Interreg CENTRAL EUROPE

Co-funded by the European Union

SuPeRBE

Towards Climate-Resilient Cities: Insights from the **SuPeRBE** Project and its Resilient Built Environment Tools

Consultation meeting
Prague City Hall | 5 November 2025

Czech Technical University in Prague - UCEEB
Licia Felicioni and the CTU Team

BUILT ENVIRONMENT

- Buildings are responsible for 35% of the EU's greenhouse gas emissions and 42% of energy consumption.
- The construction sector is the largest consumer of raw materials in the EU and generates the biggest waste stream by weight.
- Existing buildings must be renovated to meet EU climate goals; new buildings should be zero-emission by 2030.
- Buildings are increasingly exposed to climate risks like heatwaves, floods, and storms, highlighting the need for climate-resilient design.

HEATWAVES AND URBAN OVERHEATING

Heatwaves are **prolonged periods of extreme heat** that strain buildings and human health. Urban areas are particularly vulnerable due to the **heat island effect** and poor thermal comfort in buildings.

Built Environment
(buildings, infrastructure, cities)

- Overheated interiors,
- Higher energy demand for cooling
- Urban heat island effect – cities stay hot overnight

People
(health, safety, quality of life)

- Health risks: heatstroke, dehydration
- Reduced work performance, poor sleep
- High risk for elderly and people with chronic illnesses

Source: European Commission, 2023

SUPERBE PROJECT

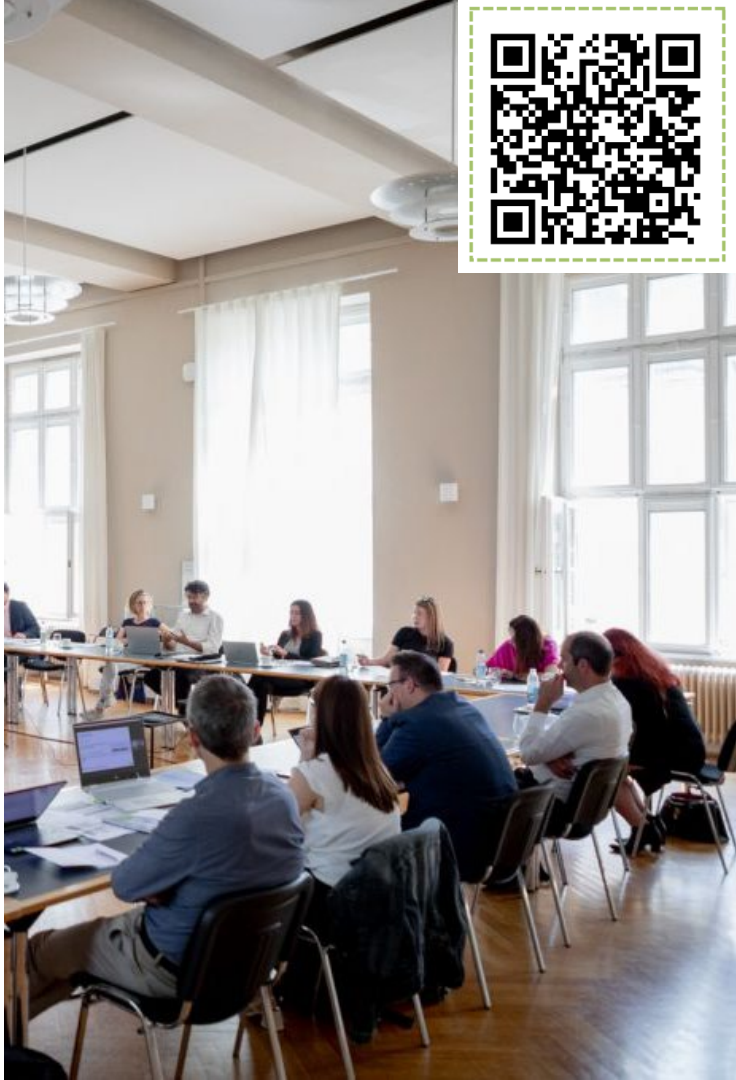
Supporting Cross-scale Planning and Policy Readiness for a Resilient Built Environment

Interreg Central Europe project (2024–2026)

