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RBE Assessment System: Climate Risk Evaluation at Building and Neighbourhood scale

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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Foreword

This CEN Workshop Agreement (CWA 18284:2026) has been developed in accordance with the CEN-CENELEC Guide 29 “CEN/CENELEC Workshop Agreements – A rapid way to standardization” and with the relevant provisions of CEN/CENELEC Internal Regulations - Part 2. It was approved by the Workshop CEN “RBE Assessment System: Climate Risk Evaluation at Building and Neighbourhood scale”, the secretariat of which is held by UNI Ente Italiano di Normazione consisting of representatives of interested parties on 2026-10-26, the constitution of which was supported by CEN following the public call for participation made on 2026-02-26. However, this CEN Workshop Agreement does not necessarily include all relevant stakeholders.

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The following organizations and individuals developed and approved this CEN Workshop Agreement:

— Andrea Moro – iiSBE Italia, Chairperson

— Licia Felicioni – University Centre for Energy Efficient Buildings, Vice-Chairperson

— Fabio Rossi – UNI Ente Italiano di Normazione, Secretary

— Carmela Apreda – CMCC Foundation

— Constantinos Balaras – National Observatory of Athens

— Stefano Baldo – Regione Veneto – Direzione Ambiente e Transizione Ecologica

— Elena Bazzan – iiSBE Italia

— Markus Berchtold – Heimaten

— Pál Bese Domonkos – FeliCITY – Tools Engineering

— Ruben Paul Borg – University of Malta

— Glorianne Borg Axisa – University of Malta

— Paola Borgaro – iiSBE Italia

— Claudio Chiapparini – Regione Veneto – Direzione Ambiente e Transizione Ecologica

— Olena Danylenko – UIRECA GmbH – Urban Institute for Regenerative Environments and Climate Adaptation

— Ludovico Lanza – Consiglio Nazionale delle Ricerche – Istituto per le Tecnologie della Costruzione (CNR-ITC)

— Elena Dascalaki – National Observatory of Athens

— Anna Devitofrancesco – Consiglio Nazionale delle Ricerche – Istituto per le Tecnologie della Costruzione (CNR-ITC)

— Ilja Drmač – Energy Institute Hrvoje Požar

— Kalliopi Droutsa – National Observatory of Athens

— Katia Federico – Regione Veneto – Direzione Ambiente e Transizione Ecologica

— Miriam Fernández-Núñez – CIEDES Foundation

— Ludmila Fictumova – University Centre for Energy Efficient Buildings

— María del Carmen García Peña – CIEDES Foundation

— Cristiano Gastaldi – iiSBE Italia

— Ilaria Gnecco – Department of Civil Chemical and Environmental Engineering, University of Genova

— Patrice Godonou – Swedish Wood

— Šárka Havránková – Municipal District of Prague 5

— Barbora Hejtmanova – University Centre for Energy Efficient Buildings

— Leon Hutschenreuther – Deggerdorf Institute of Technology

— Lucie Kamler – Municipal District of Prague 5

— Ahmed Khoja – Deggerdorf Institute of Technology

— Katerina Klepacova – University Centre for Energy Efficient Buildings

— Woytek Kujawski – Integrative Solutions Group (ISG)

— Sara Lindner – Munich University of Applied Sciences

— Daniel Lückerath – Fraunhofer Institute for Intelligent Analysis and Information Systems (IAIS)

— Niazkar Majid – CMCC Foundation

— Lluisa Marsal Llacuna – Nunsys

— Melissa Herlitz – CMCC Foundation

— Elena María Mesa Alcaraz – CIEDES Foundation

— Shaahin Nazarpour Tameh – Department of Civil Chemical and Environmental Engineering, University of Genova

— Berhard Nimbach – Nimbach Consult

— Anna Palla – Department of Civil Chemical and Environmental Engineering, University of Genova

— Raffaella Pastore – Regione Piemonte

— Virginia Pellerey – iiSBE Italia

— Ivona Prar – Energy Institute Hrvoje Požar

— Elena Purpura – Regione Piemonte

— Adithya Ramanthan Krishnan – Individual Professional

— Alfredo Reder – CMCC Foundation

— Maria Pia Repetto – Department of Civil Chemical and Environmental Engineering, University of Genova

— Guglielmo Ricciardi – CMCC Foundation

— Chiara Rinaldi – Sustainaccount AG

— Brenda Roqueta Vives – Munich University of Applied Sciences

— Kajetan Sadowski – Individual Professional

— Faye Sciberras – University of Malta

— Christian Spindler – Sustainaccount AG

— Sara Torabi Moghadam – Politecnico di Torino

— Lukáš Vacek – Municipal District of Prague 5

— Pavlina Zatecka – University Centre for Energy Efficient Buildings

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Introduction

This CEN Workshop Agreement (CWA) presents the RBE Assessment System, which was progressively developed through a series of Interreg projects and finalised within the SuPeRBE project (Supporting Cross-scale Planning and Policy readiness for a Resilient Built Environment), funded by the Interreg Central Europe Programme. SuPeRBE consolidated and finalised the methodological framework and operational tools of the RBE Assessment System, building on the results of previous Interreg projects, namely Habit.A (Interreg ALCOTRA), ADAPTNOW (Interreg Alpine Space) and ReMED (Interreg EuroMED), under the scientific coordination of iiSBE Italia R&D and with the contribution of technical and scientific partners from 14 EU countries. The RBE Assessment System provides a framework for assessing climate risks at neighbourhood and building scales, filling a relevant gap concerning the availability of operational assessment systems at these scales.

The RBE Assessment System comprises the RBE Method, which provides the common methodological principles and calculation logic, and two generic frameworks implementing the method at different spatial scales: RNTool (Resilient Neighbourhood Tool) at neighbourhood scale and RBTool (Resilient Building Tool) at building scale. Once contextualised to local climatic, territorial, regulatory and data conditions, RNTool and RBTool become operational assessment tools.

The RBE Method is an evolution of the original SBE Method (Sustainable Built Environment Method) developed by iiSBE International (international initiative for a Sustainable Built Environment). The SBE Method was originally conceived as a multi-criteria assessment method for evaluating the sustainability performance of the built environment and has been implemented through generic frameworks such as SBTool (Sustainable Building Tool) at building scale and SNTool (Sustainable Neighbourhood Tool) at neighbourhood scale. The RBE Method builds on this methodological background and adapts it to climate risk assessment by aligning its structure and assessment logic with the IPCC risk concept.

The RBE Method was originally developed based on the climate-risk framework established in the IPCC Fifth Assessment Report, in which risk is understood as the result of the interaction between hazard, exposure and vulnerability. This conceptual structure remains the methodological foundation of the RBE Assessment System. The method has subsequently evolved to align with the broader and more dynamic perspective developed in the IPCC Sixth Assessment Report, which emphasises that hazard, exposure and vulnerability may change over time and may be influenced by climate scenarios, socioeconomic and territorial transformations, and adaptation responses. Accordingly, the RBE Method supports scenario-based and repeated assessments, the evaluation of response effectiveness and residual risk. This evolution preserves the operational clarity of the original hazard–exposure–vulnerability model while extending its use to adaptation planning, option appraisal and monitoring.

The RBE Assessment System is consistent with the general principles of climate change adaptation described in EN ISO 14090 and with the vulnerability, impact and risk assessment guidance provided in EN ISO 14091.

The development of the RBE Assessment System responds to the need for tools specifically designed to evaluate climate risk at building and neighbourhood scale. In general, the sustainability assessment systems provide valuable support for evaluating environmental, social and economic performance. However, they are generally not conceived as climate risk assessment systems. In most cases, they address only selected aspects related to vulnerability without implementing a complete risk-based approach. Consequently, they do not usually assess climate risk as the combined effect of hazard, exposure and vulnerability, nor do they provide a structured method for calculating risk values for exposed elements at building and neighbourhood scales.

This gap is particularly relevant because climate adaptation measures need to be localised and implemented at operational scales. Strategic plans (e.g., SECAPS) and policies often define adaptation objectives at municipal or regional level, but the effectiveness of such objectives depends on their translation into concrete measures. Building and neighbourhood scales represent the levels at which strategic adaptation measures are operationalized, designed, implemented and monitored. The

availability of specific assessment systems at these scales is essential to identify priority risks, compare adaptation options, support decision-making and verify progress over time.

The need for climate risk assessment systems at building and neighbourhood scales is also reinforced by the evolution of European policies. A more comprehensive application of the DNSH (Do No Significant Harm) principle requires the capacity to demonstrate that interventions on buildings and urban areas do not significantly increase climate-related risks and, where relevant, contribute to adaptation objectives. Similarly, the implementation of the revised Energy Performance of Buildings Directive requires a broader understanding of building performance, including the capacity of buildings to respond to current and future climate conditions. In addition, the European Commission's Level(s) framework supports the progressive harmonisation of building sustainability assessment across Europe and includes climate resilience and adaptation among the relevant objectives to be considered throughout the building life cycle. The relevance of this need is further confirmed by the European Environment Agency's 2024 European Climate Risk Assessment, which identifies major and increasingly urgent climate risks affecting Europe's infrastructure and built environment and highlights the need to accelerate adaptation action for buildings, urban systems and critical services. More recently, the European Commission's Communication "A Resilient Europe for a Changing Climate" (COM(2026) 720 final, 27 October 2026) reinforces the importance of coherent climate risk assessments and their use in spatial planning and investment decisions, promoting a shift towards anticipating and managing risks under projected future climate conditions. The Communication also identifies cooperation with European standardisation organisations as a means of integrating climate risks into relevant standards and developing common methods for testing and performance assessment of climate resilience solutions. These policy directions further underline the relevance of a structured and transparent assessment framework, such as the RBE Assessment System, to support the translation of European climate resilience objectives into operational assessments and adaptation measures at building and neighbourhood scales.

In this context, the RBE Assessment System can support public authorities, professionals and other stakeholders by providing a structured method to evaluate climate risk and to integrate adaptation considerations into planning and design processes.

The RBE Method is the conceptual core of the RBE Assessment System. RNTool and RBTool are the two generic frameworks implementing the method respectively at neighbourhood and building scale. They specify and organise the components of the RBE Method into Issues, Macro Categories, Risk Categories, Criteria and Indicators. Through a contextualisation process, these generic frameworks can be adapted to local climatic, territorial, regulatory and policy conditions, generating fully operational risk assessment tools applicable in any European city.

The purpose of this CWA is to transfer the RBE Assessment System into a consensual European reference document, aiming to provide a common methodological basis for assessing climate risks at building and neighbourhood scale.

1 Scope

This document defines and describes the RBE Assessment System, a methodological framework for assessing climate risks in the built environment at neighbourhood and building scales.

The RBE Assessment System provides a common structure and assessment process to evaluate climate risk as the interaction between hazard, exposure and vulnerability, in accordance with the IPCC risk concept AR5 and its evolution in AR6. It supports the calculation and reporting of risk values through a hierarchical multi-criteria structure based on Issues, Macro Categories, Risk Categories, Criteria and Indicators.

The RBE Assessment System is composed of:

- RBE Method, a multi-criteria analysis method for assessing climate risk;
- RNTool (Resilient Neighbourhood Tool), a generic assessment framework implementing the RBE Method at the neighbourhood scale;
- the RBTool (Resilient Building Tool), a generic assessment framework implementing the RBE Method at the building scale.

This document specifies:

- the conceptual structure of the RBE Method;
- the application of the RBE Method through two generic frameworks:
    - RNTool, for neighbourhood-scale climate risk assessment;
    - RBTool, for building-scale climate risk assessment;
- the hierarchical organisation of the generic frameworks RNTool and RBTool;
- the principles for contextualising RNTool and RBTool generic frameworks to develop operational assessment tools tailored to the specific local territorial, climatic, regulatory and policy conditions;
- the procedure for calculating Risk Values at Risk Category, Macro Category, Issue and Overall assessment levels;
- the principles for cross-scale integration between neighbourhood and building risk assessments;
- the procedure to evaluate the effectiveness of responses and the residual risk.

The document is intended to support the localisation of strategic adaptation objectives (e.g. those defined in Sustainable Energy and Climate Action Plans) into operational assessments and actions at neighbourhood and building scales.

This document does not define local benchmarks or weights that are universally valid for all territories. These elements shall be established through the contextualisation process, considering local data availability, climate conditions, territorial characteristics, planning objectives and policy priorities.

This document does not provide a certification scheme, nor does it define conformity assessment rules for certifying buildings, neighbourhoods, plans or adaptation measures. However, it provides a common methodological basis that may be used to develop risk assessment tools, reporting formats, decision-support procedures, monitoring systems or future certification and verification schemes related to climate adaptation in the built environment at neighbourhood and building scale.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

adaptive capacity

The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences.

[SOURCE: IPCC, 2022, Annex II, Glossary]

3.2

assessment tool

operational instrument derived from the contextualisation of a generic framework, translating its methodological structure into a context-specific assessment system and enabling the assessment of climate risks

3.3

building element

specific part belonging to a building system domain

Note1 to entry: It represents a more detailed unit of analysis. For example, within the building system domain "Façade", building elements include External wall systems, Façade openings and External paints, coatings and renders (see Annex B).

3.4

building system domain

domain of analysis associated with a building, encompassing a defined set of physical, technical, functional, human or contextual aspects relevant to risk assessment

Note 1 to entry: Building system domains may include building components, technical systems, utilities, external areas, occupants and location-related conditions.

Note 2 to entry: A building system domain does not necessarily correspond to a physical component of the building.

3.5

climate change adaptation

process of adjustment to actual or expected climate and its effects

[SOURCE: EN ISO 14090:2019]

3.6

climate-related hazard

potential occurrence of a climate-related physical event or trend capable of causing adverse effects on people, property, infrastructure, livelihoods, services, ecosystems or environmental resources

Note 1 to entry: Climate-related hazards include extreme events and slow-onset processes associated with climate variability and climate change.

[SOURCE: IPCC, 2022, Annex II, Glossary, "Hazard", modified]

3.7

climate risk

potential for adverse consequences for human or ecological systems resulting from the interaction between climate-related hazards, exposure and vulnerability

Note 1 to entry: Climate risk may change over time and space as a result of changes in climatic conditions, exposed elements, vulnerability and adaptation measures.

Note 2 to entry: Hazard, exposure and vulnerability may change over time and space as a result of climate change, socioeconomic and territorial transformations, human decisions and adaptation responses.

[SOURCE: IPCC, 2022, Annex II: Glossary, "Risk", modified — The definition has been restricted to risks arising from climate-change impacts and reformulated to explicitly identify hazard, exposure and vulnerability]

3.8

climatic impact-driver

physical climate system conditions that affect an element of society or ecosystems

Note 1 to entry: Within the RBE Method, climatic impact-drivers provide the climate information used to characterise climate-related hazards and to support the selection of the relevant hazard criteria and indicators.

[SOURCE: IPCC, 2022, Annex II: Glossary]

3.9

criterion

assessment entry used to evaluate a specific aspect of hazard, exposure or vulnerability within the RBE Assessment System

Note 1 to entry: In the RBE Assessment System, each criterion is associated with a unique indicator.

3.10

exposed element

physical, social, economic or environmental entity potentially subject to the effects of a hazard considered in the assessment

Note 1: Within the RBE Assessment System, exposed elements are identified within urban sectors at neighbourhood scale and building system domains at building scale.

Note 2 to entry: Exposed elements may include people, buildings, building elements, infrastructure, ecosystems, services and economic or cultural assets.

Note 3 to entry: An exposed element identifies the entity being assessed, whereas exposure describes its presence in places and settings potentially affected by the hazard.

3.11

exposure

presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected

Note 1 to entry: Within the RBE Assessment System, exposure characterises the presence and, where relevant, the number, extent or number of exposed elements in places and settings potentially affected by the hazard considered.

[SOURCE: IPCC, 2022, Annex II: Glossary, “Exposure”]

3.12

generic framework

structured set of assessment issues, categories, criteria and indicators designed to be adapted to different contexts through a contextualisation process

Note 1 to entry: Within the RBE Assessment System, RNTool and RBTool are generic frameworks implementing the RBE Method at neighbourhood and building scales, respectively.

Note 2 to entry: Contextualisation adapts the generic framework to the relevant climatic, territorial, regulatory and data conditions, including the selection of applicable assessment categories, criteria and indicators and the definition of benchmarks, weights and assessment procedures.

Note 3 to entry: A generic framework becomes an operational assessment tool once the contextualisation process has been completed.

3.13

hazard

potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources

Note 1 to entry: Within the RBE Assessment System, hazards include climate-related hazards and other physical hazards (non climate-related hazards) whose interaction with climate-related processes is relevant to the assessment.

Note 2 to entry: A hazard represents a potential cause of adverse effects. The resulting risk depends on its interaction with the exposure and vulnerability of the affected elements.

[SOURCE: IPCC, 2022, Annex II: Glossary, “Hazard”]

3.14

indicator

quantitative or qualitative variable that can be measured or described in response to a defined criterion

[SOURCE: EN ISO 14091:2021]

3.15

non-climate-related hazard

hazard arising from a physical process whose origin is not inherently climatic, although its occurrence or severity may be influenced by climatic conditions

Note 1 to entry: Within the RBE Assessment System, such hazards are considered where they are triggered, intensified or otherwise influenced by climate-related hazards or climatic impact-drivers, or where their interaction contributes to the risk being assessed.

Note 2 to entry: The designation “non-climate-related” refers to the origin of the underlying process and does not imply independence from climatic influences.

[SOURCE: IPCC, 2014, Annex II, definitions of “hazard” and “non-climatic driver”, modified]

3.16

RBE Method

multi-criteria analysis method for assessing climate risk in the built environment at neighbourhood and building scales

Note 1 to entry: RBE stands for Resilient Built Environment.

3.17

RBE Assessment System

integrated assessment system comprising the RBE Method and the RNTool and RBTool generic frameworks for assessing climate risk at neighbourhood and building scales

Note 1 to entry: The RBE Method establishes the common conceptual basis, assessment structure and calculation procedures.

Note 2 to entry: RNTool and RBTool implement the RBE Method at neighbourhood and building scales, respectively. Through contextualisation, these generic frameworks become operational assessment tools adapted to the conditions and objectives of a specific application.

3.18

RBTool

generic assessment framework implementing the RBE Method for climate risk assessment at building scale

Note 1 to entry: RBTool stands for Resilient Building Tool.

Note 2 to entry: RBTool organises the assessment into Issues corresponding to hazards, Macro Categories corresponding to building system domains, and Risk Categories associated with specific exposed elements.

Note 3 to entry: Through contextualisation, RBTool becomes an operational assessment tool adapted to the conditions and objectives of a specific application.

3.19

residual risk

climate risk remaining at a specified reference time horizon (t_1) after implementation of the considered adaptation response, taking into account the hazard, exposure and vulnerability conditions at that time

Note 1 to entry: Within the RBE Assessment System, residual risk corresponds to the Risk Value calculated for the condition at t_1, including the effects of the response implemented and operational by that time.

Note 2 to entry: Residual risk reflects both the effects of the considered response and other changes in hazard, exposure and vulnerability between the baseline time (t_0) and the reference time horizon (t_1).

Note 3 to entry: Residual risk is distinct from response effectiveness, which expresses the net change in assessed risk between t_0 and t_1. A substantial reduction in risk may still leave a level of residual risk that is significant or unacceptable.

[SOURCE: ISO 31073:2022]

3.20

resilience

capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure

Note 1 to entry: Within the RBE Assessment System, resilience is not treated as an additional independent component of climate risk.

Note 2 to entry: The RBE Method addresses selected operational aspects of resilience through the assessment of response effectiveness and residual risk. These results do not constitute a comprehensive assessment of resilience.

[SOURCE: IPCC, 2022, Annex II: Glossary]

3.21

response effectiveness

net change in assessed climate risk between a baseline condition at an initial time (t_0) and a condition at a specified reference time horizon (t_1), taking into account the considered response and changes in hazard, exposure and vulnerability

Note 1 to entry: Within the RBE Assessment System, response effectiveness is assessed by comparing the Risk Value of the baseline condition before implementation of the considered response at t_0 with the expected or observed Risk Value at t_1, including the effects of the response implemented and operational by that time.

Note 2 to entry: Hazard, exposure and vulnerability may all change between t_0 and t_1. The comparison uses a consistent assessment boundary, benchmark system and weighting structure. Any changes affecting comparability are documented and addressed.

Note 3 to entry: Response effectiveness may be expressed as the absolute difference between the baseline Risk Value and the Risk Value at the reference time horizon, or as a relative change with respect to the baseline Risk Value, where the latter is greater than zero. A positive result indicates a net reduction in assessed risk, zero indicates no net change, and a negative result indicates a net increase.

Note 4 to entry: The result reflects both the effects of the considered response and other changes in hazard, exposure and vulnerability. It does not, by itself, measure the risk reduction attributable exclusively to the response. Response effectiveness is distinct from adaptive capacity, which concerns the ability of a system to adjust to potential damage, take advantage of opportunities or respond to consequences.

Note 5 to entry: Response effectiveness is not an additional independent component of climate risk. The effects of the considered response are represented through changes in the Hazard, Exposure and/or Vulnerability Values.

3.22

risk category

assessment unit defined by the combination of a specified hazard and a specified exposed element within an Urban Sector or Building System Domain

Note 1 to entry: Within the RBE Assessment System, a Risk Category represents the potential adverse effects of the specified hazard on the exposed element.

Note 2 to entry: Each Risk Category is assessed using the Hazard, Exposure and Vulnerability Values determined for that Risk Category.

Note 3 to entry: Risk Categories are grouped into Macro Categories corresponding to Urban Sectors in RNTool and Building System Domains in RBTool.

3.23

risk value

dimensionless numerical index representing the level of climate risk calculated using the RBE Method for a defined assessment entity under specified assessment conditions.

Note 1 to entry: Risk Values are expressed on a scale from 0 to 1, with higher values indicating higher assessed risk.

Note 2 to entry: Risk Values may be calculated at Risk Category level or obtained through aggregation at Macro Category, Issue or Overall assessment level.

Note 3 to entry: a Risk Value refers to explicitly defined conditions, including the assessment boundary, climate scenario, time horizon and assumptions concerning hazard, exposure, vulnerability and adaptation measures.

3.24

RNTool

generic assessment framework implementing the RBE Method for climate risk assessment at neighbourhood scale

Note 1 to entry: RNTool stands for Resilient Neighbourhood Tool.

Note 2 to entry: RNTool organises the assessment into Issues corresponding to hazards, Macro Categories corresponding to urban sectors, and Risk Categories associated with specific exposed elements.

Note 3 to entry: Through contextualisation, RNTool becomes an operational assessment tool adapted to the conditions and objectives of a specific application.

3.25

system

set of interrelated or interacting elements

[SOURCE: ISO 9000:2015]

3.26

urban sector

functional or thematic domain of the urban environment used to group exposed elements and organise climate risk assessment at neighbourhood scale

Note 1 to entry: Within RNTool, Urban Sectors constitute Macro Categories assessed in relation to the relevant hazards.

Note 2 to entry: Urban Sectors may include buildings, transport, energy, water, waste, agriculture and forestry, environment and biodiversity, health, civil protection and emergency services, tourism, information and communication technologies, and economic activities.

Note 3 to entry: An Urban Sector may encompass physical assets, infrastructure, services, ecosystems or population groups and does not necessarily correspond to a geographically distinct part of the neighbourhood.

3.27

vulnerability

propensity or predisposition to be adversely affected

Note 1 to entry: Because the RBE Assessment System is designed to calculate a Risk Value for a specified point in time under defined assessment conditions, the RBE Method adopts an operational characterisation of vulnerability focused on the exposed element's susceptibility to adverse effects in its assessed state. The Vulnerability Value expresses this susceptibility; adaptive capacity is not assessed as a separate component of that value.

Note 2 to entry: The assessed susceptibility may reflect intrinsic properties of the exposed element and external physical, functional, environmental, social or contextual conditions. In a current-state assessment, these include the effects of protection, preparedness, management and adaptation measures already implemented and operational, as represented through the relevant vulnerability Criteria and Indicators.

Note 3 to entry: The capacity to implement further adaptation measures is not, in itself, credited as an existing reduction in susceptibility. Resources, expertise or institutional arrangements that enable further adaptation are distinguished from the protective effects already present in the assessed state. Such capacity remains relevant to action planning, including the feasibility, sequencing and timing of interventions.

[SOURCE: EN ISO 14090:2019, 3.15, modified]

4 RBE Method

4.1 General

The RBE Method constitutes the methodological foundation of the RBE Assessment System. It is a multi-criteria analysis method for assessing climate risk in the built environment at neighbourhood and building scales.

The method provides a common assessment logic that can be applied at different spatial scales and under different assessment conditions. To be applicable, the RBE Method is translated into assessment frameworks, namely RBTool at building scale and RNTool at neighbourhood scale, which shall be contextualised to local conditions and priorities.

The application of assessment tools implementing the RBE Method produces dimensionless Risk Values on a normalised scale from 0 to 1. Higher values indicate higher assessed risk within the adopted assessment framework. The interpretation of these values depends on the criteria, benchmarks, weights and assessment conditions established during contextualisation.

A Risk Value represents the climate risk corresponding to the hazard, exposure and vulnerability conditions specified for the assessment.

The RBE Method is designed to provide a state-based representation of climate risk at a defined reference time. Each assessment therefore refers to a specific temporal and scenario-based condition. The key principle is that the assessment represents the condition of the system as it exists, or is explicitly assumed to exist, at that reference time.

4.2 Conceptual basis for risk assessment

4.2.1 General

The RBE Method is based on the climate risk concept in which risk results from the interaction between hazard, exposure and vulnerability. At conceptual level, this relationship is expressed as follows:

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability} \quad (1)$$

Equation (1) is a representation of the interaction between hazard, exposure and vulnerability. The RBE Method operationalises this conceptual relationship through the normalisation and aggregation

procedures specified in 4.4, including the weighted geometric aggregation of Hazard, Exposure and Vulnerability Values at Risk Category level.

Hazard refers to a physical event or trend capable of causing adverse effects. Within the scope of the RBE Method, this includes climate-related hazards and other physical hazards (non climate-realted hazards) whose interaction with climatic conditions is relevant to the assessment.

Exposure involves the presence of exposed elements in places and settings that could be adversely affected by hazards.

Vulnerability represents the propensity or predisposition of exposed elements to be adversely affected.

Risk increases where hazard is more severe, exposure is greater and vulnerability of the exposed elements is higher.

The RBE Assessment System calculates a Risk Value for a specified point in time under defined assessment conditions. The application of the RBE Method produces multiple Risk Values corresponding to the different levels of the assessment hierarchy. Risk Values are calculated for individual Risk Categories and may subsequently be aggregated at Macro Category, Issue and Overall assessment levels. Each value represents a different level of interpretation and shall be considered together with the underlying disaggregated results.

4.2.2 Hazard

The RBE Method considers:

- climate-related hazards: extreme weather events, such as extreme heath, droughts, heavy precipitation events, as well as climate-related slow-onset processes, such as sea-level rise;
- non-climate-related hazards: other hazards triggered by climate-related hazards, such as mass movement triggered by extreme precipitation or wildfires triggered by dry conditions.

Climate-related hazards shall be characterised using relevant climatic impact-drivers and hazard-specific information. Depending on the hazard, this information may include observed climatic data, climate projections, intensity, frequency, duration, return periods, threshold exceedances and spatial distribution.

Non-climate-related hazards shall be characterised using information on both the climatic triggers and the resulting physical processes. Relevant information may include event inventories, terrain and vegetation conditions, physical models, and the likelihood, intensity and spatial extent of the hazard.

The hazards relevant to each assessment shall be selected during contextualisation, taking into account local climatic and territorial conditions, the assessment boundary and the defined time horizon. The hazards considered by the RBE Method are presented in Annex A.

4.2.3 Exposure

Exposure describes who or what is exposed. Exposure is the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Exposure Criteria shall describe the presence and, where relevant, the number, extent or number of exposed elements in places and settings potentially affected by the specified hazard.

4.2.4 Vulnerability

Vulnerability is the propensity or predisposition of an exposed element to be adversely affected by a hazard.

Because the RBE Assessment System is designed to calculate a Risk Value for a specified point in time under defined assessment conditions (4.2.1), the RBE Method adopts an operational characterisation of vulnerability focused on the exposed element's susceptibility to adverse effects in its assessed state. This considers the effectiveness of adaptation measures already implemented and operational at the assessment time. The capacity to implement further adaptation measures is not, in itself, credited as an existing reduction in susceptibility. This approach supports the development of climate risk reduction action plans for buildings and neighbourhoods by distinguishing the risk associated with the assessed state from the capacity to achieve further improvements. It establishes a baseline that reflects existing conditions and the effectiveness of adaptation measures already implemented and operational, without treating available resources, technical expertise or planned interventions as benefits already achieved. Alternative interventions can then be assessed against this baseline under consistent assessment conditions, making their expected contribution to risk reduction explicit. Subsequent assessments can track improvements following implementation and identify remaining risks. Adaptive capacity remains essential to action planning, informing the feasibility, sequencing and timing of interventions, as well as responsibilities and support needs. It is therefore considered in planning how risk reduction can be achieved, rather than automatically credited as a reduction in the susceptibility of the element in its assessed state.

Vulnerability may reflect intrinsic properties of the exposed element and external physical, functional, environmental, social or contextual conditions influencing the severity of potential adverse effects. The effects of protection, preparedness, management or adaptation measures already implemented and operational under the assessed condition shall be reflected in the relevant Criteria and Indicators.

Prospective adaptive capacity shall not modify the Vulnerability Value of a current-state assessment unless the corresponding improvement is already implemented and operational. For an explicitly defined future or intervention scenario, the effects of measures assumed to be operational in that scenario may be assessed, provided that their implementation assumptions are documented.

4.3 Structure of the RBE Method

4.3.1 Exposed Elements, Risk Categories and Macro Categories

The assessment is structured around Exposed Elements and the Risk Categories associated with them.

A Risk Category represents the specific climate risk associated with the potential effects of a defined hazard on an Exposed Element. At the urban scale, Exposed Elements are physical, social, economic or environmental entities associated with an Urban Sector (see Annexes B and C). At the building scale, Exposed Elements are physical, technical, human or contextual entities associated with a Building System Domain (see Annexes B and C).

The RBE Method assigns a Risk Value in the interval [0,1] to each Risk Category by combining the Hazard Value associated with its Issue and the Exposure and Vulnerability Values determined for that Risk Category.

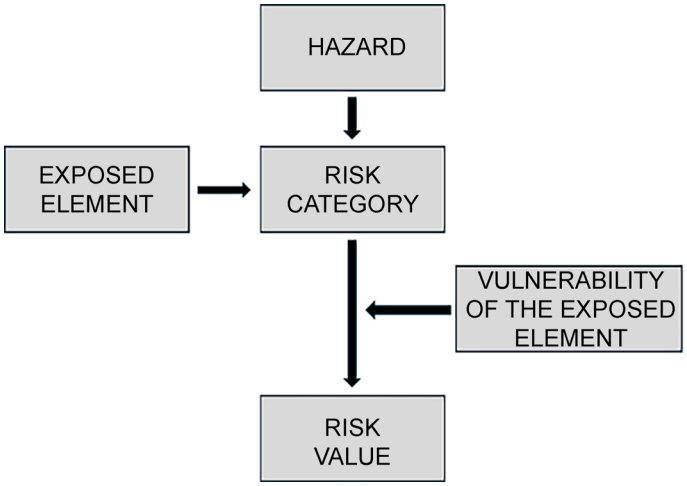

Figure 1 — Conceptual framework for Risk Category assessment in the RBE Method

Risk Categories are organised in Macro Categories representing Urban Sectors in RNTool or Building System Domains in RBTool. Macro Categories provide the organisational layer between the Hazard and the specific Risk Categories, allowing risk values to be aggregated and interpreted at the level of broader system components.

4.3.2 RBE Method as a hierarchic and modular framework

RBE Method organises the framework of criteria and indicators in modules, named Issues. Each Issue corresponds to a hazard. Modules are organised in levels, starting from Macro Categories and ending with Indicators.

The assessment framework comprises the following organisational levels (Figure 2):

- **Level 1 – Issues**: assessment modules corresponding to the hazards considered. Each Issue is associated with hazard Criteria and Indicators and contains Macro Categories. Issues are classified based on alphabetical order. For example, A. Heavy Precipitation, B. Flood, C, Extreme Heat, D. Drought, etc.;
- **Level 2 – Macro Categories**: groupings corresponding to Urban Sectors in RNTool and Building System Domains in RBTool. Each Macro Category contains the relevant Risk Categories within the specified Issue. Macro Categories are classified based on alphabetical order. For example: A1 Buildings, A2 Transport, A3 Energy, etc.;
- **Level 3 - Risk Categories**: assessment units defined by the combination of a specified hazard and a specified Exposed Element. Each Risk Category is associated with exposure and vulnerability Criteria and Indicators. Risk Categories are classified based in alphabetical order (e.g. A1.1, A1.2, A1.3, etc.);
- **Level 4 - Criteria**: assessment entries describing hazard, exposure or vulnerability. Hazard Criteria are associated with Issues, whereas Exposure and Vulnerability Criteria are associated with Risk Categories. Criteria are classified based in alphabetical order (e.g. A1.1.1, A1.1.2, A1.1.3, etc.);
- **Level 5 – Indicators**: quantitative or qualitative variables used to assess the corresponding criteria. Each criterion is associated with one defined indicator.

