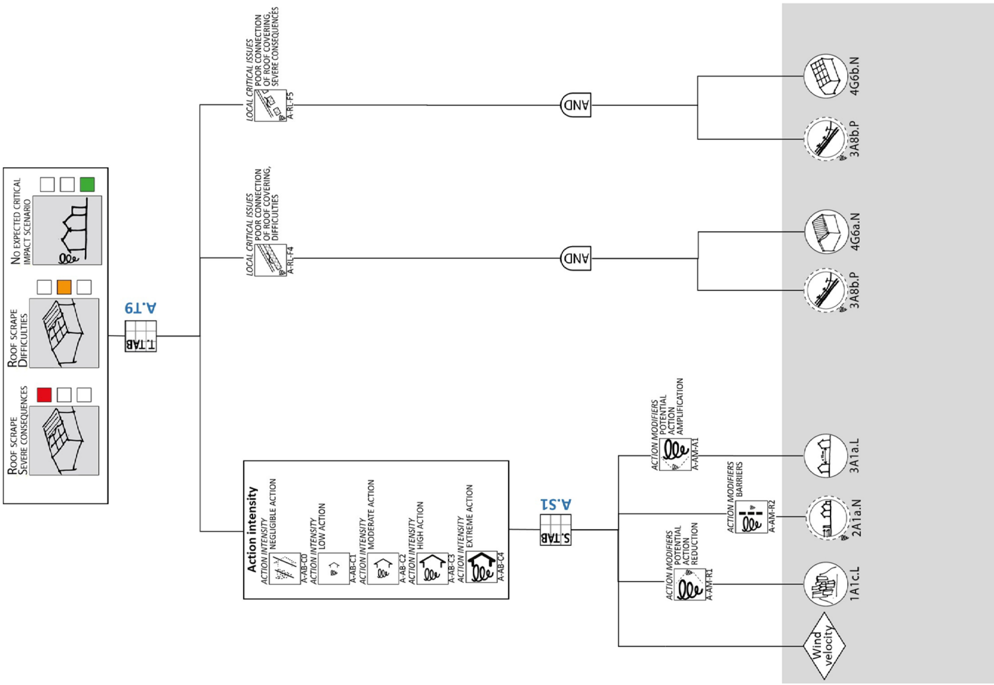


Fig. 2.33 *Air hazard: expert logical tree for the 'Flying or falling objects, inside' impact scenario*

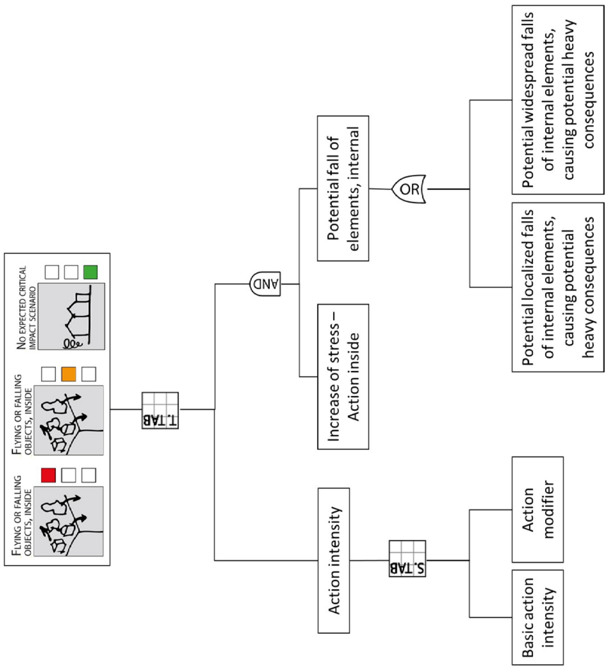


Fig. 2.34 *Air hazard: evaluation logical tree for the 'Flying or falling objects, inside' impact scenario*

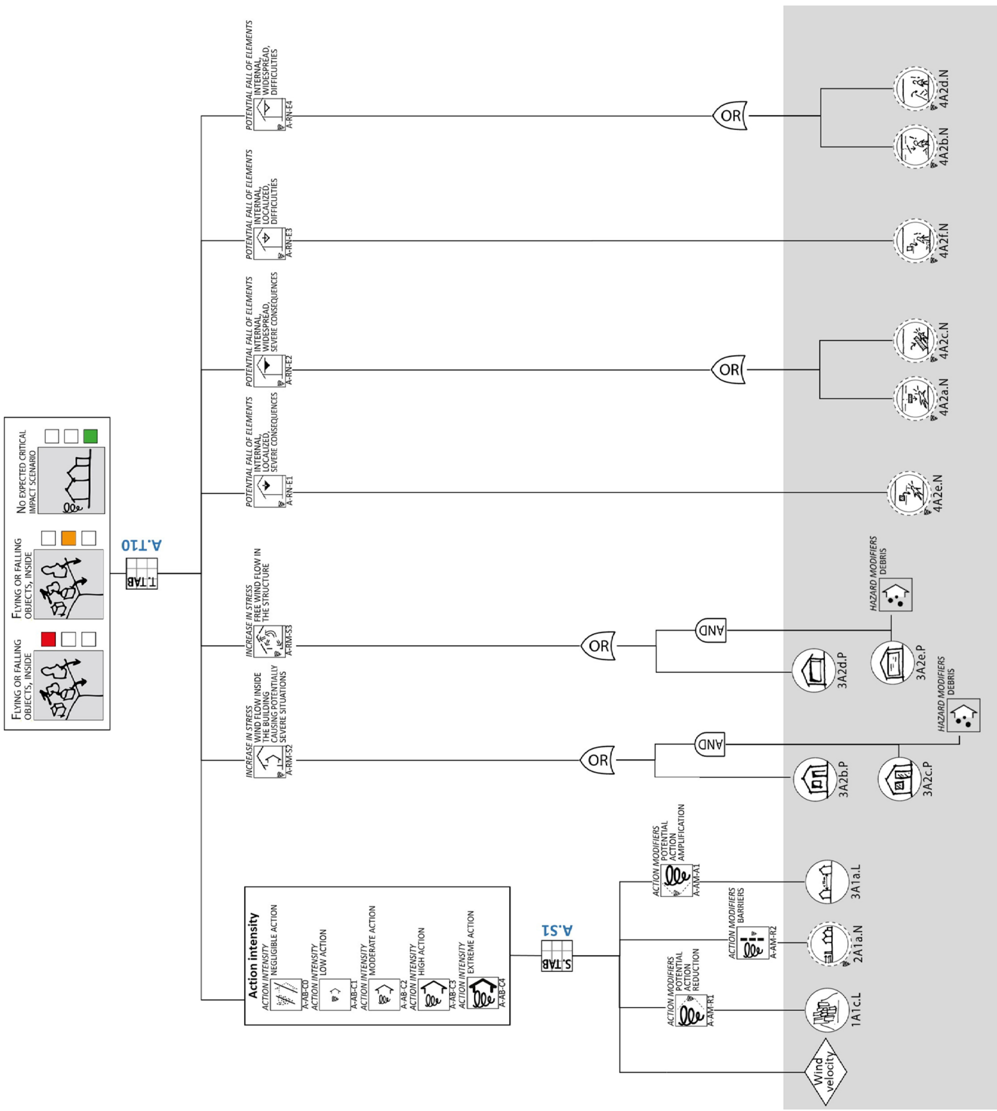


Fig. 2.35 *Air hazard: expert logical tree for the 'Flying or falling objects, outside' impact scenario*

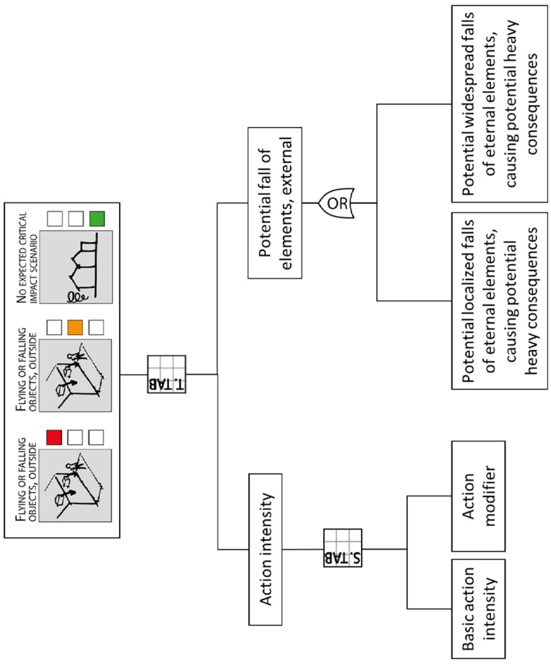


Fig. 2.36 *Air hazard: evaluation logical tree for the 'Flying or falling objects, outside' impact scenario*

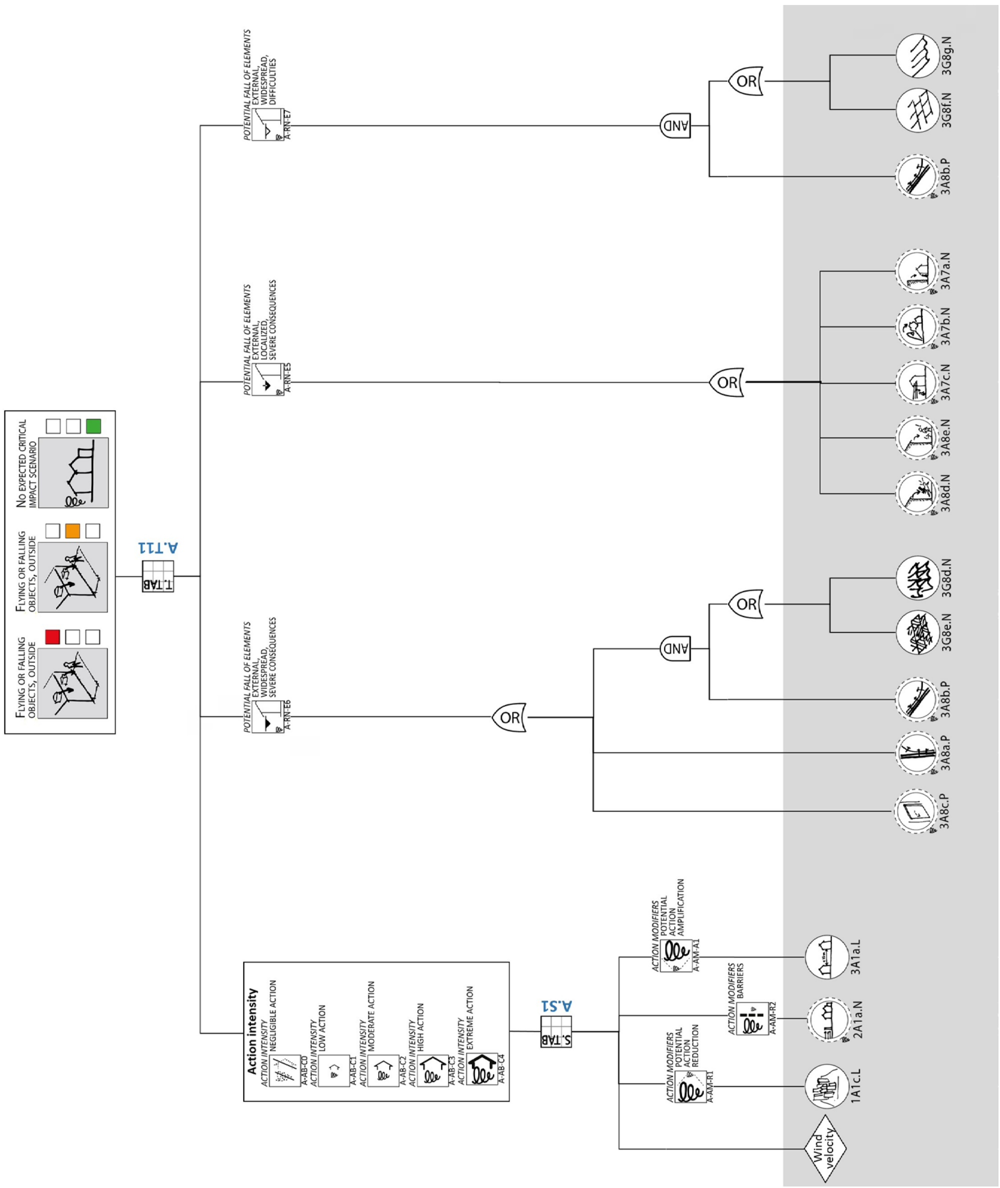


Fig. 2.37 *Air hazard: expert logical tree for the 'Collapse of electrical lines' impact scenario*

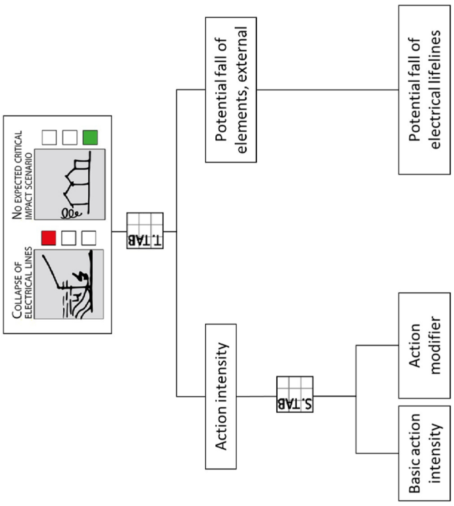


Fig. 2.38 *Air hazard: evaluation logical tree for the 'Collapse of electrical lines' impact scenario*