Goal: strengthen local/regional authorities' capacity for climate adaptation (*defining, implementing and evaluating solutions*)

Outputs:

- Digital Toolkit with Resilient Built Environment Central Europe Assessment System (RBE-CE) on the SuPeRBE open access digital platform
- Decision-making methodology
- 3D simulation platform



RBE-CE METHOD

It serves as the methodological foundation of the Resilient Built Environment (RBE) Assessment System. It is a **multi-criteria analysis approach** developed to evaluate climatic risk at the building and neighbourhood scale. Grounded in the impact chains conceptual model, the method generates an **overall risk score** for a given area and a set of complementary indicators that detail the level of climate-related risk across specific risk categories and urban sectors.

Why is it needed?

- Lack of assessment tools at the building and neighbourhood scale.
- Existing sustainability frameworks are not suited for climate risk assessment.
- Demand for comparable, adaptable, and decision-support-oriented tools for climate adaptation.

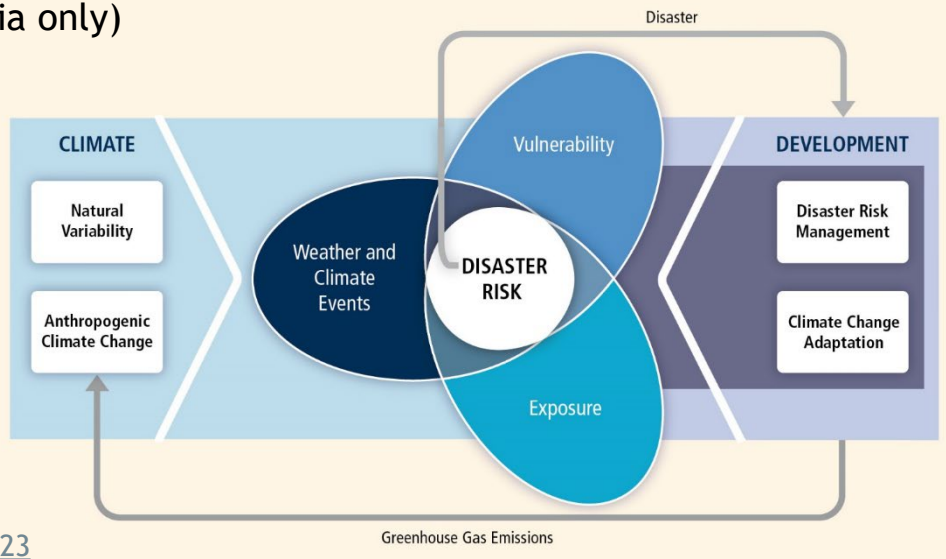
RBE-CE METHOD

Risk concept

Grounded on **EN ISO 14091:2021** and **IPCC AR6 risk model** (Hazard-Exposure-Vulnerability)

Complements sustainability assessment tools
(which are usually focused on vulnerability criteria only)

Need to **integrate** these three components into an assessment tool



Source: IPCC AR6, 2023

RBE-CE METHOD

IPCC risk concept

IPCC AR6 provides a detailed and nuanced concept of risk as it relates to climate change. The report builds on the risk framework established in previous IPCC assessments, further refining it to account for the complex interactions between climate **hazards**, **exposure**, and **vulnerability**.

$$HV^{W_{HV}} \times EV^{W_{EV}} \times VV^{W_V}$$

Vulnerability Value (VV), ^{WV} is the weight of VV
Exposure Value (EV), ^{WV} is the weight of EV
Hazard Value (HV) , ^{WV} is the weight of HV
Risk = weighted geometric mean

Source: IPCC AR6, 2023

THREE AXES OF THE RISK ASSESSMENT

HAZARD

Climate-related hazards encompass **extreme weather events** (e.g., extreme heat, droughts, heavy precipitation) as well as **slow-onset climate processes** (e.g., sea-level rise). Non-climate hazards include those triggered by climatic hazards (e.g., mass movements, biological events).