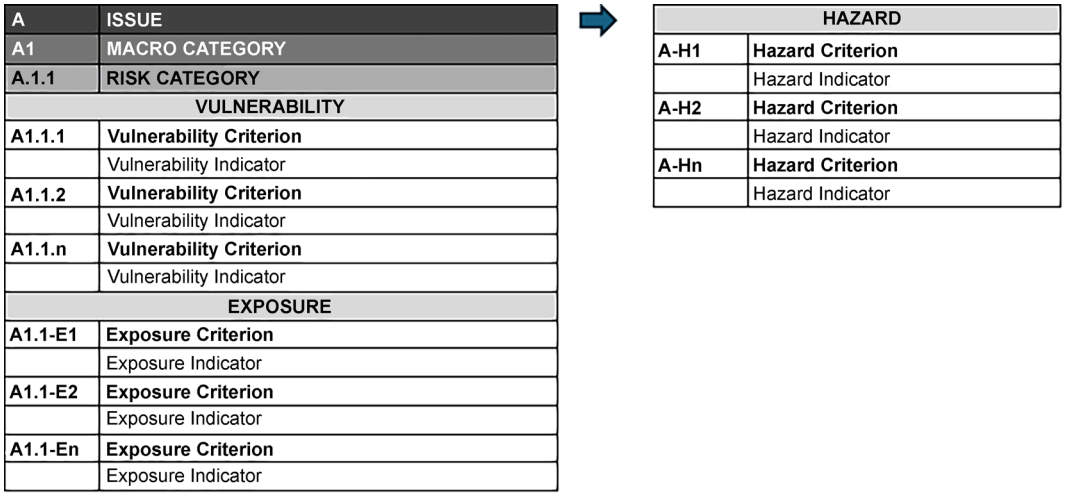

Figure 2 — Hierarchic levels in RBE Method

4.4 Assessment Process

4.4.1 General

The RBE Method assessment process is based on a progressive calculation and aggregation of Risk Values (Fig. 2) and comprises seven steps (see 4.4.3). First, a Hazard Value (HV) is determined for each Issue. Exposure (EV) and Vulnerability Values (VV) are then determined for each Risk Category:

These three component values (HV, EV, VV) are combined to calculate the Risk Category Risk Value. Risk Category Risk Values are subsequently aggregated within each Macro Category. Macro Category Risk Values are aggregated to obtain Issue Risk Values, which may then be aggregated to obtain the Overall Risk Value. The calculation of Hazard, Exposure and Vulnerability Values may be undertaken in parallel, provided that all components refer to consistent assessment conditions.

Through this process, the RBE Method provides both detailed and synthetic results. It enables the identification of the most critically exposed elements and Risk Categories, while also producing aggregated values at Macro Category, Issue and overall assessment levels.

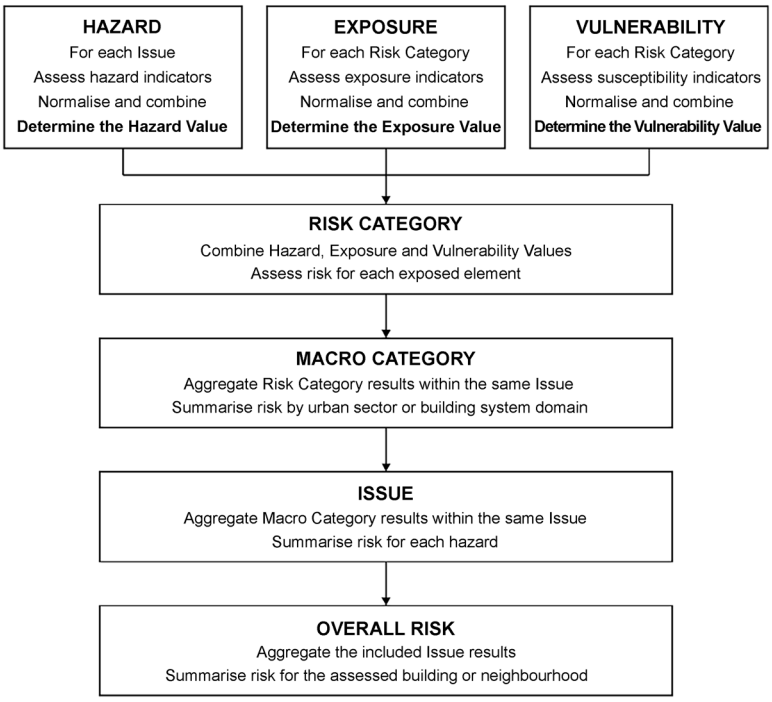

Figure 3 — RBE Method Assessment Process

4.4.2 Normalisation system

In the RBE Method, climate risk is assessed through hazard, exposure and vulnerability criteria and indicators. These indicators may be expressed using different units of measurement or categorical values. Consequently, their raw values cannot be directly aggregated to calculate the Hazard (HV), Exposure (EV) and Vulnerability (VV) values.

Normalisation is therefore required to transform all indicator values into a common, dimensionless scale. In the RBE Method, this common scale ranges from 0 to 1, where 0 represents an optimal condition and 1 represents a critical condition. Intermediate values express increasing levels of criticality. This makes it possible to combine heterogeneous information within the same assessment framework while preserving the meaning of each indicator in relation to climate risk.

The normalisation process is based on the definition of reference benchmarks (x_{min}, x_{max} – see formulas 2 and 3). For each indicator, the benchmark associated with the value 0 defines the optimal or least critical condition, while the benchmark associated with the value 1 defines the critical or most unfavourable condition. The position of the assessed value between these two benchmarks determines the normalised score.

Normalisation also considers the direction of performance of each indicator. For some indicators, higher values correspond to better conditions; for others, lower values correspond to better conditions. The normalisation formula is therefore selected according to whether the indicator is “higher is better” or “lower is better”. Qualitative indicators are normalised by assigning predefined scores to descriptive scenarios.

Through normalisation, the RBE Method enables the aggregation of different indicators into Vulnerability Values (VV), Exposure Values (EV) and Hazard Values (HV), and subsequently into Risk Category, Macro Category, Issue and Overall Risk Values. Without normalisation, this aggregation would not be methodologically consistent, because values expressed in different units and scales

would be combined without a common reference basis. The meaning of the normalisation interval used in RBE Method is described in Table 1.

Table 1 — Normalisation interval in RBE Method

Normalised values	Description
0-0,2	Optimal
>0,2-0,4	Rather positive
>0,4-0,6	Neutral
>0,6-0,8	Rather negative
>0,8-1	Critical

For the "higher is better" indicators (higher the numerical value of the indicator, the higher the performance level), the value is normalised applying the following formula:

$$X_{norm} = \frac{x_{max} - x_i}{x_{max} - x_{min}} \quad (2)$$

Where:

- Xi: value of the indicator
- X_{min} = critical indicator's value (corresponding to score 1)
- X_{max} = optimal indicator's value (corresponding to score 0)

For the "lower is better" indicators (lower the numerical value of the indicator, the higher the performance level.), the value is normalised applying the following formula:

$$X_{norm} = \frac{x_i - x_{min}}{x_{max} - x_{min}} \quad (3)$$

where:

- x_i: value of the indicator
- x_{min} = optimal indicator's value (corresponding to score 0)
- x_{max} = critical indicator's value (corresponding to score 1)

For both normalisation formulas:

- x_{max} shall be greater than x_{min}

- indicator values lower than $x_{\min}$ will be allocated to the value $x_{\min}$ and indicator values exceeding $x_{\max}$ will be allocated to the value $x_{\max}$. Values outside the benchmark interval shall be capped so that the normalised score remains within [0,1].

Qualitative indicators specified by categorical values (scenarios) are normalised using a five-level rating scheme, as shown in Table 2.

Table 2 — Rating scheme for qualitative Indicators

Normalized value	Description
0,1	Optimal
0,3	Rather positive
0,5	Neutral
0,7	Rather negative
0,9	Critical

The five qualitative scores correspond to the midpoints of the normalisation classes presented in Table 1. Each class shall be associated with an indicator-specific description sufficient to support consistent scoring.

4.4.3 RBE Method Assessment Steps

4.4.3.1 General

The RBE Method assessment process consists of 7 steps, each detailed in the following paragraphs:

1. Calculation of the Hazard Value (HV) for each Issue
2. Calculation of the Exposure Value (EV) for each Risk Category
3. Calculation of the Vulnerability Value (VV) for each Risk Category
4. Calculation of the Risk Value for each Risk Category
5. Aggregation of Risk Category Values to Calculate the Risk Value of Macro-Categories
6. Aggregation of Macro Categories Values to calculate the Risk Value of Issues
7. Aggregation of Issues Values to calculate the Overall Risk Value

4.4.3.2 Step 1: Calculation of the Hazard Value (HV) for Issues

The RBE Method foresees the assignment of a Hazard Value (HV) to each Issue included in the assessment. The Hazard Value (0,1) describes the magnitude, intensity, frequency, duration, likelihood or spatial relevance of the hazard represented by the Issue.

The method used to determine the Hazard Value shall depend on whether the Issue represents:

a) a climate-related hazard or

b) a non-climate-related hazard

For climate-related hazards, the Hazard Value shall be characterised using indicators representing the relevant climatic impact-drivers and, where necessary, hazard-specific physical variables, climate-extreme indices, thresholds, return periods, climate projections, hazard maps or model outputs. Indicators may describe:

- the intensity or magnitude of the event or process
- its frequency or probability of occurrence
- its duration
- its spatial extent or distribution
- exceedance of impact-relevant thresholds
- observed and projected changes under defined climate scenarios and time horizons.

For non-climate-related hazards, the Hazard Value shall be based on indicators representing hazard-specific information describing for instance the occurrence, probability, susceptibility, intensity, duration and spatial extent of the hazard.

A hazard criterion and indicator shall be selected where it meets the following quality requirements:

- validity and relevance: it shall effectively represent the hazard being assessed
- reliability and credibility: it shall be derived from authoritative and reliable sources, such as meteorological services or IPCC databases, in order to support future monitoring
- clear directionality: the relationship between the indicator value and the assessed hazard shall be explicitly defined. After normalisation, higher scores shall indicate higher assessed hazard
- practicality: the required data shall be accessible with reasonable effort and resources
- scale appropriateness: the spatial and temporal resolution shall be consistent with the purpose of the assessment.

The selection process is not purely technical, but also includes:

- stakeholder workshops to collect local knowledge of past extreme events that may not have been recorded in official statistics
- expert consultation to confirm that the selected thresholds are genuinely critical for the system under assessment.
- data availability. Global databases (e.g., CORDEX, Copernicus), as well as national databases, shall be reviewed to ensure that the required data are available or can be generated through modelling.

The identification the hazard criteria and indicators to calculate the Hazard Value should be supported by recognised scientific, technical and regulatory references. The detailed procedure for identifying, selecting and validating climatic indicators is outside the scope of this document. Such activities require hazard-specific climatic, statistical and modelling expertise and should be carried out with reference to the recognised scientific and technical guidance mentioned above. The RBE contextualisation process shall nevertheless document the selected criteria and indicators, their relevance to the assessed hazard, data sources, spatial and temporal resolution, reference periods, scenarios and thresholds.

The Hazard Value is calculated at the level of Issues, and it is shared by all the Risk Categories assessed under the same Issue.

To calculate the Hazard Value (HV) of an Issue:

- the values of hazard indicators are calculated. The output consists of a set of quantities expressed in different units of measurement

- the values of indicators are then normalised in the interval (0,1) – see 4.4.2
- the normalised scores are aggregated through a weighted sum:

$$HV = \sum_{i=1}^{n} \left(I_i \times W_i \right) \quad (4)$$

Where:

- I_i is the normalised value of the *i*-th indicator
- W_i is the weigh associated with the *i*-th indicator
- *n* is the number of indicators considered

Weighting factors must fulfil the following properties:

- 0<= Wi<=1
- $\sum_{i=1}^{n} W_i = 1$

Weights allow to raise the importance of specific hazard criteria in regard to others. The various weights assigned to indicators may be derived from existing literature, stakeholder information, or experts' weighting (5.2.9).

The output of this step is a Hazard Value for each Issue.

Alternatively, the Hazard Value (HV) may be derived from the climatic analyses included in Sustainable Energy and Climate Action Plans (SECAPs) or similar climate adaptation strategies, where available, or from equivalent national, regional or local climate-risk and adaptation documents. Such analyses may provide relevant information on current and projected climatic conditions, hazard frequency and intensity, critical thresholds, spatial patterns and future scenarios. Where the source document does not provide a directly usable normalised value for HV, the available climatic information may be converted into an HV value through structured expert judgement. The conversion method, assumptions, data sources and resulting value shall be documented to ensure transparency, consistency and reproducibility.

Information obtained from an existing plan or assessment shall be checked for consistency with the hazard definition, assessment boundary, reference period, climate scenario, time horizon and normalisation benchmarks adopted by the RBE assessment.

4.4.3.3 Step 2: Calculation of the Exposure Value (EV) for Risk Categories

To calculate the Exposure Value of a Risk Category:

- the values of the exposure quantitative indicators are calculated. The output consists of a set of quantities expressed in different units of measurement
- the values of quantitative indicators are then normalised in the interval (0,1) – see 4.4.2
- a normalised score (0,1) is assigned to qualitative indicators using the five-level rating scheme (see 4.4.2)

- the normalised scores of quantitative and qualitative indicators are aggregated through a weighted sum:

$$EV = \sum_{i=1}^{n} \left(I_i \times W_i \right) \quad (5)$$

Where:

- I_i is the normalised value of the *i*-th indicator
- W_i is the weigh associated with the *i*-th indicator
- *n* is the number of indicators considered

Weighting factors must fulfil the following properties:

- $0 \leq Wi \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

Weights allow to raise the importance of specific exposure criteria in regard to others. The various weights assigned to indicators may be derived from existing literature, stakeholder information, or experts' weighting (5.2.9).

The output of this step is a set of Exposure Values (EV), one per Risk Category.

4.4.3.3.1 Exposure Value in RBTool

In RBTool, the Exposure Value (EV) of a Risk Category may be assessed using the qualitative exposure Criterion "Building Element Exposure" and its associated Indicator "Exposure Level". This Indicator expresses the amount of the element exposed to a specified climate hazard within the relevant Building System Domain. The Indicator shall be assessed using an approach appropriate to the characteristics of the specific Exposed Element:

- - for discrete elements exposure is assessed according to the number of units exposed to the hazard
- - for elements characterised by their spatial extent, exposure is assessed as the surface area of the element exposed to the hazard divided by a defined reference area within the relevant Building System Domain, expressed as a percentage.

To normalise (4.4.2) the qualitative Indicator, the necessary thresholds (units counts or surface-area percentages) defining the exposure levels for each specific Exposed Element shall be established during benchmarking phase (5.2.7). Thresholds shall assign higher Exposure Levels to greater quantities or proportions of exposed elements. Table 3 presents the Exposure Levels for the qualitative Criterion "Building Element Exposure".

Table 3 — Categorical values for the Criterion "Building Element Exposure"

Normalised Value	General interpretation	Exposure Level
0,1	Very limited exposure	Lowest positive range of exposed unit counts or exposed surface-area percentages, as defined during contextualisation. (Units counts or surface-area percentages thresholds to assign this exposure level shall be set in the benchmarking phase – 5.2.7)
0,3	Limited exposure	Low range of exposed unit counts or exposed surface-area percentages, as defined during contextualisation. (Units counts or surface-area percentages thresholds to assign this exposure level shall be set in the benchmarking phase – 5.2.7)
0,5	Moderate exposure	Intermediate range of exposed unit counts or exposed surface-area percentages, as defined during contextualisation. (Units counts or surface-area percentages thresholds to assign this exposure level shall be set in the benchmarking phase – 5.2.7)
0,7	Extensive exposure	High range of exposed unit counts or exposed surface-area percentages, as defined during contextualisation. (Units counts or surface-area percentages thresholds to assign this exposure level shall be set in the benchmarking phase – 5.2.7)
0,9	Very intensive exposure	Highest range of exposed unit counts or exposed surface-area percentages, as defined during contextualisation. (Units counts or surface-area percentages thresholds to assign this exposure level shall be set in the benchmarking phase – 5.2.7)

Where reliable numerical data are unavailable, a qualitative assessment of the element's prevalence and distribution may be used.

Where the Exposed Element is absent or is not exposed to the assessed hazard, its Exposure Level shall be 0. Where the hazard affects only part of the building, only the units or surface area within the potentially affected part shall be counted as exposed.

Alternatively, specific quantitative exposure Indicators may be defined for individual Risk Categories in place of the "Exposure Level" Indicator. Such Indicators shall measure the amount or extent of the Exposed Element using a clearly defined metric and unit of measurement appropriate to the Risk Category. The measured values shall be normalised using benchmarks established during contextualisation, in accordance with the normalisation principles of the RBE Method.

4.4.3.4 Step 3: Calculation of the Vulnerability Value (VV) for Risk Categories

To calculate the Vulnerability Value (VV) of a Risk Category:

- the values of the vulnerability quantitative indicators are calculated. The output consists of a set of quantities expressed in different units of measurement
- the values of quantitative indicators are then normalised in the interval (0,1) – see 4.4.2
- a normalised score (0,1) is assigned to qualitative indicators using the five-level rating scheme (4.4.2)
- the normalised scores of quantitative and qualitative indicators are aggregated through a weighted sum:

$$VV = \sum_{i=1}^{n} \left(I_i \times W_i \right) \tag{6}$$

Where:

- I_i is the normalised value of the *i*-th indicator
- W_i is the weigh associated with the *i*-th indicator
- *n* is the number of indicators considered

Weighting factors must fulfil the following properties:

- $0 \leq W_i \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

Weights allow to raise the importance of specific vulnerability criteria in regard to others. The various weights assigned to indicators may be derived from existing literature, stakeholder information, or experts' weighting (5.2.9).

The output of this step is a set of Vulnerability Values (VV), one per Risk Category.

4.4.3.5 Step 4: Calculation of the Risk Value (RV) for Risk Categories

At this point of the process, each Risk Category considered in the assessment is characterised by:

- a Hazard Value (HV), equal for all Risk Categories belonging to the same Issue
- an Exposure Value (EV), specific for each Risk Category
- a Vulnerability Value (VV), specific for each Risk Category

This step consists in the aggregation of these 3 risk components using a weighted geometric mean to calculate the value of risk of each Risks Category:

$$RV_{RC} = HV^{W_{HV}} \times EV^{W_{EV}} \times VV^{W_{VV}} \tag{7}$$

Where:

- RV_{RC} is the Risk Value of the Risk Category
- HV is the Hazard Value
- EV is the Exposure Value

- VV is the Vulnerability Value
- W_{HV} is the weigh associated to HV
- W_{EV} is the weight associated to EV
- W_{V} is the weight associated to VV

Note: a geometric mean is used instead of an arithmetic mean because if one risk factor (HV, EV, VV) is zero, the overall risk is also zero.

Assuming that the weighting fulfils the following properties:

- $0 \leq W_i \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

Unless a different weighting scheme is justified and documented, equal weights of 1/3 should be applied.

The weights of HV, EV and VV shall be established during the contextualisation process (5.2.9). They should be defined on the basis of the expected contribution of each component to the climate risk affecting the Risk Category under assessment. Unless specific evidence or expert judgement supports a different weighting scheme, equal weights should be applied. Any deviation from equal weighting shall be documented and justified with reference to local conditions, available data, impact-chain logic and the intended use of the assessment results.

4.4.3.6 Step 5: Aggregation of Risk Category Values into Macro-Category Risk Values

In this step, the risk values of Risk Categories belonging to the same Macro Category and to the same Issue are aggregated to produce a Macro Category Risk Value.

In this step the Risk Values of Risk Categories belonging to the same Macro Category are aggregated to produce a Risk Value at Macro Category level. The aggregation takes place through a weighted mean:

$$RV_{MC} = \sum_{i=1}^{n} \left(C_i \times W_i \right) \tag{8}$$

where:

- RV_{MC} is the Risk Value of the Macro Category
- C_i is the risk value of the *i*-th Risk Category
- W_i is the weight associated with the *i*-th Risk Category
- *n* = total number of Risk Categories considered

Weighting factors must fulfil the following properties:

- $0 \leq W_i \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

4.4.3.7 Step 6: Aggregation of Macro Category Values into Issue Risk Values

In this step the Risk Values of Macro Categories are further aggregated to produce a Risk Value for Issues. The aggregation of the Macro Categories' scores take place through a weighted mean.

$$RV_I = \sum_{i=1}^{n} \left(C_i \times W_i \right) \tag{9}$$

where:

- Risk Value of the Issue
- C_i is the risk value of the *i*-th Macro Category
- W_i is the weight associated with the *i*-th Macro Category
- *n* = total number of Macro Categories considered

Weighting factors must fulfil the following properties:

- $0 \leq W_i \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

4.4.3.8 Step 7: Aggregation of Issue Values into Overall Risk Value

The Overall Risk Value (OVR) is calculated as a weighted mean of Issues' risks values:

$$RV_O = \sum_{i=1}^{n} \left(I_i \times W_i \right) \tag{10}$$

- RV_O is the Overall Risk Value
- I_i is the risk value of the *i*-th Issue
- W_i is the weight associated with the *i*-th Hazard
- *n* = total number of Hazards considered

Weighting factors must fulfil the following properties:

- $0 \leq W_i \leq 1$
- $\sum_{i=1}^{n} W_i = 1$

The Overall Risk Value shall be interpreted as a summary index providing a synthetic representation of the assessed building or neighbourhood risk profile. It shall not be considered a substitute for the disaggregated results calculated at Issue, Macro Category and Risk Category levels. Since aggregation may allow lower values to compensate for higher ones, the Overall Risk Value may conceal critical conditions associated with a specific Hazard, Exposed Element or system component. It shall therefore

always be reported and interpreted together with the underlying disaggregated Risk Values, with particular attention to individual results exceeding defined criticality thresholds.

4.5 Cross-Issue optional aggregation of Risk Values

4.5.1 General

In addition to the Overall Risk Value (4.4.3.8), the results calculated at Risk Category (4.4.3.5) and Macro Category (4.4.3.6) levels may be aggregated across Issues to produce a summary value. This enables a horizontal, or cross-hazard, interpretation of the assessment results. Risk values calculated for the same Macro Category under different Issues may be used to identify the risk affecting that Macro Category from all relevant hazards. Similarly, the values calculated for the same Exposed Element across Issues may support the identification of elements that are repeatedly affected by different hazards. Cross-Issue interpretation complements the Overall Risk Value by supporting the identification of recurring criticalities, shared vulnerability conditions and adaptation priorities across the different Issues considered in the assessment.

The purpose of cross-issue aggregation is to identify elements, sectors or system domains that are affected by several hazards and may therefore require priority adaptation action. When the RBE Method is implemented through RNTool, the analysis may identify Urban Sectors (e.g., Buildings, Transport, Energy, Water) showing high Risk Values under multiple Issues. When implemented through RBTool, it may identify Building System Domains (e.g. Foundations, Façade, Roof, Energy Systems) affected by several Hazards.

The analysis should identify:

- the Exposed Elements and Macro Categories affected by the greatest number of Hazards
- the entities presenting high or critical Risk Values across several Issues
- vulnerability conditions contributing to more than one Risk Category
- adaptation measures that may reduce risks associated with several hazards
- potential conflicts, risk transfers or maladaptation effects between measures addressing different Issues;

Cross-hazard interpretation shall be reported separately from the main horizontal aggregation process, clearly indicating the Issues considered, the weights applied, and the level of aggregation used.

4.5.2 Cross-hazard risk value for Exposed Elements

This step allows the calculation of the aggregated risk value for the same Exposed Element considering all selected Issues.

For each Exposed Element, the risk values calculated under the different Issues are aggregated through a weighted mean:

$$EE_{risk} = \sum_{i=1}^{n} (RC_i \times W_i) \tag{11}$$

where:

- $\mathrm{EE_{risk}}$ is the cross-hazard risk value of the Exposed Element;
- $\mathrm{RC_i}$ is the Risk Category risk value calculated for the Exposed Element under the i-th Issue;

- W_i is the weight associated with the i-th Issue;
- n is the number of Issues considered.

Weighting factors shall fulfil the following properties:

$$0 \leq W_i \leq 1$$

$$\sum_{i=1}^{n} W_i = 1$$

The resulting value represents the aggregated risk affecting a specific Exposed Element from all relevant hazards. This value supports the identification of exposed elements that are repeatedly or critically affected by different hazards and may therefore require priority adaptation measures.

Where no specific evidence or expert judgement supports a differentiated weighting scheme, equal weights should be applied. Any deviation from equal weighting shall be documented and justified.

4.5.3 Cross-hazard risk value for Macro Categories

This step allows the calculation of the aggregated risk value for the same Macro Category considering all selected Issues, i.e. all relevant hazards included in the assessment.

For each Macro Category, the risk values calculated under the different Issues are aggregated through a weighted mean:

$$MC_{risk} = \sum_{i=1}^{n} (MC_i \times W_i) \quad (12)$$

where:

- MC_{risk} is the cross-hazard risk value of the Macro Category;
- MC_i is the Macro Category risk value calculated under the i-th Issue;
- W_i is the weight associated with the i-th Issue;
- n is the number of Issues considered.

Weighting factors shall fulfil the following properties:

$$0 \leq W_i \leq 1$$

$$\sum_{i=1}^{n} W_i = 1$$

The resulting value represents the aggregated risk affecting a specific Macro Category from all relevant hazards. At building scale, it may be used, for example, to identify which Building System Domains are most at risk considering all selected hazards. At neighbourhood scale, it may be used to identify which Urban Sectors are most at risk across the selected hazards.

This cross-hazard value shall be reported separately from the Issue Risk Value and the Overall Risk Value, clearly indicating the Issues considered, the weights applied and the aggregation level used.

4.6 Assessment Results and Reporting

The results of the assessment provide information on the level of climate risk corresponding to the defined assessment condition. The Risk Values produced by the RBE Method shall support the identification of critical Exposed Elements, Risk Categories, Macro Categories and Issues. An individual Risk Value shall be interpreted as a state-based assessment result.

The results produced by RBE Method are:

- Risk Values at Risk Category level providing a clear understanding of which elements within the Urban Systems (RNTool) or Building System Domains (RBTool) are most at risk and highlight areas that require priority in adaptation strategies
- Risk Values at Macro Category level providing a clear understanding of which Urban Sectors (RNTool) or Building System Domains (RBTool) are most at risk and highlight areas that require priority in adaptation strategies
- Risk Values at Issue level providing an aggregated view of how each Hazard affects the overall risk profile. Issues with higher risk values indicate a greater vulnerability to climate impacts and thus require immediate and sustained efforts to mitigate these risks
- an Overall Risk Value providing a comprehensive measure of the level of climate risk
- Cross-Issues Risk Values at
    - Exposed Element level, providing an aggregated view of the risk affecting the same exposed element across all selected Issues. These results support the identification of exposed elements that are repeatedly or critically affected by multiple hazards and may therefore require priority adaptation measures;
    - at Macro Category level, providing an aggregated view of the risk affecting the same Urban Sector or Building System Domain across all selected Issues. These results support the identification of the most critical sectors or components when multiple hazards are considered together.

These results serve as an essential tool for decision-makers, designers and planners offering a clear metric to gauge the effectiveness of current adaptation measures and the urgency for additional interventions. Their interpretation is crucial for informing climate adaptation measures.

Assessment results shall be reported in a transparent and traceable way. The reporting shall include the values calculated at each relevant level of aggregation, together with the assumptions, data sources, benchmarks, weights and scoring rules used in the assessment.

The report shall distinguish between calculated values and values assigned through expert judgement or stakeholder-based procedures. Any data gaps, limitations or uncertainty aspects that may affect the interpretation of results shall be documented.

The results shall support the identification of priority risk conditions, the comparison of alternative adaptation options, the monitoring of changes over time and the communication of climate-risk information to decision makers and relevant stakeholders.

4.7 Response effectiveness and residual risk assessment

4.7.1 General

The RBE Method may be applied not only to assess climate risk under a defined set of conditions, but also to evaluate how risk may evolve over time and how it may be modified by planning, design, management and adaptation decisions.

The dynamic, scenario-based and response-oriented application of the RBE Method is operationalised through RNTool and RBTool at neighbourhood and building scales respectively. By applying the same assessment structure to different conditions, time horizons and intervention scenarios, the tools allow changes in Hazard, Exposure, Vulnerability and Risk Values to be calculated and compared.

RNTool and RBTool may therefore be used to assess:

- a current or baseline condition
- one or more future conditions
- a condition without additional adaptation measures
- one or more alternative adaptation scenarios
- a monitored condition following implementation.

For each condition or scenario, Hazard, Exposure and Vulnerability Values shall be determined in accordance with the assessment process described in Clause 4.4. The resulting Risk Values may then be compared at Risk Category, Macro Category, Issue and Overall Risk levels.

The operational characteristics and contextualisation of RNTool and RBTool are described in Clause 5.

4.7.2 Assessment of climate risk evolution over time

Climate risk shall be understood as a condition that may evolve over time. Hazard, exposure and vulnerability shall therefore not be treated as fixed characteristics of a building or neighbourhood.

Hazard conditions may change because of variations in the frequency, intensity, duration, likelihood or spatial distribution of climate-related events and trends. Exposure may change as a result of demographic development, urban expansion, changes in land use, building occupancy, infrastructure, services or the presence and relevance of exposed elements. Vulnerability may change as a consequence of deterioration, maintenance, refurbishment, changes in operational capacity, emergency preparedness, environmental conditions or adaptation measures.

Risk at a defined time *t* may be expressed as:

$$RV_{RC_t} = HV_t^{W_{HV}} \times EV_t^{w_{EV}} \times VV_t^{W_{VV}} \quad (13)$$

Where:

- RV_{RC_t} is the Risk Value of the Risk Category at time t;
- HV_t is the Hazard Value at time *t*
- EV_t is the Exposure Value at time *t*

- VV_t is the Vulnerability Value time *t*
- W_{HV} is the weigh associated to HV_t
- W_{EV} is the weight associated to EV_t
- W_V is the weight associated to VV_t

The comparison of Risk Values calculated for different time horizons supports the identification of emerging risks, worsening conditions, changing priorities and adaptation needs.

4.7.3 Assessment of response effectiveness

4.7.3.1 General

Response effectiveness expresses the net change in assessed climate risk between a baseline condition and a specified reference time horizon, taking into account the effects of a defined planning, design, management or adaptation response and other changes in hazard, exposure and vulnerability.

Response effectiveness shall be assessed by comparing two conditions:

- a condition without the considered response at an initial time (t_0)
- a condition with the considered response at a specified time horizon (t_1)

The baseline condition represents the hazard, exposure and vulnerability conditions at the starting time (t_0). The condition at the reference time horizon represents the expected hazard, exposure and vulnerability conditions at that time, including the effects of the response implemented and operational by t_1.

All three risk components may change between t_0 and t_1:

- hazard may change as a result of evolving climatic conditions, changes in the physical processes generating the hazard or measures affecting its local occurrence or intensity
- exposure may change as a result of demographic developments, land-use changes, changes in building occupancy, infrastructure or services, or measures modifying the presence and distribution of exposed elements
- vulnerability may change as a result of adaptation measures modifying the susceptibility of exposed elements to adverse effects, as well as deterioration, maintenance, refurbishment, environmental or social changes.

For prospective assessments, both conditions should refer to the same assessment boundary, benchmark system and weighting structure. Any changes affecting comparability shall be documented and addressed.

At Risk Category level, response effectiveness is assessed by comparing the Risk Value at the starting time (t_0), representing the condition before implementation of the response, with the Risk Value, at the reference time horizon (t_1).

At Risk Category level, absolute response effectiveness shall be expressed as the difference between the baseline Risk Value and the Risk Value at the reference time horizon:

$$RE_{RC}\left(t_{0,}t_1\right) = RV_{RC}\left(t_0\right) - RV_{RC}\left(t_1\right) \tag{14}$$

Where:

- $RE_{RC}(t_0,t_1)$ is the absolute response effectiveness assessed over the period from t_0 to t_1
- $RV_{RC}(t_0)$ is the Risk Value of the baseline condition
- $RV_{RC}(t_1)$ is the Risk Value at the reference time horizon.

Both Risk Values shall be calculated using the corresponding Hazard, Exposure and Vulnerability Values in accordance with 4.4.3.5.

A positive result indicates a net reduction in assessed risk relative to the baseline. A result of zero indicates no net change in the assessed Risk Value. A negative result indicates a net increase in assessed risk. Within this comparison, response effectiveness represents the net change in assessed risk over the specified period. The result reflects both the effects of the considered response and other changes in hazard, exposure and vulnerability. It shall therefore not, by itself, be interpreted as a measure of the risk reduction attributable exclusively to the response.