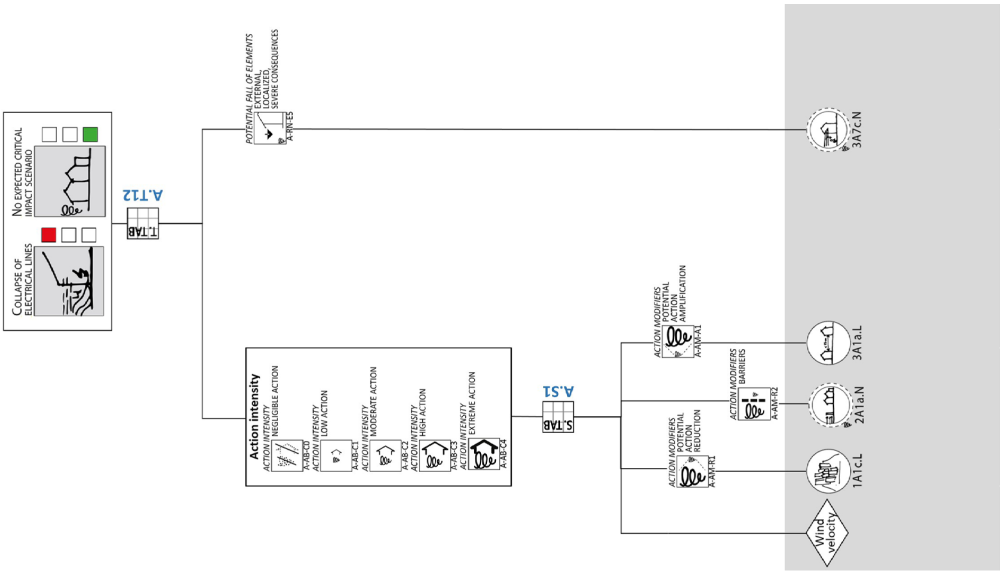


Fig. 2.39 *Air hazard: expert logical tree for the 'External threats' impact scenario*

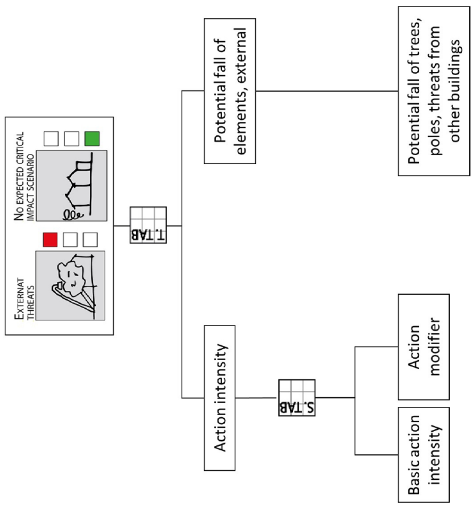


Fig. 2.40 *Air hazard: evaluation logical tree for the 'External threats' impact scenario*

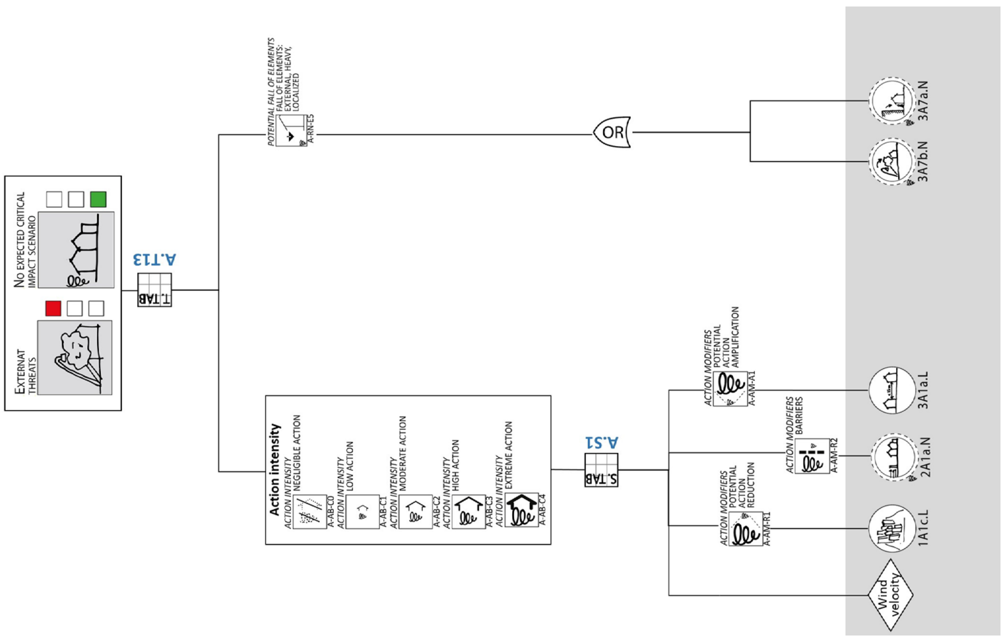


Fig. 2.41 *Air hazard: expert logical tree for the 'Water inside the building' impact scenario*

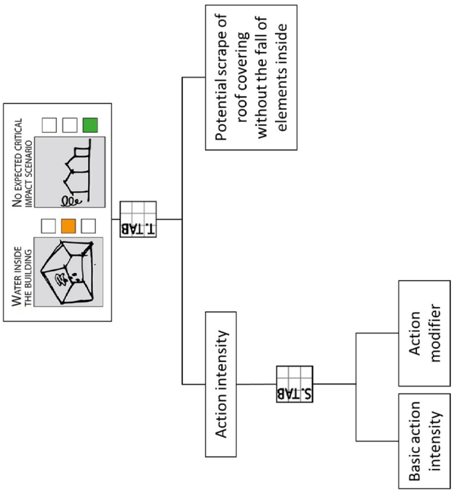


Fig. 2.42 *Air hazard: evaluation logical tree for the 'Water inside the building' impact scenario*

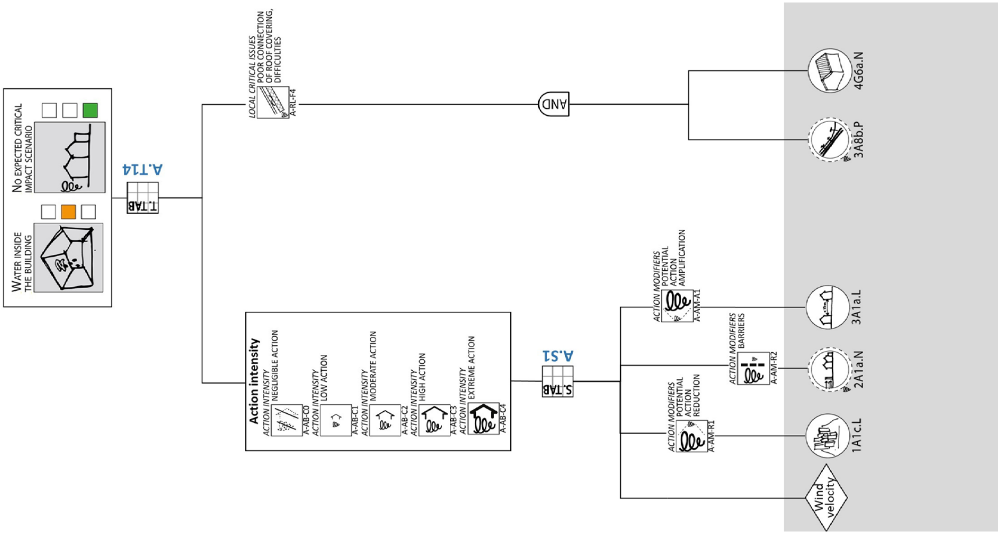


Fig. 2.43 *Air hazard: expert logical tree for the 'Wind inside the building' impact scenario*

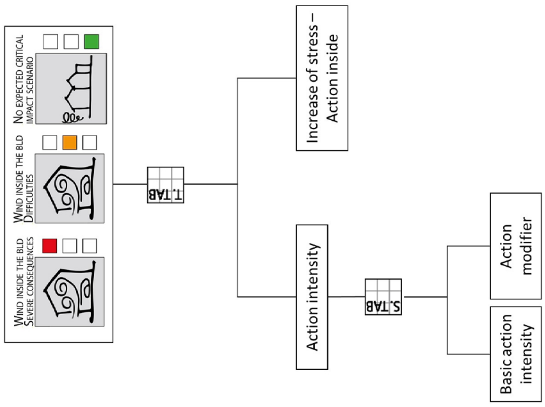


Fig. 2.44 *Air hazard: evaluation logical tree for the 'Wind inside the building' impact scenario*

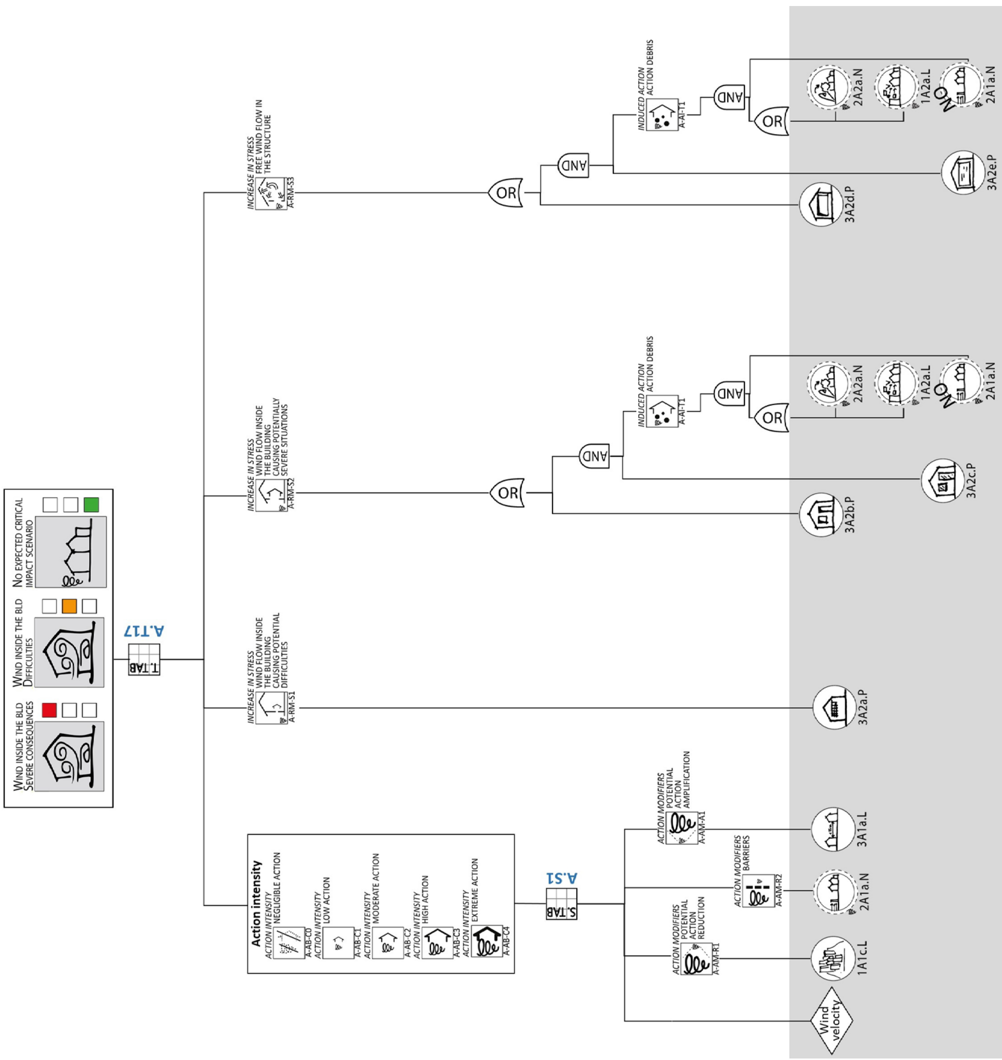


Fig. 2.45 *Air hazard: expert logical tree for the 'Impossible to reach a safe zone' impact scenario*

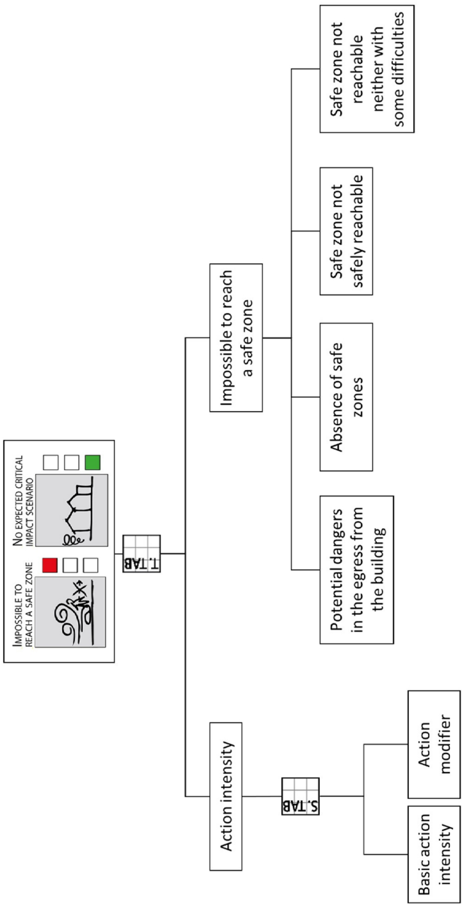


Fig. 2.46 *Air hazard: evaluation logical tree for the 'Impossible to reach a safe zone' impact scenario*