EXPOSURE

Who or what is exposed. According to the IPCC, 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

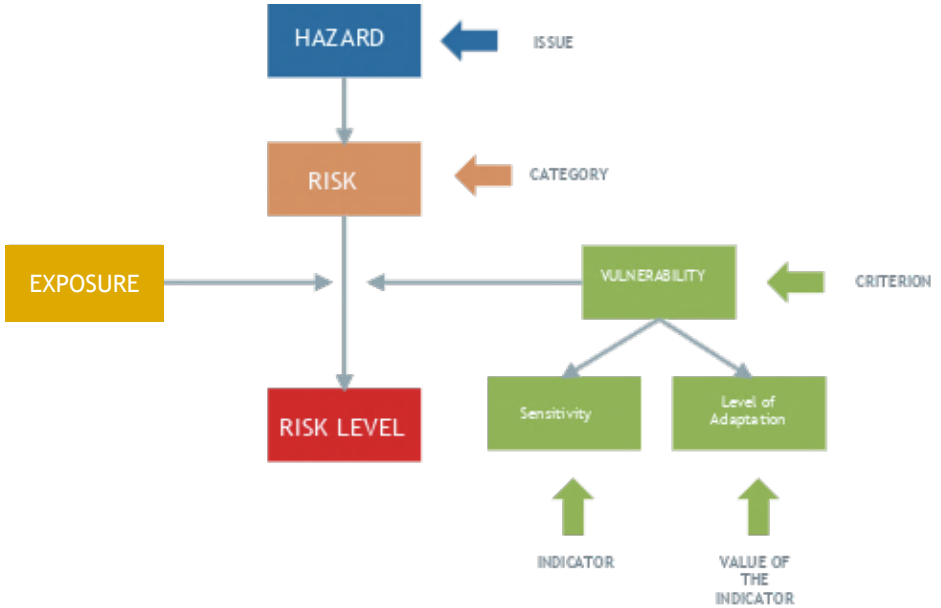
VULNERABILITY

Predisposition of an exposed element to be **adversely affected**. Vulnerability aspects refer to the criteria that influence the susceptibility of an exposed element to a climatic hazard, potentially increasing or decreasing the associated risk.

RBE-CE IMPACT CHAIN

RBE-CE Method foresees the application of the impact chain conceptual model to identify the most appropriate criteria and indicators to assess the 3 key components of climatic risk (Hazard, Exposure and Vulnerability) at building and small urban scale, tracking cause-and-effect relationships and facilitate communication of the results.

This approach enables the creation of an assessment system with numerical entities, where each element in the climate risk matrix is assigned a value on a scale of 0-1 (0 optimal, 1 critical value).



RBE-CE METHOD - CHARACTERISTICS

Cross-scale

Urban Sectors are harmonised between RNTool and RBTool, enabling consistent data use and coordinated planning across scales.

Measurable

The RBE Method is grounded in clearly defined, measurable **criteria and indicators**. The method is contextualizable, allowing them to be tailored to **local conditions and data availability**.