The assessment shall identify the main factors contributing to the change in risk and distinguish, where practicable, changes associated with the response from changes arising from other climatic, territorial, socioeconomic or environmental developments.

The same calculation approach applies at Macro Category, Issue and Overall assessment levels. Aggregated results shall be reported together with the underlying disaggregated results.

The baseline date, reference time horizon, climate scenario, implementation schedule and operational status of the response shall be documented.

The assessment of response effectiveness is also applicable at Macro Category, Issue and Overall Risk levels using the same approach.

For Macro Categories:

$$RE_{MC}\left(t_{0,}t_1\right)=RV_{MC}\left(t_0\right)-RV_{MC}\left(t_1\right) \tag{15}$$

Where:

- $RE_{MC}(t_0,t_1)$ is the absolute response effectiveness assessed over the period from t_0 to t_1;
- $RV_{MC}(t_0)$ is the Risk Value of the baseline condition;
- $RV_{MC}(t_1)$ is the Risk Value at the reference time horizon.

For Issues:

$$RE_{I}\left(t_{0,}t_1\right)=RV_{I}\left(t_0\right)-RV_{I}\left(t_1\right) \tag{16}$$

Where:

- $RE_{I}(t_0,t_1)$ is the absolute response effectiveness assessed over the period from t_0 to t_1;
- $RV_{I}(t_0)$ is the Risk Value of the baseline condition;
- $RV_{I}(t_1)$ is the Risk Value at the reference time horizon.

For the Overall Risk:

$$RE_{O}\left(t_{0,}t_1\right)=RV_{O}\left(t_0\right)-RV_{O}\left(t_1\right) \tag{17}$$

Where:

- $RE_O(t_0,t_1)$ is the absolute response effectiveness assessed over the period from t_0 to t_1;
- $RV_O(t_0)$ is the Risk Value of the baseline condition;
- $RV_O(t_1)$ is the Risk Value at the reference time horizon.

4.7.3.2 Relative Response Effectiveness

Where Risk Categories have different initial risk levels, absolute risk reduction may not provide a sufficient basis for comparison.

In such cases, response effectiveness for a Risk Category may be expressed as a Relative Response Capacity, calculated as the proportion of the baseline risk (t_0) reduced by the intervention:

$$REL_RE_{RC} = \left(\frac{RV_{RC}(t_0) - RV_{RC}(t_1)}{RV_{RC}(t_0)} \right) \times 100 \quad [\%] \tag{18}$$

where:

- REL_RE_{RC} is the relative response effectiveness of the Risk Category
- $RV_{RC}(t_0)$ is the Risk Value of the baseline condition;
- $RV_{RC}(t_1)$ is the Risk Value at the reference time horizon.

4.7.4 Assessment of residual risk

Residual risk represents the level of climate risk that remains at the reference time horizon (t_1) after the considered adaptation response has been implemented. Residual risk may remain because technical, economic, institutional or environmental constraints limit adaptation measures or for changes in hazard and exposure conditions. Residual risk shall be assessed separately from response capacity because the magnitude of the risk reduction does not, by itself, indicate whether the final condition is acceptable.

For a Risk Category, the Residual Risk is calculated as:

$$RE_RISK_{RC} = RV_{RC}(t_1) \tag{19}$$

where:

- RE_RISK_{RC} is the residual risk of the Risk Category
- $RV_{RC}(t_1)$ is the Risk Value at the reference time horizon.

Accordingly, the relationship between initial risk, response capacity and residual risk may be expressed as:

$$RV_{RC}(t_0) = RV_{RC}(t_1) + RE_RISK_{RC} \tag{20}$$

where:

- $RVRC(t_0)$ is the Risk Value of the baseline condition;
- $RVRC(t_1)$ is the Risk Value at the reference time horizon.
- RE_RISK_{RC} is the residual risk of the Risk Category

This relationship indicates that the baseline risk is composed of two parts: the portion reduced by the response and the portion that remains after implementation. The first part is represented by the absolute response capacity, while the second is represented by the residual risk.

For a Macro Category, the Residual Risk is calculated as:

$$RE_RISK_{MC} = RV_{MC}(t_1) \tag{21}$$

where:

- RE_RISK_{MC} is the residual risk of the Macro Category
- $RV_{MC}(t_1)$ is the expected or observed Risk Value at the reference time horizon.

For an Issue, the Residual Risk is calculated as:

$$RE_RISK_{I} = RV_{I}(t_1) \tag{22}$$

where:

- RE_RISK_{I} is the residual risk of the Issue
- $RV_{I}(t_1)$ is the expected or observed Risk Value at the reference time horizon.

The Overall Residual Risk is calculated as:

$$RE_RISK_{O} = RV_{O}(t_1) \tag{23}$$

where:

- RE_RISK_{O} is the Overall Residual Risk
- $RV_{O}(t_1)$ is the Risk Value at the reference time horizon.

5 The Assessment Tools: RNTool and RBTool

5.1 The Generic Frameworks approach

The RBE Method is implemented through two generic frameworks: RNTool at neighbourhood scale and RBTool at building scale. Both frameworks organise climate risk assessment around the interaction between hazard, exposure and vulnerability. The RBE Method establishes the common conceptual basis, assessment logic and calculation procedures. RNTool and RBTool translate these principles into structured sets of Issues, Macro Categories, Risk Categories, Criteria and Indicators appropriate to their respective assessment scales.

To become an operational assessment tool, a generic framework shall undergo a contextualisation process through which it is adapted to local conditions. It includes the selection of the hazards relevant for the territory, the identification of the exposed elements to be assessed, the selection of applicable Macro Categories and Risk Categories, the adaptation or development of assessment Criteria and Indicators, the definition of local benchmarks, and the assignment of weights reflecting local priorities, data availability and policy objectives.

RNTool and RBTool provide a transnational common methodological structure for local climate risk assessments. Direct comparison of results requires compatible assessment boundaries, criteria, indicator definitions, benchmarks, weights, aggregation rules and temporal assumptions.

5.2 Contextualisation of RNTool and RBTool

5.2.1 General

Through contextualisation, RNTool and RBTool can generate locally operational tools able to support climate risk assessment in a specific neighbourhood or building. This process ensures that the assessment remains coherent with the RBE Method while being responsive to local climate projections, urban and building characteristics, planning instruments, regulatory requirements and stakeholder priorities. The purpose of the contextualisation process is to transform the generic framework into a locally applicable assessment tool, reflecting the climatic conditions, territorial characteristics, building or urban features, regulatory framework, available data and policy priorities of the assessment context.

Contextualisation allows users to select the components of the framework that are applicable, adapt benchmarks and assessment methods to local conditions, and assign weights that reflect the relative importance of hazards, exposed elements, criteria and aggregation levels. The result is an operational tool able to produce meaningful risk values to support diagnosis, prioritisation of adaptation measures, planning decisions and monitoring over time.

Before selecting the assessment components, contextualisation shall establish the assessment purpose, spatial boundary, assessment units, baseline date and, where relevant, reference time horizons. For future assessments, the climatic, demographic, land-use and other relevant assumptions shall be specified. Existing measures and measures assumed to be implemented and operational at each reference time shall be distinguished. The selected Issues, exposed elements, criteria, indicators and data shall be consistent with these assessment conditions.

The contextualisation process is organised in the following steps:

- Selection of relevant Issues
- Selection of applicable Macro Categories
- Selection of Risk Categories
- Adaptation of criteria and indicators
- Development of vulnerability and exposure Criteria for Risk Categories.
- Definition of local benchmarks for Indicators
- Definition or adaptation of assessment methods for Indicators
- Assignment of weights
- Verification of data availability and quality
- Scale-based predefinition and locking of contextualisation choices
- Documentation of contextualisation choices
- Finalisation of the contextualised operational assessment tool

5.2.2 Selection of relevant Issues

The first step in the contextualisation process is the selection of the relevant Issues to be included in the local tool. In the RBE Assessment System, Issues correspond to both climate-related hazards and non-climate-related hazards and represent the highest level of the hierarchical structure of RNTool and RBTool. Therefore, selecting the relevant hazards means selecting the main assessment modules that will be integrated into the locally operational version of the tool.

Not all Issues are relevant in every territorial or building context. The selection shall therefore be based on the likelihood and potential severity of each hazard in the local context, as well as on its expected

impacts on the exposed elements considered in the assessment. Issues that are not relevant, have negligible probability, or are not expected to generate significant impacts may be excluded from the local tool, provided that the rationale for their exclusion is documented.

This selection may be informed by local or regional climate risk assessments, Sustainable Energy and Climate Action Plans, national or regional adaptation strategies, historical data on extreme weather events, climate projections, hazard maps, and consultation with local experts and stakeholders. The outcome of this step is the definition of the set of Issues, i.e. hazard-related modules, that constitute the upper level of the local assessment tool. A list of hazards for selection is reported in Annex A.

5.2.3 Selection of applicable Macro Categories

For each selected Issue, the applicable Macro Categories shall be identified. Macro Categories represent the broader functional domains of the assessed system. At the urban scale, they correspond to Urban Sectors. At the building scale, they correspond to Building System Domains.

The selection of Macro Categories shall reflect the actual characteristics of the assessment context. At the urban scale, this means identifying the Urban Sectors that are present, relevant, exposed or potentially affected by the selected Issues. At the building scale, this means identifying the building components, spaces, systems, occupants or contextual conditions that are effectively present and relevant for the specific building under assessment.

Macro Categories that are not present, not relevant or not assessable in the local context may be excluded. This ensures that the assessment tool remains focused, proportionate and aligned with the actual risk profile of the assessed system.

A reference list of Macro Categories at neighbourhood and building scale is available in Annex B, together with indicative relationship matrixes useful to support the selection of applicable Macro Categories available in Annex C.

5.2.4 Selection of Risk Categories

Once the relevant hazards and Macro Categories have been selected, the Risk Categories shall be defined or selected. A Risk Category represents the specific risk arising from the combination of a specified hazard and a specified exposed element.

The selection of Risk Categories shall identify the combinations of hazards and exposed elements that represent tangible, meaningful and assessable climate risks in the local context. This step should consider the presence of exposed elements, data availability, relevance for local adaptation planning, expected consequences of damage or disruption, stakeholder priorities and the possibility of implementing adaptation measures.

Only Risk Categories that are relevant and assessable should be retained in the operational tool. The resulting set of Risk Categories forms the core of the local assessment tool, because it determines which specific risks will be quantified and reported.

Annex B provides a reference list of Risk Categories organised per Macro Categories.

Annexes D and E provide a reference list of Key Risk Categories, including the description of Criteria and Indicators, recommended for inclusion in operational assessment tools derived from RNTool or RBTool because of its importance and general relevance to climate risk assessment at the respective spatial scale.

5.2.5 Adaptation of Criteria and Indicators

Risk Category are assessed using Criteria and Indicators related to vulnerability, exposure and hazard. Where the reference Key Risk Categories provided in Annexes D and E of this CWA are used during

contextualisation, their associated Criteria and Indicators shall be reviewed to verify their applicability to the local context.

This step includes checking whether the Indicators can be calculated or assessed with available data, whether the proposed assessment method is suitable for the local context, and whether additional or alternative Indicators are needed to properly represent local conditions. Indicators may be quantitative or qualitative, depending on the nature of the criterion and on data availability.

The adaptation of Criteria and Indicators shall not alter the conceptual logic of the RBE Method. Indicators shall remain linked to the assessment of hazard, exposure or vulnerability and shall support the calculation of the corresponding values within the risk assessment process.

5.2.6 Development of vulnerability and exposure Criteria for Risk Categories

For each Risk Category, the RBE Assessment System requires the definition of appropriate exposure and vulnerability criteria, supported by measurable indicators.

Within this CWA, some Risk Categories are identified as Key Risk Categories, because they are considered of common relevance for the assessment of climate risks at building and neighbourhood scale. For these Key Risk Categories, a reference set of vulnerability and exposure Criteria is provided in Annex D and Annex E, together with related indicators and methodological guidance. Other Risk Categories are included in the general structure of RNTool and RBTool, reported in Annexes B.2 and B.4. For these Risk Categories, users may define the most appropriate Criteria and Indicators according to the local context, the available data, the assessment scale and the specific purpose of the evaluation.

When Criteria and Indicators are developed by users, they shall remain coherent with the logic of the RBE Method, which acts as a common methodological language for climate risk assessment. This means that each Criterion should be clearly attributable to one of the three risk components: hazard, exposure or vulnerability.

The coherence of newly proposed Criteria and Indicators with the RBE Method can be verified through a set of basic checks:

- the Criterion should be linked to the specific Risk Category, meaning that it should describe a factor that directly affects the risk level of the exposed element considered
- the Criterion should be relevant to the selected hazard and should contribute to explaining why that hazard may generate impacts on the exposed element
- the Indicator should be measurable or assessable through reliable information, such as spatial data, technical documentation, field surveys, design data, administrative datasets or expert assessment
- the Indicator should be suitable for normalisation within the RBE scoring logic, producing a value within the common performance scale from 0, corresponding to optimal or low-risk conditions, to 1, corresponding to critical or high-risk conditions
- the direction of the Indicator shall be clearly defined, specifying whether higher values correspond to better performance or worse performance.

Users should also verify that new Criteria and Indicators are not redundant with existing ones and that they are applicable at the intended scale of assessment. In RNTool, indicators should be suitable for neighbourhood or urban-scale analysis, while in RBTool they should be suitable for building-scale assessment.

Where possible, Criteria should be formulated in a way that allows comparison between different assessment areas or buildings, while still allowing local contextualisation of benchmarks, thresholds and weights. This approach ensures that the RBE Method remains flexible and adaptable to different territorial contexts, while preserving a consistent structure for evaluating and comparing climate risk across hazards, exposed elements and scales of assessment.

Some Criteria may be relevant to more than one hazard. In such cases, the same criterion may be reused across different Risk Categories, provided that its role in the assessment is clearly defined for each specific hazard-exposed element relationship. The reuse of a criterion across several Risk Categories shall not imply that the criterion has the same relevance, weight, benchmark or assessment method in each case. These elements shall be defined or adapted according to the specific impact mechanism linking the hazard to the exposed element.

Each Criterion shall be explicitly assigned to hazard, exposure or vulnerability according to its role in the assessment. The same physical condition or effect shall not be counted more than once within the calculation of a Risk Category Risk Value.

New or adapted Indicators shall have a documented definition, unit or categorical scale, assessment method, direction of scoring, benchmarks, data requirements and rationale. Their technical suitability shall be reviewed before inclusion in the operational tool. Indicators may be quantitative or qualitative.

5.2.7 Definition of local benchmarks

For each quantitative Indicator, local benchmarks shall be defined in order to normalise the indicator value within the common scale from 0 to 1. The benchmark associated with 0 represents the optimal or least critical condition, while the benchmark associated with 1 represents the critical or most unfavourable condition.

In the normalisation functions (see 4.4.2), benchmarks are noted as x_{min} and x_{max}.

Benchmarks shall be adapted to the local context because climatic conditions, territorial features, building characteristics, regulatory requirements and policy objectives may differ significantly from one place to another. When defining benchmarks, priority should be given to binding regulations, recognised technical standards, authoritative guidelines, official planning documents, scientific literature and validated technical references.

The definition of benchmarks is a key step because it determines how raw indicator values are translated into normalised scores and, consequently, how criticality is represented in the assessment. The rationale for the selected benchmarks should therefore be documented.

For qualitative Indicators, the descriptive conditions associated with each score shall be defined.

Benchmarks and scoring rules shall remain consistent across the baseline, reference time horizons and alternatives included in a comparison. Where they are revised, the compared conditions shall be recalculated using the same rules.

5.2.8 Definition or adaptation of assessment methods

For every Indicator included in the operational tools, including new developed Indicators, the assessment method shall be defined or adapted. It shall specify how the Indicator is measured, calculated, estimated or assigned, together with the required data, units, spatial and temporal resolution. Assessment methods should be sufficiently clear to ensure transparency and repeatability.

When different data sources or calculation approaches are available, the selected method should be appropriate to the scale of assessment, the purpose of the evaluation, the required level of accuracy and the resources available. When data are limited, simplified methods may be used, provided that their limitations are clearly reported.

5.2.9 Assignment of weights

Weights shall be assigned to represent the relative importance of the different elements included in the RBE Method. Weighting may be required at several levels, including:

- aggregation of Indicators into Vulnerability, Exposure and Hazard Values

- combination of Hazard, Exposure and Vulnerability Values into Risk Category Values
- aggregation of Risk Categories into Macro Category Values
- aggregation of Macro Categories into Issue Risk Values
- aggregation of Issue Risk Values into the Overall Risk Value.

Weights should reflect local policy priorities, expected severity of impacts, criticality of exposed elements, strategic relevance for adaptation planning, reliability of available data and stakeholder priorities. The weighting process should be transparent, documented and, where possible, supported by participatory methods or expert judgement.

The weighting approach shall be appropriate to the purpose, scale and context of the assessment. Weights may be established using one or a combination of the following approaches:

- Equal weighting

  Equal weighting assigns the same importance to all elements included at a given aggregation level. This approach may be used where:

  - there is insufficient evidence to justify differentiated weights;
  - all elements are considered equally relevant;
  - the purpose is to provide a transparent and neutral baseline;
  - comparability and simplicity are prioritised.

  Equal weighting should be considered the default approach where no robust technical, scientific, policy-based or participatory justification exists for assigning different weights. The use of equal weights does not imply that the assessed elements are identical, but that no sufficiently justified basis is available for differentiating their relative importance.
- Expert judgement

  Weights may be derived through structured consultation with experts possessing relevant scientific, technical, territorial or sectoral knowledge. Experts may assign weights individually or collectively using scoring, ranking, pairwise comparison or structured elicitation procedures.
- Stakeholder engagement

  Weights may be defined through the involvement of public authorities, infrastructure operators, building owners, professionals, community representatives, vulnerable groups and other relevant stakeholders.

  Stakeholder-based weighting is particularly appropriate where the relative importance of risks depends on: local policy priorities, societal values, perceived criticality of services or assets, acceptability of consequences, distributional or equity considerations, local adaptation objectives. Possible methods include workshops, facilitated discussions, ranking exercises, weighted voting, questionnaires and participatory multi-criteria procedures. Stakeholder engagement shall be designed to avoid over-representation of particular interests and should make visible any relevant differences between stakeholder groups.
- Analytic Hierarchy Process

  The Analytic Hierarchy Process (AHP) may be used to derive weights through pairwise comparisons between assessment elements. Participants compare the relative importance of two elements at a time, and the resulting comparison matrix is used to calculate a set of normalised weights. AHP is particularly suitable where: the number of elements is manageable, expert or stakeholder judgement needs to be structured, the rationale for relative importance should be made explicit, consistency of judgements needs to be checked.
- Delphi method

  The Delphi method may be used to obtain weights through an iterative and anonymous expert-consultation process. Experts provide their judgements in successive rounds and receive controlled feedback on the results of the preceding round. This approach may be appropriate where: direct consensus is difficult to achieve, experts are geographically dispersed, dominant

individuals could influence an open discussion, uncertainty or disagreement is significant, a documented convergence process is required.

- Direct rating, ranking and point allocation

  Weights may be established through direct rating or ranking methods. Participants may:

  - assign importance scores to each element;
  - rank the elements from most to least important;
  - distribute a fixed number of points among the elements;
  - allocate percentages summing to 100 %.

- Literature- and evidence-based weighting

  Weights may be derived from scientific literature, technical standards, historical-loss data, climate-risk studies, sectoral analyses, damage functions, vulnerability studies or other recognised evidence. This approach is appropriate where robust evidence exists on:

  - the relative contribution of risk factors;
  - the criticality of exposed elements;
  - the frequency or severity of consequences;
  - historical damage or disruption;
  - the effectiveness of adaptation measures.

- Policy- and priority-based weighting

  Weights may reflect formally adopted policy objectives, adaptation strategies, emergency plans, SECAP priorities, planning instruments, service-criticality classifications or other institutional priorities. Policy-based weighting may be used where the assessment is intended to support a specific decision-making process. The relationship between the assigned weights and the relevant policy objectives shall be explicitly documented. Policy priorities should not replace technical evidence but may complement it.

Regardless of the selected method, the resulting weights shall be reviewed for plausibility, transparency and consistency with the purpose of the assessment.

Sensitivity analysis should be performed where changes in weights may significantly affect the:

- ranking of Risk Categories;
- identification of priority Macro Categories;
- Issue Risk Values;
- Overall Risk Value;
- comparison of adaptation options.

Sensitivity analysis may include:

- comparison with an equal-weight baseline;
- variation of individual weights within a defined range;
- use of alternative weighting scenarios;
- testing of different expert or stakeholder weight sets;
- identification of threshold values at which rankings change.

Where small changes in weights produce substantial changes in the results, this shall be documented and considered in the interpretation of the assessment.

5.2.10 Verification of data availability and quality

The contextualisation process shall include a verification of data availability and data quality. The operational tool should only include Indicators and Risk Categories for which data can be obtained with an acceptable level of reliability, accuracy and effort.

Data may derive from municipal datasets, geographic information systems, building documentation, climate databases, monitoring systems, surveys, inspections, technical studies or expert assessments.

For each Indicator, the data source should be identified and the quality of the data should be evaluated in relation to completeness, spatial resolution, temporal resolution, update frequency and reliability.

Where data gaps exist, the contextualisation process may define proxy indicators, simplified assessment methods or data collection procedures. However, the use of assumptions or proxy data should be clearly documented.

5.2.11 Scale-based predefinition and locking of contextualisation choices

In order to increase consistency and comparability between assessments, selected contextualisation choices may be predefined at higher spatial or administrative levels and then applied to lower-level assessments. This approach is particularly relevant for choices that should remain consistent across a wider territory, such as a region or a province, including the selection of tool components (Issues, Macro Categories, Risk Categories and related Criteria and Indicators) as well as the definition of benchmarks and weights.

The spatial level at which a contextualisation choice is predefined should depend on the nature and spatial extent of the parameter. Choices related to hazards and their relative importance should generally be defined at broader spatial levels, such as regional, provincial, catchment, metropolitan or municipal level. Choices related to exposure and vulnerability should generally remain adjustable at neighbourhood, building, component or exposed-element level, where local conditions can be assessed more accurately.

For example, the weight assigned to Issue “Droughts” may be predefined at regional or provincial level where the hazard affects a large territory in a relatively homogeneous way. The weight assigned to Issue “Floods” be locked at city, catchment or flood-prone area level, reflecting local hydrological conditions and flood hazard maps. The weight assigned to Issue “Extreme Heat” may be predefined at city level, with justified adjustments allowed for neighbourhoods affected by specific urban heat island conditions.

A scale-based contextualisation control matrix may be used to specify which choices are locked, adjustable or inherited at each spatial level. Locked choices shall be applied consistently to all assessments within the defined spatial unit. Adjustable choices may be modified at a lower level only where the modification is justified by local evidence. Inherited choices are used in lower-level assessments without modification.

Table 4 — Informative locking options for the contextualization process

Contextualisation choice	Regional/provincial level	City/catchment level	Neighbourhood level	Building level
Selection of relevant Issues	L/A	L	U	U
Issue weights	A	L	U/A	U
Hazard benchmarks	A	L	U	U
Selection of Macro Categories	—	A	L	U
Selection of Risk Categories	—	A	L	U/A
Selection of Exposed Elements	—	A	A	L
Exposure criteria	—	A	L	L
Vulnerability criteria	—	A	A	L

Indicator benchmarks	A	A/L	U/A	U/A
Indicator weights	—	A	A/L	L

Key:

L = locked at this level and applied consistently to lower-level assessments;

A = adjustable at this level, provided that the adjustment is justified;

U = inherited from a higher level and used in the assessment; **—** = normally not applicable at this level.

Table 5 — Informative locking options for the selection of Issues in the contextualization process

Issue/ Hazard	Regional/provincial level	City/catchment level	Neighbourhood level	Building level
A – Heavy precipitation	A	L	U/A	U
B – Floods	A	L	U/A	U
C – Extreme heat	A	L	A	U
D – Drought	L/A	A	U	U
E – Storms	A	L	U	U
F – Wildfires	A	L in exposed zones	U/A	U/A
G – Mass movement	A	L in exposed zones	U/A	U
H – Sea level rise	L/A	L for coastal areas	U	U
I – Extreme cold	A	L	U/A	U
J – Air pollution	A	L	A	U/A

Legend:

L = the Issue weight should be locked at this level and consistently applied to lower-level assessments;

A = the Issue weight may be adjusted at this level if justified by local evidence;

U = the Issue weight is inherited from a higher level and used in the assessment;

L/A = the Issue weight may be locked or adjusted depending on the spatial extent and homogeneity of the hazard.

Predefinition may establish common terminology, indicator definitions, assessment methods, benchmarks, scoring rules and weighting structures for assessments intended to be compared within a defined territory.

The inheritance of common assessment rules shall not imply the inheritance of local Hazard, Exposure or Vulnerability Values. These values shall represent the conditions of the specific assessment unit and scenario.

A predefined set of Issues may establish a common minimum assessment scope. Locally relevant hazards shall not be omitted solely because they are absent from that predefined set.

Issue weights shall represent the intended importance of Issues in the aggregation of results. Local differences in hazard intensity, frequency or likelihood shall be represented through Hazard Values rather than through adjustments to Issue weights intended to reproduce those same differences.

A locked choice shall remain unchanged within the assessments covered by the relevant comparison framework. Any proposed revision shall follow a documented review and approval procedure, create an identifiable framework version and state its implications for comparability.

This approach does not remove the need for local contextualisation. Rather, it distinguishes between parameters that should remain consistent across a wider territory and parameters that should reflect local exposure, vulnerability, building characteristics or data availability. Any deviation from locked or inherited choices shall be documented and justified in the contextualisation report.

5.2.12 Documentation of contextualisation choices

All choices made during contextualisation shall be documented. This includes:

- the selection or exclusion of Issues, Macro Categories and Risk Categories
- the adaptation of Criteria and indicators
- the definition of benchmarks
- the selection of assessment methods
- the assignment of weights
- the identification of data sources.

Documentation is essential to ensure transparency, comparability, repeatability and future updating of the assessment tool. It also allows users and decision-makers to understand the assumptions underlying the results and to revise the tool when new data, policies, standards or climate projections become available.

The contextualisation report shall also identify the framework version, responsible organisation, review or approval date, assessment boundary, baseline date, reference time horizons and scenario assumptions.

Relevant risks that remain unassessed or insufficiently assessed shall be listed together with the associated data gaps and limitations. Changes to criteria, benchmarks, weights or methods shall be recorded so that their effects on comparability can be evaluated.

5.2.13 Outcome of the contextualisation process

The outcome of the contextualisation process is a locally adapted operational risk assessment tool (RNTool, RBTool). The tool includes the Issues, Macro Categories, Risk Categories, Criteria, Indicators, benchmarks, assessment methods, weights and data sources that are relevant for the specific assessment context.

The operational tool shall be able to calculate climate risk values in accordance with the RBE Method and to provide results that are meaningful for local decision-making. It can be used to support the identification of priority risks, the design and prioritisation of adaptation measures, the integration of climate resilience into planning and design processes, and the monitoring of progress over time.

Before operational use, the contextualised tool shall be checked for consistency of its structure, indicator directionality, scoring rules, weight normalisation and calculation procedures. Its intended application, assessment coverage and known limitations shall be stated.

6 Cross-scale assessment and integration

6.1 General

RNTool and RBTool implement the same RBE Method at neighbourhood and building scales, respectively. Both frameworks assess climate risk through the interaction between hazard, exposure and vulnerability, while organising the assessment according to the Exposed Elements and Macro Categories relevant to each scale.

In RNTool, Macro Categories correspond to Urban Sectors. In RBTool, Macro Categories correspond to Building System Domains. These categories provide complementary perspectives on the built environment and may be linked to support the exchange of information, interpretation of results and coordination of adaptation measures.

Cross-scale integration shall be based on an explicit mapping between the relevant RBTool Building System Domains and RNTool Urban Sectors. This mapping identifies how building-scale conditions and results may inform neighbourhood-scale assessment. It does not imply that the linked categories are equivalent or that their Risk Values can be aggregated without further verification.

The cross-scale alignment presented in Annex B.5 provides a reference for identifying relevant relationships. Its application shall be reviewed during contextualisation, taking into account the selected hazards, exposed elements, assessment boundaries and intended use of the results.

Cross-scale assessment may support:

- the use of building-level data to inform neighbourhood-scale Criteria and Indicators
- the identification of buildings and Building System Domains contributing to critical conditions within an urban sector
- the interpretation of building-level risks in their neighbourhood context
- the coordination of adaptation measures across building and neighbourhood scales
- the assessment of changes between the baseline and specified reference time horizons.

For each assessed condition, cross-scale information shall refer to a consistent time reference and compatible scenario assumptions. Baseline results shall be distinguished from results for future or intervention conditions.

Cross-scale integration supports climate risk assessment and adaptation planning.

6.2 Building derived risk value of an Urban Sector

6.2.1 General

RBTool results may be used to inform the assessment of a corresponding RNTool Urban Sector where the relationship between the Building System Domains and the Urban Sector is explicitly defined.

Before numerical aggregation, the assessment shall verify:

- compatibility of the reference time, climate scenario and assessment assumptions
- consistency of the meaning and scope of the linked assessment categories
- the coverage and representativeness of the buildings included
- the treatment of missing data, non-applicable domains and overlapping information.

Where only a sample of buildings is assessed, the sampling approach and any extrapolation to the wider building stock shall be documented.

For a given Issue, the building-derived risk value ($BR_{s,h}$) of an RNTool Urban Sector may be calculated by aggregating the Risk Values of the RBTool Building System Domains linked to that Urban Sector. This means computing the weighted sum of all Risk Values of the Building System Domains for each selected building for a given Issue, as well as the weighted sum of the resulting values of every building:

$$BR_{s,h} = \frac{\sum_{b=1}^{m}\sum_{c=1}^{n}\left(RB_{b,c,h} \times L_{c,s} \times W_b \times W_c\right)}{\sum_{b=1}^{m}\sum_{c=1}^{n}\left(L_{c,s} \times W_b \times W_c\right)} \quad (24)$$

where:

- $BR_{s,h}$ is the building-derived risk value of an Urban Sector under Issue h;
- $RB_{b,c,h}$ is the Risk Value of Building System Domain c in building b under Issue h;
- $L_{c,s}$ is the taxonomic linkage coefficient between Building System Domain c and the Urban Sector;
- W_b is the weight assigned to building b;
- W_c is the weight assigned to Building System Domain c;
- m is the number of buildings considered;
- n is the number of Building System Domains linked to Urban Sector.

Weighting factors of buildings shall fulfil the following properties:

$$0 \leq W_b \leq 1$$

$$\sum_{i=1}^{n} W_b = 1$$

Building weights may reflect floor area, occupancy, service provision or another measure relevant to the assessed Urban Sector.

Weighting factors of Building System Domains shall fulfil the following properties:

$$0 \leq W_c \leq 1$$

$$\sum_{i=1}^{n} W_c = 1$$

The taxonomic linkage coefficient $L_{c,s}$ may be defined according to the cross-scale alignment matrix:

- $L_{c,s}$ = 1.0 for direct or primary links;
- $L_{c,s}$ = 0.0 for no typical link, unless a different value is justified during contextualisation.

The linkage coefficient shall identify whether a Building System Domain is included in the aggregation for the specified Urban Sector. A value of 1 indicates an included relationship and a value of 0 indicates an excluded relationship. The inclusion of a domain shall be justified in relation to its relevance to the Urban Sector and Issue being assessed.

6.2.2 Optional combination with RNTool results

Where a building-derived sector index ($BR_{s,h}$)and a directly calculated RNTool Macro Category Risk Value refer to compatible assessment scopes and conditions, they may be combined using Equation (25) to produce a complementary cross-scale index:

$$R^{*}_{s,h} = \left(RN_{s,h} \times W_{RN} \right) + \left(BR_{s,h} \times W_{RB} \right) \quad (25)$$

where:

- $R^{*}_{s,h}$ is the integrated cross-scale risk value of Urban Sector s under Issue h;
- $RN_{s,h}$ is the risk value calculated directly in RNTool for Urban Sector s under Issue h;
- $BR_{s,h}$ is the building-derived risk value calculated from linked RBTool results;
- W_{RN} is the weight assigned to the neighbourhood-scale RNTool contribution;
- W_{RB} is the weight assigned to the building-derived RBTool contribution.

The weights shall fulfil the following properties:

$0 \leq W_{RN} \leq 1$

$0 \leq W_{RB} \leq 1$

$W_{RN} + W_{RB} = 1$

Before applying this combination, the assessment shall identify information shared by the two contributions and demonstrate that the combination does not introduce unjustified duplication or disproportionate weighting of the same exposed elements or conditions.

The weights assigned to the RNTool and building-derived contributions shall be justified and documented.

The combined result shall be identified as a complementary cross-scale index. It shall be reported separately from the standard RNTool Macro Category Risk Value and the original RBTool results. It shall not automatically replace either result.

Where the two contributions describe substantially different scopes or cannot be made sufficiently compatible, they shall be reported alongside one another rather than combined numerically.