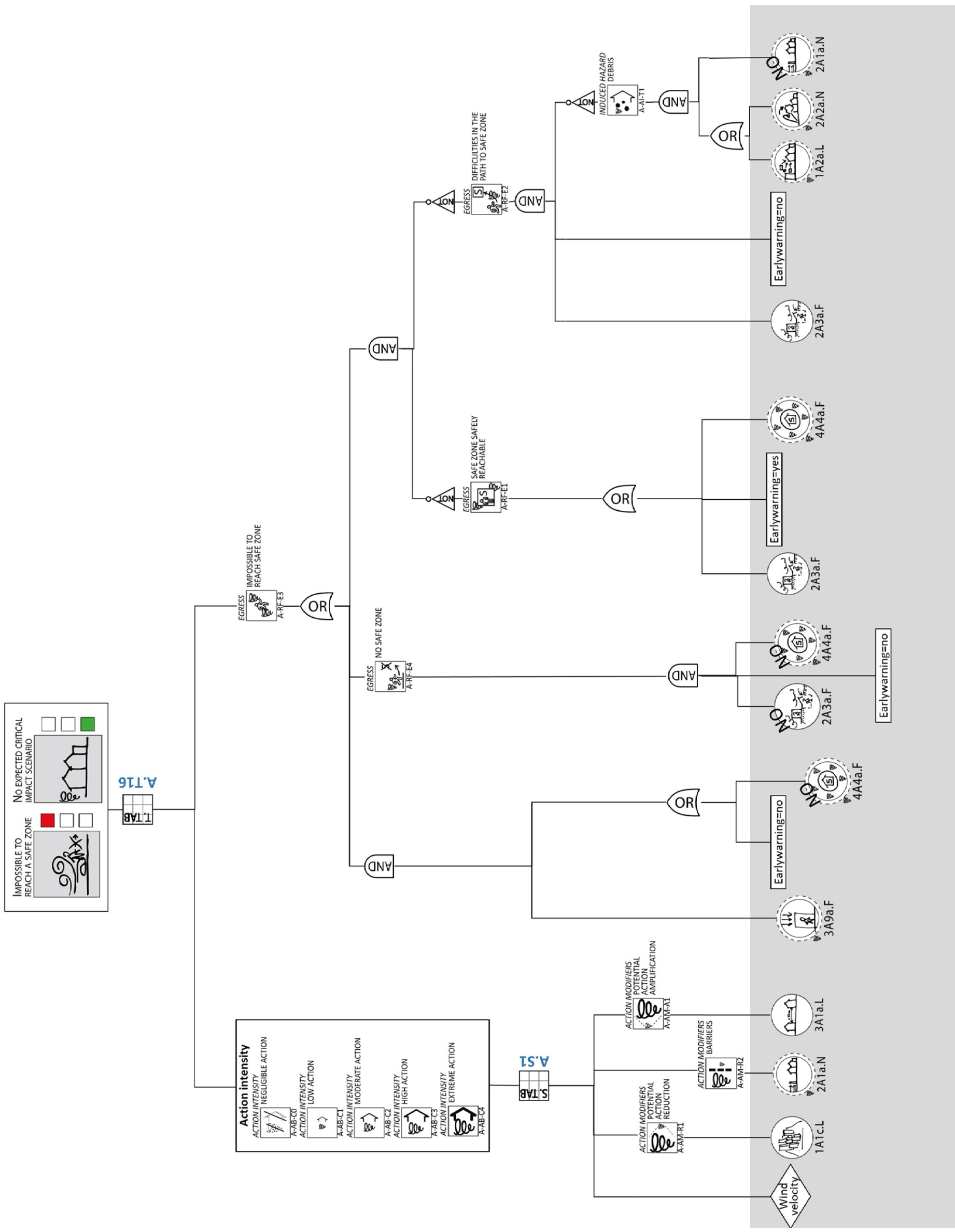


Fig. 2.47 *Air hazard: expert logical tree for the 'Difficulties in the path to a safe zone' impact scenario*

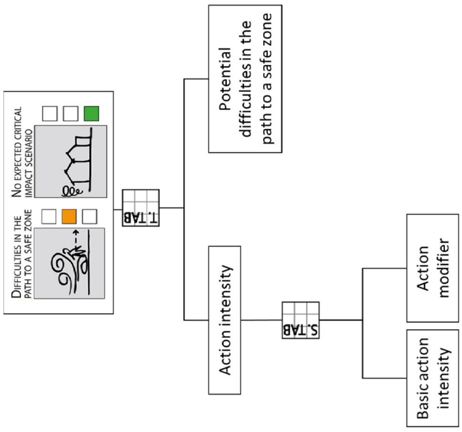
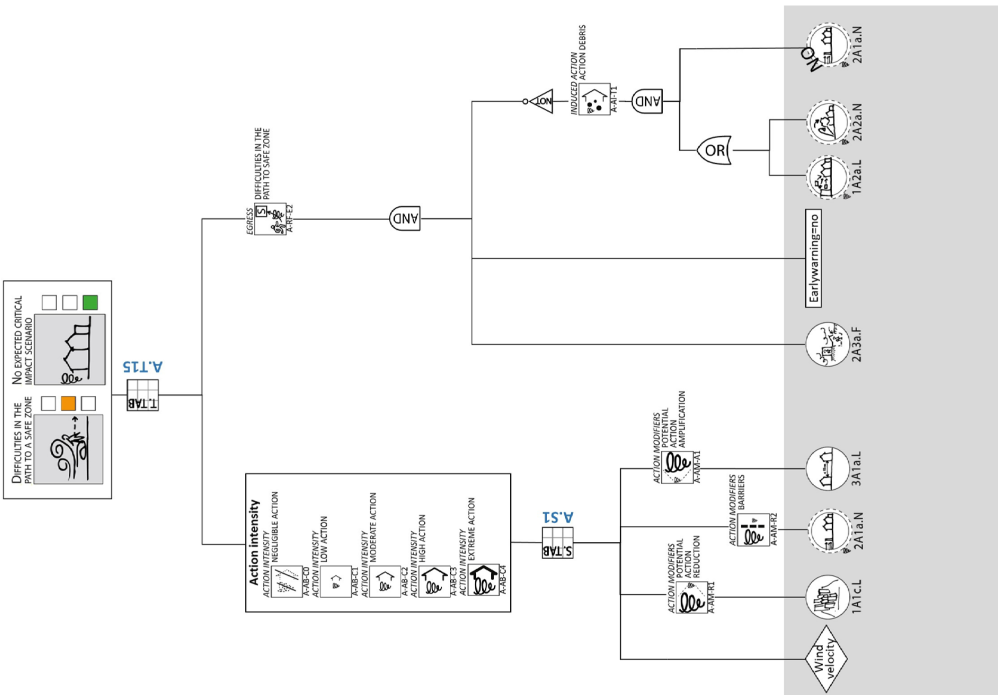


Fig. 2.48 *Air hazard: evaluation logical tree for the 'Difficulties in the path to a safe zone' impact scenario*



3. REFERENCE EVENTS AND OBSERVABLES

3.1 Reference events

Table 3.1 *List of the reference events used for air hazard evaluation*

Survey phase	Focus group	Code	Observable	Name
0	Reference event characterization – Air – Wind force	Wind velocity	–	Breeze or moderate gale (< 62 km/h)
			–	Gale (62–74 km/h)
			–	Strong gale (75–88 km/h)
			–	Storm or violent storm (89–118 km/h)
			–	Class 1 (119–153 km/h)
			–	Class 2 (154–177 km/h)
			–	Class 3 (178–208 km/h)
			–	Class 4 (209–251 km/h)
			–	Class 5 (≥252 km/h)
0	Reference event characterization – Air – Early warning wind	Early warning=Yes	–	Early warning for wind: Yes
		Early warning=-No	–	Early warning for wind: No

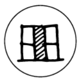
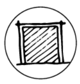
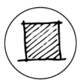
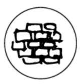
3.2 Observables for the schoolyard

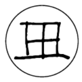
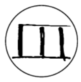
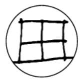
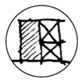
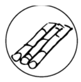
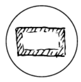
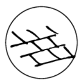
Table 3.2 *List of the observables (OBS) used for air hazard evaluation of the schoolyard*

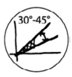
Survey phase	Focus group	Code	Observable	Name
1	A1 - Land roughness (wind speed)	1A1c.L		Surrounded by tall buildings – protected
1	A2 - Debris generation	1A2a.L		Context could cause large items of debris
2	A1 - Protection	2A1a.N		Stable wind barriers
2	A2 - Falls of elements	2A2a.N		Potential falls of trees or poles
		2A2b.N		Potential overturning of fences
		2A2c.N		Potential falls of suspended live lines (e.g. electrical)
2	A3 - Shelter	2A3a.F		Wind shelters in the schoolyard

3.3 Observables for school buildings

Table 3.3 *List of the observables (OBS) used for air hazard evaluation of school buildings*

Survey phase	Focus group	Code	Observable	Name
3	G2 - Type of function, class of building and VISUS typology	VT	–	VISUS typology number
3	G3 - Building characteristics: plan shape	–	–	Simple
		–	–	Complex
		–	–	Compact
		–	–	Elongated
		–	–	Winged
3	G3 - Building characteristics	–	–	Gross floor area (m^2)
		N.units	–	Structural units (number of)
		Nag	–	Above-ground stories (number of)
		Nug	–	Underground stories (number of)
		–	–	External staircases (number of)
		–	–	Exits (number of)
		–	–	Construction date/period
		–	–	Building code/s (standards/regulations)
3	G4 - Structural system: reinforced concrete	3G4a.S		Reinforced concrete walls
		3G4b.S		Reinforced concrete dual frame wall system
		3G4c.S		Reinforced concrete frame
		3G4d.S		Precast
		3G4e.S		Reinforced concrete vertical piers only
3	G4 - Structural system: masonry	3G4f.S		Reinforced masonry
		3G4g.S		Confined masonry
		3G4h.S		Unreinforced masonry
		3G4i.S		Masonry vertical piers only
3	G4 - Structural system: earth or adobe	3G4j.S		Earth or adobe structure

Survey phase	Focus group	Code	Observable	Name
3	G4 - Structural system: steel	3G4k.S		Unbraced steel frame
		3G4m.S		Steel vertical piers only
3	G4 - Structural system: wood	3G4n.S		Wood frame unbraced
		3G4o.S		Wood panels or wood frame braced
		3G4p.S		Wood vertical piers only
3	G4 - Structural system: bamboo	3G4q.S		Bamboo structure
3	G4 - Structural system: other	3G4r.S		Other
3	G5 - Horizontal distribution and organization of lateral resistance elements	3G5d.S		Resistance distributed mainly to the perimeter
3	G6 - Material resistance	3G6a.S		Poor material resistance (lower than ordinary)
3	G7 - Construction quality and building condition	3G7c.S		Poor connection of vertical load carrying elements
3	G8 - Roof covering and architectural features	3G8a.S		Concrete or masonry structure
		3G8d.N		Tiles/pieces heavy
		3G8e.N		Tiles/pieces sharp
		3G8f.N		Tiles/pieces light
		3G8g.N		Sheets
3	A1 - Local intensity increase	3A1a.L		Proximity to other buildings (less than 15 m)

Survey phase	Focus group	Code	Observable	Name
3	A2 - Air permeability	3A2a.P		Small openings always open
		3A2b.P		Medium openings (windows and doors) always open
		3A2c.P		Medium openings (windows and doors) with fragile closure (glass)
		3A2d.P		Large openings (> 30%) always open
		3A2e.P		Large openings (> 30%) with fragile closure
		3A2f.P		No openings or enclosed openings (e.g. shut-ters)
3	A3 - Connection to ground	3A3a.S		Raised building
		3A3b.S		No foundations (simple support)
3	A4 - Roof shape (suc-tion)	3A4a.P		Flat roof
		3A4b.P		Sloping roof
		3A4c.P		Barrel roof
3	A5 - Roof slope (suc-tion)	3A5a.P		Low slope
		3A5b.P		Moderate slope
		3A5c.P		Steep slope
3	A6 - Irregularities (local stress)	3A6a.P		Complex architectural shape
		3A6b.P		Dormers or gables
		3A6c.P		Roof of veranda is extension of main roof
		3A6d.P		Indentation (> 1 m)

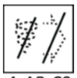
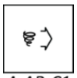
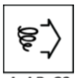
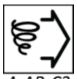
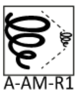
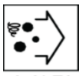
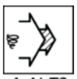
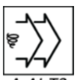
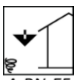
Survey phase	Focus group	Code	Observable	Name
3	A7 - Falls from nearby buildings or elements	3A7a.N		Hazards from nearby buildings
		3A7b.N		Potential falls of trees or poles
		3A7c.N		Potential falls of suspended live lines (e.g. electrical)
3	A8 - Falls from building	3A8a.P		Envelope poorly anchored to structure
		3A8b.P		Roof covering poorly anchored to structure
		3A8c.P		Unsecured infills or sidings
		3A8d.N		Falls of unsafe elements – severe consequences
		3A8e.N		Falls of unsafe elements – difficulties
3	A9 - Egress	3A9a.F		Exit exposed to potential threats
4	G4 - Floor behaviour and connection	4G4c.S		Floor: heavy
4	G5 - Roof behaviour and connection	4G5b.S		Roof: poorly or not connected to vertical structure
4	G6 - Roof decking	4G6a.N		Continuous roof decking
		4G6b.N		Not continuous or fragile decking
4	G7 - Quality	4G7a.S		Ineffective connections
4	A1 - Connections	4A1a.S		Roof poorly connected to vertical structure locally

Survey phase	Focus group	Code	Observable	Name
4	A2 - Falls of elements or objects	4A2a.N		Falls of unsafe elements – severe consequences
		4A2b.N		Falls of unsafe elements – difficulties
		4A2c.N		Overturning of unsafe elements – severe consequences
		4A2d.N		Overturning of unsafe elements – difficulties
		4A2e.N		Falls or overturning of unsafe objects - severe consequences
		4A2f.N		Falls or overturning of unsafe objects – difficulties
4	A3 - Egress	4A3a.F		Obstructed egress
		4A3b.F		Presence of safe areas for people with disabilities
4	A4 - Shelter	4A4a.F		Wind shelter

4. PROFILE QUALIFIERS

4.1 Profile qualifiers for the schoolyard

Table 4.1 *Definition of the profile qualifiers for air hazard evaluation of the schoolyard*

Focus	Icon and code	Name	Evaluation logic
Hazard intensity	 A-AB-C0	Negligible action	Table A.S1
	 A-AB-C1	Low action	Table A.S1
	 A-AB-C2	Moderate action	Table A.S1
	 A-AB-C3	High action	Table A.S1
	 A-AB-C4	Extreme action	Table A.S1
Action modifiers	 A-AM-R1	Potential hazard reduction	 1A1c.L
	 A-AM-R2	Barriers	 2A1a.N
Induced hazard	 A-AI-T1	Action debris	( 1A2a.L OR  2A2a.N) AND NOT ( A-AM-R2)]
	 A-AI-T2	Induced danger: moderate	 2A2a.N OR  2A2c.N
	 A-AI-T3	Induced danger: severe	 2A2b.N
Potential falls of elements	 A-RN-E5	External, localized – severe consequences	 2A2a.N OR  2A2c.N
	 A-RN-E6	External, widespread – severe consequences	 2A2b.N

Focus	Icon and code	Name	Evaluation logic
Egress	A-RF-E1	Safe zone safely reachable	2A3a.F OR Early warning=Yes
	A-RF-E2	Difficulties in the path to safe zone	2A3a.F AND Early warning=No AND NOT (A-AI-T1)
	A-RF-E3	Impossible to reach safe zone	A-RF-E4 OR [NOT (A-RF-E1) AND NOT (A-RF-E2)]
	A-RF-E4	No safe zone	NOT (2A3a.F) AND Early warning=No

4.2 Profile qualifiers for school buildings

Table 4.2 *Definition of the profile qualifiers for air hazard evaluation of school buildings*

Focus	Icon and code	Name	Evaluation logic
Action intensity	A-AB-C0	Negligible action	**Table A.S1**
	A-AB-C1	Low action	**Table A.S1**
	A-AB-C2	Moderate action	**Table A.S1**
	A-AB-C3	High action	**Table A.S1**
	A-AB-C4	Extreme action	**Table A.S1**
Action modifiers	A-AM-R1	Potential action reduction	1A1c.L
	A-AM-A1	Potential action increase	3A1a.L
	A-AM-R2	Barriers	2A1a.N

Focus	Icon and code	Name	Evaluation logic
Induced hazard	A-AI-T1	Action debris	(1A2a.L OR 2A2a.N) AND NOT (A-AM-R2)]
	A-AI-T2	Induced danger: moderate	3A7b.N OR 3A7c.N
Structural robustness class	A-RB-C1	Very high class for wind	**Table A.S2**
	A-RB-C2	High class for wind	**Table A.S2**
	A-RB-C3	Moderate class for wind	**Table A.S2**
	A-RB-C4	Low class for wind	**Table A.S2**
	A-RB-C5	Very low class for wind	**Table A.S2**
	VT*n*	VISUS typology	If the VISUS typology 'n' is assigned
Increase in stress	A-RM-S0	No wind flow inside the building	NOT (A-RM-S1 OR A-RM-S2 OR A-RM-S3)
	A-RM-S1	Wind flow inside the building causing potential difficulties	3A2a.P
	A-RM-S2	Wind flow inside the building causing potentially severe situations	3A2b.P OR (3A2c.P AND A-AI-T1)
	A-RM-S3	Free wind flow in the structure	3A2d.P OR (3A2e.P AND A-AI-T1)
	A-RM-S4	Increase in stress on the structure	A-RM-S1 AND A-RL-C3 AND NOT(3G8a.S AND 4G6a.N)

Focus	Icon and code	Name	Evaluation logic
Increase in local stress	A-RL-N0	No increase in local stress	NOT (A-RL-C1 OR A-RL-C2 OR A-RL-C3)
	A-RL-C1	Increase in stress on extensions	3A6c.P
	A-RL-C2	Irregularities	3A6a.P OR 3A6b.P OR 3A6d.P OR PS_complex
	A-RL-C3	Uplift force increase	3A5a.P OR 3A5c.P OR 3A6a.P
	A-RL-C4	Weaknesses in structural behaviour	4G7a.S OR 3G6a.S OR 3G7c.S
Connection to ground	A-RB-A1	Anchored	NOT (A-RB-A2)
	A-RB-A2	Unanchored	(3A3a.S OR 3A3b.S) AND Nug=0
Building weight	A-RB-W1	Light	{(Nag+Nug=1) AND [3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)]} OR {(Nag+Nug=2) AND {[3G4k.S OR 3G4l.S OR 3G4m.S OR 3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S OR (3G4r.S AND 3G5d.S)] AND NOT (4G4c.S AND 3G6a.S AND 4G6a.N)}} OR {(Nag+Nug=3) AND [3G4n.S OR 3G4o.S OR 3G4p.S OR 3G4q.S] AND NOT (4G4c.S)}
	A-RB-W2	Heavy	NOT (A-RB-W1)

Focus	Icon and code	Name	Evaluation logic
Local critical issues	A-RL-F0	Good	NOT (A-RL-F1 OR A-RL-F2 OR A-RL-F3 OR A-RL-F4 OR A-RL-F5 OR A-RL-F6)
	A-RL-F1	Poor connections among structural elements (walls or columns)	3G7c.S
	A-RL-F2	Poor connection of the roof with the structure (walls or columns)	4A1a.S OR 4G5b.S
	A-RL-F3	Poor connection of sidings	3A8a.P
	A-RL-F4	Poor connection of roof covering – difficulties	3A8b.P AND 4G6a.N
	A-RL-F5	Poor connection of roof covering – severe consequences	3A8b.P AND 4G6b.N
	A-RL-F6	Localized failures, weaknesses	3A8c.P
Potential falls of elements	A-RN-E0	No problems	Not(A-RN-E1 OR A-RN-E2 OR A-RN-E3 OR A-RN-E4 OR A-RN-E5 OR A-RN-E6 OR A-RN-E7)
	A-RN-E1	Internal, localized, severe consequences	4A2e.N
	A-RN-E2	Internal, widespread, severe consequences	4A2a.N OR 4A2c.N
	A-RN-E3	Internal, localized, difficulties	4A2f.N
	A-RN-E4	Internal, widespread, difficulties	4A2b.N OR 4A2d.N
	A-RN-E5	External, localized, severe consequences	3A7a.N OR 3A7b.N OR 3A7c.N OR 3A8d.N OR 3A8e.N
	A-RN-E6	External, widespread, severe consequences	3A8a.P OR 3A8c.P OR [3A8b.P AND (3G8e.N OR 3G8d.N)]
	A-RN-E7	External, widespread, difficulties	3A8b.P AND (3G8f.N OR 3G8g.N)

Focus	Icon and code	Name	Evaluation logic
Egress	A-RF-E1	Safe zone safely reach-able	2A3a.F OR Early warning=Yes OR 4A4a.F
	A-RF-E2	Difficulties in the path to safe zone	2A3a.F AND Early warning=No AND NOT (A-AI-T1)
	A-RF-E3	Impossible to reach safe zone	{ 3A9a.F AND [Early warning=No OR NOT (4A4a.F)]} OR A-RF-E4 OR [NOT (A-RF-E1) AND NOT (A-RF-E2)]
	A-RF-E4	No safe zone	[NOT (2A3a.F)] AND [NOT (4A4a.F)] AND Early warning=No

5. SUPPORTING TABLES

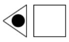
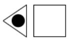
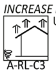
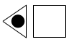
Table A.S1 *Air hazard: criteria for assigning the hazard intensity class*

Reference event	Action modifier		
	NOT(A-AM-R1 OR A-AM-R2 OR A-AM-A1)	A-AM-A1	(A-AM-R1 OR A-AM-R2)
No air action	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0
Breeze OR Moderate gale < 62 km/h	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0
Gale (62–74 km/h)	*ACTION INTENSITY* LOW ACTION A-AB-C1	*ACTION INTENSITY* LOW ACTION A-AB-C1	*ACTION INTENSITY* NEGLIGIBLE ACTION A-AB-C0
Strong gale (75–88 km/h)	*ACTION INTENSITY* LOW ACTION A-AB-C1	*ACTION INTENSITY* MODERATE ACTION A-AB-C2	*ACTION INTENSITY* LOW ACTION A-AB-C1
Storm or violent storm (89–118 km/h)	*ACTION INTENSITY* MODERATE ACTION A-AB-C2	*ACTION INTENSITY* MODERATE ACTION A-AB-C2	*ACTION INTENSITY* LOW ACTION A-AB-C1
Class 1	*ACTION INTENSITY* MODERATE ACTION A-AB-C2	*ACTION INTENSITY* HIGH ACTION A-AB-C3	*ACTION INTENSITY* MODERATE ACTION A-AB-C2
Class 2	*ACTION INTENSITY* HIGH ACTION A-AB-C3	*ACTION INTENSITY* HIGH ACTION A-AB-C3	*ACTION INTENSITY* MODERATE ACTION A-AB-C2
Class 3	*ACTION INTENSITY* HIGH ACTION A-AB-C3	*ACTION INTENSITY* HIGH ACTION A-AB-C3	*ACTION INTENSITY* HIGH ACTION A-AB-C3
Class 4	*ACTION INTENSITY* EXTREME ACTION A-AB-C4	*ACTION INTENSITY* EXTREME ACTION A-AB-C4	*ACTION INTENSITY* EXTREME ACTION A-AB-C4
Class 5	*ACTION INTENSITY* EXTREME ACTION A-AB-C4	*ACTION INTENSITY* EXTREME ACTION A-AB-C4	*ACTION INTENSITY* EXTREME ACTION A-AB-C4

Table A.S2 *Air hazard: criteria for assigning the robustness class, considering the different structural systems*

Observables (OBS)	OBS description	Robustness class (profile qualifier)
3G4a.S	Reinforced concrete walls	STRUCTURAL ROBUSTNESS CLASS VERY HIGH CLASS FOR WIND A-RB-C1
3G4b.S	Reinforced concrete dual frame wall system	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4c.S	Reinforced concrete frame	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4d.S	Precast	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4e.S	Reinforced concrete vertical piers only	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3
3G4f.S	Reinforced masonry	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4g.S	Confined masonry	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4h.S	Unreinforced masonry	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4i.S	Masonry vertical piers only	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3
3G4j.S	Earth or adobe structure	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3
3G4k.S	Unbraced steel frame	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3
3G4l.S	Braced steel frame	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4m.S	Steel vertical piers only	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3
3G4n.S	Wood frame unbraced	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR WIND A-RB-C4
3G4o.S	Wood panels or wood frame braced	STRUCTURAL ROBUSTNESS CLASS HIGH CLASS FOR WIND A-RB-C2
3G4p.S	Wood vertical piers only	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR WIND A-RB-C4
3G4q.S	Bamboo structure	STRUCTURAL ROBUSTNESS CLASS LOW CLASS FOR WIND A-RB-C4
OTHER 3G4r.S	Other	STRUCTURAL ROBUSTNESS CLASS MODERATE CLASS FOR WIND A-RB-C3

Table A.S3 *Air hazard: structural robustness modifiers*

Profile qualifier	Modifier
INCREASE IN STRESS  WIND FLOW INSIDE THE BUILDING CAUSING POTENTIAL DIFFICULTIES A-RM-S1	
INCREASE IN STRESS  WIND FLOW INSIDE THE BUILDING CAUSING POTENTIALLY SEVERE SITUATIONS A-RM-S2	
INCREASE IN STRESS  FREE WIND FLOW IN THE STRUCTURE A-RM-S3	
INCREASE IN LOCAL STRESS  INCREASE IN STRESS ON EXTENSIONS A-RL-C1	
INCREASE IN LOCAL STRESS  IRREGULARITIES A-RL-C2	
INCREASE IN LOCAL STRESS  UPLIFT FORCE A-RL-C3	
INCREASE IN LOCAL STRESS  WEAKNESSES IN STRUCTURAL BEHAVIOUR A-RL-C4	

6. TRIGGERING TABLES

Table A.T1 *Triggering table for defining the potential presence of large items of debris uplifted by air action (location/site critical issue)*

Profile qualifier	Action class A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
Induced action Action debris A-AI-T1	No expected critical impact scenario	No expected critical impact scenario	Potential presence of large items of debris	Potential presence of large items of debris	Potential presence of large items of debris

Table A.T2 *Triggering table for the 'Structural collapse' and 'Damage' impact scenarios (structural global critical issue)*

Profile qualifier	Modifier Table A.S3	Action class A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RB-C1	⊡	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Damage
	◀● □	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse
	◀● ◁ □	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse	Structural collapse
A-RB-C2	⊡	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse
	◀● □	No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse	Structural collapse
	◀● ◁ □	No expected critical impact scenario	No expected critical impact scenario	Structural collapse	Structural collapse	Structural collapse

Profile qualifier	Modifier Table A.S3	Action class A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RB-C3		No expected critical impact scenario	No expected critical impact scenario	Damage	Structural collapse	Structural collapse
		No expected critical impact scenario	Damage	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
A-RB-C4		No expected critical impact scenario	Damage	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
A-RB-C5		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse
		Damage	Structural collapse	Structural collapse	Structural collapse	Structural collapse

Table A.T3 *Triggering table for the 'Slip or uplift' impact scenario (structural global critical issue)*

Profile qualifier combination criteria	Action A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RB-A2 AND A-RB-W1 AND (A-RM-S2 OR A-RM-S3)	No expected critical impact scenario	No expected critical impact scenario	Slip or uplift	Slip or uplift	Slip or uplift
A-RB-A2 AND A-RB-W1 AND NOT (A-RM-S2 OR A-RM-S3)	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Slip or uplift	Slip or uplift

Table A.T4 *Triggering table for the 'Disconnection' impact scenario (structural global critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F1 AND A-RM-S4	No expected critical impact scenario	No expected critical impact scenario	Disconnection	Disconnection	Disconnection
A-RL-F1 AND NOT A-RM-S4	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Disconnection	Disconnection

Table A.T5 *Triggering table for the 'Local collapse' impact scenario (structural local/envelope critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F6 AND A-RL-C2	No expected critical impact scenario	No expected critical impact scenario	Local collapse	Local collapse	Local collapse
A-RL-F6 AND NOT A-RL-C2	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Local collapse	Local collapse

Table A.T6 *Triggering table for the 'Roof detached' impact scenario (structural local/envelope critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F2 AND (A-RM-S2 OR A-RM-S3 OR A-RM-S4)	No expected critical impact scenario	No expected critical impact scenario	Roof detached	Roof detached	Roof detached
A-RL-F2 AND NOT (A-RM-S2 OR A-RM-S3 OR A-RM-S4)	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Roof detached	Roof detached

Table A.T7 *Triggering table for the 'Local detachments' impact scenario (structural local/envelope critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F3	No expected critical impact scenario	No expected critical impact scenario	Local detachments	Local detachments	Local detachments

Table A.T8 *Triggering table for the 'Roof uplift' impact scenario (structural local/envelope critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F2 AND A-RL-C1	No expected critical impact scenario	No expected critical impact scenario	Roof uplift	Roof uplift	Roof uplift
A-RL-F2 AND NOT A-RL-C1	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	Roof uplift	Roof uplift

Table A.T9 *Triggering table for the 'Roof scrape' impact scenario (structural local/envelope critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F4	No expected critical impact scenario	No expected critical impact scenario	Roof scrape Difficulties	Roof scrape Difficulties	Roof scrape Difficulties
A-RL-F5	No expected critical impact scenario	No expected critical impact scenario	Roof scrape Severe consequences	Roof scrape Severe consequences	Roof scrape Severe consequences