The report shall document the taxonomic mapping, included buildings and domains, linkage coefficients, weights, assessment conditions, data coverage, assumptions and limitations.

This calculation shall be considered a complementary cross-scale integration procedure. It may be applied only when the taxonomic links, linkage coefficients, building weights, component weights, and data sources are clearly documented. The resulting integrated value shall be reported separately from the standard RNTool and RBTool results, together with the assumptions and limitations of the cross-scale aggregation.

Annex A
(informative)

Hazards

Annex A provides the RBE Method reference list of Issues relevant to climate-risk assessment in the built environment providing a common reference framework for RNTool and RBTool.

Table A.1 — List of Issues relevant to climate-risk assessment

Code	Issue	Type	Description
A	**Heavy precipitation**	Climate related	A precipitation event that is of very high magnitude with a very rare occurrence at a particular place. Sub-hazards: rainstorm, monsoon, heavy snow, hail
B	**Floods**	Climate related	The overflowing of the normal confines of a stream or other water body, or the accumulation of water over areas that are not normally submerged.
C	**Extreme heat**	Climate related	Marked warming of the air or the invasion of very warm air, over a large area, lasting from a few days to a few weeks. Sub-Hazards: heat wave, extreme hot days.
D	**Droughts**	Climate related	A period of abnormally dry weather long enough to cause a serious hydrological imbalance which may result in long-term water imbalances and insufficient water resources to satisfy long-term average requirements
E	**Storms**	Climate related	An atmospheric disturbance that can manifest in strong winds and accompanied by rain, snow, or other precipitation and by thunder and lightning. Sub-hazards: severe wind, tornado, cyclone, extra tropical storm, tropical storm, storm surge, lighting/thunderstorm
F	**Wildfires**	Non climate related	Any uncontrolled and non-prescribed combustion or burning of plants in a natural setting such as a forest, grassland, brush land or tundra, which consumes the natural fuels and spreads based on environmental conditions. Sub-hazards: Forest fire, land fire
G	**Mass Movement**	Non climate related	Any type of downslope movement of earth materials (landslide, avalanche, rockfall, subsidence)
H	**Sea-level rise**	Climate related	Change to the height of sea level, both globally and locally due to a change in ocean volume.
I	**Extreme Cold**	Climate related	Marked cooling of the air or the invasion of very cold air, over a large area
J	**Air Pollution**	Non climate related	Refers to the presence of harmful substances in the atmosphere—such as particulate matter (PM), nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and greenhouse gases (GHGs) like carbon dioxide (CO_2) and methane (CH_4)—which contribute to both immediate health risks and long-term environmental degradation.

Annex B
(informative)

Macro Categories and Risk Categories

B.1 RNTool Macro Categories: Urban Sectors

RNTool structures the neighbourhood-scale assessment around a set of Macro Categories representing the urban sectors supporting a systematic reading of the urban context by grouping the physical, functional, environmental and socio-spatial aspects that may be affected by hazards. The Macro Categories reported in the following table provide a common reference framework for the application of RNTool and for the contextualisation of the assessment at local scale.

Table B.1 — Description of Urban Sectors macro-categories of RNTool

Urban Sector	**Description**
1. Buildings	Refers to groups of structures, surrounding spaces, permanently constructed or erected on its site
2. Transport	Includes road, rail, air and water transport networks and related infrastructure.
3. Energy	Refers to the energy supply service and related infrastructure
4. Water	Refers to the water supply service and related infrastructure. It also covers water use and the (waste-, rain-) water management system that includes sewers, drainage and treatment systems
5. Waste	Includes activities related to the management (including collection, treatment and disposal)
6. Agriculture & forestry	Includes land classified / designated for agriculture & forestry use. It includes animal husbandry, aquaculture, agroforestry, beekeeping, horticulture and other agriculture & forestry management and services in the area.
7. Environment & biodiversity	Environment refers to green and blue landscapes, including urban hinterland. Biodiversity refers to the variety of life in a specific region, measurable as the variety within species, between species, and the variety of ecosystems
8. Health	Refers to the well-being of humans. It also includes the health care service and related infrastructure.
9. Emergency Services	Refers to the operation of the civil protection and emergency services by or on behalf of public authorities.
10. Tourism	Refers to the activities of persons travelling to and staying in places outside their usual environment.
11. ICT	Refers to different types of communications networks and the technologies used in them (ICT = Information & Communication Technologies).
12. Economic systems	Refers to the set of economic activities, financial infrastructures and trade networks

B.2 RNTool: Risk Categories and Exposed Elements

The Macro Categories of RNTool are subdivided in Risk Categories, that identified the specific exposed elements within the Urban Sector. The Risk Categories reported in the following table provide a common reference framework for the application of RNTool and for the contextualisation of the assessment at local scale.

Table B.2 — Risk Categories and Exposed Elements of RNTool

1 BUILDINGS						
1.1	1.2	1.3	1.4	1.5	1.6	
Residential buildings	Public buildings	Commercial buildings	Industrial buildings	Historic and cultural sites	Other	
2 TRANSPORT						
2.1	2.2	2.3	2.4	2.5	2.6	2.7
Public transit infrastructure	Road transport network and infrastructure	Rail transport network and infrastructure	Air transport infrastructure	Bicycle and pedestrian paths	Water transport network and infrastructure	Other
3 ENERGY							
3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
Power plants	Substations	Electrical grid infrastructure	Renewable energy installations	Gas pipelines	District Heating and Cooling Systems	Fuel storage facilities	Other
4 WATER						
4.1	4.2	4.3	4.4	4.5		
Waste treatment plants	Water supply network	Sewage system	Wastewater treatment plants	Other		
5 WASTE						
5.1	5.2	5.3	5.4	5.5		
Waste collection infrastructure	Waste treatment plans	Hazardous waste storage Site	Landfills	Other		
6 AGRICULTURE & FORESTRY						
6.1	6.2	6.3	6.4			
Urban forests	Urban and peri-urban agricultural zones	Animal husbandry	Other			
7 ENVIRONMENT & BIODIVERSITY						
7.1	7.2	7.3	7.4	7.5	7.6	7.7
Urban green spaces	Urban water bodies	Street Trees	Biodiversity and ecosystems	Wetlands and riparian zones	Coastal ecosystems	Other
8 HEALTH						
8.1	8.2	8.3				
Population	Healthcare facilities	Other				
9 EMERGENCY SERVICES						
9.1	9.2	9.3	9.4	9.5		
Civil Protection service	Fire brigade service	Police service	Emergency medical services	Other		
10 TOURISM						
10.1	10.2	10.3	10.4	10.5	10.6	
Hotels and resorts	Beaches and coastal Areas	Restaurants and cafes	Event venues	Touristic attractions	Other	
11 INFORMATION AND COMMUNICATION TECHNOLOGIES						
11.1	11.2	11.3	11.4	11.5	11.6	
Telecommunication towers	Data centres	Fibre optic and cable networks	Smart city infrastructure	Internet Exchange Points (IXPs)	Other	
12 ECONOMIC SYSTEMS						
12.1	12.2	12.3	12.4			
Economic assets	Supply chains and logistics hubs	Financial services infrastructure	Other			

B.3 RBTool Macro Categories; Building System Domains

RBTool structures the building-scale assessment around a set of Macro Categories representing the main Building system domains that may be exposed to hazards. They support a systematic analysis of the building by grouping its main physical, functional and technical parts. The Macro Areas reported in the following table provides a common reference framework for the application of RBTool and for the contextualisation of the assessment according to the specific building typology, use, location and available data.

Table B.3 — Description of Building System Domains macro-categories of RBTool

Building system domain	Description
1. Foundations	Substructure elements that transfer loads from the building to the ground and ensure stability, including footings, slabs, piles, retaining structures and basement structures.
2. Load-bearing structural frame	Primary structural system responsible for supporting vertical and horizontal loads, including columns, beams, slabs, walls, bracing systems and other structural members.
3. Non-load-bearing elements	Building parts that do not contribute significantly to structural stability but may influence safety, functionality and damage propagation, such as partitions, ceilings, internal linings and lightweight envelope elements.
4. Façade	External vertical envelope system separating indoor and outdoor environments, including walls, windows, doors, cladding, shading devices, balconies and other façade-related elements.
5. Roof	Upper envelope system protecting the building from external climatic conditions, including roof structure, waterproofing layers, insulation, drainage elements, roof openings and rooftop installations
6. Fittings and furnishings	Fixed or movable internal equipment and furniture that support building use and occupancy, including built-in furniture, internal finishes, appliances and user-related equipment.
7. In-built lighting system	Permanent lighting installations integrated into the building, including luminaires, wiring, controls, sensors and emergency lighting systems.
8. Energy system	Systems used for energy generation, distribution, storage and consumption within the building, including heating, cooling, renewable energy systems, electrical distribution and energy storage devices.
9. Ventilation system	Natural, mechanical or hybrid systems that provide air exchange and indoor air quality control, including ducts, fans, air handling units, vents, filters and control devices.
10. Sanitary systems	Systems related to water supply, wastewater collection and sanitary services, including pipes, fixtures, drains, pumps, tanks and related control devices.

11. Other systems	Additional technical systems not included in the previous categories but relevant to building operation, safety or resilience, such as fire protection, security, communication, automation or monitoring systems.
12. Utilities	External or internal service networks that support building operation, including connections to electricity, water, gas, sewage, district heating/cooling, telecommunications and other essential services.
13. Landscaping	Outdoor areas and site features associated with the building, including green areas, paved surfaces, trees, drainage systems, soil, fences, access paths and external furniture.
14. Occupants	People using, living in, working in or visiting the building, whose presence, behaviour, sensitivity and capacity to respond may influence exposure and vulnerability.
15. Location	Spatial and environmental context of the building, including its position in relation to hazards, topography, surrounding urban fabric, infrastructure and environmental conditions.
16. Community	Social dimension of safety within the building, encompassing occupants' collective awareness, cooperation and coordinated behaviour during emergencies, supported by shared spaces.

B.4 RBTool: Risk Categories and Exposed Elements

The Macro Categories of RBTool are subdivided in Risk Categories, that identified the specific element exposed within the Building System Domain. The Risk Categories reported in the following table provide a common reference framework for the application of RBTool and for the contextualisation of the assessment at local scale.

Table B.4 — Risk Categories and Exposed Elements of RBTool

1 FOUNDATION				
1.1	**1.2**	**1.3**	**1.4**	
Piles	Basements	Retaining walls	Shallow foundation	
2 LOAD-BEARING STRUCTURAL FRAME				
2.1	**2.2**	**2.3**	**2.4**	
Frame (beams, columns and slabs)	Upper floors	External walls	Balconies	
3 NON-LOAD BEARING ELEMENTS				
3.1	**3.2**	**3.3**		
Ground floor slab	Internal walls, partitions and doors	Stairs and ramps		
4 FAÇADE				
4.1	**4.2**	**4.3**		
External wall systems, cladding and shading devices	Façade openings	External paints, coatings and renders		
5 ROOF				
5.1	**5.2**			
Structure	Weatherproofing			
6 FITTINGS AND FURNISHINGS				
6.1	**6.2**	**6.3**	**6.4**	**6.5**
Sanitary fittings	Cupboards, wardrobes and worktops	Ceilings	Wall and ceiling finishes	Floor coverings and finishes
7 IN-BUILT LIGHTING SYSTEM				
7.1	**7.2**			

Light fittings	Control systems and sensors		
8 ENERGY SYSTEM			
8.1	**8.2**	**8.3**	
Heating plant and distribution	Cooling plant and distribution	Electricity generation and distribution	
9 VENTILATION SYSTEM			
9.1	**9.2**		
Air handling units	Ductwork and distribution		
10 SANITARY SYSTEMS			
10.1	**10.2**	**10.3**	**10.4**
Cold water distribution	Hot water distribution	Water treatment systems	Drainage systems
11 OTHER SYSTEMS			
11.1	**11.2**	**11.3**	**11.4**
Lifts and escalators	Firefighting installations	Communication and security installation	Telecoms and data installation
12 UTILITIES			
12.1	**12.2**		
Connection and diversions	Substation and equipment		
13 LANDSCAPING			
13.1	**13.2**	**13.3**	
Paving and other hard surfacing	Fencing, railing and walls	Drainage system	
14 LOCATION			
14.1	**14.2**	**14.3**	
Proximity	Greenery	Urban Morphology	
15 OCCUPANTS			
15.1	**15.2**	**15.3**	
Comfort	Accessibility	Emergency	
16 COMMUNITY			
16.1			
Safety			

B.5 Cross-scale assessment

The cross-scale assessment is supported by a taxonomic alignment between RBTool Building System Domains and RNTool Urban Sectors. This alignment identifies the potential direct or contextual relationships between the building and neighbourhood-scale Macro Categories. It does not imply automatic numerical aggregation, but provides a structured basis for information exchange, interpretation of results and identification of possible cross-scale dependencies.

Table B.5 — Cross-scale assessment

RNTool Urban sectors RBTool Building system domain	1 Buildings	2 Transport	3 Energy	4 Water	5 Waste	6 Agriculture & forestry	7 Environment & biodiversity	8 Health	9 Civil protection & emergency	10 Tourism	11 ICT	12 Economic systems
1 Foundations	Y	—	—	—	—	—	—	—	—	—	—	—
A2 Load-bearing structural frame	Y	—	—	—	—	—	—	Y	—	—	—	—
3 Non-load-bearing elements	Y	—	—	—	—	—	—	Y	—	—	—	—
4 Façade	Y	—	—	—	—	—	—	Y	—	—	—	—
5 Roof	Y	—	—	—	—	—	—	Y	—	—	—	—
6 Fittings and furnishings	Y	—	—	—	—	—	—	Y	—	—	—	—
7 In-built lighting system	Y	—	Y	—	—	—	—	—	—	—	—	—
8 Energy system	Y	—	Y	—	—	—	—	—	—	—	—	—
9 Ventilation system	Y	—	Y	—	—	—	—	—	—	—	—	—
10 Sanitary systems	Y	—	—	Y	—	—	—	—	—	—	—	—
11 Other systems	Y	—	—	—	—	—	—	—	—	—	Y	—
12 Utilities	Y	—	Y	Y	—	—	—	—	—	—	Y	—
13 Landscaping	—	Y	—	Y	—	—	Y	Y	—	—	—	—
14 Location	—	Y	—	Y	—	—	Y	—	Y	—	—	—
15 Occupants	—	—	—	—	—	—	—	Y	Y	—	—	—
16 Community	—	—	—	—	—	—	—	Y	Y	Y	—	—

Legend:
Y = direct cross scale relationship ;
— = not evident relationship

Annex C
(informative)

Hazard-specific application of Macro Categories and Risk Categories

C.1 RNTool Macro Categories and Risk categories affected by each hazard

The following tables identify the Macro Categories and Risk Categories selected as most relevant for each Issue. These tables shall not replace the contextualisation process, since the final selection shall always be based on local priorities, such as the site's exposure, urban characteristics, data availability, and the intended purpose of the assessment.

Table C.1 — Heavy precipitation

A HEAVY PRECIPITATION
A1 BUILDINGS
A1.1 Damage risk for residential buildings
A1.2 Damage risk for public buildings
A1.3 Damage risk for commercial buildings
A1.4 Damage risk for industrial buildings
A1.5 Damage risk for historical and cultural sites
A2 TRANSPORT
A2.1 Damage risk for public transit infrastructure
A2.2 Damage risk for road transport network
A2.3 Damage risk for rail transport network
A2.5 Damage risk for bicycle and pedestrian paths
A2.6 Damage risk for water transportation network
A3 ENERGY
A3.4 Damage risk for renewable energy installations
A3.8 Damage risk for power lines
A3.9 Damage risk for substations
A4 WATER
A4.1 Damage risk for water treatment plants
A4.2 Damage risk for water supply network
A4.3 Damage risk for sewage system
A4.4 Damage risk for wastewater treatment plants
A7 ENVIRONMENT & BIODIVERSITY
A7.1 Damage risk for urban green spaces
A7.2 Damage risk for urban water bodies
A7.3 Damage risk for street trees
A7.4 Damage risk for biodiversity and ecosystems
A7.6 Damage risk for coastal ecosystems

A8 HEALTH
A8.1 Health risk for the population
A8.2 Damage risk for healthcare facilities
A9 EMERGENCY SERVICES
A9.1 Efficiency risk for civil protection service
A9.2 Efficiency risk for the fire brigade
A9.4 Efficiency risk for emergency medical services
A10 TOURISM
A10.1 Damage risk for hotels and resorts
A10.2 Damage risk for beaches and coastal areas
A10.3 Damage risk for restaurants and cafes
A10.5 Damage risk for touristic attractions
A11 INFORMATION AND COMMUNICATION TECHNOLOGIES
A11.1 Damage risk for telecommunication towers
A12 ECONOMIC SYSTEMS
A12.1 Damage risk for economic assets
A12.2 Damage risk for supply chains and logistics hubs

Table C.2 — Floods

B FLOODS
B1 BUILDINGS
B1.1 Damage risk for residential buildings
B1.2 Damage risk for public buildings
B1.3 Damage risk for commercial buildings
B1.4 Damage risk for industrial buildings
B1.5 Damage risk for historical and cultural sites
B2 TRANSPORT
B2.1 Damage risk for public transit infrastructure
B2.2 Damage risk for road transport network
B2.3 Damage risk for rail transport network
B2.5 Damage risk for bicycle and pedestrian paths
B2.6 Damage risk for water transportation network
B3 ENERGY
B3.9 Damage risk for substations
B4 WATER
B4.1 Damage risk for water treatment plants
B4.2 Damage risk for water supply network
B4.3 Damage risk for sewage system
B4.4 Damage risk for wastewater treatment plants
B5 WASTE
B5.1 Damage risk for waste collection infrastructure
B5.4 Damage risk for landfills
B7 ENVIRONMENT & BIODIVERSITY
B7.1 Damage risk for urban green spaces
B7.2 Damage risk for urban water bodies
B7.3 Damage risk for street trees
B8 HEALTH
B8.1 Health risk for the population
B8.2 Damage risk for healthcare facilities
B9 EMERGENCY SERVICES
B9.1 Efficiency risk for civil protection service
B9.2 Efficiency risk for the fire brigade
B9.4 Efficiency risk for emergency medical services
B12 ECONOMIC SYSTEMS
B12.1 Damage risk for economic assets

Table C.3 — Extreme heat

C EXTREME HEAT
C1 BUILDINGS
C1.1 Damage risk for residential buildings
C1.2 Damage risk for public buildings
C1.3 Damage risk for commercial buildings
C1.4 Damage risk for industrial buildings
C1.5 Damage risk for historical and cultural sites
C2 TRANSPORT
C2.2 Damage risk for road transport network
C2.5 Damage risk for bicycle and pedestrian paths
C3 ENERGY
C3.1 Damage risk for power plants
C3.3 Damage risk for electrical grid infrastructure
C3.4 Damage risk for renewable energy installations
C3.6 Damage risk for district heating and cooling systems
C3.9 Damage risk for substations
C4 WATER
C4.1 Damage risk for water treatment plants
C5 WASTE
C5.1 Damage risk for waste collection infrastructure
C6 AGRICOLTURE & FORESTRY
C6.1 Damage risk for urban forests
C6.2 Damage risk for urban and peri-urban agricultural zones
C6.3 Damage risk for animal husbandry
C7 ENVIRONMENT & BIODIVERSITY
C7.1 Damage risk for urban green spaces
C7.3 Damage risk for street trees
C7.4 Damage risk for biodiversity and ecosystems
C8 HEALTH
C8.1 Health risk for the population
C8.2 Efficiency risk for healthcare facilities
C9 EMERGENCY SERVICES
C9.1 Efficiency risk for civil protection service
C9.2 Efficiency risk for the fire brigade
C9.4 Efficiency risk for emergency medical services
C10 TOURISM
C10.1 Damage risk for hotels and resorts
C10.3 Damage risk for restaurants and cafes
C10.5 Damage risk for touristic attractions

Table C.4 — Droughts

D DROUGHTS
D4 WATER
D4.1 Damage risk for water treatment plants
D4.2 Damage risk for water supply network
D6 AGRICOLTURE & FORESTRY
D6.1 Damage risk for urban forests
D6.2 Damage risk for urban and peri-urban agricultural zones
D6.3 Damage risk for animal husbandry
D7 ENVIRONMENT & BIODIVERSITY
D7.1 Damage risk for Urban green spaces
D7.2 Damage risk for urban water bodies
D7.3 Damage risk for Street Trees
D7.4 Damage risk for biodiversity and ecosystems
D8 HEALTH
D8.1 Health risk for the population
D9 EMERGENCY SERVICES
D9.2 Efficiency risk for the fire brigade
D9.4 Efficiency risk for emergency medical services
D10 TOURISM
D10.1 Damage risk for hotels and resorts
D10.3 Damage risk for restaurants and cafes

Table C.5 — Storms

E STORMS
E1 BUILDINGS
E1.1 Damage risk for residential buildings
E1.2 Damage risk for public buildings
E1.3 Damage risk for commercial buildings
E1.4 Damage risk for industrial buildings
E1.5 Damage risk for historical and cultural sites
E2 TRANSPORT
E2.1 Damage risk for public transit infrastructure
E2.2 Damage risk for road transport network
E2.3 Damage risk for rail transport network
E2.5 Damage risk for bicycle and pedestrian paths
E2.6 Damage risk for water transportation network
E3 ENERGY
E3.4 Damage risk for renewable energy installations
E3.8 Damage risk for power lines
E3.9 Damage risk for substations

E8 HEALTH
E8.1 Health risk for the population
E9 EMERGENCY SERVICES
E9.1 Efficiency risk for civil protection service
E9.2 Efficiency risk for the fire brigade

Table C.6 — Wildfires

F WILDFIRES
F1 BUILDINGS
F1.1 Damage risk for residential buildings
F1.2 Damage risk for public buildings
F1.3 Damage risk for commercial buildings
F1.4 Damage risk for industrial buildings
F1.5 Damage risk for historical and cultural sites
F2 TRANSPORT
F2.2 Damage risk for road transport network
F6 AGRICOLTURE & FORESTRY
F6.1 Damage risk for urban forests
F9 EMERGENCY SERVICES
F9.1 Efficiency risk for civil protection service
F9.2 Efficiency risk for the fire brigade

Table C.7 — Mass movement

G MASS MOVEMENT
G1 BUILDINGS
G1.1 Damage risk for residential buildings
G1.2 Damage risk for public buildings
G1.4 Damage risk for industrial buildings
G2 TRANSPORT
G2.1 Damage risk for public transit infrastructure
G2.2 Damage risk for road transport network
G2.5 Damage risk for bicycle and pedestrian paths
G9 EMERGENCY SERVICES
G9.1 Efficiency risk for civil protection service
G9.2 Efficiency risk for the fire brigade

Table C.8 — Sea-level rise

H SEA-LEVEL RISE
H1 BUILDINGS
H1.1 Damage risk for residential buildings
H1.5 Damage risk for historical and cultural sites
H2 TRANSPORT
H2.2 Damage risk for road transport network
H2.5 Damage risk for bicycle and pedestrian paths
H10 TOURISM
H10.1 Damage risk for hotels and resorts
H10.2 Damage risk for Beaches and Coastal Areas

Table C.9 — Extreme cold

I Extreme cold
I1 BUILDINGS
I1.1 Damage risk for residential buildings
I1.5 Damage risk for historical and cultural sites
I7 ENVIRONMENT & BIODIVERSITY
I7.1 Damage risk for Urban green spaces
I7.3 Damage risk for Street Trees
I7.4 Damage risk for biodiversity and ecosystems
I8 HEALTH
I8.1 Health risk for population

Table C.10 — Air pollution

J AIR POLLUTION
J1 BUILDINGS
J1.1 Damage risk for residential buildings
J1.5 Damage risk for historical and cultural sites
J7 ENVIRONMENT & BIODIVERSITY
I7.4 Damage risk for biodiversity and ecosystems
J8 HEALTH
J8.1 Health risk for population
J9 EMERGENCY SERVICES
J9.4 Efficiency risk for emergency medical services

C.2 RBTool Macro Categories and Risk categories affected by each hazard

The following tables identify the Macro Categories and Risk Categories selected as most relevant for each Issue. These tables shall not replace the contextualisation process, as the final selection shall always be based on local priorities, including the site's exposure, building characteristics, data availability, and the intended purpose of the assessment.

Table C.11 — Heavy precipitation

A Heavy precipitation
A1 FOUNDATIONS
A1.1 Piles
A1.2 Basements
A2 LOAD-BEARING STRUCTURAL FRAME
A2.1 Frame (beams, columns and slabs)
A2.3 External walls
A2.4 Balconies
A3 NON-LOAD-BEARING ELEMENTS
A3.1 Ground floor slab
A3.2 Internal walls, partitions and doors
A3.3 Stairs and ramps
A4 FAÇADE
A4.1 External wall systems, cladding and shading devices
A4.2 Façade openings
A4.3 External paints, coatings and renders
A5 ROOF
A5.1 Structure
A5.2 Weatherproofing
A6 FITTINGS AND FURNISHINGS
A6.3 Ceilings
A7 IN-BUILT LIGHTING SYSTEM
A7.2 Control systems and sensors
A8 ENERGY SYSTEM
A8.3 Electricity generation and distribution
A9 VENTILATION SYSTEM
A9.2 Ductwork and distribution
A10 SANITARY SYSTEMS
A10.3 Water treatment systems
A11 OTHER SYSTEMS
A11.1 Lifts and escalators
A11.2 Firefighting installations
A11.3 Communication and security installation
A12 UTILITIES
A12.1 Connection and diversions

A13 LANDSCAPING
A13.1 Paving and other hard surfacing
A13.3 Drainage system
A14 LOCATION
A14.1 Proximity
A14.2 Greenery
A15 OCCUPANTS
A15.3 Emergency
A16 COMMUNITY
A16.1 Safety

Table C.12 — Floods

B Floods
B1 FOUNDATION
B1.1 Piles
B1.2 Basements
B1.3 Retaining walls
B1.4 Shallow foundation
B2 LOAD-BEARING STRUCTURAL FRAME
B2.1 Frame (beams, columns and slabs)
B2.3 External walls
B3 NON-LOAD-BEARING ELEMENTS
B3.1 Ground floor slab
B3.2 Internal walls, partitions and doors
B4 FAÇADE
B4.1 External wall systems, cladding and shading devices
B4.2 Façade openings
B6 FITTINGS AND FURNISHINGS
B6.1 Sanitary fittings
B6.2 Cupboards, wardrobes and worktops
B6.5 Floor coverings and finishes
B7 IN-BUILT LIGHTING SYSTEM
B7.1 Light fittings
B7.2 Control systems and sensors
B8 ENERGY SYSTEM
B8.1 Heating plant and distribution
B8.2 Cooling plant and distribution
B8.3 Electricity generation and distribution
B9 VENTILATION SYSTEM
B9.1 Air handling units
B10 SANITARY SYSTEMS
B10.1 Cold water distribution

B10.2 Hot water distribution
B10.3 Water treatment systems
B10.4 Drainage systems
B11 OTHER SYSTEMS
B11.1 Lifts and escalators
B11.3 Communication and security installation
B12 UTILITIES
B12.1 Connection and diversions
B12.2 Substation and equipment
B13 LANDSCAPING
B13.1 Paving and other hard surfacing
B13.2 Fencing, railing and walls
B13.3 Drainage system
B14 LOCATION
B14.1 Proximity
B14.2 Greenery
B15 OCCUPANTS
B15.2 Accessibility
B15.3 Emergency
B16 COMMUNITY
B16.1 Safety

Table C.31 — Extreme heat

C EXTREME HEAT
C2 LOAD-BEARING STRUCTURAL FRAME
C2.3 External walls
C4 FAÇADE
C4.1 External wall systems, cladding and shading devices
C4.2 Façade openings
C4.3 External paints, coatings and renders
C5 ROOF
C5.1 Roof structure
C5.2 Roof weatherproofing
C7 IN-BUILT LIGHTING SYSTEM
C7.2 Control systems and sensors
C8 ENERGY SYSTEM
C8.1 Heating plant and distribution
C8.2 Cooling plant and distribution
C8.3 Electricity generation and distribution
C9 VENTILATION SYSTEM
C9.2 Ductwork and ventilation distribution
C10 SANITARY SYSTEMS
C10.1 Cold water distribution
C10.3 Water treatment systems
C11 OTHER SYSTEMS
C11.3 Communication and security installation
C11.4 Telecoms and data installation
C13 LANDSCAPING
C13.1 Paving and other hard surfacing
C14 LOCATION
C14.1 Proximity
C14.2 Greenery
C15 OCCUPANTS
C15.1 Comfort

Table C.14 — Droughts

D DROUGHTS
D6 FITTINGS AND FURNISHINGS
D6.1 Sanitary fittings
D9 VENTILATION SYSTEM
D9.1 Air handling units
D10 SANITARY SYSTEMS
D10.1 Cold water distribution
D10.3 Water treatment systems
D14 LOCATION
D14.1 Proximity
D14.2 Greenery

Table C.15 — Storms

E STORMS
E1 FOUNDATION
E1.2 Basements
E2 LOAD-BEARING STRUCTURAL FRAME
E2.1 Frame (beams, columns and slabs)
E2.3 External walls
E3 NON-LOAD-BEARING ELEMENTS
E3.2 Internal walls, partitions and doors
E4 FAÇADE
E4.1 External wall systems, cladding and shading devices
E4.2 Façade openings
E4.3 External paints, coatings and renders
E5 ROOF
E5.1 Structure
E7 IN-BUILT LIGHTING SYSTEM
E7.1 Light fittings
E7.2 Control systems and sensors
E8 ENERGY SYSTEM
E8.1 Heating plant and distribution
E8.3 Electricity generation and distribution
E10 SANITARY SYSTEMS
E10.4 Drainage systems
E11 OTHER SYSTEMS
E11.3 Communication and security installation
E12 UTILITIES
E12.1 Connection and diversions
E14 LOCATION
E14.1 Proximity
E14.2 Greenery

E15 OCCUPANTS
E15.2 Accessibility
E15.3 Emergency
E16 COMMUNITY
E16.1 Safety

Table C.16 — Wildfires

F WILDFIRES
F2 LOAD-BEARING STRUCTURAL FRAME
F2.1 Frame (beams, columns and slabs)
F2.3 External walls
F3 NON-LOAD-BEARING ELEMENTS
F3.1 Ground floor slab
F3.2 Internal walls, partitions and doors
F3.3 Stairs and ramps
F4 FACADE
F4.1 External wall systems, cladding and shading devices
F4.2 Façade openings
F5 ROOF
F5.1 Structure
F6 FITTINGS AND FURNISHINGS
F6.1 Sanitary fittings
F6.2 Cupboards, wardrobes and worktops
F7 IN-BUILT LIGHTING SYSTEM
F7.1 Light fittings
F8 ENERGY SYSTEM
F8.1 Electricity generation and distribution
F9 VENTILATION SYSTEM
F9.1 Ductwork and distribution
F11 OTHER SYSTEMS
F11.1 Lifts and escalators
F11.2 Firefighting installations
F12 UTILITIES
F12.1 Connection and diversions
F12.2 Substation and equipment
F13 LANDSCAPING
F13.2 Fencing, railing and walls
F14 LOCATION
F14.1 Proximity
F15 OCCUPANTS
F15.1 Comfort
F15.3 Emergency

F16 COMMUNITY
F16.1 Safety

Table C.17 — Mass movement

G MASS MOVEMENT
G1 FOUNDATION
G1.1 Piles
G2 LOAD-BEARING STRUCTURAL FRAME
G2.1 Frame (beams, columns and slabs)
G2.3 External walls
G7 IN-BUILT LIGHTING SYSTEM
G7.2 Control systems and sensors
G8 ENERGY SYSTEM
G8.1 Electricity generation and distribution
G14 LOCATION
G14.1 Proximity
G14.2 Greenery

Table C.18 — Extreme cold

I EXTREME COLD
I6 FITTINGS AND FURNISHINGS
I6.1 Sanitary fittings
I10 SANITARY SYSTEMS
I10.1 Hot water distribution
I14 LOCATION
I14.2 Greenery
I15 OCCUPANTS
I15.1 Comfort

Table C.19 — Air pollution

J AIR POLLUTION
J4 FAÇADE
J4.1 External wall systems, cladding and shading devices
J4.2 Façade openings
J9 VENTILATION SYSTEM
J9.2 Ductwork and distribution
J14 LOCATION
J14.1 Proximity
J14.2 Greenery
J14.3 Urban Morphology
J15 OCCUPANTS
J15.3 Emergency

Annex D
(informative)

Criteria and Indicators for RNTool Key Risk Categories

Table D.1 — RNTool Key Risk Categories, criteria and indicators – Heavy precipitation

A	**HEAVY PRECIPITATION**					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
A1	**BUILDINGS**					
A1.1	**Damage risk for residential buildings**					
A1.1.v1	Vulnerability of residential buildings	This criterion refers to the vulnerability of residential buildings based on features that influence flood or heavy rainfall vulnerability. Highlights structural weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	Mean Vulnerability Value of residential buildings in the urban area, in reference to their construction period	number	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability 0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability 0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations

A1.1.v2	Surface infiltration capacity	This criterion evaluates the level of soil permeability in an urban area, in order to assess its capacity to absorb and infiltrate rainwater. A high permeability value indicates the presence of draining or green surfaces, while a low value signals extensive impermeabilization and a reduced ability of the area to manage stormwater.	Percentage of permeable external surfaces	%	HIB	To calculate the value of the indicator: - Calculate the total external surface area of the urban area, Se [m^2] - Divide the surfaces by type and calculate each area Se,i, so that Se = ΣSe,i - Assign a runoff coefficient Φi to each surface type, using predefined values (e.g., uncultivated Φ=0.20, impermeable pavements Φ=0.70–0.80, etc.) - Identify the total permeable surfaces Sp, i.e., surfaces with Φ < 0.50, excluding areas confined by structures that prevent water infiltration - Compute the performance index as the percentage ratio between permeable surfaces B and total external area Se
A1.1.v3	Presence of Green Roofs	This criterion assesses the presence of vegetated rooftops that help retain rainwater, slow runoff, and improve thermal regulation. Green roofs contribute to urban cooling, biodiversity, and long-term resilience of buildings.	Share of buildings with functional green roofs	%	HIB	To calculate the value of the indicator: - Collect data on all buildings within the site area - Identify which buildings have functioning green roofs based on building records or site inspection - Calculate the proportion of buildings with green roofs relative to the total number of buildings
A1.1.v4	Sustainable Urban	In cases where the area is highly	Ratio of coverage of	%	HIB	To calculate the value of the indicator: - Calculate the excess impermeable area (A) as:

	Drainage Systems	impermeable, this criterion evaluates the implementation of sustainable urban drainage systems (SDUS), i.e., surface or underground structures designed to retain, attenuate, infiltrate, reuse, or slow the runoff of stormwater, such as rain gardens, retention basins, bioretention areas, drainage trenches, infiltration wells, permeable surfaces with storage capacity, or other equivalent systems. The criterion assesses whether the SDUS systems present in the urban area are adequate to meet the hydrological compensation needs associated with the area's current excessive imperviousness.	hydrological compensation needs (R)			A = 60% − value of indicator criterion A8.1.2 [%] - Calculate the total external surface area (B), Atot [m^2] - Calculate the equivalent excess surface (C) as: C = A × B [m^2] - Calculate the required compensation volume (Vr) using the formula: Vr = (C × 15) / 1000 [m^3] - Calculate the volume actually managed by the existing SDUS systems, VSDUS [m^3], by summing the contributions of each individual device present in the area. - Calculate the indicator value as the percentage of VSDUS in respect to Vr: R = (VSDUS / Vr) × 100 Note: assume R = 100% if VSDUS ≥ Vr Note: assume R = 100% if V_SDUS ≥ V_req
A1.1.v5	Buildings equipped with	This criterion assesses the	Percentage of buildings in	%	HIB	To calculate the value of the indicator: - Determine the total number of buildings in the

	rainwater storage tanks	proportion of buildings in the urban area equipped with rainwater retention tanks that are properly sized to delay water discharge. The objective is to determine the extent to which the building stock contributes, through localized stormwater retention measures, to reducing peak runoff generated by heavy rainfall.	the area equipped with rainwater retention tanks			urban area, considering only those with a roof area greater than 50 m^2 (Ntot) - Identify the number of buildings equipped with properly sized stormwater detention tanks (Ndet) - Calculate the indicator as a percentage ratio between Ndet and Ntot
A1.1.v6	Inadequate surface sloping and grading	This criterion assesses whether surface areas are properly graded to direct water away from buildings and critical infrastructure. Poor surface sloping increases the risk of local flooding, structural water damage, and long-term degradation of built assets.	Share of site surface with improper slope for water runoff	%	LIB	To calculate the value of the indicator: - Review site grading plans and compare against required slope standards - Conduct terrain analysis using digital elevation models or on-site laser scanning to identify flat or reverse-sloped surfaces - Calculate the share of surface area with inadequate slope relative to total site area

A1.1.v7	Transparent envelope waterproofing	This criterion assesses the degree to which residential building envelopes (glazing, transparent façades, skylights, curtain walls, etc.) prevent water ingress under design and extreme weather conditions. It captures the performance of the transparent façade or roof element in resisting rain penetration and leakage, while maintaining transparency.	Percentage of buildings with transparent building envelopes in poor conditions	%	LIB	To calculate the value of the indicator: - Classify each residential building based on the conditions of the transparent envelopes (windows, doors, glazing, transparent façades, skylights, curtain walls). Classification scale: A: All transparent envelopes in good conditions, sufficient thermic insulation, perfect seal (no air or water leakage observed); B: Some outdoor surfaces of transparent envelopes are damaged, good seal (limited air or water leakage observed); C: Some outdoor and indoor surfaces of transparent envelopes are damaged, poor seal (limited air or water leakage observed; D: All transparent envelopes are damaged, all frames are damaged, insufficient thermic insulation, no seal (limited air or water leakage observed) and difficult closure - Calculate the percentage of buildings classified as poor or very poor (C or D) conditions in respect to the total number of buildings
A1.1-e1	Presence of basements	This criterion assesses the exposure of basements. Water pressure on buried walls and foundations can cause leaks, cracks or even compromise stability if the design did not take these levels of hydraulic load into account.	Percentage of residential buildings with basements	%	LIB	To calculate the value of the indicator: - Collect building footprint area in the urban area - Count the number of residential buildings with floors below ground level - Count the total number of residential buildings in the urban area - Calculate the percentage of buildings with floors below ground level in respect to the total number of residential buildings

		Basements often house key elements of the building (electrical panels, pumps, tanks, utility rooms), so flooding can leave the entire building without power, water or sanitation.				
A1.1-e2	Residential buildings density	This criterion refers to the ratio of total built volume of residential structures to the urban area's horizontal surface. Higher building volume often correlates with impermeable surfaces, reducing infiltration and increasing flood runoff during heavy precipitation.	Total built volume of residential buildings divided by the extension of the urban area	m^3/m^2	LIB	To calculate the value of the indicator: - Collect building footprint area and height for each residential building - Compute volume for each building - Sum built volume - Divide the built volume by the total urban area
A1.2	**Damage risk for public buildings**					
A1.2.v1	Vulnerability of public buildings	This criterion refers to the vulnerability of public buildings based on features that influence flood or heavy rainfall vulnerability.	Mean Vulnerability Value of public buildings in the urban area, in	number	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability

		Highlights structural weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	reference to their construction period			0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability 0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations
A1.2.v2	Surface infiltration capacity	This criterion evaluates the level of soil permeability in an urban area, in order to assess its capacity to absorb and infiltrate rainwater. A high permeability value indicates the presence of draining or green surfaces, while a low value signals extensive impermeabilization and a reduced ability of the area to manage stormwater.	Percentage of permeable external surfaces	%	HIB	To calculate the value of the indicator: - Calculate the total external surface area of the urban area, Se [m^2] - Divide the surfaces by type and calculate each area Se,i, so that Se = ΣSe,i - Assign a runoff coefficient Φi to each surface type, using predefined values (e.g., uncultivated Φ=0.20, impermeable pavements Φ=0.70–0.80, etc.) - Identify the total permeable surfaces Sp, i.e., surfaces with Φ < 0.50, excluding areas confined by structures that prevent water infiltration - Compute the performance index as the percentage ratio between permeable surfaces B and total external area Se
A1.2.v3	Presence of Green Roofs	This criterion assesses the presence of vegetated rooftops that help retain	Share of buildings with functional green roofs	%	HIB	To calculate the value of the indicator: - Collect data on all buildings within the site area; - Identify which buildings have functioning green roofs based on building records or site inspection;

		rainwater, slow runoff, and improve thermal regulation. Green roofs contribute to urban cooling, biodiversity, and long-term resilience of buildings.				- Calculate the proportion of buildings with green roofs relative to the total number of buildings.
A1.2.v4	Sustainable Urban Drainage Systems	In cases where the area is highly impermeable, this criterion evaluates the implementation of sustainable urban drainage systems (SDUS), i.e., surface or underground structures designed to retain, attenuate, infiltrate, reuse, or slow the runoff of stormwater, such as rain gardens, retention basins, bioretention areas, drainage trenches, infiltration wells, permeable surfaces with storage capacity, or other equivalent systems. The criterion assesses whether the SDUS systems	Ratio of coverage of hydrological compensation needs (R)	%	HIB	To calculate the value of the indicator: - Calculate the excess impermeable area (A) as: A = 60% − value of indicator criterion A8.1.2 [%] - Calculate the total external surface area (B), Atot [m^2] - Calculate the equivalent excess surface (C) as: C = A × B [m^2] - Calculate the required compensation volume (Vr) using the formula: Vr = (C × 15) / 1000 [m^3] - Calculate the volume actually managed by the existing SDUS systems, VSDUS [m^3], by summing the contributions of each individual device present in the area. - Calculate the indicator value as the percentage of VSDUS in respect to Vr: R = (VSDUS / Vr) × 100 Note: assume R = 100% if VSDUS ≥ Vr Note: assume R = 100% if V_SDUS ≥ V_req

		present in the urban area are adequate to meet the hydrological compensation needs associated with the area's current excessive imperviousness.				
A1.2.v5	Buildings equipped with rainwater storage tanks	This criterion assesses the proportion of buildings in the urban area equipped with rainwater retention tanks that are properly sized to delay water discharge. The objective is to determine the extent to which the building stock contributes, through localized stormwater retention measures, to reducing peak runoff generated by heavy rainfall.	Percentage of buildings in the area equipped with rainwater retention tanks	%	HIB	To calculate the value of the indicator: - Determine the total number of buildings in the urban area, considering only those with a roof area greater than 50 m^2 (Ntot) - Identify the number of buildings equipped with properly sized stormwater detention tanks (Ndet) - Calculate the indicator as a percentage ratio between Ndet and Ntot
A1.2.v6	Inadequate surface sloping and grading	This criterion assesses whether surface areas are properly graded to	Share of site surface with improper	%	LIB	To calculate the value of the indicator: - Review site grading plans and compare against required slope standards - Conduct terrain analysis using digital elevation

		direct water away from buildings and critical infrastructure. Poor surface sloping increases the risk of local flooding, structural water damage, and long-term degradation of built assets.	slope for water runoff			models or on-site laser scanning to identify flat or reverse-sloped surfaces - Calculate the share of surface area with inadequate slope relative to total site area
A1.2.v7	Transparent envelope waterproofing	This criterion assesses the degree to which public building envelopes (glazing, transparent façades, skylights, curtain walls, etc.) prevent water ingress under design and extreme weather conditions. It captures the performance of the transparent façade or roof element in resisting rain penetration and leakage, while maintaining transparency.	Percentage of buildings with transparent building envelopes in poor conditions	%	LIB	To calculate the value of the indicator: - Classify each public building based on the conditions of the transparent envelopes (windows, doors, glazing, transparent façades, skylights, curtain walls). Classification scale: A: All transparent envelopes in good conditions, sufficient thermic insulation, perfect seal (no air or water leakage observed); B: Some outdoor surfaces of transparent envelopes are damaged, good seal (limited air or water leakage observed); C: Some outdoor and indoor surfaces of transparent envelopes are damaged, poor seal (limited air or water leakage observed; D: All transparent envelopes are damaged, all frames are damaged, insufficient thermic insulation, no seal (limited air or water leakage observed) and difficult closure - Calculate the percentage of buildings classified as poor or very poor (C or D) conditions in respect to the total number of buildings

A1.2-e1	Public buildings density	This criterion refers to the percentage of public buildings in relation to the total number of buildings in the urban area. The higher the percentage, the greater the relevance of public buildings in the urban area that may be exposed to heavy precipitation.	Percentage of public buildings out of the total number of buildings in the urban area	%	LIB	To calculate the value of the indicator: - Collect building footprint area in the urban area - Count the number of public buildings - Count the total number of buildings in the urban area - Calculate the percentage of public buildings in respect to the total number of buildings
A2	**TRANSPORTS**					
A2.1	**Damage risk for public transit infrastructure**					
A4.2.v1	Safe Windows and Shutters	This criterion assesses the proportion of windows protected against hail impact through resistant glazing, shutters, or protective screens.	Share of windows protected against hail	%	HIB	To calculate the value of the indicator: - Review window specifications, certifications, and design documentation - Count the number of protected windows - Count the total number of windows - Divide the number of protected windows by the total number of windows and multiply by 100
A4.2.v2	Sealed openings	This criterion assesses the ability of windows, doors, and other external openings to resist water penetration during heavy rainfall events.	Water tightness class	index	HIB	To calculate the value of the indicator: - Identify all external windows, doors, and openings - Collect the declared watertightness class from product documentation or test reports - Identify the lowest watertightness class among all assessed openings

						- Assign the indicator value based on the lowest class
A2.2	**Damage risk for Road Transportation Network**					
A2.2.v1	Maintenance condition of road network	This criterion assesses the structural condition of roads, affecting their resilience to heavy precipitation.	Percentage of road segments in poor or critical condition	%	LIB	To calculate the value of the indicator: - Identify and classify all road segments within the study area using condition assessment frameworks (e.g., Pavement Condition Index - PCI or visual grading) - Categorize segments as good, fair, poor, or critical according to standard thresholds - Sum the total length (or area) of road segments classified as poor or critical, and divide this value by the total length (or area) of all road segments in the network - Calculate the percentage of of roads in poor or critical condition in respect to the total road network length
A2.2.v2	Drainage points in road streets	This criterion assesses the velocity in which surface runoff water is discharged on the roads in a specific area to retain safe functionality for users. The objective is to quantify how many drainage points there are along roads or the lack of them.	Number of drainage point per length of road.	No/km	HIB	To calculate the value of the indicator: - Calculate the number of drainage points - Calculate the total length of roads - Divide the number of drainage points by the total length of roads
A2.1.v4	Green infrastructure	This criterion assesses the	Presence of bioswales,	%	HIB	To calculate the value of the indicator: - Identify and map all green infrastructure and

	and water retention solutions	presence of green infrastructure around the roads. The objective is to quantify the proportional area of these systems to the whole transit infrastructure area.	rain gardens, and retention basins around roads to manage water flow and reduce heavy precipitation impacts			water retention solutions within the area around roads - Calculate the percentage of green infrastructure area in respect to the total area around roads
A2.1.v5	Permeable Infrastructure around roads	This criterion assesses the presence of permeable infrastructure around roads. The objective is to quantify the proportional area of these systems to the whole transit infrastructure area.	Percentage of permeable materials around roads to reduce surface runoff and absorb excess rainwater to total footprint area of the road	%	HIB	To calculate the value of the indicator: - Identify and map all permeable infrastructure within the area around roads - Calculate the percentage of permeable infrastructure area in respect to the total area around roads
A2.4-e1	Length of road transportation network	This criterion measures the total length of roads exposed to heavy precipitation, indicating the extent of transport infrastructure that may be affected by disruptive events.	Total length of road transportation network per square kilometre	m/km2	LIB	To calculate the value of the indicator: - Obtain complete road network GIS layer - Clip to urban administrative boundary - Compute total length of roads - Calculate road density by dividing the total length by the urban area

A2.5	**Damage risk for bicycle and pedestrian paths**					
A2.5.v1	Pavement type and permeability	This criterion assesses the resistance of surface materials (e.g. asphalt, concrete, gravel) to water damage.	Surface material permeability rating	index (adimensional)	HIB	To calculate the value of the indicator: - Identify all types of surface materials covering bicycle and pedestrian paths within the assessment area - Assign each material a permeability rating index ranging from 0 (impermeable) to 1 (fully permeable) based on standardized material permeability data or local technical guidelines - Calculate the weighted average permeability rating by multiplying each material's permeability index by its respective surface area - Sum the weighted permeability values for all materials and divide by the total surface area of all bicycle and pedestrian paths - Calculate the indicator value as sum of permeability rating by surface area for all materials, divided by the total surface area of bicycle and pedestrian paths
A2.5.v2	Drainage points in bicycle and pedestrian paths	This criterion assesses the velocity in which surface runoff water is discharged on bicycle and pedestrian paths in a specific area to retain safe functionality for users. The objective is to quantify how many drainage points there are	Number of drainage point per length of pedestrian and bicycle paths	No/km	HIB	To calculate the value of the indicator: - Calculate the number of drainage points along pedestrian and bicycle paths - Calculate the total length of pedestrian and bicycle paths - Calculate the ratio of the number of drainage points to the total length of pedestrian and bicycle paths

		along pathways or the lack of them.				
A2.5.v3	Slip resistance of cycling and pedestrian surfaces	This criterion assesses the resistance of cycling and pedestrian paths to slip	Proportion of path with high PTV (>36) per unit area of existing paths	%	HIB	To calculate the value of the indicator: - Identify all bicycle and pedestrian paths within the study area - For each path segment, identify the construction material - Estimate the PTV value of each segment using the DIN 51130 classification of materials - Calculate the percentage of paths that have a PTV higher than 36 relative to the total length of all paths
A2.5.v4	Physical separation from vehicular traffic	This criterion refers to the presence of physical barriers separating cycling paths from vehicular traffic. Physical separation becomes very important to ensure safety of cyclist in cases of heavy rain and limited visibility.	Proportion of path with physical barriers per unit area of existing paths	%	HIB	To calculate the value of the indicator: - Identify all bicycle paths within the study area - For each path segment, assess whether it has a physical separation from vehicular traffic - Calculate the total length (or area) of paths with physical separations - Calculate the total length (or area) of all bicycle paths - Calculate the percentage of paths with physical separation in respect to the total length of all paths
A2.5.v5	Green infrastructure and water retention solutions	This criterion assesses the presence of green infrastructure around bicycle and pedestrian paths. The objective is to quantify the proportional area of these systems to the	Presence of bioswales, rain gardens, and retention basins around bicycle and pedestrian paths manage water flow and reduce	%	HIB	To calculate the value of the indicator: - Identify and map all green infrastructure and water retention solutions within the area around bicycle and pedestrian paths - Calculate the percentage of green infrastructure area in respect to the total area around bicycle and pedestrian paths

		whole transit infrastructure area.	heavy precipitation impacts			
A2.5.v1	Permeable Infrastructure around bicycle and pedestrian paths	This criterion assesses the presence of permeable infrastructure around roads. The objective is to quantify the proportional area of these systems to the whole transit infrastructure area.	Percentage of permeable materials around bicycle and pedestrian paths to reduce surface runoff and absorb excess rainwater to total footprint area of the road	%	HIB	To calculate the value of the indicator: - Identify and map all permeable infrastructure within the area around bicycle and pedestrian paths - Calculate the percentage of permeable infrastructure area in respect to the total area around bicycle and pedestrian paths
A2.5-e1	Density of bicycle and pedestrian paths	This criterion measures the length of cycle lanes and footpaths per 1000 inhabitants. Refers to the cumulative length of infrastructure dedicated to non-motorized mobility exposed to heavy precipitation.	Total length of cycle lanes and footpaths per 1000 inhabitants	km/1000 inhabitants	LIB	To calculate the value of the indicator: - Collect GIS or engineering datasets of bicycle and pedestrian path networks - Compute the total length - Calculate the density by dividing the total length by the number of inhabitants

A4	**WATER**					
A4.3	**Damage risk for Sewage System**					
A4.3.v1	Age of sewage system	This criterion measures the average age and renewal status of a municipality's or utility's sewer network.	Length-weighted average age (in years) of the sewer network assets in the assessment area	years	LIB	To calculate the value of the indicator: - Obtain records from municipal services, utility providers, or private operators on the length and construction years of the sewer and drainage network - Calculate the length-weighted average age using the formula: MeanAge = (Σ (Length_i × Age_i)) / (Σ Length_i)
A4.3.v2	Surface infiltration capacity	This criterion evaluates the level of soil permeability in an urban area, in order to assess its capacity to absorb and infiltrate rainwater. A high permeability value indicates the presence of draining or green surfaces, while a low value signals extensive impermeabilization and a reduced ability of the area to manage stormwater.	Percentage of permeable external surfaces	%	HIB	To calculate the value of the indicator: - Calculate the total external surface area of the urban area, Se [m^2] - Divide the surfaces by type and calculate each area Se,i, so that Se = ΣSe,i - Assign a runoff coefficient Φi to each surface type, using predefined values (e.g., uncultivated Φ=0.20, impermeable pavements Φ=0.70–0.80, etc.) - Identify the total permeable surfaces Sp, i.e., surfaces with Φ < 0.50, excluding areas confined by structures that prevent water infiltration - Compute the performance index as the percentage ratio between permeable surfaces B and total external area Se
A4.3.v3	Sustainable Urban	This criterion assesses the extent to which sustainable urban drainage	Ratio of coverage of hydrological	%	HIB	To calculate the value of the indicator: - Calculate the excess impermeable area (A) as: A = 60% − value of indicator criterion A8.1.2 [%] - Calculate the total external surface area (B),

	Drainage Systems	systems (SUDS), designed to retain, infiltrate, attenuate, reuse, or delay stormwater runoff, provide sufficient hydrological compensation for the existing impervious surfaces within the urban area.	compensation needs (R)			Atot [m^2] - Calculate the equivalent excess surface (C) as: C = A × B [m^2] - Calculate the required compensation volume (Vr) using the formula: Vr = (C × 15) / 1000 [m^3] - Calculate the volume actually managed by the existing SDUS systems, VSDUS [m^3], by summing the contributions of each individual device present in the area - Calculate the indicator as percentage of VSDUS in respect to Vr Note: assume R = 100% if VSDUS ≥ Vr Note: assume R = 100% if V_SDUS ≥ V_req
A4.3.v4	Buildings equipped with rainwater storage tanks	This criterion assesses the proportion of buildings in the urban area equipped with rainwater retention tanks that are properly sized to delay water discharge. The objective is to determine the extent to which the building stock contributes, through localized stormwater retention measures, to reducing peak runoff generated by heavy rainfall.	Percentage of buildings in the area equipped with rainwater storage tanks	%	HIB	To calculate the value of the indicator: - Determine the total number of buildings in the urban area, considering only those with a roof area greater than 50 m^2 (Ntot) - Identify the number of buildings equipped with properly sized stormwater detention tanks (Ndet) - Calculate the indicator as a percentage ratio between Ndet and Ntot

A4.3-e1	Population covered by the sewage system	This criterion assesses share of urban population that is served by a functioning sewer network	Percentage of residents connected to the sewage network per unit area of the urban area	%	LIB	To calculate the value of the indicator: - Delineate the service area of the neighbourhood sewage network using utility data or GIS mapping - Obtain population data from municipal registries, census records, or statistical models - Estimate or verify the number of individuals residing within the service area who are connected to the network - Calculate the percentage of the population connected to the sewage network in respect to the total population in the service area - If needed, cross-reference with flood zones to interpret exposure levels
A4.3-e2	Length of the sewage system by street length	This criterion measures the total linear extent of the sewage network by street length, including pipelines and conduits used for wastewater transport. It reflects the scale of infrastructure potentially exposed to hazards.	Length of the sewage system by street length	m/m	LIB	To calculate the value of the indicator: - Calculate the total length of the sewage system components using GIS datasets or engineering records - Calculate the total length of roads and streets in the same area - Calculate the ratio of the total length of the sewage system to the total length of roads and streets
A8	**HEALTH**					
A8.1	**Health risk for population**					
A8.1.v1	Surface infiltration capacity	This criterion evaluates the level of soil permeability in an urban area, in	Percentage of permeable	%	HIB	To calculate the value of the indicator: - Calculate the total external surface area of the urban area, Se [m^2] - Divide the surfaces by type and calculate each

		order to assess its capacity to absorb and infiltrate rainwater. A high permeability value indicates the presence of draining or green surfaces, while a low value signals extensive impermeabilization and a reduced ability of the area to manage stormwater.	external surfaces			area Se,i, so that Se = ΣSe,i - Assign a runoff coefficient Φi to each surface type, using predefined values (e.g., uncultivated Φ=0.20, impermeable pavements Φ=0.70–0.80, etc.) - Identify the total permeable surfaces Sp, i.e., surfaces with Φ < 0.50, excluding areas confined by structures that prevent water infiltration - Compute the performance index as the percentage ratio between permeable surfaces B and total external area Se
A8.1.v2	Sustainable Urban Drainage Systems	In cases where the area is highly impermeable, this criterion evaluates the implementation of sustainable urban drainage systems (SDUS), i.e., surface or underground structures designed to retain, attenuate, infiltrate, reuse, or slow the runoff of stormwater, such as rain gardens, retention basins, bioretention areas, drainage trenches, infiltration wells, permeable surfaces with storage	Ratio of coverage of hydrological compensation needs (R)	%	HIB	To calculate the value of the indicator: - Calculate the excess impermeable area (A) as: A = 60% − value of indicator criterion A8.1.2 [%] - Calculate the total external surface area (B), Atot [m^2] - Calculate the equivalent excess surface (C) as: C = A × B [m^2] - Calculate the required compensation volume (Vr) using the formula: Vr = (C × 15) / 1000 [m^3] - Calculate the volume actually managed by the existing SDUS systems, VSDUS [m^3], by summing the contributions of each individual device present in the area - Calculate the indicator as percentage of VSDUS in respect to Vr Note: assume R = 100% if VSDUS ≥ Vr Note: assume R = 100% if V_SDUS ≥ V_req

		capacity, or other equivalent systems. The criterion assesses whether the SDUS systems present in the urban area are adequate to meet the hydrological compensation needs associated with the area's current excessive imperviousness.				
A8.1.v3	Buildings equipped with rainwater storage tanks	This criterion assesses the proportion of buildings in the urban area equipped with rainwater retention tanks that are properly sized to delay water discharge. The objective is to determine the extent to which the building stock contributes, through localized stormwater retention measures, to reducing peak runoff generated by heavy rainfall.	Percentage of area buildings equipped with stormwater detention tanks	%	HIB	To calculate the value of the indicator: - Determine the total number of buildings in the urban area, considering only those with a roof area greater than 50 m^2 (Ntot) - Identify the number of buildings equipped with properly sized stormwater detention tanks (Ndet) - Calculate the indicator as a percentage ratio between Ndet and Ntot

A8.1.v4	Vulnerability of residential buildings	This criterion refers to the vulnerability of residential buildings based on features that influence flood or heavy rainfall vulnerability. Highlights structural weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	Mean Vulnerability Value of residential buildings in the urban area, in reference to their construction period	number	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability 0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability 0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations
A8.1-e1	Population density	This criterion measures population density (inhabitants per square meter or per square kilometre) of an urban area. High-density areas are typically more vulnerable due to greater exposure, compounded risks, and more difficult emergency response logistics	Total number of inhabitants divided by the size of the urban area	Inhabitant/Km2	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data. Convert Area to km^2 (if not already) - Calculate the population density by dividing the total number of inhabitants by urban area

A8.1-e2	Ground-floor dwellings	This criterion measures the percentage of residential units located at ground-floor level. Ground-floor dwellings are particularly vulnerable to stormwater intrusion, mold, sewage backflow, and other public health risks. In Mediterranean cities, where older housing stock and dense urban form are common, this indicator reflects the physical and social vulnerability of residents to health hazards	Share of Ground-Floor Dwellings	%	LIB	To calculate the value of the indicator: - Identify ground-floor dwelling units using cadastral or housing typology data - Calculate the percentage of ground-floor dwellings located within hazard zones in respect to the total number of dwellings in the city or neighbourhood

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table D.2 — RNTool Key Risk Categories, criteria and indicators — Floods

B	FLOODS					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
B1	**BUILDINGS**					
B1.1	**Damage risk for residential buildings**					
B1.1.v1	Vulnerability of residential buildings	This criterion refers to the vulnerability of residential buildings based on features that influence flood or heavy rainfall vulnerability. Highlights structural weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	Mean Vulnerability Value of residential buildings in the urban area, in reference to their construction period	number	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability 0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability 0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations
B1.1.v2	Critical Infrastructure Protection	This criterion assesses the protection level of critical urban infrastructure (e.g. electrical substations, water treatment plants,	Protection level of critical infrastructure	Qualitative	QI	To calculate the value of the indicator: - Identify all critical infrastructure assets located within the neighbourhood’s residential buildings (e.g. substations, water plants, emergency services) - Assess whether each facility is physically protected against flood (e.g. flood barriers, water-resistant materials) - Classify each facility as protected or not protected

		hospitals) against floods. Ensuring their functionality during and after extreme events is essential for neighbourhood resilience				- Determine the overall protection level based on majority class
B1.1.v3	Shape and orientation of residential buildings	This criterion refers to the assessment of the geometric form and spatial orientation of residential buildings relative to flood flow direction and local topography, which affects how much water force and accumulation they experience.	Verification of the residential buildings' characteristics with respect to flooding hazards	index	HIB	To calculate the value of the indicator: - Assess residential building shapes (rectangular, square, L-shape, irregular) - Assess orientation in relation to dominant slope/water flow direction using GIS (angle of longest façade to contour lines or modelled water flow vector) - Score each residential building based on criteria: Narrow side facing flow: 2 Elevated base or stilts: 2 Compact shape (square, rectangular): 1 Irregular shape, long façades facing flow: 0 - Compute mean orientation & shape suitability score. Note: max score = 5 per building
B1.1-e1	Residential buildings density	This criterion refers to the ratio of total built volume of residential structures to the urban area's horizontal surface. Higher building volume often correlates with impermeable	Total built volume of residential buildings divided by the extension of the urban area	m^3/m^2	LIB	To calculate the value of the indicator: - Collect building footprint area and height for each residential building - Compute volume for each building - Sum built volume - Divide the built volume by the total urban area

		surfaces, reducing infiltration and increasing flood runoff during heavy precipitation.				
B1.1-e2	Residential Building Façades above Flood Level	This criterion assesses how much of a building's facade is not affected by the flooding in a flood zone area and is thus safe for the occupants. This indicator will highlight which buildings need to install drainage infrastructure inside and in the surrounding area to prevent part of the lower floor(s) of the building from flooding	Area of residential building façades above the flood level divided by the total area of residential building façades, multiplied by 100	%	LIB	To calculate the value of the indicator: - Identify residential building facades located above the flood level - Calculate the percentage of residential building facade area above the flood level in respect to the total residential building facade area
B1.1-e3	Building Elevation	This criterion assesses the extent to which residential buildings in the neighbourhood are elevated above known flood levels, specifically the design level for a 50-year flood. Elevated	Share of residential buildings with elevated entrance openings above the level of a flood which statistically	%	LIB	To calculate the value of the indicator: - Identify the design flood level for a 50-year return period using flood hazard maps or hydrological models - Collect residential building-level elevation data (e.g. through building permits, surveys, or LiDAR) - Determine whether the lowest entrance or ground floor opening is located above the flood level - Determine the proportion of compliant buildings

		ground floors reduce the risk of flood damage and support long-term resilience.	occurs every 50 years			by dividing their number by the total building stock within the assessed area
B1.2	**Damage risk for public buildings**					
B1.1.v1	Vulnerability of public buildings	This criterion refers to the vulnerability of public buildings based on features that influence flood or heavy rainfall vulnerability. Highlights structural weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	Mean Vulnerability Value of public buildings in the urban area, in reference to their construction period	number	LIB	To calculate the value of the indicator: - Collect year-built data for public buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability 0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability 0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations
B1.1.v2	Critical Infrastructure Protection	This criterion assesses the protection level of critical urban infrastructure (e.g. electrical substations, water treatment plants, hospitals) against floods. Ensuring their functionality during and after	Protection level of critical infrastructure	Qualitative	QI	To calculate the value of the indicator: - Identify all critical infrastructure assets located within the neighbourhood’s public buildings (e.g. substations, water plants, emergency services) - Assess whether each facility is physically protected against flood (e.g. flood barriers, water-resistant materials) - Classify each facility as protected or not protected - Determine the overall protection level based on majority class

		extreme events is essential for neighbourhood resilience.				
B1.1.v3	Shape and orientation of public buildings	This criterion refers to the assessment of the geometric form and spatial orientation of public buildings relative to flood flow direction and local topography, which affects how much water force and accumulation they experience.	Verification of the public buildings' characteristics with respect to flooding hazards	index	HIB	To calculate the value of the indicator: - Assess public building shapes (rectangular, square, L-shape, irregular) - Assess orientation in relation to dominant slope/water flow direction using GIS (angle of longest façade to contour lines or modelled water flow vector) - Score each building based on criteria: Narrow side facing flow: 2 Elevated base or stilts: 2 Compact shape (square, rectangular): 1 Irregular shape, long façades facing flow: 0 - Compute mean orientation & shape suitability score. Note: max score = 5 per building
B1.1-e1	Public buildings density	This criterion refers to the percentage of public buildings in relation to the total number of buildings in the urban area. The higher the percentage, the greater the relevance of public buildings in the urban area that may be exposed to heavy precipitation.	Percentage of public buildings out of the total number of buildings in the urban area	%	LIB	To calculate the value of the indicator: - Collect building footprint area in the urban area - Count the number of public buildings - Count the total number of buildings in the urban area - Calculate the percentage of public buildings in respect to the total number of buildings

B1.1-e2	Public Building Façades above Flood Level	This criterion assesses how much of a public building's facade is not affected by the flooding in a flood zone area and is thus safe for the occupants. This indicator will highlight which buildings need to install drainage infrastructure inside and in the surrounding area to prevent part of the lower floor(s) of the building from flooding	Area of public building façades above the flood level divided by the total area of public building façades, multiplied by 100	%	LIB	To calculate the value of the indicator: - Identify public building facades located above the flood level - Calculate the percentage of public building facade area above the flood level in respect to the total public building facade area
B1.1-e3	Building Elevation	This criterion assesses the extent to which public buildings in the neighbourhood are elevated above known flood levels, specifically the design level for a 50-year flood. Elevated ground floors reduce the risk of flood damage and support long-term resilience.	Share of public buildings with elevated entrance openings above the level of a flood which statistically occurs every 50 years	%	LIB	To calculate the value of the indicator: - Identify the design flood level for a 50-year return period using flood hazard maps or hydrological models - Collect public building-level elevation data (e.g. through building permits, surveys, or LiDAR) - Determine whether the lowest entrance or ground floor opening is located above the flood level - Determine the proportion of compliant buildings by dividing their number by the total building stock within the assessed area

B2	**TRANSPORT**					
B2.1	**Damage risk for public transit infrastructure**					
B2.1.v1	Functionality of underground Stations during flood	This criterion assesses the degree of functionality of the underground stations in a specific area to retain safe functionality for users. The objective is to quantify how many underground stations have sufficient infrastructure, and which stations are susceptible/vulnerable to this hazard.	Percentage of underground transit stations with adequate flood protection measures.	%	HIB	To calculate the value of the indicator: - Identify all underground stations within the study area - Assess which stations are adequately protected against flood (e.g., presence of flood barriers, pumps, sealed access points) - Calculate the percentage of adequately protected stations in respect to the total number of stations
B2.1.v2	Functionality of public transit underpasses during flood	This criterion assesses the degree of functionality of public transit underpasses in a specific area to retain safe functionality for users. The objective is to quantify how many public transit underpasses have sufficient infrastructure, and which underpasses	Percentage of underpasses that remain safe during floods	%	HIB	To calculate the value of the indicator: - Identify all public transit underpasses within the study area - Assess which underpasses are adequately protected against flood (e.g., presence of flood barriers, pumps, drainage systems) - Calculate the percentage of adequately protected underpasses in respect to the total number of underpasses

		are susceptible/vulnerable to this hazard.				
B2.1.v3	Access to Flood-resilient facilities	This criterion assesses the degree of functionality of accessible paths in a specific area to retain safe functionality for users. The objective is to quantify how many paths have sufficient infrastructure, and which sites are susceptible/vulnerable to this hazard.	Availability of accessible paths, elevated walkways and flood-resilient waiting areas at transit sites to ensure passenger safety	%	HIB	To calculate the value of the indicator: - Identify all pathways providing access to flood-resilient facilities within the study area - Assess which pathways remain safe and passable during flood events - Calculate the percentage of safe pathway area in respect to the total pathway area
B2.1.v4	Operational Redundancy and Resilience	This criterion assesses the ability to reroute or maintain operations during localized flooding.	Percentage of network with functional alternatives (rerouting options)	%	HIB	To calculate the value of the indicator: - Identify all segments of the public transit network and for each segment, determine whether a viable alternative route (within an acceptable increase in travel time, e.g., < 15 minutes) exists in the event of flooding - Count the total length or number of segments with such alternatives and divide this by the total length or number of segments in the network - Calculate the percentage of segments with viable rerouting options in respect to the total length of network segments
B2.1-e1	Length of public transport lines	This criterion measures the total length of public transport routes	Total length of public transport lines	m/km2	LIB	To calculate the value of the indicator: - Obtain GIS line data for all public transport routes - Clip to the urban boundary - Compute the total length of public transport

		exposed to flood, indicating the extent of transport infrastructure that may be affected by disruptive events.	per square kilometre			routes - Calculate the density of public transport by dividing the total length by the urban area
B2.1-e2	Quantity of public transport stops/stations	This criterion measures the number of public transport stations exposed to flood, indicating the extent of transport infrastructure that may be affected by disruptive events.	Number of stops or stations per square kilometre	n/km2	LIB	To calculate the value of the indicator: - Extract GIS point data for transit stops/stations - Filter within urban boundaries - Count the total number of stops/stations - Calculate the density by dividing the total count by the urban area
B2.1-e3	Elevation of Infrastructure	Height of transit assets (e.g. stations, depots, tracks) relative to nearby flood-prone areas.	Percentage of infrastructure below flood elevation benchmarks	%	LIB	To calculate the value of the indicator: - Identify all relevant public transit infrastructure elements (e.g., stations, depots, tracks) within the study area - For each element, determine the ground elevation (in meters above sea level or reference datum) - Identify the applicable flood elevation benchmark for each location using hydrological flood maps or national flood hazard datasets - Classify infrastructure elements as “below flood elevation” if their elevation is lower than or equal to the benchmark - Calculate the percentage of infrastructure elements below benchmark in respect to the total number of infrastructure elements

B2.4	Damage risk for road transport network					
B2.4.v1	Road Foundation Stability and Design	This criterion assesses the lack of stability of a road in a flood-prone area. The indicator highlights the state of the foundations of a road and the likelihood of the road collapsing due to water erosion and flooding.	Proportion of roads in flood-prone areas with poor foundation integrity, as measured by susceptibility to water-induced erosion and risk of collapse during flood events	%	LIB	To calculate the value of the indicator: - Identify roads in flood-prone areas with poor foundation integrity, i.e., high susceptibility to water-induced erosion or high risk of collapse during flood events - Calculate the percentage of road length with poor foundation integrity in respect to the total length of roads within the identified flood-prone zones
B2.4.v2	Alternative Routes for Critical Connections	This criterion assesses which roads do not have alternative routes for safe access when found in a flood prone area.	Vulnerability Route Percentage: lack of alternate routes for critical road connections in high flood-risk areas, increasing the risk of access disruption when primary routes are affected	%	LIB	To calculate the value of the indicator: - Identify critical road segments that have no alternative route in case of flooding - Calculate the total length of the concerned route - Calculate the percentage of critical road segment length with no alternative route in respect to the total length of the concerned route

B2.4-e1	Length of road transportation network	This criterion measures the total length of roads exposed to floods, indicating the extent of transport infrastructure that may be affected by disruptive events.	Total length of road transportation network per square kilometre	m/km2	LIB	To calculate the value of the indicator: - Obtain complete road network GIS layer - Clip to urban administrative boundary - Compute total length - Calculate road density dividing the total length of roads by urban area
B2.4-e1	Elevation of Infrastructure	Height of roads relative to nearby flood-prone areas.	Percentage of infrastructure below flood elevation benchmarks	%	LIB	To calculate the value of the indicator: - Identify all relevant roads within the study area - For each element, determine the ground elevation (in meters above sea level or reference datum) - Identify the applicable flood elevation benchmark for each location using hydrological flood maps or national flood hazard datasets - Classify infrastructure elements as “below flood elevation” if their elevation is lower than or equal to the benchmark - Calculate the percentage of infrastructure elements below benchmark in respect to the total number of infrastructure elements
B8	**HEALTH**					
B8.1	**Health risk for population**					
B8.1.v1	Vulnerability of residential buildings	This criterion refers to the vulnerability of residential buildings based on features that influence flood or heavy rainfall vulnerability. Highlights structural	Mean Vulnerability Value of residential buildings in the urban area, in reference to their	number	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS). - Determine buildings' construction period and assign the score using this table: N score (S) Main construction period Vulnerability 0.68 pre-1945 High vulnerability 0.74 1946-1969 Very high vulnerability 0.62 1970-1989 High vulnerability

		weakness within housing stock and prioritizes retrofits, investments, or zoning changes to prevent precipitation-driven damage and losses.	construction period			0.48 1990-2005 Moderately high vulnerability 0.37 2006-2015 Low vulnerability 0.26 post-2015 Low vulnerability - Determine average construction period computing the average weighted according to the buildings' volume. Additional details can be integrated in the analysis through on-field observations
B8.1-e1	Population density	This criterion measures population density (inhabitants per square meter or per square kilometre) of an urban area. High-density areas are typically more vulnerable due to greater exposure, compounded risks, and more difficult emergency response logistics.	Total number of inhabitants divided by the size of the urban area	Inhabitant/Km2	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data. Convert Area to km^2 (if not already) - Calculate the population density by dividing the total number of inhabitants by urban area
B8.1-e2	Ground-floor dwellings	This criterion measures the percentage of residential units located at ground-floor level. Ground-floor dwellings are particularly vulnerable to stormwater intrusion, mould,	Share of Ground-Floor Dwellings	%	LIB	To calculate the value of the indicator: - Identify ground-floor dwelling units using cadastral or housing typology data - Calculate the percentage of ground-floor dwellings located within hazard zones in respect to the total number of dwellings in the city or neighborhood

		sewage backflow, and other public health risks. In Mediterranean cities, where older housing stock and dense urban form are common, this indicator reflects the physical and social vulnerability of residents to health hazards.				
B9	**EMERGENCY SERVICES**					
B9.1	**Efficiency risk for civil protection service**					
B9.1.v1	Trained civil protection staff	This criterion assesses the number of trained civil protection staff on flood risk in relation to the population density in the investigated area per year. A high number of civil protection workers trained and able to properly intervene in case of flooding in the area, can ensure a wider coverage of the area affected by the climate risk and of	Number of trained civil protection staff on flood risk in relation to the population density in the investigated area per year	n/(ab/km 2) year	HIB	To calculate the value of the indicator: - Obtain the number of civil protection staff trained on flood risk in the investigated area, for the reference year - Calculate the population density per km^2 in the investigated area - Calculate the ratio of the number of civil protection staff trained on flood risk to the population density

		course, the safety for people in the area.				
B9.1.v2	Knowledge of the territory by the civil protection staff	This criterion assesses the number of training exercises performed on flood risk in the investigated area per year by the civil protection staff. Training exercises are one of the most effective ways to know the prerogatives of the territory and the areas more vulnerable to flood events.	Number of training exercises performed on flood risk in the investigated area per year	n/km2 year	HIB	To calculate the value of the indicator: - Obtain the number of training exercises related to flood risk performed by civil protection staff, for the reference year - Calculate the extension of the investigated area in km^2 - Calculate the ratio of the number of training exercises related to flood risk to the extension of the investigated area
B9.1.v3	Civil Protection Plan	This criterion assesses the year of the Civil Protection Plan contents update in relation to the year in which the last severe flood event happened in the investigated area. The constant updating of the Civil Protection Plan can ensure a better intervention organisation and	Year of the Civil Protection Plan contents update in relation to the year in which the last flood event happened in the area	Year/Year	LIB	To calculate the value of the indicator: - Determine the year of the Civil Protection Plan's last update in relation to flood risk - Determine the year of the last severe flood event in the investigated area - Compare the two years to assess how recently the plan has been updated relative to the most recent flood event

		higher knowledge of the vulnerable flooding areas within the territory.				
B9.1.v4	Availability of civil protection vehicles	This criterion assesses the availability of civil protection vehicles properly equipped for flood risk within the investigated area. High number of civil protection vehicles can contribute to guarantee timely aid and to ensure a wider territorial coverage simultaneously.	Number of civil protection vehicles properly equipped for flood risk in relation to the investigated area	n/km2	HIB	To calculate the value of the indicator: - Assess the number of civil protection vehicles properly equipped for flood risk in the investigated area - Calculate the extension of the investigated area in km^2 - Calculate the ratio of the number of civil protection vehicles properly equipped for flood risk to the extension of the investigated area
B9.1.v5	Travel times for Aid	This criterion assesses the necessary travel time from the civil protection headquarters to reach the inhabited zone of the investigated area. Less time is taken to reach the inhabited zone, less vulnerable the area is.	Average of travel times between the centre of the inhabited reference locality and the civil protection headquarters	minutes	LIB	To calculate the value of the indicator: - Calculate the average of travel times between the inhabited centre zone of the investigated area and the civil protection headquarters
B9.1.v6	Alert system (sirens)	This criterion assesses the number	Number of alert systems	n/km2	HIB	To calculate the value of the indicator: - Assess the number of alert systems concerning

	installed in the flood risk investigated area	of alert systems concerning flood risk installed on the total extension of the area investigated. Alert systems facilitate risk detection and provide early warning towards the inhabitants, contributing to their protection.	(sirens) concerning flood risk installed on the total extension of the investigated area			flood risk installed in the investigated area - Calculate the extension of the investigated area in km^2 - Calculate the ratio of the number of alert systems installed in the investigated area to the extension of the investigated area
B9.1.v7	Informative campaigns performed	This criterion assesses the number of informative campaigns performed by civil protection staff in the territory, in relation to flood risk, during the year. The aim is to educate, raise awareness, inform rather than influence behaviour, and even promote social change in relation to flood risk	Number of informative campaigns performed in the investigated area in relation to flood risk, during the year	n/year	HIB	To calculate the value of the indicator: - Identify all informative campaigns performed by civil protection staff in relation to flood risk - Count the number of campaigns performed within a specific reference year
B9.1-e1	Population density	This criterion measures population density (inhabitants per square meter or per square kilometre) of an	Total number of inhabitants divided by the size of the urban area	Inhabitant/Km2	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data. Convert Area to km^2 (if not

		urban area. High-density areas are typically more vulnerable due to greater exposure, compounded risks, and more difficult emergency response logistics.				already) - Calculate the population density by dividing the total number of inhabitants by urban area

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table D.3 — RNTool Key Risk Categories, criteria and indicators – Extreme Heat

C	**EXTREME HEAT**					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
C2	**TRANSPORT**					
C2.4	**Damage risk for bicycle and pedestrian paths**					
C2.4.v1	Surface Material Albedo	This criterion measures how much solar radiation is reflected or absorbed by the pavement.	Albedo value	n	HIB	To calculate the value of the indicator: - Identify and list all surface materials used in pedestrian and cycling infrastructure - Assign each material its corresponding albedo value based on reflectance data - Measure or estimate the surface area covered by each material and multiply the albedo of each material by its corresponding surface area - Sum all weighted values and divide by the total area of all bike and pedestrian surfaces - Calculate the indicator value as: (Σ ($Albedo_i \times Area_i$)) / (Total area of all pedestrian and cycling surfaces)

C2.4.v2	Shade Provision	This criterion assesses the extent of natural or artificial shading along paths reducing surface temperatures.	Share of shaded path segments within the urban area	%	HIB	To calculate the value of the indicator: - Map the entire network of bicycle and pedestrian paths in the study area - Identify and measure segments that benefit from consistent shading during peak daytime hours in summer - Determine the total length of these shaded segments and divide by the total length of all bicycle and pedestrian paths - Multiply the result by 100 to express as a percentage of shaded path coverage - Calculate the percentage of shaded segments /in relation to total path length
C2.4.v3	Surface Material Sensitivity	This criterion evaluates the susceptibility of path materials (e.g., asphalt, rubberized surfaces) to soften, crack, or deform in heat.	Percentage of paths made from heat-sensitive materials	%	LIB	To calculate the value of the indicator: - Identify and categorize all bicycle and pedestrian path segments in the assessment area - For each segment, determine the surface material and classify it as heat-sensitive or heat-resistant, based on its softening point or thermal deformation behaviour (e.g., asphalt with softening point < 60°C = heat-sensitive) - Calculate the total surface area of heat-sensitive paths - Calculate the total area of all bicycle and pedestrian paths - Calculate the percentage of total area of heat-sensitive path materials in respect to the total area of all bicycle and pedestrian paths
C2.4.v4	Vegetative buffer and cooling	This criterion measures the presence of cooling vegetation near path edges	Share of vegetated area within 5–10m of paths	%	HIB	To calculate the value of the indicator: - Identify all bicycle and pedestrian paths within the study area - Create a 10-meter buffer zone around each side of the path - Map or digitize vegetated areas within this

						buffer - Calculate the total vegetated area within the buffer and divide the vegetated area by the total buffer area and express as a percentage - Calculate the percentage of total vegetated area within buffer in respect to total buffer area
C2.4-e1	Density of bicycle and pedestrian paths	This criterion measures the length of cycle lanes and footpaths per 1000 inhabitants. Refers to the cumulative length of infrastructure dedicated to non-motorized mobility exposed to extreme heat	Total length of cycle lanes and footpaths per 1000 inhabitants	km/1000 inhabitants	LIB	To calculate the value of the indicator: - Collect GIS or engineering datasets of bicycle and pedestrian path networks - Compute the total length - Calculate the density by dividing the total length by the number of inhabitants
C3	**ENERGY**					
C3.1	**Damage risk for Electrical Grid Infrastructure**					
C3.1.v1	Electrical demand	This criterion assesses the peak demand for electricity during the reference cooling within the investigated area that is mainly dependent on the demand at building scale.	Total number of days per year with peak daily electrical demand exceeding the 99th percentile during the cooling period (May – September)	days	LIB	To calculate the value of the indicator: - Cooling period is considered from May to September - Collect the available data for the electric power demand (kW) of all buildings in the area of interest and other end-uses, if significant, during the cooling period. The time interval should be consistent among the various data (e.g. 15-minute interval, a half-hour, or an hour) on a daily basis - Summarize the electrical demand for all end-uses (kW), for the corresponding time interval - Calculate the daily peak electrical demand (kW) - Analyse the daily peak demand values for the cooling period and calculate the 99th percentile

						threshold (Percentiles divide a data set into 100 equal parts. The 99th percentile marks the value below which 99% of the data falls) - Identify and sum the number of days during the cooling period that there is at least one-time interval that the data exceeds 99th percentile of the reference period
C3.1.v2	Electrical demand of buildings	This criterion assesses the average power demand intensity for electricity (i.e. electrical power demand per internal useful floor area) for all the buildings within the investigated area during the cooling period.	Electrical peak demand for building operations during the cooling period (May-September)	kW/m2	LIB	To calculate the value of the indicator: - Cooling period is considered from May to September - Collect the available data for the electric power demand (kW) of all buildings in the area of interest, for the reference cooling period. - Calculate the aggregated electrical demand (kW) of all buildings, for the corresponding time interval during the cooling period - Define the peak electrical demand (kW) of all buildings in the investigated area, for the cooling period (May - September) - Collect the corresponding internal useful floor area (m2) of each building and calculate the total internal floor area (m2) - Calculate the peak electrical demand intensity (kW/m2) for all buildings during the cooling period. A weather correction should be performed, using Cooling Degree Days (CDD)
C3.1.v3	Electrical energy use of office buildings	This criterion assesses the average electrical energy use intensity (i.e. electricity consumption per internal useful floor area) for all the office	Final electrical energy use of office building stock in the cooling period (May-September)	kWh/m2	LIB	To calculate the value of the indicator: - Cooling period is considered from May to September - Collect the available data for the electricity use (kWh) of all buildings in the investigated area, for the cooling period and calculate the aggregated electrical energy use of the cooling period (kWh). It should take the average over the previous three

		buildings within the investigated area during the reference period.				years, as long as the building and its use pattern have been the same. If the time period is shorter than three years, a weather correction shall be performed, using Cooling Degree Days (CDD) - Collect the corresponding internal useful floor area (m2) of all buildings in the investigated area, and calculate the total internal floor area (m2) - Calculate the average value of the electricity use intensity (kW/m2) for all the buildings in the area of interest for the cooling period. If only one complete year of data is available, a weather correction should be performed, using Cooling Degree Days (CDD)
C3.1.v4	Electrical energy use of dwellings	This criterion assesses the average electrical energy use intensity (i.e. electricity consumption per internal useful floor area) for all the dwelling within the investigated area during the reference period.	Final electrical energy use of dwelling stock in the cooling period (May-September)	kWh/m2	LIB	To calculate the value of the indicator: - Cooling period is considered from May to September - Collect the available data for the electricity use (kWh) of all buildings in the investigated area, for the cooling period and calculate the aggregated electrical energy use of the cooling period (kWh). It should take the average over the previous three years, as long as the building and its use pattern have been the same. If the time period is shorter than three years, a weather correction shall be performed, using Cooling Degree Days (CDD) - Collect the corresponding internal useful floor area (m2) of all buildings in the investigated area, and calculate the total internal floor area (m2) - Calculate the average value of the electricity use intensity (kW/m2) for all the buildings in the area of interest for the cooling period. If only one complete year of data is available, a weather correction should be performed, using Cooling Degree Days (CDD)

C3.1.v5	Autonomy of buildings	This criterion evaluates the capacity of buildings to maintain essential functions and liveable indoor conditions during power outages caused by extreme weather events or other disruptions. It considers the building's ability to operate independently from the main grid through renewable energy generation, energy storage, or backup systems, as well as its passive resilience (e.g. thermal comfort under free-floating conditions) when external power supply is unavailable..	Average autonomous operation period of the buildings during power outages during the cooling period (May – September)	hr	HIB	To calculate the value of the indicator: - Collect the corresponding internal useful floor area (m2) of each building - Calculate the total internal useful floor area of all buildings (m2) - For the total number of buildings with a capacity for autonomous operation that cover HVAC and other basic services (e.g. installed backup power generating stations or installed photovoltaics, with storage, that can serve the building) in the investigated area - Collect the technical specifications of the installed equipment for autonomous operation of all buildings. If technical specifications are not available, use information / data from technical departments and/ or owners of each building - Estimate the hours for autonomous operation that cover HVAC and other basic (essential) services. - Calculate the weighted average number of continuous hours of autonomous operation
C3.1-e1	Size of the building stock	This criterion refers to the cumulative internal useful floor area of buildings connected to the electrical grid infrastructure.	Percentage coverage of the area by buildings built-up area.	%	LIB	To calculate the value of the indicator: - Define stock boundaries (e.g., neighbourhood) - Aggregate useful floor area (UFH) data per building (from EPCs or municipal records) - Identify buildings connected to the energy grid - Sum UFH of connected buildings, compute ratio to total UFH

C3.6	Damage risk for district heating and cooling systems					
C3.6.v1	Supply temperature stability	This criterion evaluates the ability of district heating and cooling systems to maintain stable supply temperatures during periods of extreme heat, identifying risks of underperformance or overheating.	Variation in supply temperature relative to target temperature during high-temperature events	°C	LIB	To calculate the value of the indicator: - Measure the actual supply temperature (Tsupplymeasured at the selected monitoring point - Identify the target or design supply temperature (Ttarget) specified for the system - Caclulate the indicator as difference between Tsupplymeasured and Ttarget
C3.6.v2	System operational efficiency	This criterion assesses how much system efficiency declines during extreme heat, focusing on losses in heat transfer, pump performance, and cooling capacity.	Percentage decrease in operational efficiency compared to standard operational conditions	%	LIB	To calculate the value of the indicator: - Determine the system efficiency under standard operating conditions (η standard). This value serves as the baseline or reference efficiency - Measure or simulate the system efficiency under extreme heat conditions (η extreme heat) - Calculate the efficiency loss as the difference between η standard and η extreme heat, divided by η standard, and multiplied by 100
C3.6.v3	Peak cooling/heating demand	This criterion evaluates the increase in peak cooling or heating demand during extreme heat events and its impact on system load and resilience.	Peak demand recorded for cooling/heating during extreme heat	%	LIB	To calculate the value of the indicator: - Determine the maximum system demand during the selected heat event (Dmax (heat event)) - Determine the historical average peak summer demand (D historical summer) using an appropriate reference period (e.g., the average peak demand over the previous 5–10 summer seasons) - Calculate the Peak Demand Index as percentage of D max (heat event) in reference to D historical summer

C3.6-e1	Network exposure to temperature stress	This criterion assesses the extent of above-ground or poorly insulated network segments exposed to high ambient temperatures, increasing risk of energy loss and physical damage.	Share of network length exposed to high temperatures	%	LIB	To calculate the value of the indicator: - Determine the total length of the network within the system boundary - Identify and measure the length of the network that is exposed to external environmental conditions, such as above-ground pipelines or sections directly subjected to solar radiation and ambient weather conditions - Calculate the percentage of exposed network in relation to the total lenght of the network
C7	**ENVIRONMENT AND BIODIVERSITY**					
C7.1	**Damage risk for Urban green spaces**					
C7.1.v1	Heat-tolerant Species	This criterion measures the percentage of urban vegetative cover that consists of species classified as heat-tolerant.	Percentage of heat-tolerant vegetation in the urban green spaces	%	HIB	To calculate the value of the indicator: - Define urban boundaries (administrative or functional) - Map all vegetated areas (using satellite imagery, NDVI data, or urban green space inventory) - Classify vegetation types based on species or plant functional types - Identify heat-tolerant species (drought resistance, high albedo, deep roots, etc.) - Calculate total area of heat-tolerant vegetation - Calculate the percentage of heat-tolerant vegetation in respect to the total vegetated area in the city
C7.1.v2	Mulching coverage	This criterion assesses the proportion of soil in urban green spaces covered by organic mulching materials to reduce soil moisture	Percentage of soil in urban green spaces covered with organic mulch	%	HIB	To calculate the value of the indicator: - Determine the Total Soil Area: Measure the entire area of the field or land plot. This can be done by using surveying tools (GPS, total station) or remote sensing data (satellite or drone imagery). - Measure the Mulched Area: Identify and measure

		loss, improve water retention, and enhance resilience to extreme heat.				the parts of the field that are covered by mulch. This may be achieved by field measurements, grid sampling techniques, or digital image analysis from remote-sensed data - Divide the mulched area by the total soil area and multiply by 100 to express the result as a percentage
C7.1.v3	Natural shading (tree canopy coverage)	This criterion refers to the proportion of an area that is covered by shade from natural features like trees, shrubs, and topography. This is important in urban planning, agriculture, and environmental management, as shading can reduce heat island effects, improve microclimates, and protect soil moisture.	Percentage of tree canopy shades in green urban spaces in summer	%	HIB	To calculate the value of the indicator: - Define the area to be measured (e.g., a park, agricultural field, or urban block), marking the boundaries accurately using GIS tools or physical measurements - Collect data using satellite images, drone photography, field observations, or digital mapping tools to capture the extent of shading - Calculate the total area of the region under study (At) - Measure the shaded area within the region (As) - Calculate the percentage of shaded area in respect to the total area
C7.1-e1	Availability of urban green spaces	This criterion evaluates the total availability of vegetated public and semi-public green spaces, such as parks, gardens, green corridors, and urban forests, relative to the number of inhabitants within the	Total area of urban green spaces per inhabitant	m^2/inhabitant	LIB	To calculate the value of the indicator: - Sum the total surface (in m^2) of mapped urban green spaces using high-resolution satellite imagery, local cadastral or land-use GIS data. - Categorize and validate green space types (e.g., recreational parks, natural areas, tree-lined avenues). Note: This may be complemented by aerial surveys or municipal land-use registries. - Divide the area of urban green spaces by the number of inhabitants

		assessed urban area. A higher green space area per inhabitant means a greater exposure to extreme temperatures.				
C8	**HEALTH**					
C8.1	**Health risk for inhabitants**					
C8.1.v1	Capacity of paved surfaces to reflect solar radiation	This criterion assesses the urban area's ability to reflect solar radiation and dissipate accumulated heat, thereby mitigating the urban heat island effect.	Mean Solar Reflectance Index	n	HIB	To calculate the value of the indicator: - List all types of paved materials (e.g., roads, sidewalks) while excluding roofs and green areas - Assign each material a Solar Reflectance Index based on its reflective and emissive properties - Calculate the contribution of each material by multiplying its SRI value by its surface area - Sum the weighted contributions and divide by the total area of all paved surfaces to obtain the reflectance index
C8.1.v2	Capacity of flat roofs to reflect solar radiation	This criterion assesses the ability of flat roof surfaces to reflect solar radiation and emit absorbed heat through the Solar Reflectance Index (SRI), thereby reducing heat accumulation and mitigating urban overheating.	Mean Solar Reflectance Index	n	HIB	To calculate the value of the indicator: - List all types of flat roof materials while excluding paved areas and green areas - Assign each flat surface material a Solar Reflectance Index based on its reflective and emissive properties - Calculate the contribution of each flat surface material by multiplying its SRI value by its surface area - Sum the weighted contributions and divide by the total area of all flat roof surfaces to obtain the mean reflectance index

C8.1.v3	Capacity of sloped roofs to reflect solar radiation	This criterion assesses the ability of sloped roof surfaces to reflect solar radiation and emit absorbed heat through the Solar Reflectance Index (SRI), thereby reducing heat accumulation and mitigating urban overheating.	Mean Solar Reflectance Index	n	HIB	To calculate the value of the indicator: - List all types of sloped roof materials while excluding paved areas and green areas - Assign each sloped surface material a Solar Reflectance Index based on its reflective and emissive properties - Calculate the contribution of each sloped surface material by multiplying its SRI value by its surface area - Sum the weighted contributions and divide by the total area of all sloped roof surfaces to obtain the mean reflectance index
C8.1.v4	Urban Area Reflectivity	This criterion refers to the average fraction of solar radiation reflected by urban surfaces over a defined area (roofs, pavements, walls, vegetation), typically in the 0–1 scale.	Mean albedo	n	HIB	To calculate the value of the indicator: - Define the spatial extent, including sealed surfaces, rooftops, and green spaces - Collect data: Acquire multispectral imagery (e.g., MODIS, Sentinel-2) or airborne sensors - Compute surface albedo: Use satellite BRDF-based algorithms (MODIS white-sky/dark-sky), converting narrowband to surface albedo - Aggregate mean albedo: Calculate area-weighted average over urban extent
C8.1.v5	Shading of paved surfaces	This criterion refers to the proportion of paved surfaces (streets, sidewalks, plazas, parking) that receive shade during critical exposure times.	Share of shaded paved areas	%	HIB	To calculate the value of the indicator: - Define target area (e.g., specific street segment) - Collect geometric data: e.g., tree canopy, building heights, sun angles - Model sun/shade patterns at key times (e.g., using Ladybug Tools or GIS sun-path analysis) - Identify shaded pavements: map shaded vs sunlit paved areas - Calculate percentage of shaded area

C8.1.v6	Visibility of the Sky	This criterion assesses the visibility of the sky from the urban environment, accounting for the obstruction caused by buildings, vegetation, and terrain, to evaluate the potential for radiative heat loss and urban heat accumulation.	Mean Sky View Factor	n	HIB	To calculate the value of the indicator: - Gather 3D data: digital surface model (DSM) of buildings, trees, and terrain. - Geometric calculation using DSM and ray-tracing in tools like UMEP or GIS - SVF formula: SVF = 1ni=1ncos(θ_i) where θ_i = elevation angle to the sky in direction i - Average across locations to obtain mean SVF for the study area
C8.1.v7	Availability of green areas	This criterion refers to the proportion of urban land covered by vegetation (parks, street trees, community gardens, urban forests).	Share of green areas of total urban zone area	%	HIB	To calculate the value of the indicator: - Define area boundary, including built-up and green features - Acquire geospatial data: high-res satellite imagery or city greenspace shapefiles - Use GIS classification to segment green vs. non-green zones - Calculate share of green areas in relation to the total urban zone area
C8.1.v8	Presence of households in bad conditions	This criterion refers to the average age of residential structures within a defined urban area	Dominant construction period of residential buildings in the area	Mean Vulnerability Value of residential buildings in the urban area, in reference to their construc	LIB	To calculate the value of the indicator: - Collect year-built data for residential buildings (source: cadastral records, municipal GIS) - Determine the dominant construction period - Assign the score using this table: N score (S) Main construction period Vulnerability 0.00 – 0.20 ≥ 2000 Very low vulnerability 0.21 – 0.40 1980–1999 Low to moderate vulnerability 0.41 – 0.60 Pre-1960 Moderate to high vulnerability 0.61 – 0.80 1960–1969 High vulnerability 0.81 – 1.00 1970–1980 Very high vulnerability

				tion period		- Determine the average construction period by computing the weighted average according to the buildings' volume
C8.1.v9	Green Space Density	This criterion refers to the counts distinct green space patches (parks, tree clusters, vegetated spots) per unit area, reflecting spatial distribution and density	Number of green spaces patches per unit area	n/ha	HIB	To calculate the value of the indicator: - Define the study area - Acquire green space layer, identifying patches via GIS (polygon features > 100 m^2) - Count n_patches within the area with at least a 100 m2 size - Compute the density by dividing the number of patches by the area of the study area
C8.1-e1	Population density	This criterion measures population density (inhabitants per square meter or per square kilometre) of an urban area. High-density areas are typically more vulnerable due to greater exposure, compounded risks, and more difficult emergency response logistics	Total number of inhabitants divided by the size of the urban area	Inhabitants/km2	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data. Convert Area to km^2 (if not already) - Calculate the population density by dividing the total number of inhabitants by urban area
C8.1-e2	Age-Sensitive Exposed Population	This criterion measures the proportion of the population that falls within age groups more physiologically vulnerable to extreme heat: children under 10 and elderly over	Percentage of residents aged under 10 and over 65	%	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data - Calculate the percentage of population under 10