Table A.T10 *Triggering table for the 'Flying or falling objects, inside' impact scenario (non-structural critical issue)*

Profile qualifier combination criteria	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
NOT (A-RM-S2 OR A-RM-S3) AND (A-RN-E1 OR A-RN-E2 OR A-RN-E3 OR A-RN-E4)	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario	No expected critical impact scenario
(A-RM-S2 OR A-RM-S3) AND A-RN-E1	No expected critical impact scenario	No expected critical impact scenario	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside
(A-RM-S2 OR A-RM-S3) AND A-RN-E2	No expected critical impact scenario	No expected critical impact scenario	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside
(A-RM-S2 OR A-RM-S3) AND A-RN-E3	No expected critical impact scenario	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside
(A-RM-S2 OR A-RM-S3) AND A-RN-E4	No expected critical impact scenario	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside	Flying or falling objects, inside

Table A.T11 *Triggering table for the 'Flying or falling objects, outside' impact scenario (non-structural critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RN-E5	No expected critical impact scenario	No expected critical impact scenario	Flying or falling objects, outside	Flying or falling objects, outside	Flying or falling objects, outside
A-RN-E6	No expected critical impact scenario	No expected critical impact scenario	Flying or falling objects, outside	Flying or falling objects, outside	Flying or falling objects, outside

Table A.T12 *Triggering table for the 'Collapse of electrical lines' impact scenario (non-structural critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RN-E5	No expected critical impact scenario	No expected critical impact scenario	Collapse of electrical lines	Collapse of electrical lines	Collapse of electrical lines

Table A.T13 *Triggering table for the 'External threats' impact scenario (non-structural critical issue)*

Profile qualifier	Action: A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RN-E5	No expected critical impact scenario	No expected critical impact scenario	External threats	External threats	External threats

Table A.T14 *Triggering table for the 'Water inside the building' impact scenario (functionality critical issue)*

Profile qualifier	Action: A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RL-F4	No expected critical impact scenario	No expected critical impact scenario	Water inside the building	Water inside the building	Water inside the building

Table A.T15 *Triggering table for the 'Difficulties in the path to a safe zone' impact scenario (functionality critical issue)*

Profile qualifier	Action: A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RF-E2	No expected critical impact scenario	No expected critical impact scenario	Difficulties in the path to a safe zone	Difficulties in the path to a safe zone	Difficulties in the path to a safe zone

Table A.T16 *Triggering table for the 'Impossible to reach a safe zone' impact scenario (functionality critical issue)*

Profile qualifier	Action: A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RF-E3	No expected critical impact scenario	No expected critical impact scenario	Impossible to reach a safe zone	Impossible to reach a safe zone	Impossible to reach a safe zone

Table A.T17 *Triggering table for the 'Wind inside the building' impact scenario (functionality critical issue)*

Profile qualifier	Action				
	A-AB-C0	A-AB-C1	A-AB-C2	A-AB-C3	A-AB-C4
A-RM-S1	No expected critical impact scenario	No expected critical impact scenario	Wind inside the bld difficulties	Wind inside the bld difficulties	Wind inside the bld difficulties
A-RM-S2	No expected critical impact scenario	No expected critical impact scenario	Wind inside the bld difficulties	Wind inside the bld severe consequences	Wind inside the bld severe consequences
A-RM-S3	No expected critical impact scenario	No expected critical impact scenario	Wind inside the bld severe consequences	Wind inside the bld severe consequences	Wind inside the bld severe consequences

7. SAFETY INDICATOR: ROSE OF WARNING LEVELS

7.1 Warning level evaluation for the schoolyard

Table A.WS.L *Air hazard evaluation of the warning levels for the schoolyard: site/location safety issue*

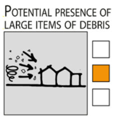
Warning level	Evaluation logic
	NOT( OR )
	
	No scenario

Table A.WS.S *Air hazard evaluation of the warning levels for the schoolyard: structural global safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table A.WS.P *Air hazard evaluation of the warning levels for the schoolyard: structural local/envelope safety issue*

Warning level	Evaluation logic
	No scenario
	No scenario
	No scenario

Table A.WS.N *Air hazard evaluation of the warning levels for the schoolyard: non-structural safety issue*

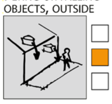
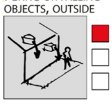
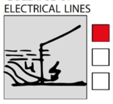
Warning level	Evaluation logic
	NOT ( OR )
	FLYING OR FALLING OBJECTS, OUTSIDE 
	FLYING OR FALLING OBJECTS, OUTSIDE  OR EXTERNAT THREATS  OR COLLAPSE OF ELECTRICAL LINES 

Table A.WS.F *Air hazard evaluation of the warning levels for the schoolyard: functionality safety issue*

Warning level	Evaluation logic
	NOT ( OR )
	DIFFICULTIES IN THE PATH TO A SAFE ZONE 
	IMPOSSIBLE TO REACH A SAFE ZONE 

7.2 Warning level evaluation for school buildings

Table A.WB.L *Air hazard evaluation of the warning levels for school buildings: site/location safety issue*

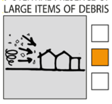
Warning level	Evaluation logic
	NOT( OR )
	POTENTIAL PRESENCE OF LARGE ITEMS OF DEBRIS 
	No scenario

Table A.WB.S *Air hazard evaluation of the warning levels for the school buildings: structural global safety issue*

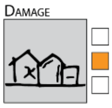
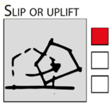
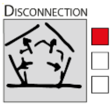
Warning level	Evaluation logic
	NOT( OR )
	DAMAGE 
	STRUCTURAL COLLAPSE  OR SLIP OR UPLIFT  OR DISCONNECTION 

Table A.WB.P *Air hazard evaluation of the warning levels for school buildings: structural local/envelope safety issue*

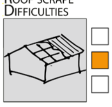
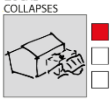
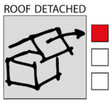
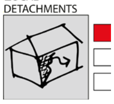
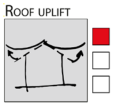
Warning level	Evaluation logic
	NOT( OR )
	ROOF SCRAPE DIFFICULTIES 
	LOCAL COLLAPSES  OR ROOF DETACHED  OR LOCAL DETACHMENTS  OR ROOF UPLIFT  OR ROOF SCRAPE SEVERE CONSEQUENCES 

Table A.WB.N *Air hazard evaluation of the warning levels for school buildings: non-structural safety issue*

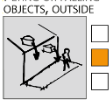
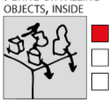
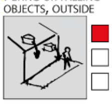
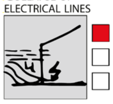
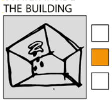
Warning level	Evaluation logic
	NOT( OR )
	FLYING OR FALLING OBJECTS, INSIDE  OR FLYING OR FALLING OBJECTS, OUTSIDE 
	FLYING OR FALLING OBJECTS, INSIDE  OR FLYING OR FALLING OBJECTS, OUTSIDE  OR COLLAPSE OF ELECTRICAL LINES  OR EXTERNAT THREATS 

Table A.WB.F *Air hazard evaluation of the warning levels for school buildings: functionality safety issue*

Warning level	Evaluation logic
	NOT( OR )
	WATER INSIDE THE BUILDING  OR WIND INSIDE THE BLD DIFFICULTIES  OR DIFFICULTIES IN THE PATH TO A SAFE ZONE 
	WIND INSIDE THE BLD SEVERE CONSEQUENCES  OR IMPOSSIBLE TO REACH A SAFE ZONE 

Annex to the VISUS Methodology

AM6 Evaluation Criteria: Safety Upgrading Needs

Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

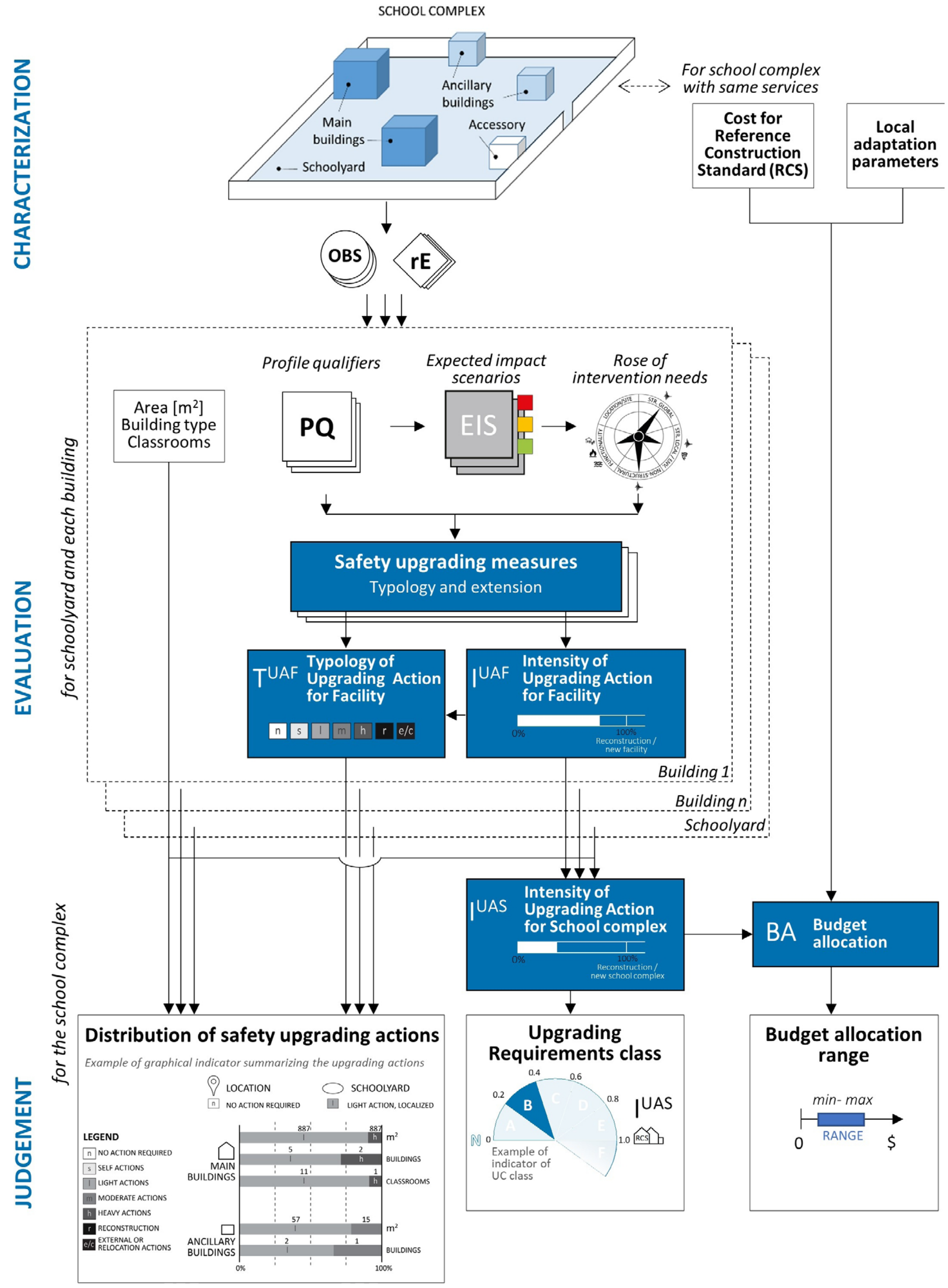
1. SAFETY UPGRADING NEEDS

The Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology aims at providing decision-makers with indicators related to the needs required to upgrade the safety level of schools. The methodology incorporates expert judgement in estimating the budget allocation required to upgrade the safety of a school as well as in determining the intensity of the upgrading actions for a school complex.

The methodology assesses the index of the Intensity of Upgrading Actions for School Complex (I^{UAS}) by comparing it with the efforts that would be required for constructing – in accordance with national building standards – a new school of the same size and services as the school assessed (this school is called the reference construction school). The budget allocation that is potentially required to upgrade the safety level of the school is calculated by multiplying the I^{UAS} index by the cost of a new school per square metre and then by the entire area of the new school. Furthermore, as the VISUS evaluation of the safety situation identifies the potentially critical issues of a school through expected impact scenarios (EIS) and their related profile qualifiers (PQs), it is also possible to identify the potential measures that could remove these critical issues.

Figure 1.1 shows the framework for assessing the indicators for safety upgrading needs, which leads to the determination of the I^{UAS} index and the budget allocation. Following the characterization of a school and the evaluation of its safety situation, the framework enables PQs, EIS and the rose of intervention needs to be assigned or determined. The methodology for assessing safety upgrading needs assigns pre-identified safety upgrading measures to remove the safety critical issues. These measures allow the Typology and Intensity of Upgrading Actions for Facility, T^{UAF} and I^{UAF}, respectively, to be assigned (these parameters are assigned to every building and the schoolyard). These indices are then used to calculate the indicators for the safety upgrading needs of the entire school complex, that is, the distribution of the safety upgrading actions in the school complex, the I^{UAS} index, the upgrading requirements class and the budget allocation.

Fig. 1.1 *VISUS framework for assigning indicators for safety upgrading needs*



1.1 Budget allocation

The budget allocation is an estimate of the financial resources required for implementing the safety upgrading actions for the school. It is calculated multiplying the I^{UAS} index by the area of all the school buildings (main and ancillary) and the range of the reference cost for the construction of a new school (RC_{NCS}). Local circumstances are considered in calculating the final value (Eq. 1.1). The values assigned to RC_{NCS} and to the adaptation coefficients are defined by the VISUS local committee (see Volume 2). Table 1.1 provides the default values for the adaptation coefficients.

The minimum and maximum RC_{NCS} values are determined by considering the cost of the construction of a new school in accordance with the national buildings standards of each country, that is, a school typical for the specific country. The cost is presented as cost per square metre of school building and differs among countries and even regions, provinces and districts. It can also differ depending on the structural type of the building and the site of the building.

Equation 1.1 shows how an estimated range of the budget allocation is calculated.

Eq. 1.1

$$BA[min \div max] = I^{UAS} \cdot RC_{NCS}[min \div max] \cdot \left(\sum_{i=main} A_i + \sum_{j=ancillary} A_j \right) \cdot K_r \cdot K_l \cdot K_s$$

where:

$BA[min \div max]$	range (minimum and maximum values) of the budget allocation (United States dollars)
I^{UAS}	intensity of upgrading action for school complex
$RC_{NCS}[min \div max]$	range (minimum and maximum values) of the reference cost for the new construction of a school per square metre ($/m²)
i	main building
A_i	area of the i-th main building (m²)
j	ancillary building
A_j	area of the j-th ancillary building (m²)
K_r	adaptation coefficient for the variation of RC_{NCS} by country, region, province or district (Table 1.1)
K_l	adaptation coefficient for the variation of RC_{NCS} for disadvantaged location (Table 1.1)
K_s	adaptation coefficient for the variation of RC_{NCS} for difficulties in construction site (Table 1.1)

Table 1.1 *Default values for the adaptation coefficients for calculating budget allocation*

Adaptation coefficient	Default value
K_r	Regional variation. If not defined, $K_r = 1.0$
K_l	Disadvantaged location: $K_l = 1.1$ Otherwise: $K_l = 1.0$
K_s	Difficulties in the constructions site: $K_s = 1.2$ Otherwise: $K_s = 1.0$

1.2 Intensity of Upgrading Actions for School Complex index

The I^{UAS} index expresses the intensity of the actions required to upgrade the safety of a school by comparing them with the effort required to build a new school. The index can also be expressed as the percentage of the effort expected to be required for implementing the safety upgrading actions, with respect to the effort expected to be required for constructing a new school.

Equation 1.2 shows how the I^{UAS} index is calculated.

Eq. 1.2

$$I^{UAS} = \frac{I_{sy}^{UAF} \cdot A_{sy} \cdot w_{sy} + \sum_{i=main} \left(I_i^{UAF} \cdot A_i \cdot w_{type,i} \cdot w_{h,i} \right) + \sum_{j=ancillary} \left(I_j^{UAF} \cdot A_j \cdot w_{type,j} \cdot w_{h,j} \cdot w_{ancil,j} \right)}{\sum_i A_i + \sum_j A_j}$$

where:

I^{UAS}	index of Intensity of Upgrading Actions for School Complex
I_{sy}^{UAF}	index of Intensity of Upgrading Actions for Facility, for the schoolyard (see section 1.3)
A_{sy}	area of the schoolyard (m²)
W_{sy}	weighting for interventions in the schoolyard (Table 1.2)
i	main buildings
I^{UAF}	index of Intensity of Upgrading Actions for Facility, for the i-th main building
A_i^i	area of the i-th main building (m2)
j	ancillary buildings
	index of Intensity of Upgrading Actions for Facility, for the j-th ancillary building
A_j	area of the j-th ancillary building (m2)
W_{type}	weighting for interventions in the temporary, semi-permanent and permanent buildings (Table 1.2)
W_h	weighting for interventions in heritage buildings (Table 1.2)
W_{ancil}	weighting for interventions in ancillary buildings (Table 1.2)

Table 1.2 *Default values for the weightings used in Equation 1.2*

Weighting	Default value
w_{sy}	0.05
w_{type}	Interventions in permanent buildings: 1 Reconstruction of semi-permanent or temporary buildings: 1 (the new building will be permanent) Other interventions in semi-permanent buildings: 0.8 Other interventions in temporary buildings: 0.5
w_h	1.5
w_{ancil}	0.5

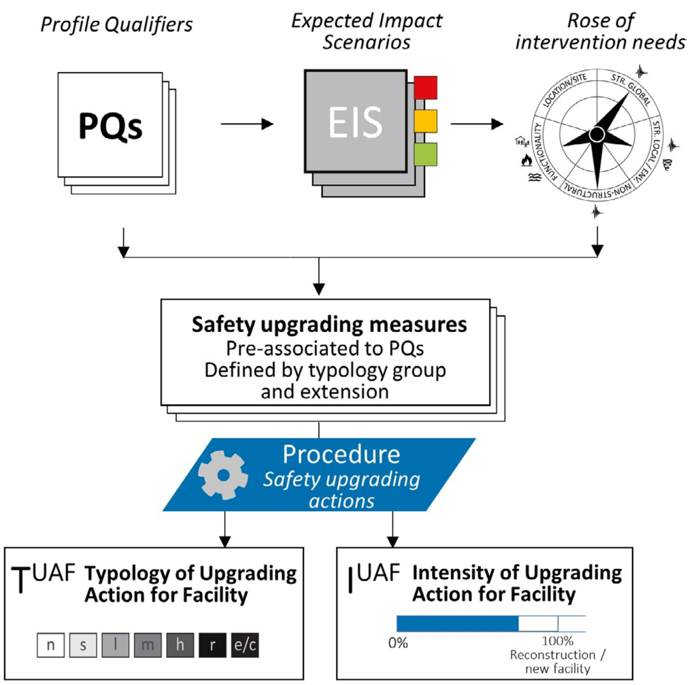
As Equation 1.2 shows, I^{UAS} depends mainly on the I^{UAF} index of the schoolyard and the main and ancillary buildings.

1.3 Typology and Intensity of Upgrading Actions for F*acility* indices

The evaluation of the needs for safety upgrading (which includes the distribution of safety upgrading actions, the upgrading requirements class and the budget allocation) depends on the evaluation of the T^{UAF} and I^{UAF} indices (Fig. 1.1). T^{UAF} and I^{UAF} are calculated for each learning facility of a school complex, that is, the main and ancillary buildings and the schoolyard. For the sake of simplicity, hereinafter the subscripts referring to the schoolyard ('sy'), main building ('i') and ancillary buildings ('j') are not used. The algorithm presented in section 1.4 of this annex describes the procedure for calculating T^{UAF} and I^{UAF} and applies to both schoolyard and buildings.

Both T^{UAF} and I^{UAF} depend on the outcomes of the VISUS safety evaluation and in particular on PQs and on the rose of intervention needs assigned to each facility (Fig. 1.2). The procedure for calculating the indices depends on the assigned safety upgrading measures, which correspond to a generic description of what to do in order to remove a potentially dangerous situation connected to specific PQs. An algorithm is applied to the safety upgrading measures and enables calculation of the indices.

Fig. 1.2 *Determination of Typology and Intensity of Upgrading Actions for Facility indices starts from the profile qualifiers and the rose of intervention needs*



1.3.1 Safety upgrading measures

Experts pre-identify the PQs for which to intervene in order to remove the critical situations (i.e. the needles of the rose of intervention needs) and then assign them a pre-codified safety upgrading measure. Each pre-identified measure is characterized by a specific group and extension.

The groups of safety upgrading measures are:

- **Group 0.** Works on the location to protect the school, or relocation of the school to a safer site.
- **Group 1.** Measures concerning non-structural elements, performed directly by school personnel or by workers with no specific technical skills.
- **Group 2.** Measures concerning non-structural elements, usually performed by skilled workers.
- **Group 3.** Restricted or localized work on structural elements, usually entailing the installation of a small construction site by groups of skilled workers or a small construction company.
- **Group 4.** Significant work on structural elements, usually entailing the installation of a construction site by a large construction company.

Each measure is also characterized by an extension class, which depends on the PQ. The extension class provides an indication of the extension of the measure, that is, of the greatest percentage of the volume (or surface area) of the facility potentially affected by the measure itself and its realization. Table 1.3 shows the pre-codified classes of extension.

Table 1.4 lists the measures defined after expert elicitation (as described in Volume 2, section 3.2.2).

Table 1.3 *Extension classes for the safety upgrading measures*

Extension class	Default value
Localized	0.1 (maximum 10% of the volume or surface area of the facility)
Limited	0.3 (maximum 30% of the volume or surface area of the facility)
Diffused	0.6 (maximum 60% of the volume or surface area of the facility)
Overall	1 (entire facility)

Table 1.4 *List of safety upgrading measures by group*

Measure	Group	Needle-related profile qualifiers	Extension
The intervention is external to the school complex or it is preferable to relocate the school to a safer site	0	*REACHABILITY* POTENTIAL DIFFICULTIES FOR PERSONAL SAFETY U-RF-R2 *REACHABILITY* UNSAFE PATH TO THE SCHOOL U-RF-R3 *TRIGGER / SOURCE* EXTERNAL TRIGGER: RADIATION F-AT-T2 *ACTION INTENSITY* EXTREME ACTION W-AB-C5 *ACTION INTENSITY* TSUNAMY ACTION W-AB-C6 *INDUCED ACTION* POTENTIAL MUD FLOW W-AI-T2 *INDUCED HAZARD* POTENTIAL FLOOD E-AI-M1 *INDUCED HAZARD* POTENTIAL ELECTROCUTION E-AI-M2 *INDUCED HAZARD* POTENTIAL TECHNOLOGICAL ACCIDENT E-AI-M3 *INDUCED HAZARD* POTENTIAL IMPACT BY A ROCKFALL E-AI-N1 *INDUCED HAZARD* ON A LANDSLIDE E-AI-N2 *INDUCED HAZARD* INVOLVED IN A LANDSLIDE E-AI-N3 *INDUCED HAZARD* ON AN ACTIVE FAULT E-AI-N4 *INDUCED HAZARD* POTENTIAL LIQUEFACTION E-AI-N5 *INDUCED HAZARD* POTENTIAL TSUNAMI E-AI-N6 *INDUCED HAZARD* POTENTIAL VOLCANIC HAZARD E-AI-N7	Overall
Secure or remove the falling elements	1	*DANGERS* OBJECTS OR ELEMENTS COULD FALL WITH CONSEQUENT DIFFICULTIES U-RN-E1	Localized
Secure or remove the protruding ele-ments	1	*DANGERS* PEOPLE COULD BUMB THEMSELVES ON PRO-TRUDING ELEMENTS, DIFFICULTIES U-RN-P4	Localized
Secure or remove the dangerous ele-ments	2	*DANGERS* PEOPLE COULD COME INTO CONTACT WITH DANGEROUS ELEMENTS, DIFFICULTIES U-RN-P6	Limited
Confirm pipe seals, and/or add specific devices in corre-spondence of joints	2	*POTENTIAL FALLS OF ELEMENTS* INTERNAL RELEASES OF HAZARDOUS MATERIAL E-RN-E7	Localized
Add lightning conductors and a grounding system	2	*TRIGGER / SOURCE* EXTERNAL TRIGGER: LIGHTNING F-AT-T1	Localized
Secure free flames and take precau-tions to avoid po-tential activation of flammable material	2	*TRIGGER / SOURCE* FREE FLAMES F-AT-T3	Localized
Secure or remove high temperature devices and take precautions to avoid potential ignition of flammable material	2	*TRIGGER / SOURCE* INTERNAL TRIGGER: HIGH TEMPERATURE F-AT-T4	Localized
Take precautions to avoid contaminant dispersion in flood-water	2	*INDUCED DANGERS* FLOOR SUBMERGED W-RN-D1	Localized

Measure	Group	Needle-related profile qualifiers	Extension
Set up an early-warning system and/or define an emergency plan and/or establish emergency paths	2	EGRESS: EGRESS FROM BUILDING POTENTIALLY DIFFICULT (U-RF-E2) EGRESS: SINGLE EGRESS PATH (NO ALTERNATIVES) (F-RF-E1) EGRESS: POTENTIALLY TRAPPED PEOPLE (F-RF-E3) EGRESS: POTENTIAL DIFFICULTIES IN CROWDED AREAS (F-RF-E4) ACTION MODIFIERS: FLASH FLOOD (W-AM-A2) EGRESS: UNSAFE PATH TO SAFE ZONE (W-RF-E3) EGRESS: IMPOSSIBLE TO REACH SAFE ZONE (W-RF-E4) EGRESS: TRAPPED PEOPLE IN FLOODED AREAS (W-RF-E5) EGRESS: TRAPPED PEOPLE IN DRY AREAS (W-RF-E6) EGRESS: DIFFICULTIES IN THE EGRESS PATH (E-RF-E2) EGRESS: NO SAFE ZONES (E-RF-E3) EGRESS: IMPOSSIBLE TO EXIT (E-RF-E4) EGRESS: DIFFICULTIES IN THE PATH TO SAFE ZONE (A-RF-E2) EGRESS: IMPOSSIBLE TO REACH SAFE ZONE (A-RF-E3) EGRESS: NO SAFE ZONE (A-RF-E4)	Localized
Take precautions to avoid potential electrocution, for example by securing and stabilizing electrical connections	2	DANGERS: PEOPLE COULD COME INTO CONTACT WITH DANGEROUS ELEMENTS, SEVERE CONSEQUENCES (U-RN-P5) INDUCED DANGERS: POTENTIAL ELECTROCUTION (W-RN-D2)	Localized
Confirm the stability of non-structural elements and eventually stabilize, remove or replace them	2	POTENTIAL FALLS OF ELEMENTS: FALLS, INTERNAL, LOCALIZED, SEVERE CONSEQUENCES (E-RN-E1) POTENTIAL FALLS OF ELEMENTS: FALLS, INTERNAL, LOCALIZED, DIFFICULTIES (E-RN-E3) POTENTIAL FALL OF ELEMENTS: INTERNAL, LOCALIZED, SEVERE CONSEQUENCES (A-RN-E1) POTENTIAL FALL OF ELEMENTS: INTERNAL, LOCALIZED, DIFFICULTIES (A-RN-E3) POTENTIAL FALL OF ELEMENTS: EXTERNAL, LOCALIZED, SEVERE CONSEQUENCES (A-RN-E5)	Localized
		DANGERS: OBJECTS OR ELEMENTS COULD FALL WITH CONSEQUENT SEVERE CONSEQUENCES (U-RN-E2) POTENTIAL FALLS OF ELEMENTS: FALLS, INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES (E-RN-E2) POTENTIAL FALLS OF ELEMENTS: FALLS, INTERNAL, WIDESPREAD, DIFFICULTIES (E-RN-E4) POTENTIAL FALLS OF ELEMENTS: OVERTURNING, INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES (E-RN-E5) POTENTIAL FALLS OF ELEMENTS: OVERTURNING, INTERNAL, WIDESPREAD, DIFFICULTIES (E-RN-E6) POTENTIAL FALLS OF ELEMENTS: FALLS, EXTERNAL, WIDESPREAD, DIFFICULTIES (E-RN-E8) POTENTIAL FALLS OF ELEMENTS: FALLS, EXTERNAL, WIDESPREAD, SEVERE CONSEQUENCES (E-RN-E9) POTENTIAL FALLS OF ELEMENTS: FALLS, EXTERNAL FROM OTHER CONSTR., WIDESPREAD, SEVERE CONSEQUENCES (E-RN-E10) POTENTIAL FALL OF ELEMENTS: INTERNAL, WIDESPREAD, SEVERE CONSEQUENCES (A-RN-E2) POTENTIAL FALL OF ELEMENTS: INTERNAL, WIDESPREAD, DIFFICULTIES (A-RN-E4) POTENTIAL FALL OF ELEMENTS: EXTERNAL, WIDESPREAD, SEVERE CONSEQUENCES (A-RN-E6) POTENTIAL FALL OF ELEMENTS: EXTERNAL, WIDESPREAD, DIFFICULTIES (A-RN-E7)	Limited
Provide safe and resistant windows and doors	2	INCREASE IN STRESS: WIND FLOW INSIDE THE BUILDING CAUSING POTENTIAL DIFFICULTIES (A-RM-S1)	Localized
		INCREASE IN STRESS: WIND FLOW INSIDE THE BUILDING CAUSING POTENTIALLY SEVERE SITUATIONS (A-RM-S2)	Limited
		INCREASE IN STRESS: FREE WIND FLOW IN THE STRUCTURE (A-RM-S3)	Diffused
Provide protection against dangerous animals	2	DANGERS: DANGEROUS ANIMALS COULD ENTER IN THE SCHOOL (U-RN-P7)	Limited
Install a fire protection system or protect from fire activation (i.e. remove fire triggers)	2	EXPECTED FIRE SCENARIO: POTENTIAL ELEVATED GENERATION OF SMOKE SCENARIO (F-AB-T1) EXPECTED FIRE SCENARIO: POTENTIAL SMALL FIRE SCENARIO (F-AB-T2) EXPECTED FIRE SCENARIO: POTENTIAL VERTICALLY DEVELOPED FIRE SCENARIO (F-AB-T3) EXPECTED FIRE SCENARIO: POTENTIAL HORIZONTALLY DEVELOPED FIRE SCENARIO (F-AB-T4) EXPECTED FIRE SCENARIO: POTENTIAL ENVELOPE FIRE SCENARIO (F-AB-T5) EXPECTED FIRE SCENARIO: POTENTIAL EXTENDED FIRE SCENARIO (F-AB-T6) EXPECTED FIRE SCENARIO: POTENTIAL EXPLOSION SCENARIO (F-AB-T7)	Limited