		65. These age groups have reduced thermoregulation capacities and higher rates of heat-related morbidity and mortality. A high percentage of such population groups in an area increases its vulnerability to heatwaves.				and Population over 65 in respect to total population in the area
C9	**EMERGENCY SERVICES**					
C9.4	**Emergency medical services**					
C9.4.v1	Trained emergency medical staff	This criterion assesses the number of emergency medical staff trained on extreme hot temperature risk in relation to the population density in the investigated area per year. A high number of medical staff trained and able to properly intervene in case of heat island effect in the area, can ensure a wider coverage of the area affected by the climate risk and of	Number of trained emergency medical staff on extreme hot temperature risk in relation to the population density in the investigated area per year	n/(ab/km2)/year	HIB	To calculate the value of the indicator: - Obtain the number of emergency medical staff trained on extreme heat risk in the investigated area, for the reference year - Calculate the population density per km^2 in the investigated area - Calculate the ratio of the number of emergency medical staff trained on extreme heat risk to the population density

		course, the safety for people in the area.				
C9.4.v2	Availability of emergency medical service vehicles	This criterion assesses the availability of emergency medical vehicles properly equipped for heat island risk in relation to the total population of the investigated area. High number of emergency medical vehicles can contribute to operate efficiently, to guarantee timely aid and to ensure a wider territorial coverage simultaneously .	Number of emergency medical service vehicles properly equipped for extreme hot temperature risk in relation to the total population within the investigated area	n/inhabitants	HIB	To calculate the value of the indicator: - Assess the number of emergency medical vehicles able to intervene in case of extreme heat risk - Calculate the number of people living in the investigated area - Calculate the ratio of the number of emergency medical vehicles able to intervene in case of extreme heat risk to the number of inhabitants in the investigated area
C9.4.v3	Travel times for the Health Aid	This criterion assesses the necessary travel time from the inhabited zone of the investigated area and the nearest medical rescue building. Less time is taken to reach the inhabited area, less vulnerable the area is.	Average of travel times between the centre of the inhabited locality and the nearest medical rescue building	minutes	LIB	To calculate the value of the indicator: - Calculate the average of travel times between the inhabited centre zone of the investigated area and the nearest medical rescue building

C9.4.v4	Warning tool on extreme hot temperature risk installed on the citizens phone	This criterion assesses the availability for the investigated area of a warning tool, specific for extreme hot temperatures, able to alert citizens in case of heat island effect in the area. The warning tool must be downloadable on the smartphone in order to ensure a quick notice about the risk.	Availability of hot temperature warning tool for citizens' phones	Qualitative	QI	To calculate the value of the indicator: - Evaluate if a warning tool app is available in the investigated area and if it is possible for citizens to have it on their smartphones. Optimal value (0): warning tool app available / Critical value (1): no warning tool app available
C9.4-e1	Age-Sensitive Exposed Population	This criterion measures the proportion of the population that falls within age groups more physiologically vulnerable to extreme heat: children under 10 and elderly over 65. These age groups have reduced thermoregulation capacities and higher rates of heat-related morbidity and mortality. A high percentage of such population groups in an area increases its	Percentage of residents aged under 10 and over 65	%	LIB	To calculate the value of the indicator: - Define the Urban Area: Use official city or metropolitan boundaries (administrative or built-up area) - Collect Population Data: Use census or administrative data - Calculate the percentage of population under 10 and Population over 65 in respect to total population in the area

		vulnerability to heatwaves.				
C9.4-e2	Areas with a high probability of heat island effect	This criterion assesses the extent of the areas with a high probability of heat island effect in relation to the investigated area. The greater the extent of the areas at risk of extreme heat, the greater the exposure of the area is.	Extent of the areas with a high probability of heat island effect in relation to the investigated area	%	LIB	To calculate the value of the indicator: - Identify areas with a high probability of extreme hot temperature within the investigated area - Calculate the percentage of area with a high probability of extreme hot temperature in respect to the extension of the investigated area

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table D.4 — RNTool Key Risk Categories, criteria and indicators — Drought

D	DROUGHT					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
D4	**WATER**					
D4.2	**Damage risk for water supply network**					
D4.2.v1	Consumption	This criterion assesses the average daily water consumption per capita.	Water consumption per capita	L/capita/day	LIB	To calculate the value of the indicator: - Obtain the average daily water consumption for the area from the national or water supply company's database - Divide the average daily consumption by the number of days in the month to obtain the average daily consumption
D4.2.v2	Water loss	This criterion assesses the average percentage of water lost in the water supply network in a year. It refers to the amount of water delivered to the household (charged) in m3 compared to the amount of water that left the water reservoir (m3).	Losses in the water supply network	%	LIB	To calculate the value of the indicator: - Obtain data on the volume of water supplied into the network and the volume delivered to (billed) end users - Calculate the percentage of water lost in the network as the difference between the two values in respect to the volume supplied
D4.2-e1	Water supply network at risk	This criterion assesses the density of water supply network in the area.	Length of water supply network per number of residents	m/inhabitant	LIB	To calculate the value of the indicator: - Find the data about the length of the water supply network and the number of inhabitants in the selected area - Divide the length of the water supply

						network by the total number of inhabitants
D6	**AGRICOLTURE & FORESTRY**					
D6.2	**Damage risk for urban forests**					
D6.2.v1	Vegetation Condition Index (VCI)	This criterion assesses the health and condition of vegetation by comparing current vegetation cover with its historical variability using the Vegetation Condition Index (VCI), thereby evaluating vegetation stress associated with drought conditions.	Percentage of healthy vegetation in the area	%	HIB	To calculate the value of the indicator: - Identify the three required NDVI values for the area: NDVIcurrent: the current NDVI value for the time period of interest NDVImin: the historical minimum NDVI value for that area NDVImax: the historical maximum NDVI value for that area - Subtract the historical minimum NDVI from the current NDVI. This indicates how much the current vegetation condition exceeds the lowest historical condition - Subtract the historical minimum NDVI from the historical maximum NDVI. This gives the total range of vegetation variability in the area - Divide the result from Step 2 by the result from Step 3: This normalizes the current NDVI within the historical range - Multiply the result by 100 to express the Vegetation Condition Index as a percentage
D6.2.v2	Drought-Tolerant Tree Species	This criterion quantifies the degree to which a forest, urban green space, or reforestation project	Percentage of drought-tolerant trees in the total urban forest area	%	HIB	To calculate the value of the indicator: - Identify key physiological and morphological traits that reflect drought tolerance, such as High water use efficiency, Low leaf turgor loss point, Deep rooting depth, Xylem resistance to

		is composed of tree species that can sustain performance under water-limited conditions. In its simplest form, the indicator is a percentage that reflects the proportion of trees that fulfill established drought tolerance criteria.				embolism. - Use international or regional guidelines (e.g., FAO reports, Mediterranean forestry standards) to define threshold values for each trait. A species is considered drought tolerant if its performance under stress (e.g., leaf water potential, stomatal conductance) meets or exceeds these thresholds (e.g., as per FAO, 2018). - Compile and Score Species data species Inventory: - Create a list of all tree species present in the study area.Include data on species abundance or ecological importance, if available. - Collect species-specific data for the selected drought tolerance traits. - Use published values or direct field measurements (e.g., water use efficiency, leaf water potential, root depth). - Count the number of trees that are considered drought-tolerant. - Calculate the percentage of drought-tolerant trees by dividing the number of drought-tolerant trees by the number of total trees and multiplying by 100
D6.2.v3	Mulching Coverage	This criterion assesses the proportion of soil in urban green spaces covered by organic mulching materials to reduce soil moisture loss, improve water	Percentage of forest trees with mulched coverage	%	HIB	To calculate the value of the indicator: - Determine the Total Soil Area: Measure the total surface area of the land plot or field under observation - Use field surveying tools such as GPS units or total stations. Alternatively, use remote sensing data from satellites or drones for larger or less accessible areas - Measure the Mulched Area: Identify and

		retention, and enhance resilience to extreme heat.				quantify the portion of the land that is covered by mulch (e.g., organic residues, plastic films, straw) - Calculate the percentage of area covered by mulch in respect to total soil area
D6.2-e1	Size of urban forests	This criterion refers to the surface area covered by tree-dominated vegetation within an urban environment, including parks, greenways, street trees, and natural forest remnants.	Percentage of urban forests in relation to the defined urban area	%	LIB	To calculate the value of the indicator: - Define Urban Boundaries: Use administrative boundaries or functional urban areas - Acquire Spatial Data: Obtain high-resolution satellite imagery (e.g., Sentinel-2, Landsat 8) or aerial LiDAR to detect tree cover - Land Cover Classification: Perform remote sensing classification (e.g., supervised classification or NDVI thresholding) to identify forested areas - Calculate Area of Urban Forests (A_UF): Measure the total land surface classified as urban forest in hectares or km^2 - Calculate Total Urban Area (A_U): Sum the total urban surface using the same spatial dataset - Calculate the percentage of A_UF in respect to A_U
D6.3	**Damage risk for urban and peri-urban agricultural zones**					
D6.3.v1	Irrigation water consumption	Crop irrigation water consumption refers to the total volume of water used for irrigating crops, including both surface and groundwater	Percentage of water consumption for irrigation purposes	%	LIB	To calculate the value of the indicator: - Measure the total land area designated for irrigation. Express the area in square meters (m^2) or hectares (ha), depending on the scale of the land - Use local meteorological data or agricultural extension sources to get evapotranspiration (ETo) (in mm/day or

		sources. It is often expressed in terms of evapotranspiration requirements and irrigation efficiency, considering factors such as climate, soil type, and irrigation methods. Efficient irrigation management is essential for optimizing water use in agriculture.				mm/month) - Use established crop coefficient (Kc) values specific to the crop type and growth stage - Multiply Eto by Kc to estimate how much water the crop needs under current climatic conditions (CWR) - Asses effective rainfall using FAO estimation method: If monthly rainfall (P) > 75 mm: Pe = 0.8 × P If monthly rainfall (P) < 75 mm: Pe = 0.6 × P - Calculate net irrigation requirement (NIR) by subtracting Pe to CWR, to Indicate the actual amount of irrigation water needed after considering rainfall contributions - Determine irrigation efficiency (IE). Choose the efficiency value based on your irrigation method: Drip irrigation: ~90% Sprinkler systems: ~75% Surface irrigation: ~60% - Calculate the gross irrigation requirement (GIR), divide NIR by IE - Estimate total irrigation water consumption multiplying GIR by irrigated area. Typically expressed in cubic meters (m^3) per season or irrigation cycle
D6.3.v2	Variety of crops	The variety of crops grown within a defined area refers to the number and distribution of	Shannon diversity index	index	HIB	To calculate the value of the indicator: - Create a list of all crop types grown within the defined area - Record the area covered by each crop, typically in hectares or square meters

		different plant species cultivated within a specific geographic region. Higher crop diversity enhances soil health, reduces pest vulnerability, and increases resilience to climate change.				- For each crop, divide its area by the total cropped area to obtain its proportional share (Pi) - Square the Pi value of each crop to get Pi^2 - Sum the Squared Proportions - Calculate the Shannon diversity index: Subtract the sum of squared proportions from 1
D6.3.v3	Water Recycling	The Crop Water Recycling Indicator (CWRI) measures the proportion of water applied to a crop that is effectively used and/or reused within the agricultural system. It helps evaluate the efficiency of water use in cropping systems, particularly under water-scarce conditions like droughts. Higher CWRI values suggest better water reuse efficiency, contributing to more sustainable water management.	Percentage of agricultural land irrigated with recycled water	%	HIB	To calculate the value of the indicator: - Estimate the Total Water Required by the Crop: Begin by determining how much water the crop needs over its growing season. This value is based on two main factors: local climate (including sunlight, temperature, humidity, and wind), and type of crop (as each crop has its own water requirement, which changes at different growth stages). Experts calculate this using crop evapotranspiration, which combines water lost from the soil and water used by the plant. - Subtract Any Water That Comes Naturally from Rainfall: From the total crop water requirement, subtract the amount of useful rainwater that actually helps the crop. This is called effective rainfall, and it only includes the portion of rain that infiltrates the soil and is usable by the plant. - Calculate How Much Irrigation Water the Crop Needs: After accounting for

		CWRI is essential for evaluating how much of the irrigation water is beneficially used versus lost through evaporation, drainage, or runoff.				effective rainfall, the remaining water needed must be supplied through irrigation. This is known as the net irrigation requirement it's the amount of water you still need to apply to fully meet the crop's needs. - Measure How Much Recycled Water Was Actually Used for Irrigation: Find out how much of the irrigation water applied to the field came from recycled or reclaimed water sources. This includes treated wastewater, drainage water reused on-site, or other non-conventional water sources. - Compare the Recycled Water Used with the Total Crop Water Needs: Finally, determine the proportion of the crop's total water requirement that was met by recycled water.
D6.3.v4	Drought-Tolerant Crops	The Drought-Tolerant Crops Indicator measures the share (in percentage) of the total cultivated agricultural area that is sown with crop varieties known for their ability to endure periods of low water availability. The primary aim of this indicator is to assess and enhance the	Percentage of agricultural area planted with drought-tolerant crops	%	HIB	To calculate the value of the indicator: - Compile a list of crop varieties officially recognized as drought tolerant - Measure the total land area cultivated with the identified drought-tolerant varieties - Determine the entire agricultural area under cultivation in the region of interest, including all crop types - Calculate the percentage of agricultural area under drought-tolerant crop varieties in respect to the total agricultural area

		resilience of food production systems in regions prone to drought.				
D6.3-e1	Size of agricultural zones	This criterion measures the total surface area dedicated to agricultural activities (urban farming, peri-urban farming, community gardens, agro-parks, etc.) within the urban boundaries.	Total area of agricultural zones in urban areas	%	LIB	To calculate the value of the indicator: - Define urban boundaries using GIS data or municipal definitions - Identify agricultural zones (urban farms, gardens, greenhouses, etc.) via: Land-use/land-cover (LULC) datasets Satellite imagery or remote sensing classification Municipal agricultural zoning maps - Calculate area (in hectares or square meters) of all identified agricultural zones. - Calculate total urban area using the same spatial data source - Apply the formula to derive the percentage: Divide the total area of agricultural zones within urban boundaries by the total urban area multiplied by 100
D7	**ENVIRONMENT & BIODIVERSITY**					
D7.1	**Damage risk for Urban green spaces**					
D7.1.v1	Green Species Sensitivity	This criterion assesses the tolerance of vegetation species within the neighbourhood to high temperatures and drought	Share of heat-sensitive species (e.g., shallow-rooted, non-native)	%	LIB	To calculate the value of the indicator: - Conduct an inventory within the neighbourhood to identify species composition - Classify species based on their tolerance to heat and drought conditions - Calculate the percentage of trees that are heat-sensitive

		conditions, identifying the share of trees vulnerable to drought.				
D7.1.v2	Age and Health Status of Trees	This criterion assesses the proportion of trees within the neighbourhood that are older, declining, or in poor health, as these trees are more vulnerable to heat damage and drought stress.	Share of trees classified as mature/declining/poor health	%	LIB	To calculate the value of the indicator: - Conduct a tree inventory and health assessment within the neighbourhood - Classify trees by age and health status - Calculate the percentage of trees identified as mature, declining, or in poor health
D7.1-e1	Exposed urban green spaces	The criterion assesses the presence and distribution of green spaces, based on the percentage of green areas in relation to the total urban surface.	Share of green areas of total urban zone area	%	LIB	To calculate the value of the indicator: - Define area boundary, including built-up and green features - Use GIS classification to segment green vs. non-green zones - Calculate the share of green areas in relation to the total area
D7.3	**Damage risk for Street Trees**					
D7.3.v1	Tree Species Sensitivity	This criterion assesses the tolerance of tree species within the neighbourhood to high temperatures and drought conditions,	Share of heat-sensitive species (e.g., shallow-rooted, non-native)	%	LIB	To calculate the value of the indicator: - Conduct a tree inventory within the neighbourhood to identify species composition - Classify species based on their tolerance to heat and drought conditions - Calculate the percentage of trees that are heat-sensitive

		identifying the share of trees vulnerable to drought.				
D7.3.v2	Age and Health Status of Trees	This criterion assesses the proportion of trees within the neighbourhood that are older, declining, or in poor health, as these trees are more vulnerable to heat damage and drought stress.	Share of trees classified as mature/declining/poor health	%	LIB	To calculate the value of the indicator: - Conduct a tree inventory and health assessment within the neighbourhood - Classify trees by age and health status - Calculate the percentage of trees identified as mature, declining, or in poor health
D7.3-e1	Exposed trees	The criterion assesses the density and distribution of trees within the neighbourhood.	Percentage of area covered by tree covers	%	LIB	To calculate the value of the indicator: - Calculate the total area of the neighbourhood - Map the trees in the neighbourhood and estimate the size of their cover - Calculate the percentage of tree cover in respect to the total area of the neighbourhood

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Annex E
(informative)

Criteria and Indicators for RBTool Key Risk Categories

Table E.1 — RNTool Key Risk Categories, criteria and indicators — Heavy precipitation

A	**HEAVY PRECIPITATION**					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
A3	**NON-LOAD BEARING ELEMENTS**					
A3.3	**Stairs and ramps**					
A3.3.v1	Slip Resistance of Surface	This criterion assesses the slip resistance of ramps, stairs, and walking surfaces under wet conditions to ensure safe pedestrian movement during heavy precipitation events.	R Class	index	HIB	To calculate the value of the indicator: - Identify all ramps, stairs, and walking surfaces exposed to precipitation - Collect the declared slip resistance (R class) for each surface from product documentation or test reports - Identify the lowest R class among all assessed surfaces - Assign the indicator value based on the lowest R class
A4	**FACADE**					
A4.1	**External wall systems, cladding and shading devices**					
A4.1.v1	Façade Water Resistant Materials	This criterion assesses the extent to which external wall materials and finishes resist water penetration caused by	Percentage of external wall surfaces equipped with water	%	HIB	To calculate the value of the indicator: - Collect architectural drawings and façade material specifications - Identify façade areas protected by water-resistant materials or cladding

		driving rain, splash, and runoff.	resistant materials or protective cladding			- Calculate the protected façade area - Divide the protected façade area by the total external wall area and multiply by 100
A4.1.v2	Ease of disassembly of damaged materials	This criterion assesses the proportion of façade components designed for easy removal, replacement, or upgrading after damage without major structural intervention.	Percentage by weight of façade components designed for easy removal, replacement, or upgrading without major structural intervention	%	HIB	To calculate the value of the indicator: - Review façade design documentation and material specifications - Identify façade components designed for easy removal or replacement - Determine the total weight of these components - Divide their weight by the total weight of façade components and multiply by 100
A4.1.v3	Direct Rain Protection	This criterion assesses the extent to which façade surfaces are protected from direct rainfall by overhangs, canopies, cornices, or other architectural projections.	Share of a façade effectively shielded from driving rain by overhangs, cornices, or projections	%	HIB	To calculate the value of the indicator: - Measure the depth and position of façade overhangs and projections - Determine the façade areas protected from driving rain based on rainfall angle - Adjust the protected area according to detailing efficiency factors where applicable - Divide the protected façade area by the total façade area and multiply by 100
A4.2	**Façade openings**					
A4.2.v1	Safe Windows and Shutters	This criterion assesses the proportion of windows protected against hail impact through resistant glazing, shutters, or protective screens.	Share of windows protected against hail	%	HIB	To calculate the value of the indicator: - Review window specifications, certifications, and design documentation - Count the number of protected windows - Count the total number of windows

						- Divide the number of protected windows by the total number of windows and multiply by 100
A4.2.v2	Sealed openings	This criterion assesses the ability of windows, doors, and other external openings to resist water penetration during heavy rainfall events.	Water tightness class	index	HIB	To calculate the value of the indicator: - Identify all external windows, doors, and openings - Collect the declared watertightness class from product documentation or test reports - Identify the lowest watertightness class among all assessed openings - Assign the indicator value based on the lowest class
A5	**ROOF**					
A5.1	**Structure**					
A5.1.v1	Slope Efficiency	This criterion assesses whether the roof slope promotes efficient rainwater runoff and minimizes water accumulation.	Slope angle to optimize runoff	degrees	HIB	To calculate the value of the indicator: - Review roof drawings and design documentation - Determine the roof slope for each roof section - Compare the measured slopes with the recommended drainage requirements - Assign the indicator value according to the roof slope
A5.1.v1	Ease of Maintenance Access	This criterion assesses the proportion of technical spaces that provide safe and convenient access for inspection, maintenance, and repair activities.	Share of technical spaces easily accessible	%	HIB	To calculate the value of the indicator: - Review architectural and MEP drawings - Identify technical spaces with safe and unobstructed maintenance access - Count the accessible technical spaces - Divide the number of accessible technical spaces by the total number of technical spaces and multiply by 100
A5.2	**Weatherproofing**					
A5.2.v1	Discharge Capacity	This criterion assesses whether the roof drainage system provides sufficient	Ratio between the discharge	%	HIB	To calculate the value of the indicator: - Collect roof drainage drawings and hydraulic calculations

		discharge capacity for a 100-year return period precipitation event.	rate of the roof drainage system and the optimal discharge rate required for a 100-year return period precipitation event			- Determine the discharge capacity of the roof drainage system - Determine the required discharge capacity for a 100-year precipitation event - Divide the available discharge capacity by the required discharge capacity and multiply by 100
A5.2.v2	Integrated Rainwater Diversion Systems	This criterion assesses the presence and effectiveness of roof and site drainage systems designed to divert excessive rainwater away from the building.	Presence of roof systems designed to divert excessive rainwater away from the building foundation.	Qualitative	QI	To calculate the value of the indicator: - Review drainage system drawings and specifications - Verify the presence of gutters, downspouts, and rainwater diversion systems - Assess whether the system effectively diverts rainwater away from the building foundation - Normalize the indicator (0 = Optimal drainage system; 1 = Critical drainage system)
A5.2.v3	Roof Sealing Effectiveness	This criterion assesses the proportion of the roof protected by waterproofing membranes, coatings, or sealing systems to prevent water infiltration.	Share of roof sealed against water	%	HIB	To calculate the value of the indicator: - Review roof waterproofing drawings and specifications - Identify roof areas protected by waterproofing systems - Calculate the protected roof area - Divide the protected roof area by the total roof area and multiply by 100
A5.2.v4	Protection of the roof	This criterion assesses the presence of hail protection systems for vulnerable rooftop	Presence of a hail net to protect fragile	Qualitative	QI	To calculate the value of the indicator: - Review architectural and mechanical design documentation - Verify the installation of hail protection systems for

		elements such as skylights, photovoltaic panels, and HVAC equipment.	elements on the roof			vulnerable rooftop elements - Assess the level of protection provided - Normalize the indicator (0 = High level of protection; 1 = No protection system)
A5.2.v5	Rainwater Collection	This criterion assesses the proportion of rainwater runoff captured and stored through rainwater harvesting systems.	Share of rainwater harvested vs total runoff	%	HIB	To calculate the value of the indicator: - Determine the roof catchment area - Calculate the expected rainwater runoff using local rainfall data - Determine the collection or storage capacity of the rainwater harvesting system - Divide the collected rainwater volume by the total runoff volume and multiply by 100
A10	**SANITARY SYSTEMS**					
A10.3	**Water treatment systems**					
A10.3.v1	Separation of Rainwater and Wastewater	This criterion assesses the degree to which rainwater and wastewater drainage systems are separated to reduce sewer overload and improve stormwater management.	Degree of separation	%	HIB	To calculate the value of the indicator: - Review plumbing and drainage drawings - Verify the separation between rainwater and wastewater systems - Assess whether the separation is full, partial, or absent - Assign the indicator value according to the level of separation
A13	**LANDSCAPING**					
A13.1	**Paving and other hard surfacing**					
A13.1.v2	Permeable Outdoor Surrounding Surfaces	This criterion assesses the permeability of outdoor surrounding surfaces to facilitate infiltration, improve drainage, and reduce flood risk.	Mean permeability coefficient of surrounding surfaces	%	HIB	To calculate the value of the indicator: - Identify all outdoor surface materials from the site plan - Collect the permeability coefficient for each material - Calculate the weighted average permeability coefficient according to the corresponding surface

						areas - Assign the resulting weighted average permeability coefficient
A13.3	**Drainage system**					
A13.3.v1	Onsite Stormwater Retainage	This criterion assesses the capacity of on-site stormwater retention systems to reduce runoff during extreme precipitation events.	Volume of the flood retention tank	%	HIB	To calculate the value of the indicator: - Collect stormwater management drawings and hydrological calculations - Determine the storage volume of the on-site stormwater retention systems - Determine the required storage volume for a 200-year precipitation event - Divide the available storage volume by the required storage volume and multiply by 100
A13.3.v2	Drainage systems	This criterion assesses the presence and functionality of drainage systems designed to collect, convey, and manage stormwater around the building.	Presence and functional performance of infiltration systems	Qualitative	QI	To calculate the value of the indicator: - Review drainage system drawings and specifications - Verify the presence of gutters, channels, infiltration systems, and perimeter drains - Assess the planned functionality and capacity of the drainage system - Normalize the indicator (0 = Optimal drainage system; 1 = Critical drainage system)

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table E.2 — RNTool Key Risk Categories, criteria and indicators — Floods

B	**FLOODS**					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
B1	**FOUNDATIONS**					
B1.2	**Basements**					
B1.2.v1	Groundwater resilient basement	This criterion assesses the proportion of basement foundations constructed with water-resistant concrete to reduce groundwater infiltration and improve flood resilience.	Share of foundations using water-resistant concrete	%	HIB	To calculate the value of the indicator: - Review structural design drawings and material specifications - Identify foundation elements constructed with water-resistant concrete - Calculate the area or volume of foundations using water-resistant concrete - Divide the resilient foundation area or volume by the total foundation area or volume and multiply by 100
B1.2.v2	Basement waterproofing	This criterion assesses the presence and effectiveness of waterproofing systems applied to basement foundations to prevent water ingress from groundwater and flooding.	Waterproofing protection measures (e.g., internal coating, external membrane, chemical barriers)	Qualitative	QI	To calculate the value of the indicator: - Review structural drawings, wall sections, and construction specifications - Identify the waterproofing systems specified for basement walls and foundations - Assess the expected level of protection provided by the waterproofing system - Normalize the indicator (0 = Optimal basement waterproofing; 1 = Critical basement waterproofing)

B1.2.v3	Drainage layer under foundation slab	This criterion assesses the proportion of foundation area equipped with a drainage layer to manage groundwater and reduce hydrostatic pressure beneath the building.	Share of drainage layer area under foundations	%	HIB	To calculate the value of the indicator: - Review foundation and drainage design drawings - Identify foundation areas provided with a drainage layer - Calculate the area protected by the drainage layer - Divide the protected foundation area by the total foundation area and multiply by 100
B1.4	**Shallow foundations**					
B1.4.v1	Flood resilience of continous foundations	This criterion assesses the capacity of continuous foundations to withstand hydrostatic pressure, soil erosion, and water-induced degradation while maintaining structural stability and serviceability.	Flood resilience level	Qualitative	QI	To calculate the value of the indicator: - Review structural and geotechnical design documentation - Verify the use of durable or waterproof materials - Assess the presence of drainage systems and protection against uplift and erosion - Evaluate the foundation depth in relation to flood resilience requirements - Normalize the indicator (0 = Optimal flood resilience; 1 = Critical flood resilience)
B1.4.v2	Continous Foundation Depth	This criterion assesses whether the depth of continuous foundations is appropriate for the site's soil conditions to ensure stability during flooding and	Depth of the foundation in relation to the type of soil	m	HIB	To calculate the value of the indicator: - Review foundation design drawings - Review the geotechnical investigation report to identify the soil classification - Determine the planned foundation depth - Compare the planned depth with the recommended depth for the identified soil conditions

		groundwater fluctuations.				
B1.4.v3	Flood resilience of isolated foundations	This criterion assesses the capacity of isolated foundations to withstand hydrostatic pressure, soil erosion, and water-induced degradation while maintaining structural stability and serviceability.	Flood resilience level	Qualitative	QI	To calculate the value of the indicator: - Review structural and geotechnical design documentation - Verify the use of durable or waterproof materials - Assess the presence of drainage systems and protection against uplift and erosion - Evaluate the foundation depth in relation to flood resilience requirements - Normalize the indicator (0 = Optimal flood resilience; 1 = Critical flood resilience)
B1.4.v4	Isolated Foundation Depth	This criterion assesses whether the depth of isolated foundations is appropriate for the site's soil conditions to ensure stability during flooding and groundwater fluctuations.	Depth of the foundation in relation to the type of soil	m	HIB	To calculate the value of the indicator: - Review foundation design drawings - Review the geotechnical investigation report to identify the soil classification - Determine the planned foundation depth - Compare the planned depth with the recommended depth for the identified soil conditions
B1.4.v5	Prevention of foundation shifts	This criterion assesses the presence of structural measures that prevent foundation displacement caused by hydrostatic pressure, erosion, or	Strategies to prevent foundation shifts during flooding (e.g., hydrostatic flood vents, open floors)	Qualitative	QI	To calculate the value of the indicator: - Review architectural and structural design documentation - Identify flood-resilient design features such as hydrostatic vents, reinforced anchoring systems, or open ground floors - Assess the expected effectiveness of these measures in preventing foundation shifts

		uplift during flooding events.				- Normalize the indicator (0 = Optimal prevention strategies; 1 = No prevention strategies)
B2	**LOAD BEARING STRUCTURAL FRAME**					
B2.1	**Frame (beams, columns and slabs)**					
B2.1.v1	Use of water-resistant structural materials	This criterion assesses the proportion of structural elements below the design flood level constructed with water-resistant and low-absorption materials.	Proportion made of low-absorption materials (e.g., concrete, steel)	%	HIB	To calculate the value of the indicator: - Review structural material specifications and construction documentation - Identify structural elements below the design flood level constructed with water-resistant materials - Calculate the quantity of resilient structural elements - Divide the quantity of resilient structural elements by the total quantity of structural elements below flood level and multiply by 100
B2.1.v2	Corrosion-Resistant Structural Materials	This criterion assesses the proportion of structural elements constructed with corrosion-resistant materials below the design flood level.	Percentage of structural elements made from materials resistant to water-induced corrosion	%	HIB	To calculate the value of the indicator: - Review material datasheets and manufacturer certifications - Identify structural elements using corrosion-resistant materials - Calculate the quantity of corrosion-resistant structural elements below flood level - Divide the quantity of corrosion-resistant elements by the total quantity of structural elements below flood level and multiply by 100
B2.3	**External walls**					
B2.3.v1	Flood resilience of load-bearing exterior walls	This criterion assesses the capacity of load-bearing exterior walls to resist impact from	The capacity of the load-bearing external walls to resist the impact of	Qualitative	QI	To calculate the value of the indicator: - Review structural wall design documentation and material specifications - Verify the impact resistance of the proposed wall system - Assess the expected resistance against water-borne debris based on engineering criteria

		water-borne debris during flood events.	water-borne debris			- Normalize the indicator (0 = Optimal resistance; 1 = Critical resistance)
B3	**NON-LOAD BEARING ELEMENTS**					
B3.1	**Ground floor slab**					
B3.1.v1	Water and moisture resilience of floor slabs	This criterion assesses the proportion of ground floor slabs designed to resist water and moisture penetration while maintaining durability and structural integrity.	Share of resilient ground floor slabs	%	HIB	To calculate the value of the indicator: - Review floor slab construction details and material specifications - Identify ground floor slabs incorporating moisture-resistant materials and protection measures - Calculate the resilient slab area - Divide the resilient slab area by the total ground floor slab area and multiply by 100
B4	**FACADE**					
B4.1	**External wall systems, cladding and shading devices**					
B4.1.v1	Structural resilience of exterior walls below flood level	This criterion assesses the capacity of exterior walls below the design flood level to maintain structural integrity and resist impact from water-borne debris during flood events.	Structural resistance to debris impact	Qualitative	QI	To calculate the value of the indicator: - Review wall construction details and material specifications - Verify the impact resistance of the proposed wall system - Assess the expected structural performance during flood events - Normalize the indicator (0 = High resistance; 1 = Critical resistance)
B4.1.v2	Waterproofing of external walls	This criterion assesses the proportion of exterior wall surfaces below the design flood level	Share of exterior wall under flood level protected with	%	HIB	To calculate the value of the indicator: - Review façade drawings and material specifications - Identify exterior wall areas below the design flood level protected with waterproof materials - Calculate the protected wall area

		protected with waterproof materials.	waterproof materials			- Divide the protected wall area by the total exterior wall area below flood level and multiply by 100
B4.1.v3	Replaceability of damaged façade elements	This criterion assesses the proportion of façade elements designed for easy replacement after flood damage without major structural intervention.	Share of easily replaceable façade elements	%	HIB	To calculate the value of the indicator: - Review façade system drawings and connection details - Identify façade elements designed for easy replacement - Calculate the quantity of replaceable façade elements - Divide the quantity of replaceable façade elements by the total quantity of façade elements and multiply by 100
B6	**FITTINGS AND FURNISHINGS**					
B6.1	**Sanitary fittings**					
B6.1.v1	Anti-Backflow Sanitary Fixtures	This criterion assesses the proportion of sanitary fixtures equipped with anti-backflow devices to prevent wastewater from returning into occupied spaces during flooding or drainage system overload.	Share of sanitary fixtures equipped with anti-backflow mechanisms	%	HIB	To calculate the value of the indicator: - Review plumbing design drawings and sanitary fixture specifications - Identify sanitary fixtures equipped with anti-backflow devices - Count the number of protected sanitary fixtures - Divide the number of protected sanitary fixtures by the total number of sanitary fixtures and multiply by 100