Measure	Group	Needle-related profile qualifiers	Extension
Protect foundations from erosion	2	UNDERMINING: UNDERMINING WITH GROUND EROSION AND NO DIGGING OUT OF FOUNDATIONS (W-RL-U1); UNDERMINING: POTENTIAL UNDERMINING WITH DIGGING OUT OF FOUNDATIONS (W-RL-U2)	Limited
Improve the connection of non-structural elements (e.g. sidings, roofs)	2	LOCAL CRITICAL ISSUES: POOR CONNECTION OF SIDINGS (A-RL-F3); LOCAL CRITICAL ISSUES: POOR CONNECTION OF ROOF COVERING, DIFFICULTIES (A-RL-F4); LOCAL CRITICAL ISSUES: POOR CONNECTION OF ROOF COVERING, SEVERE CONSEQUENCES (A-RL-F5)	Limited
Secure areas from falls of people (e.g. with a parapet)	2	DANGERS: PEOPLE COULD FALL WITH CONSEQUENT DIFFICULTIES (U-RN-P1); DANGERS: PEOPLE COULD FALL, WITH SEVERE CONSEQUENCES (U-RN-P2)	Limited
Improve comfort and healthiness in the building (e.g. check for water infiltration)	2	HEALTHINESS: PRESENCE OF DISCOMFORTS WITH POT. CONSEQUENCES FOR HEALTH (U-RF-S2)	Limited
Define an emergency plan and prepare, where possible, valuable contents to be moved to a safe zone	2	INDUCED DANGERS: POTENTIAL LOSS OF CONTENTS (W-RN-D3)	Limited
Prepare equipment to withstand floodwater or move it above expected floodwater level	2	INDUCED DANGERS: POTENTIAL LOSS OF EQUIPMENT (W-RN-D4)	Limited
Secure objects containing contaminants	2	INDUCED DANGERS: POTENTIAL RELEASE OF CONTAMINANTS IN THE SCHOOLYARD (W-RN-D5); INDUCED DANGERS: POTENTIAL RELEASE OF CONTAMINANT IN THE BUILDING (W-RN-D6)	Diffused
Level the ground surface and provide adequate flooring	2	DANGERS: PEOPLE COULD SLIP WITH CONSEQUENT DIFFICULTIES (U-RN-P3)	Diffused
Improve the condition of the building repairing the elements with poor condition	2	STRUCTURAL CRITICAL ISSUES: STRUCTURAL WEAKNESSES WITH FEEBLE EFFECTS (U-RB-T1); LOCAL CRITICAL ISSUES: LOCALIZED FAILURES DIFFICULTIES (E-RL-C4)	Diffused
Confirm the structural global resistance by in-depth analysis	3	(STR. GLOBAL warning level 1); (STR. GLOBAL warning level 2)	Localized
Improve the connection of structural elements (e.g. walls, roof)	3	LOCAL CRITICAL ISSUES: LOCALIZED FAILURES WEAKNESSES (A-RL-F6)	Localized
		LOCAL CRITICAL ISSUES: POOR CONNECTIONS AMONG STRUCTURAL ELEMENTS (WALLS OR COLUMNS) (A-RL-F1); LOCAL CRITICAL ISSUES: POOR CONNECTION OF THE ROOF WITH THE STRUCTURE (WALLS OR COLUMNS) (A-RL-F2)	Limited
		LOCAL STRESS: LOCAL STRESS CONCENTRATION (W-RL-C2)	Diffused

Measure	Group	Needle-related profile qualifiers	Extension
Remove stress concentration, eventually adding new structural elements for the distribution of loads, or if this is not possible, reinforce critical parts	3	*LOCAL CRITICAL ISSUES* SLIDING E-RL-C1; *LOCAL CRITICAL ISSUES* LOCALIZED STRESS CONCENTRATED DIFFICULTIES E-RL-C2; *LOCAL CRITICAL ISSUES* LOCALIZED STRESS CONCENTRATED SEVERE CONSEQUENCES E-RL-C3; *INCREASE IN LOCAL STRESS* INCREASE IN STRESS ON EXTENSIONS A-RL-C1	Limited
Stabilize and/or reinforce elements, eventually adding new load-supporting elements	3	*LOCAL CRITICAL ISSUES* LOCALIZED FAILURES SEVERE CONSEQUENCES E-RL-C5; *INCREASE IN LOCAL STRESS* WEAKNESSES IN STRUCTURAL BEHAVIOUR A-RL-C4	Limited
Provide good anchorage of the building to the ground	3	*CONNECTION TO GROUND* LOCAL ANCHORAGE, MOVABLE W-RB-A2; *CONNECTION TO GROUND* UNANCHORED A-RB-A2	Limited
Minimize wings effects, eventually adding new structural elements or reinforcing local elements	3	*ROBUSTNESS MODIFIERS* HORIZONTAL, WINGS E-RM-B5	Limited
Reinforce structural elements along their weaker direction, eventually adding new structural elements	3	*ROBUSTNESS MODIFIERS* WEAKER DIRECTION E-RM-Q2	Limited
Confirm the stability of the floor and/or of structural elements with the potential to fall, eventually reinforcing them	3	*LOCAL CRITICAL ISSUES* LOCAL FAILURE OR FALLS U-RL-F1	Limited
Improve the quality of structural material (e.g. substitute elements or reinforce existing elements)	3	*ROBUSTNESS MODIFIERS* POOR CONSTRUCTION OR MATERIAL QUALITY E-RM-Q5	Limited
Minimize stress concentration potentially caused by vertical irregularities, eventually adding new structural elements or reinforcing local elements	3	*ROBUSTNESS MODIFIERS* VERTICAL BEHAVIOUR, DIFFERENT PHASES E-RM-B7	Limited
		ROBUSTNESS MODIFIERS VERTICAL BEHAVIOUR, KNEE E-RM-B8	Diffused

Measure	Group	Needle-related profile qualifiers	Extension
Minimize torsional effects, eventually adding new structural elements or reinforcing local elements	3	ROBUSTNESS MODIFIERS NON-UNIFORM DISTRIBUTION OF RESISTANCE SYSTEM E-RM-D2; ROBUSTNESS MODIFIERS HORIZONTAL, TORSION E-RM-B4	Diffused
Stabilize and connect disconnected structural elements	4	ROBUSTNESS MODIFIERS DISCONNECTABLE E-RM-B2	Diffused
Protect the structural elements from fire	4	STRUCTURAL BEHAVIOUR COMBUSTIBLE STRUCTURE F-RB-T1; STRUCTURAL BEHAVIOUR HEAT-SENSIBLE STRUCTURE F-RB-T2; STRUCTURAL BEHAVIOUR DROPPING WHILE BURNING F-RB-T3	Overall
Reinforce or upgrade the entire structure	4	STRUCTURAL CRITICAL ISSUES POTENTIAL GLOBAL STRUCTURAL FAILURE U-RB-T2; ROBUSTNESS MODIFIERS WEAK (FEEBLE STRUCTURE) E-RM-Q3	Overall
Stabilize and/or reinforce crumbling structural material	4	ROBUSTNESS MODIFIERS CRUMBLING E-RM-B1	Overall

j

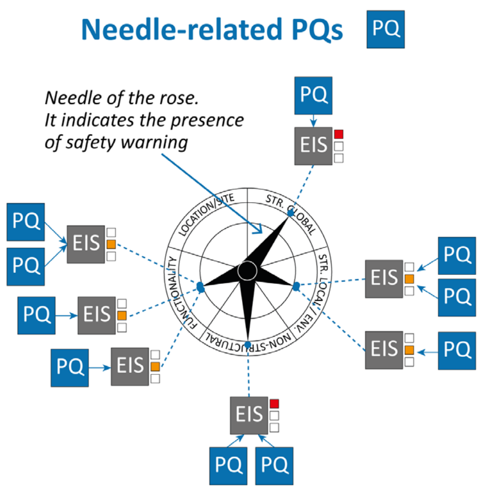
1.4 Algorithm for calculating Typology and Intensity of Upgrading Actions for Facility indices

This section describes the algorithm for calculating the T^{UAF} and I^{UAF} indices. The algorithm is applied to each school facility (school buildings and schoolyard). The process first identifies the potentially dangerous situations for which to intervene (point 1), and then assigns pre-codified measures to remove these situations (point 2). It groups the measures and calculates the effort for implementing the measures of each group (points 3 to 7). The I^{UAF} index is a weighted sum of the level of effort calculated for each group of measures (point 9). T^{UAF} is calculated considering the highest group of assigned measures, or the value of I^{UAF} for assigning reconstruction (points 10 and 11). A value of I^{UAF} is assigned to each school facility, and together these values enable I^{UAS} for the entire school complex to be calculated.

The algorithm for T^{UAF} and I^{UAF} is described in the following points and illustrated in the flowchart shown in Figure 1.5.

1. For each needle of the assigned rose of intervention needs, the algorithm identifies and extracts all the assigned PQs. These PQs are the 'needle-related PQs'. Figure 1.3 shows how the needle-related PQs are associated with the rose.

Fig. 1.3 *Definition of the needle-related profile qualifiers*



2. The needle-related PQs are used to identify the required safety upgrading measures (M_i) listed in Table 1.4 with their extension (E_{Mi}) and group. Each measure can be selected only once for each building (or schoolyard); the methodology supposes that if there are multiple PQs requiring the same measure, the realization of the measure will result in removal of the potentially dangerous situations connected to all those PQs.

3. The extracted measures are grouped in accordance with their typology. If a measure of Group 0 is selected, then = 'external or relocation'.

4. Using the default values for extension classes in Table 1.3, a value is assigned to the extension of each measure (E_{Mi}).
5. For each group (Gi), the wideness (Wid_{Gi}, where i= 1 ÷ 4) is calculated by summing the extension values ($E_{M\ GI}$).

Eq. 1.3 $$Wid_{Gi} = \sum_j E_{M_j Gi} \quad \text{for } i=1 \div 4$$

6. For each group, T_{Gi} is calculated using Equation 1.4.

Eq. 1.4 $$T_{Gi} = \begin{cases} 0 & \text{if } Wid_{Gi}=0 \\ 1 & \text{otherwise} \end{cases}$$

7. For each group, the level of effort L_{Gi} is calculated using Equation 1.5.

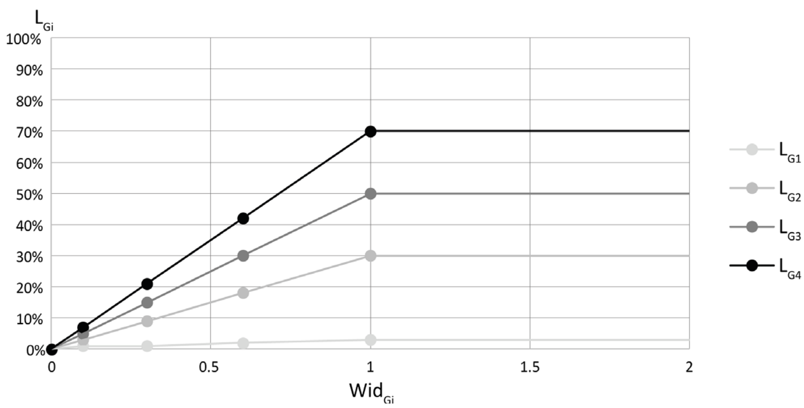
Eq. 1.5 $$L_{Gi}(Wid_{Gi}) = \begin{cases} L_{Gi}(1.0) \cdot Wid_{Gi} & \text{if } Wid_{Gi} \le 1 \\ L_{Gi}(1.0) & \text{if } Wid_{Gi} > 1 \end{cases}$$

The maximum value of the level of effort ($L_{Gi}(1.0)$) expresses the maximum allowable effort as a percentage of the effort necessary for the reconstruction of a new school. As an example, $L_{G2}(1.0)$ = 30 per cent means that the maximum effort allowed for implementing all the measures in group G2 (extension 1.0) is 30 per cent of the expected effort for the construction of a new school with the same characteristics. Table 1.5 gives the default values assigned to $L_{Gi}(1.0)$. The graphs in Figure 1.4 illustrate the potential values of Equation 1.5.

Table 1.5 *Proposed values for the maximum level of effort of each group*

	G1	G2	G3	G4
$L_{Gi}(1.0)$	3.0%	30.0%	50.0%	70.0%

Fig. 1.4 *Graphical representation of equation 1.5, using the values of table 1.5*



8. The coefficient T_{max} is calculated as the maximum of the T_{Gi} values (Eq. 1.6). T_{max} represents the highest group with at least one measure.

Eq. 1.6 $$T_{max}=\max(T_{G1},T_{G2},T_{G3},T_{G4})$$

9. The algorithm then calculates I^{UAF}. The index is calculated by summing the level of effort of each group, but it is assumed that the level of effort of a group is reduced if it is summed to the level of effort of a higher group. This aims at reproducing the fact that a measure, if performed with measures of a higher group, has a lower impact on the overall upgrading needs. This aspect is considered through a reduction coefficient α (Table 1.7) multiplied for each shift from a group to the higher group. As an example, if T_{max} = 3, the level of effort of the measures of group G1 is multiplied twice by $\alpha(\alpha^2)$, while the level of effort of group G2 is multiplied by α.

Table 1.6 *Reduction of the level of effort from a group to the higher group*

	Proposed value
α	0.7

Equation 1.7 shows how the I^{UAF} index is calculated.

Eq. 1.7

$$I^{UAF} = \sum_{i=1:4} L_{Gi} \cdot \alpha^{(T_{max}-i)}$$

As an example, if a building requires measures that imply L_{G2} = 18%, L_{G3} = 15% and L_{G4} = 42%, then T_{max} = 4 and I^{UAF} is calculated as:
I^{UAF} = 0% · 0.7(4-1) + 18% · 0.7(4-2) + 15% · 0.7(4-3) + 42% · 0.7(4-4) = 61.3%

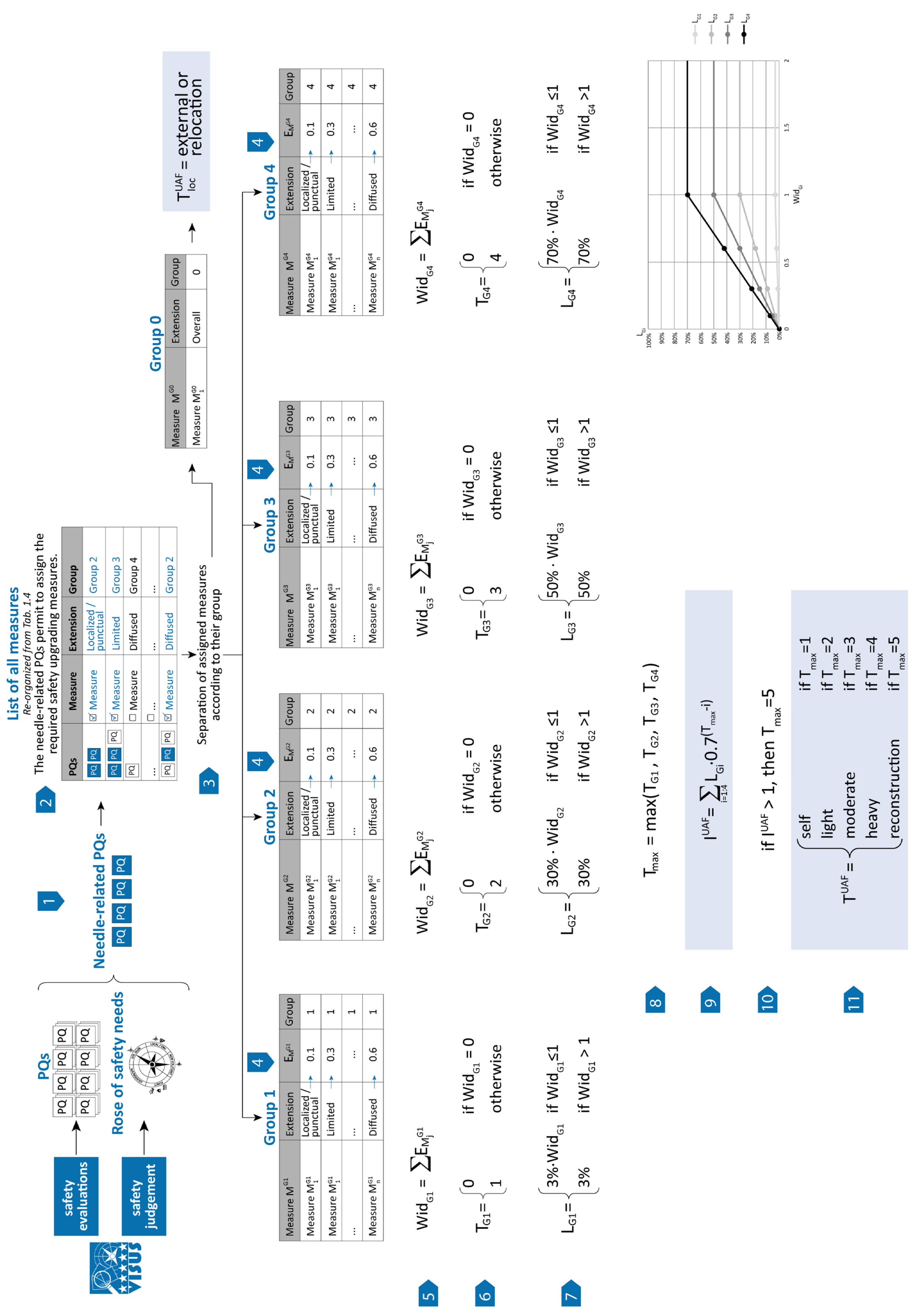
10. If I^{UAF} is larger than one (default value), it means that it could be more economical to reconstruct the school than to implement the safety upgrading actions for the school facilities. Therefore, T_{max} is set to the value of 5 in order to consider this aspect.

11. The T^{UAF} index is then assigned. T^{UAF} depends on the values of T_{max} (Table 1.7) and define the upgrading action.

Table 1.7 *Association between T_{max} and the Typology of Upgrading Actions for Facility (T^{UAF}) index*

T_{max}	T^{UAF}
1	Self
2	Light
3	Moderate
4	Heavy
5	Reconstruction

Fig. 1.5 *Flowchart for calculating the Typology and Intensity of Upgrading Actions for Facility indices*



Annex to the VISUS Methodology

AM7 Evaluation Criteria: Status

Please kindly note that the content of the annex is subject to updates. The latest version of the annex can be accessed here:

- http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/school-safety/safety-assessment-method-visus/
- http://sprint.uniud.it/en/research/methodologies/visus

1. STATUS

This annex describes the criteria adopted for evaluating the status conditions for each school building and for the school complex as a whole.

The Visual Inspection for defining Safety Upgrading Strategies (VISUS) methodology enables evaluation of the following status conditions:

- Accessibility: the possibility of people with mobility impairments attending the school.
- Water and sanitation: the main conditions related to hygiene.
- Contents/equipment: the presence of furnishings, equipment and materials.
- Maintenance: whether the school is kept in a suitable condition.
- Comfort: the presence of conditions that could hinder student attendance in classes.
- Security: the security conditions of the school, including the protection of students from external dangers.

The status conditions assigned to the school complex (section 1.1) depend on the status conditions of the schoolyard (section 1.2) and of the school buildings (section 1.3).

In the remainder of this annex, the criteria for assigning the status judgements for a school complex are described, and then the logical rules used for assigning each class for each status, considering the school complex, the schoolyard and the school building, are presented.

1.1 Status of the school complex

The status of the school complex depends on the evaluation of the status for the schoolyard and the school buildings. Table 1.2 lists the rules for attributing the status to the school complex in accordance with the descriptions in Table 1.1.

Table 1.1 *Status conditions evaluated in VISUS*

Status name and icon	Pictogram	Description of meaning
Accessibility (usability)	NOT ACCESSIBLE	People with mobility impairments are not able to attend the school
	PARTIALLY ACCESSIBLE	People with mobility impairments have partial access to the school and to basic services
	ACCESSIBLE	People with mobility impairments have full access to the school and the school services
Water and sanitation	POOR	Poor water and sanitation conditions; absence of drinking water
	BASIC	Basic water and sanitation conditions; presence of drinking water
	GOOD	Good water and sanitation conditions; hygiene is guaranteed
Content / equipment	POOR	Minimal educational equipment, very poor contents
	BASIC	Intermediate contents
	HIGH TECH	High-tech contents

Status name and icon	Pictogram	Description of meaning
Maintenance	POOR	Evidence of poor maintenance and/or unrepaired damage in most of the main buildings
	BASIC	Intermediate conditions
	GOOD	All the school buildings (both main and ancillary) have good maintenance conditions
Comfort	POOR	Some students attend classes with uncomfortable conditions
	BASIC	Intermediate comfort conditions
	GOOD	Good comfort conditions
Security	UNCONTROLLED OR UNLIMITED ACCESS	Access to the schoolyard and/or buildings is not controlled or limited: anyone can enter the school
	LIMITED ACCESS	No access control, but access to the school is limited by fences
	CONTROLLED ACCESS	Access to the schoolyard and buildings is controlled

Table 1.2 *Evaluation of the status conditions for the school complex considering the evaluation of the schoolyard and the school buildings*

Status	Pictogram	Conditions
Accessibility	NOT ACCESSIBLE	Other
	PARTIALLY ACCESSIBLE	At least one building with accessible toilet
	ACCESSIBLE	(All main buildings are accessible) AND (Schoolyard is accessible)
Water and sanitation	POOR	Schoolyard or all main buildings are poor
	BASIC	Other
	GOOD	Schoolyard and all main building is good
Contents/equipment	POOR	All main buildings are poor
	BASIC	Other
	HIGH TECH	All main buildings are high-tech
Maintenance	POOR	All main buildings are poor
	BASIC	Other
	GOOD	All buildings (main and ancillary) are good
Comfort	POOR	Schoolyard or at least one main buildings are poor
	BASIC	Other
	GOOD	Schoolyard and all main building is good

Status	Pictogram	Conditions
Security	UNCONTROLLED OR UNLIMITED ACCESS	Schoolyard has uncontrolled or unlimited access
	LIMITED ACCESS	Other
	CONTROLLED ACCESS	Schoolyard and buildings have controlled access

1.2 Status of the schoolyard

Table 1.3 lists the rules for attributing the status to the schoolyard.

Table 1.3 *Evaluation of the status conditions for the schoolyard*

Status	Pictogram	Conditions
Accessibility (usability)	NOT ACCESSIBLE	2S1a.D OR 1U1c.L OR 1U1d.L
	PARTIALLY ACCESSIBLE	2S1b.D
	ACCESSIBLE	Other
Water and sanitation	POOR	2S2a.D
	BASIC	Other
	GOOD	2S2c.D AND 2S2a.D
Comfort	POOR	Other
	BASIC	2S3b.D AND 2S3d.D
	GOOD	2S3a.D AND 2S3b.D AND 2S3d.D
Security	UNCONTROLLED OR UNLIMITED ACCESS	Other
	LIMITED ACCESS	(2S4c.D AND 2S4d.D) OR (2S4c.D AND 2S4e.D AND NOT 2S4g.D)
	CONTROLLED ACCESS	2S4c.D AND 2S4e.D AND 2S4g.D

1.3 Status of the school buildings

Table 1.4 lists the rules for attributing the status to the schoolyard, using the definitions in Table 1.5.

Table 1.4 *Evaluation of the status conditions for the school buildings*

Status	Pictogram	Conditions
Accessibility (usability)	NOT ACCESSIBLE	NOT (**Free_Mobil**)
	PARTIALLY ACCESSIBLE	(**Free_Mobil**) AND NOT 4S1d.D
	ACCESSIBLE	(**Free_Mobil**) AND 4S1d.D
Water and sanitation	POOR	Other
	BASIC	4S2a.D
	GOOD	4S2a.D AND 4S2f.D AND 2S2c.D AND 4S4d.D
Contents/ equipment	POOR	4S4b.D
	BASIC	Other
	HIGH TECH	4S3b.D AND 4S3c.D
Maintenance	POOR	4S7a.D OR 3G7e.S OR 4G7b.S
	BASIC	3G7g.S AND NOT (4S7a.D OR 3G7e.S OR 4G7b.S)
	GOOD	Other

Comfort	POOR	(4S5f.D OR 4U6a.F OR 4U6d.F OR 4U6e.F) OR [(4U6c.F OR 4U6b.F) AND NOT (4S5a.D OR 4S5b.D OR 4S5c.D OR 4S5d.D OR 4S5e.D)]
	BASIC	[(4U6c.F OR 4U6b.F) AND (4S5a.D OR 4S5b.D OR 4S5c.D OR 4S5d.D OR 4S5e.D)] OR other
	GOOD	NOT (4U6c.F OR 4U6b.F) AND (4S5a.D OR 4S5b.D OR 4S5c.D OR 4S5d.D OR 4S5e.D)
Security	UNCONTROLLED OR UNLIMITED ACCESS	4S6a.D OR other
	LIMITED ACCESS	2S4c.D AND 2S4d.D
	CONTROLLED ACCESS	2S4c.D AND 2S4e.D AND 2S4g.D

Table 1.5 *Supporting definitions for evaluating the status of the school buildings*

Name	Description	Conditions
Floors_ag	Number of above-ground floors (or stories) – NUMBER	–
Toilets	Presence of toilets in the building – LOGICAL	–
Free_Mobil	Free mobility in the building	{[Floors_ag>1 AND (NOT 4S1b.D OR 4S1c.D)] OR [Floors_ag=1]} AND NOT (4S1a.D OR 4S1b.D)

Annex to the VISUS Methodology

AM8 Bibliography

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- http://sprint.uniud.it/en/research/methodologies/visus

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VOLUME 1 - Introduction to learning facilities assessment and to the VISUS methodology

VOLUME 2 - VISUS Methodology

VOLUME 3 - VISUS Implementation

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