B8	**ENERGY SYSTEM**					
B8.3	**Electricity generation and distribution**					
B8.3.v1	Electric energy systems located above the flood threshold	This criterion assesses the elevation of electrical energy systems relative to the design flood level to reduce the risk of flood-induced damage and service interruption.	Elevation of electric energy systems	m	HIB	To calculate the value of the indicator: - Identify all electrical energy systems from the design documentation - Determine the design flood level using local flood hazard data - Review the planned installation elevations of the electrical systems - Compare the installation elevations with the design flood level
B8.3.v2	Quick-Disconnect Power Systems	This criterion assesses the availability of electrical systems that allow rapid disconnection of power to reduce electrical hazards during flood events.	Availability of systems allowing rapid disconnection of power to prevent electrical hazards during floods	Qualitative	QI	To calculate the value of the indicator: - Review electrical design drawings and system schematics - Identify quick-disconnect devices such as emergency shutoff switches, remote disconnects, or automatic breakers - Assess the capability of the proposed system to isolate electrical power during flooding - Normalize the indicator (0 = Comprehensive quick-disconnect system; 1 = No quick-disconnect system)
B8.3.v3	Elevated Electrical Outlets	This criterion assesses the proportion of electrical outlets installed above the design flood level to reduce electrical hazards and maintain service	Share of electrical outlets installed above the designated flood level	%	HIB	To calculate the value of the indicator: - Review electrical design drawings and outlet layouts - Identify electrical outlets located above the design flood level - Count the number of elevated electrical outlets - Divide the number of elevated electrical outlets by the total number of electrical outlets and multiply by 100

		continuity during flood events.				
B15	**OCCUPANTS**					
B15.2	**Accessibility**					
B15.2.v1	Accessibility of Safe Zones	This criterion assesses the accessibility of designated safe zones by measuring the time required for occupants to reach them during flood emergencies.	Minutes to reach the safe area	min	LIB	To calculate the value of the indicator: - Review building and site layout drawings - Identify designated safe zones and evacuation routes - Determine the travel distance from occupied spaces to the nearest safe zone - Estimate the travel time under emergency conditions
B15.2.v2	Entry Points and Accessibility	This criterion assesses the availability and accessibility of building entry points for occupants and emergency responders during normal operation and flood events.	Number and accessibility of entry points divided by the internal useful area	number/ 1000 m^2 indoor area	HIB	To calculate the value of the indicator: - Review architectural drawings and site plans - Count the number of accessible building entry points - Determine the internal useful floor area - Divide the number of accessible entry points by the internal useful area expressed in 1,000 m^2
B15.2.v3	Elevation of Lowest Occupied Floor	This criterion assesses the elevation of the lowest occupied floor relative to the design flood level to reduce occupants' exposure to flood hazards.	Elevation of the lowest occupied floor	meters	HIB	To calculate the value of the indicator: - Review architectural elevation drawings - Determine the elevation of the lowest occupied floor - Determine the design flood level using flood hazard information - Calculate the vertical difference between the occupied floor and the design flood level

A15.3	Emergency					
A15.3.v1	Emergency Response Training	This criterion assesses the proportion of building occupants expected to receive emergency response training related to flood events.	Share of occupants trained	%	HIB	To calculate the value of the indicator: - Review emergency preparedness plans and project documentation - Identify the planned emergency response training programme - Determine the number of occupants covered by the training programme - Divide the number of trained occupants by the total number of occupants and multiply by 100

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table E.3 — RNTool Key Risk Categories, criteria and indicators — Extreme heat

C	EXTREME HEAT					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
C4	**FAÇADE**					
C4.1	**External wall systems, cladding and shading devices**					
C4.1.v1	Thermal Expansion Management	This criterion assesses the susceptibility of the building envelope to deformation, cracking, or joint failure caused by thermal expansion during extreme heat events.	Average thermal expansion coefficient of primary building materials used in the envelope and structure	µm/m/°C	LIB	To calculate the value of the indicator: - Identify the primary materials used in the building envelope from construction documentation - Collect the thermal expansion coefficient of each material from manufacturer specifications or technical standards - Calculate the area-weighted average thermal expansion coefficient of the building envelope - Assign the resulting weighted average value

C4.1.v2	Heat-Resilient Mortars and Sealants	This criterion assesses whether the mortars and sealants used in building envelopes are resistant to degradation, cracking, or loss of adhesion under extreme heat conditions, ensuring continued weatherproofing and structural integrity during heat waves.	Presence of heat-resistant and compatible mortar and sealant materials in joints, facade finishes, and roof interfaces that maintain elasticity and bonding properties under high temperatures	Qualitative	QI	To calculate the value of the indicator: - Review construction documentation and material specifications - Identify mortars and sealants designed for high-temperature applications - Verify their compatibility with adjacent construction materials - Normalize the indicator (0 = Heat-resistant mortars and sealants provided; 1 = Heat-resistant mortars and sealants not provided)
C4.1.v3	Façade Comfort Optimization	This criterion assesses the optimization of façade design, materials, and detailing (including insulation, glazing ratio, orientation, and shading) to reduce peak indoor temperatures during extreme heat events, thereby enhancing occupant thermal comfort and reducing cooling energy demand.	Highest indoor operative temperature measured or simulated in regularly occupied spaces during the statistically hottest day (design summer day) under non-active cooling or limited cooling scenarios	°C	LIB	To calculate the value of the indicator: - Identify the representative design summer day using local climate data - Perform dynamic thermal simulations or measurements in regularly occupied spaces under passive or limited cooling conditions - Determine the highest operative indoor temperature recorded during the simulation period - Assign the maximum operative temperature as the indicator value
C4.1.v4	Heat loss transmission	This criterion assesses the thermal	Average U-value of the building	W/m^2K	LIB	To calculate the value of the indicator: - Review construction drawings and material

	of the building envelope	transmittance of the building envelope and its ability to reduce heat transfer between outdoor and indoor environments during extreme heat events.	envelope components			specifications - Calculate the thermal transmittance (U-value) of each envelope component according to ISO 6946 - Calculate the area-weighted average U-value of opaque and transparent envelope elements - Assign the resulting weighted average U-value
C4.1.v5	Thermal inertia of walls	This criterion assesses the ability of external wall assemblies to delay heat transfer through thermal inertia, thereby reducing indoor overheating during extreme heat events.	Delay between the peak outdoor temperature (or heat flux) and the corresponding peak on the indoor side of the element	hours	HIB	To calculate the value of the indicator: - Perform transient thermal simulations using representative summer weather data - Determine the time lag between the peak outdoor and indoor temperatures for each external wall element - Calculate the area-weighted average time lag of all external walls - Assign the resulting weighted average time lag
C4.1.v6	Thermal wave damping and attenuation of walls	This criterion assesses the ability of external wall assemblies to attenuate periodic heat transfer during daily temperature fluctuations.	Periodic thermal transmittance (Y)	W/m^2K	LIB	To calculate the value of the indicator: - Review construction documentation and material properties - Calculate the periodic thermal transmittance (Y-value) according to EN ISO 13786 - Calculate the area-weighted average Y-value of all external wall elements - Assign the resulting weighted average Y-value
C4.2	**Façade openings**					
C4.2.v1	High-Performance Window Glazing	This criterion assesses the use of high-performance window glazing with low thermal transmittance (U-value) to reduce heat	U-value of the installed window glazing systems	W/m^2K	LIB	To calculate the value of the indicator: - Collect the declared glazing U-value from manufacturer documentation or calculate it according to ISO 10077-1 - Verify the glazing configuration, coatings, gas filling, and frame characteristics - Determine the representative glazing U-value for

		gains during extreme heat, improve thermal comfort, and support passive cooling while maintaining daylight availability.				the building - Assign the resulting U-value
C4.2.v2	Optimized Window Orientation and Placement	This criterion assesses the design and placement of windows to optimize solar gains and daylight while minimizing overheating risks during extreme heat events, considering building orientation, room function, shading potential, and natural ventilation strategies.	Solar equivalent area per indoor useful area	n	LIB	To calculate the value of the indicator: - Review architectural drawings and façade orientations - Calculate the solar equivalent area according to the applicable methodology - Divide the solar equivalent area by the indoor useful floor area - Assign the resulting ratio
C4.2.v3	Solar Shading Devices for Windows	This criterion assesses the installation and use of external or integrated solar shading devices (e.g., louvres, overhangs, blinds) on windows to reduce solar heat gains during extreme heat events while maintaining daylight	Solar factor (glass + screen - gtot)	n	LIB	To calculate the value of the indicator: - Identify all external or integrated shading devices - Collect the declared total solar factor or shading coefficient from manufacturer documentation or simulations - Determine the representative value for the building - Assign the resulting solar factor

		availability and occupant comfort.				
C4.2.v4	Automated Blind Systems	This criterion assesses the implementation of automated blind systems that respond to solar radiation, indoor temperature, or time schedules to reduce heat gains and improve thermal comfort during extreme heat events while maintaining daylight availability and supporting passive cooling strategies.	Share of regularly occupied rooms in the building equipped with automated blind systems capable of reducing solar gains during extreme heat conditions.	%	HIB	To calculate the value of the indicator: - Count the number of regularly occupied rooms - Count the number of rooms equipped with automated blind systems - Verify that the systems respond automatically to solar radiation, indoor temperature, or programmed schedules - Divide the number of protected rooms by the total number of occupied rooms and multiply by 100
C4.2.v5	Solar Radiation Control	This criterion assesses the ability of window systems to limit solar heat gains by controlling the total solar energy transmittance of glazing and shading devices.	Total solar factor of the window system (g_tot)	n	LIB	To calculate the value of the indicator: - Collect the total solar factor from product documentation or calculate it according to EN 410 and EN ISO 52022-3 - Verify the value for each façade orientation considering the operating position of shading devices - Determine the representative building value - Assign the resulting total solar factor
C4.3	**External paints, coatings and renders**					
C4.3.v1	High-Albedo Coating Solutions	This criterion assesses the use of high-albedo coatings on exterior surfaces	Albedo value (solar reflectance) of	n	HIB	To calculate the value of the indicator: - Collect the declared solar reflectance (albedo) from manufacturer documentation - If unavailable, measure the solar reflectance

		to reduce solar heat absorption and mitigate overheating during extreme heat events.	the applied coating			using a suitable reflectometer according to the applicable standard - Determine the representative albedo value of the treated surfaces - Assign the resulting albedo value
C4.3.v2	Solar Reflectance of Roof	This criterion assesses the application of high solar reflectance coatings on roofs to reduce heat absorption, mitigate urban heat island effects, and lower indoor temperatures during extreme heat events.	Mean Solar Reflectance Index (SRI) of paving surfaces	n	HIB	To calculate the value of the indicator: - Collect the Solar Reflectance Index (SRI) values for all roof finishes - Calculate the area-weighted average SRI of the roof surface - Verify material properties using manufacturer documentation or on-site measurements where necessary - Assign the resulting weighted average SRI
C5	**ROOF**					
C5.1	**Roof structure**					
C5.1.v1	Thermal inertia of roof	This criterion assesses the ability of the roof assembly to delay heat transfer and reduce indoor overheating during extreme heat events.	Delay between the peak outdoor temperature (or heat flux) and the corresponding peak on the indoor side of the element	hours	LIB	To calculate the value of the indicator: - Review roof construction drawings and material specifications - Perform transient thermal simulations or calculations using representative summer weather conditions - Determine the time lag between the peak outdoor and indoor temperatures for the roof assembly - Assign the resulting time lag
C5.1.v2	Thermal wave damping and	This criterion assesses the ability of the roof assembly to	Periodic thermal transmittance (Y)	W/m^2K	LIB	To calculate the value of the indicator: - Review roof construction details and material properties

	attenuation of roof	attenuate periodic heat transfer caused by daily temperature fluctuations.				- Calculate the periodic thermal transmittance (Y-value) according to EN ISO 13786 - Determine the representative Y-value of the roof assembly - Assign the resulting periodic thermal transmittance
C5.1.v3	Extensive or Intensive Green Roofs	This criterion assesses the implementation of extensive or intensive green roof systems to reduce roof surface temperatures, lower indoor heat gains, improve microclimate resilience during extreme heat events, enhance stormwater management, and contribute to urban biodiversity.	Green roof coverage expressed as the percentage of the total roof area covered by functional green roof systems	%	HIB	To calculate the value of the indicator: - Review architectural drawings and green roof design documentation - Identify roof areas covered by functional green roof systems - Calculate the total green roof area - Divide the green roof area by the total roof area and multiply by 100
C8	**ENERGY SYSTEM**					
C8.2	**Cooling plant and distribution**					
C8.2.v1	Heat-Resilient HVAC Systems	This criterion assesses the deployment of HVAC systems with high performance and efficiency during extreme heat events, maintaining cooling capacity and energy efficiency at elevated	Coefficient of Performance (COP) of the HVAC system at high outdoor temperatures (e.g., 35–40 °C)	°C	HIB	To calculate the value of the indicator: - Review manufacturer performance data for the HVAC system - Determine the coefficient of performance (COP) at outdoor temperatures between 35 °C and 40 °C - Verify the operating conditions used for the declared performance - Assign the resulting COP

		outdoor temperatures to ensure indoor thermal comfort and operational resilience.				
C8.2.v2	Passive Cooling and Ventilation Design	This criterion assesses the implementation of design strategies enabling effective passive cooling and natural ventilation to maintain acceptable indoor temperatures during extreme heat events without relying on mechanical HVAC systems, enhancing thermal resilience and reducing energy demand.	Presence and effectiveness of passive cooling and ventilation strategies in the building	Qualitative	QI	To calculate the value of the indicator: - Review architectural drawings and passive cooling design strategies - Verify the presence of passive cooling measures such as natural ventilation, thermal mass, night ventilation, and external shading - Assess their expected effectiveness in reducing overheating - Normalize the indicator (0 = Passive cooling strategies implemented; 1 = Passive cooling strategies not implemented)
C8.2.v3	Active Cooling and Ventilation Systems	This criterion assesses the deployment of efficient active cooling and mechanical ventilation systems to maintain acceptable indoor thermal comfort during extreme heat events	Energy demand of active cooling and ventilation systems measured in annual energy consumption per unit area	kWh/m^2	LIB	To calculate the value of the indicator: - Collect annual cooling and ventilation energy consumption from monitoring systems or simulations - Determine the conditioned floor area served by the systems - Divide the annual energy consumption by the conditioned floor area - Assign the resulting annual energy demand

		while minimising energy demand and operational costs, supporting building resilience and climate adaptation.				
C8.2.v4	District Cooling System Integration	This criterion assesses the integration or readiness for connection to a district cooling system to provide efficient, centralized cooling during extreme heat events, reducing building-level cooling energy demand, operational risks, and greenhouse gas emissions.	Availability and readiness of the building for connection to a district cooling system	Qualitative	QI	To calculate the value of the indicator: - Review building services documentation and site infrastructure plans - Verify whether the building is connected to a district cooling network - If not connected, assess the technical readiness for future connection - Normalize the indicator (0 = Connected or connection-ready; 1 = No connection or readiness)
C8.2.v5	Ground Source Cooling Systems	This criterion assesses the implementation or readiness for ground source (geothermal) cooling systems to provide efficient, low-energy cooling during extreme heat events by utilizing stable underground temperatures to reduce indoor heat	Availability and readiness of the building for connection to or integration of a ground-source cooling system	Qualitative	QI	To calculate the value of the indicator: - Review building services documentation and site plans - Verify the presence of operational ground source cooling systems - If not installed, assess the technical and spatial readiness for future installation - Normalize the indicator (0 = Ground source cooling system installed or ready; 1 = No system or readiness)

		and cooling energy demand.				
C8.3	**Electricity generation and distribution**					
C8.3.v1	Battery Backup and Storage Systems	This criterion assesses the deployment of battery backup and energy storage systems to ensure the continued operation of critical building systems (e.g., cooling, ventilation, communication) during power outages.	Availability and operational readiness of an on-site battery backup and energy storage system	Qualitative	QI	To calculate the value of the indicator: - Review the building electrical design and energy management documentation - Verify the presence and capacity of battery backup systems - Assess the coverage of critical electrical loads during outages - Normalize the indicator (0 = Battery backup system available; 1 = No battery backup system)
C8.3.v2	Emergency Power Supply	This criterion assesses the provision of emergency power supply systems (e.g., diesel generators, battery systems) to maintain operation of critical building systems (cooling, ventilation, lighting, communication) during grid outages.	Available backup power capacity for operating critical systems during a blackout	kW	HIB	To calculate the value of the indicator: - Review emergency power system documentation - Determine the installed backup power capacity - Verify that the available capacity meets the demand of critical building systems - Assign the available backup power capacity
C8.3.v3	Heat-Tolerant Electrical Infrastructure	This criterion assesses the deployment of electrical	Operating temperature range of the electrical	°C	HIB	To calculate the value of the indicator: - Review manufacturer specifications for electrical equipment - Identify the maximum certified operating

		infrastructure (cabling, distribution boards, transformers, switchgear) designed to operate safely and reliably under high ambient temperatures during extreme heat events.	infrastructure designed and certified to operate within extended high-temperature conditions			temperature of the installed infrastructure - Determine the representative operating temperature of the electrical systems - Assign the resulting operating temperature
C8.3.v4	Solar Energy Generation Systems	This criterion assesses the deployment of onsite solar photovoltaic (PV) systems to generate renewable electricity, reducing grid dependency during extreme heat events, lowering operational carbon emissions, and enhancing building energy resilience.	Annual energy output of the installed solar PV system	kWh/year	HIB	To calculate the value of the indicator: - Review photovoltaic system documentation and monitoring records - Determine the annual electricity generation of the photovoltaic system - Verify the calculated annual energy production - Assign the resulting annual electricity generation
C9	**VENTILATION SYSTEM**					
C9.1	**Ductwork and ventilation distribution**					
C9.1.v1	Integrated Passive Cooling Strategies	This criterion assesses the incorporation of design measures and systems that passively reduce indoor temperatures during extreme heat	Presence and effectiveness of integrated passive cooling strategies assessed qualitatively based on design	Qualitative	QI	To calculate the value of the indicator: - Review architectural drawings, ventilation strategies, and operational documentation - Identify passive cooling measures such as night ventilation, cross-ventilation, thermal mass, evaporative cooling, and external shading - Assess the expected effectiveness of the integrated passive cooling strategy

		events, such as night ventilation, thermal mass utilization, cross-ventilation, evaporative cooling, and shading, reducing reliance on mechanical cooling and improving thermal resilience.	documentation and on-site verification			- Normalize the indicator (0 = Passive cooling strategies effectively integrated; 1 = Passive cooling strategies not implemented)
C13	**LANDSCAPING**					
C13.1	**Paving and other hard surfacing**					
C13.1.v1	Reflective Paving Surfaces	This criterion assesses the use of reflective paving materials with a high Solar Reflectance Index (SRI) on outdoor surfaces (walkways, plazas, parking areas) to reduce heat absorption, lower surface and surrounding air temperatures, and mitigate urban heat island effects during extreme heat events.	mean SRI	n	HIB	To calculate the value of the indicator: - Collect the Solar Reflectance Index (SRI) of the paving materials from manufacturer documentation or on-site measurements - Identify the paving materials used throughout the site - Calculate the area-weighted average Solar Reflectance Index of all paved surfaces - Assign the resulting weighted average SRI

C14	**LOCATION**					
C14.2	**Greenery**					
C14.2.v1	Greenery and water on the property	This criterion assesses the implementation and maintenance of green areas (lawns, trees, shrubs, green roofs, vertical greenery) and water features (ponds, rain gardens) on the property to reduce heat island effects, improve microclimate resilience during extreme heat events, enhance stormwater management, and support biodiversity.	Share of the property area covered by functional greenery, including permeable vegetated surfaces and water features	%	HIB	To calculate the value of the indicator: - Determine the total property area from site plans or GIS data - Identify the areas covered by vegetation and water features - Calculate the total green and blue infrastructure area - Divide the green and blue infrastructure area by the total property area and multiply by 100
C14.2.v2	Tree-Based Building Shading	This criterion assesses the use of strategically planted trees and woody vegetation to provide natural shading for building façades and windows, reducing solar heat gains, lowering indoor temperatures during extreme heat events, and enhancing site	Share of the building's wall surface area effectively shaded by trees during peak solar radiation periods (summer months) under typical conditions	%	HIB	To calculate the value of the indicator: - Review site plans or perform a shading analysis during peak summer conditions - Identify façade areas shaded by tree canopies - Calculate the total shaded façade area - Divide the shaded façade area by the total façade area and multiply by 100

		microclimate and outdoor comfort.				
C14.2.v3	Water-efficient landscaping	This criterion assesses the implementation of landscaping using drought-tolerant, native, and climate-adapted plant species with low irrigation requirements to reduce potable water demand, increase resilience during extreme heat and drought periods, and support biodiversity on the site.	Share of total landscaped area designed with low-irrigation or no-irrigation plant species, minimizing water consumption while maintaining greenery benefits	%	HIB	To calculate the value of the indicator: - Review landscape design documentation and planting schedules - Identify landscaped areas planted with drought-tolerant or climate-adapted species - Calculate the total low-irrigation landscaped area - Divide the low-irrigation landscaped area by the total landscaped area and multiply by 100
C15	**OCCUPANTS**					
C15.1	**Thermal Comfort**					
C15.1.v1	Thermal Comfort	This criterion assesses thermal comfort in buildings during the current climate by evaluating the share of time during the cooling season when operative indoor temperatures exceed 27 °C, indicating overheating risks and building resilience	Share of occupied time during the cooling season when the operative indoor temperature in regularly occupied spaces exceeds 27 °C	%	LIB	To calculate the value of the indicator: - Perform dynamic thermal simulations or on-site measurements during the cooling season using representative current climate data - Determine the occupied periods in regularly occupied spaces - Calculate the proportion of occupied time during which the operative temperature exceeds 27 °C - Assign the resulting percentage

		during extreme heat events.				
C15.1.v2	Thermal Comfort in 2050	This criterion assesses future thermal comfort in buildings under 2050 climate scenarios by evaluating the share of time during the cooling season when operative indoor temperatures exceed 27 °C, indicating potential overheating risks during extreme heat periods under climate change conditions.	Share of occupied time during the cooling season in 2050 when the operative indoor temperature in regularly occupied spaces exceeds 27 °C	%	LIB	To calculate the value of the indicator: - Perform dynamic thermal simulations using representative 2050 climate weather files - Determine the occupied periods in regularly occupied spaces - Calculate the proportion of occupied time during which the operative temperature exceeds 27 °C - Assign the resulting percentage
C15.1.v3	Thermal Comfort Index	This criterion assesses thermal comfort in occupied spaces during extreme heat periods using the Predicted Mean Vote (PMV) index, reflecting occupant thermal sensation based on air temperature, radiant temperature, humidity, air speed, clothing, and activity level.	Predicted Mean Vote (PMV) index value	index	LIB	To calculate the value of the indicator: - Perform dynamic thermal simulations or on-site measurements during representative summer conditions - Calculate the Predicted Mean Vote (PMV) according to EN ISO 7730, indicating the average thermal sensation vote of occupants on a seven-point scale ranging from -3 (cold) to +3 (hot) - Determine the representative PMV value for regularly occupied spaces - Assign the resulting PMV value

C15.1.v4	Comfort optimization	This criterion assesses the provision of user-adjustable and controllable thermal conditions in occupied spaces to enhance thermal comfort, empower occupants during extreme heat events, and support passive and active thermal adaptation strategies within the building.	Share of regularly occupied rooms in which occupants can adjust and control thermal conditions to respond to extreme heat	%	HIB	To calculate the value of the indicator: - Review architectural drawings and building services documentation - Identify regularly occupied spaces with user-adjustable thermal comfort features such as operable windows, controllable shading devices, thermostats, or local fans - Count the number of spaces equipped with user-adjustable thermal controls - Divide the number of equipped spaces by the total number of regularly occupied spaces and multiply by 100

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

Table E.4 — RNTool Key Risk Categories, criteria and indicators — Drought

D	DROUGHT					
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Benchmarks***	**Assessment methodology**
D10	**SANITARY SYSTEM**					
D10.1	**Cold water distribution**					
D10.1.v1	Water consumption for indoor uses	This criterion assesses the reduction in potable water consumption for indoor uses achieved through water reuse systems compared with standardized water demand.	Volume of saved potable water in regard to a standardised water consumption for indoor uses	%	HIB	To calculate the value of the indicator: - Determine the annual volume of potable water saved through rainwater harvesting, greywater reuse, or other alternative water sources - Determine the standardized indoor potable water demand based on building type and occupancy - Divide the annual volume of saved potable water by the standardized indoor water demand and multiply by 100 - Assign the resulting percentage
D10.1.v2	Water consumption for irrigation	This criterion assesses the reduction in potable water consumption for irrigation achieved through alternative water sources compared with standardized irrigation demand.	Volume of saved potable water in regard to a standardised water consumption for irrigation	%	HIB	To calculate the value of the indicator: - Determine the annual volume of water supplied by alternative water sources for irrigation - Determine the standardized irrigation water demand based on landscape characteristics - Divide the annual volume of saved potable water by the standardized irrigation demand and multiply by 100 - Assign the resulting percentage
D10.1.v3	Water leakage alarm	This criterion assesses the proportion of water distribution systems equipped with real-	Share of water installations that provide a real-time system alarm when leaking	%	HIB	To calculate the value of the indicator: - Review plumbing design documentation and monitoring system specifications - Identify water installations equipped with leak detection and alarm systems - Count the number of protected installations

		time leak detection and alarm systems.				- Divide the number of protected installations by the total number of water installations and multiply by 100
D10.1.v4	Water system maintenance	This criterion assesses the proportion of water installations subject to routine maintenance programmes to minimize water losses and leakage.	Share of water installations regularly maintained to reduce leakage	%	HIB	To calculate the value of the indicator: - Review maintenance plans and operational documentation - Identify water installations included in routine maintenance programmes - Count the number of maintained installations - Divide the number of maintained installations by the total number of water installations and multiply by 100
D10.1.v5	Backup Water System Capacity	This criterion assesses the ability of the building's backup water supply system to maintain standardized potable water demand during supply interruptions.	Number of hours that the building's backup water system can cover standardised indoor potable water needs	hours	HIB	To calculate the value of the indicator: - Determine the storage capacity of the backup water supply system - Determine the standardized potable water demand based on building type and occupancy - Calculate the duration for which the backup system can supply potable water under normal demand conditions - Assign the resulting autonomy expressed in hours
D10.1.v6	Percentage of drinking water replacement	This criterion assesses the proportion of potable water demand replaced by non-potable water sources such as rainwater or greywater.	Share of non-potable water use (rainwater, greywater) replacing drinking water	%	HIB	To calculate the value of the indicator: - Determine the annual volume of non-potable water supplied by alternative water sources - Determine the total annual water demand - Divide the annual non-potable water volume by the total annual water demand and multiply by 100 - Assign the resulting percentage
D10.1.v7	Water consumption monitoring	This criterion assesses the implementation and	Presence, completeness and operational	Qualitative	QI	To calculate the value of the indicator: - Review the water monitoring system documentation

		functionality of water consumption monitoring systems supporting efficient water management and leak detection.	performance of water metering and monitoring systems			- Verify the presence of main meters, sub-meters, data logging, and alarm functions - Assess the monitoring coverage and operational functionality - Normalize the indicator (0 = Comprehensive monitoring system; 1 = No monitoring system)
D10.3	**Water treatment systems**					
D10.3.v1	Rainwater collection	This criterion assesses the proportion of rainwater collected and reused on-site for non-potable building operations.	Share of rainwater collected on-site and reused for building operations	%	HIB	To calculate the value of the indicator: - Determine the annual volume of rainwater collected by the harvesting system - Determine the annual non-potable water demand or total runoff volume, as applicable - Divide the collected rainwater volume by the reference volume and multiply by 100 - Assign the resulting percentage
D10.3.v2	Greywater collection	This criterion assesses the proportion of greywater collected and reused on-site for non-potable building operations.	Share of greywater collected on-site and reused for building operations	%	HIB	To calculate the value of the indicator: - Determine the annual volume of greywater collected and reused - Determine the annual greywater generation potential or non-potable water demand, as applicable - Divide the collected greywater volume by the reference volume and multiply by 100 - Assign the resulting percentage
D14	**LOCATION**					
D14.1	**Proximity**					
D14.1.v1	Stormwater harvesting system	This criterion assesses the capacity of stormwater harvesting systems to capture and store	Share of captured and stored stormwater	%	HIB	To calculate the value of the indicator: - Determine the storage capacity of the stormwater harvesting system - Determine the maximum volume of stormwater that can be harvested on-site - Divide the storage capacity by the harvestable

		stormwater for future reuse.				stormwater volume and multiply by 100 - Assign the resulting percentage
D14.1.v2	Onsite water supply	This criterion assesses the availability of on-site water supply systems capable of providing water during interruptions to the public supply network.	Supply of fresh water from onsite water storage or wells	Qualitative	QI	To calculate the value of the indicator: - Review water supply system documentation - Verify the presence of onsite water storage or groundwater supply systems - Assess the operational readiness of the system - Normalize the indicator (0 = Onsite water supply available; 1 = No onsite water supply)
D14.1.v3	Urban gardening	This criterion assesses the proportion of the site dedicated to food production through urban gardening.	Share of dedicated site area to the production of vegetables and nuts	%	HIB	To calculate the value of the indicator: - Determine the total site area - Determine the area allocated to urban gardening - Divide the gardening area by the total site area and multiply by 100 - Assign the resulting percentage
D14.1.v4	Outdoor Shaded Recreational Areas	This criterion assesses the proportion of outdoor recreational areas protected from direct solar radiation through natural or artificial shading.	Share of outdoor shaded recreational areas	%	HIB	To calculate the value of the indicator: - Determine the total outdoor recreational area - Determine the shaded recreational area - Divide the shaded area by the total recreational area and multiply by 100 - Assign the resulting percentage
D14.1.v5	Landscape Cooling Features	This criterion assesses the proportion of the site occupied by landscape features that contribute to outdoor cooling	Share of outdoor cooling elements' area	%	HIB	To calculate the value of the indicator: - Identify landscape cooling features such as trees, vegetated areas, and water bodies - Calculate their total surface area - Divide the cooling feature area by the total site area and multiply by 100 - Assign the resulting percentage

		through shading or evapotranspiration.				
D14.2	**Greenery**					
D14.2.v1	Water-efficient landscaping	This criterion assesses the proportion of landscaped areas designed with drought-tolerant or native vegetation requiring limited irrigation.	Share of landscaping designed with low irrigation needs	%	HIB	To calculate the value of the indicator: - Review landscape design documentation and planting schedules - Identify landscaped areas planted with drought-tolerant or native species - Calculate the corresponding landscaped area - Divide the drought-tolerant landscaped area by the total landscaped area and multiply by 100
D14.2.v2	Smart irrigation systems	This criterion assesses the implementation of smart irrigation systems capable of optimizing water consumption using soil moisture monitoring or similar control technologies.	Presence of irrigation systems with soil moisture sensors	Qualitative	QI	To calculate the value of the indicator: - Review irrigation system documentation - Verify the presence of soil moisture sensors and automated irrigation controls - Assess the operational functionality of the irrigation system - Normalize the indicator (0 = Smart irrigation system implemented; 1 = No smart irrigation system)
D14.2.v3	Drought-tolerant plant species	This criterion assesses the proportion of planted vegetation composed of drought-tolerant species.	Share of drought-tolerant plants to total plants	%	HIB	To calculate the value of the indicator: - Review planting schedules and landscape documentation - Count the number of drought-tolerant plant species or calculate their planted area - Determine the total number of plant species or planted area - Divide the drought-tolerant component by the total and multiply by 100

D14.2.v4	Xeriscaping	This criterion assesses the implementation of xeriscaping techniques that minimize irrigation demand through appropriate landscape design and plant selection.	Use of xeriscaping techniques for minimal irrigation needs	Qualitative	QI	To calculate the value of the indicator: - Review landscape design documentation - Verify the implementation of xeriscaping principles and drought-resistant planting strategies - Assess the overall implementation of xeriscaping techniques - Normalize the indicator (0 = Xeriscaping implemented; 1 = Xeriscaping not implemented)
D14.2.v5	Water consumption for irrigation	This criterion assesses the reduction in potable water consumption for irrigation achieved through efficient irrigation strategies and alternative water sources.	Volume of saved potable water in regard to a standardised water consumption for irrigation	%	HIB	To calculate the value of the indicator: - Determine the annual volume of potable water saved for irrigation - Determine the standardized irrigation water demand - Divide the annual saved potable water volume by the standardized irrigation demand and multiply by 100 - Assign the resulting percentage

*HIB = Higher is better, LIB = Lower is better, QI = qualitative

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SuPeRBE Project Deliverables

[1] Interreg Central Europe SuPeRBE, D.1.2.1 RBE-CE Assessment System

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