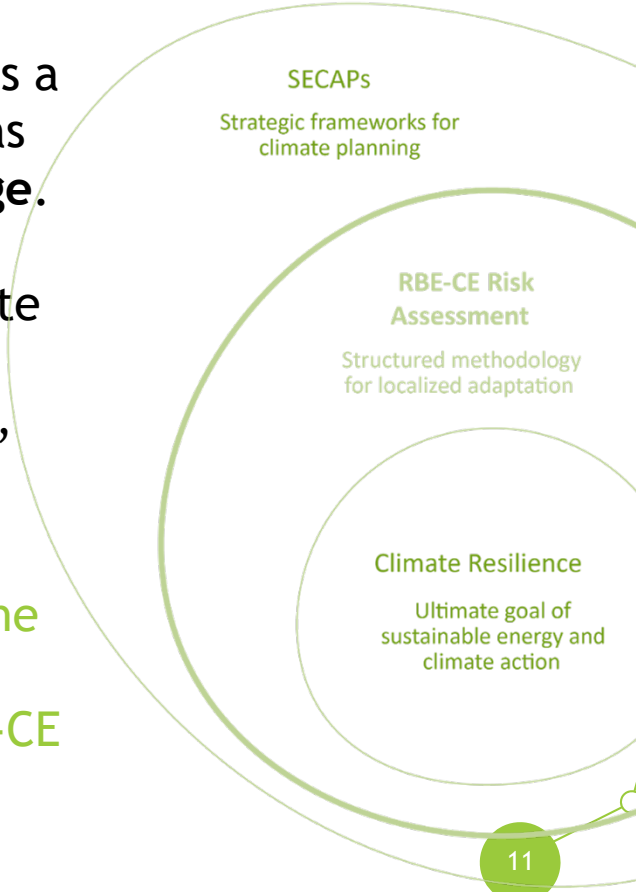
Modular Structure

The modular structure enables RBE method to be **applied across diverse building types and urban areas.**
Users can **adjust benchmarks and indicator** relevance according to specific local priorities.

RBE-CE FOR SECAPS

A **Sustainable Energy and Climate Action Plan** (SECAP) is a local government action plan for reducing greenhouse gas emissions and **adapting to the impacts of climate change**. Mandated by the Covenant of Mayors for Climate and Energy, a SECAP includes an emissions inventory, a climate risk assessment, and a concrete set of measures for mitigation (e.g., energy efficiency) and adaptation (e.g., improving climate resilience).

RBE-CE adds localised, site-specific risk data, ensuring the **adaptation solutions are tailored** to specific vulnerabilities. SECAPs outline the strategies, while RBE-CE operates at a tactical level to localise them.



TWO MAIN TOOLS FROM RBE-CE

From the Sustainable Built Environment (SBE) Method → Resilient Built Environment (RBE) method and two tools, maintaining the **same usability** akin to sustainability protocols.

RNTool (Resilient Neighbourhoods Tool)

- Multi-criteria, modular structure
- Hazards → Urban Sectors → Risk categories → Criteria and Indicators

RBTool (Resilient Buildings Tool)

- Evaluates resilience at the building level
- Hazards → Urban Sectors → Exposed elements
- Integrates Level(s) framework (building components and structure)

HAZARDS FOR CENTRAL EUROPE

HEAVY PRECIPITATION

DROUGHT

MASS MOVEMENT

WILDFIRE

FLOOD

STORM

EXTREME HEAT

Source: EEA, 2024

RNTOOL-CE

HAZARDS

A - Heavy Precipitation
B - Floods
C - Extreme heat
D - Drought
E - Storms
F - Wildfires
G - Mass movement

URBAN SECTORS

A1 - Buildings
A2 - Transport
A3 - Energy
A4 - Water
A5 - Waste
A6 Environment and Biodiversity
A7 - Health
A8 - Emergency Services
A9 - Tourism
A10 - ICT

RISK CATEGORIES

A7.1 - Health risk for the population

A7.2 - Damage risk for healthcare facilities

vulnerability and exposure indicators

RBTOOL-CE

A - Heavy Precipitation
B - Floods
C - Extreme heat
D - Drought
E - Storms
F - Wildfires
G - Mass movement

Buildings (A1 to A14)
Health (A15-A16)

A1 - Foundations
    A1.1 Piles
    A1.2 Basements
        A1.2.1 *criterion and indicator*
A2 - Load-bearing structural frame
…

RNTOOL-CE

84 Risk Categories for 7 Hazards

A Heavy precipitation
A1 BUILDINGS
A1.1 Damage risk for residential buildings
A1.2 Damage risk for public buildings
A1.3 Damage risk for commerical 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
A4 WATER
A4.1 Damage risk for water treatments plants
A4.2 Damage risk for water supply network
A4.3 Damage risk for sewage system
A4.4 Damage risk for waste water treatments plants
A8 HEALTH
A8.1 Health risk for population
A8.2 Damage risk for healthcare facilities
A9 EMERGENCY SERVICES
A9.1 Efficiency risk for civil protection service
A9.2 Efficiency risk for fire brigade
A9.3 Efficiency risk for emergency medical service
A10 TOURISM
A10.1 Damage risk for hotels and resorts
A10.5 Damage risk for touristic attractions
22

B Floods
B1 BUILDINGS
B1.1 Damage risk for residential buildings
B1.2 Damage risk for public buildings
B1.3 Damage risk for commerical 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
B4 WATER
B4.1 Damage risk for water treatments plants
B4.2 Damage risk for water supply network
B4.3 Damage risk for sewage system
B4.4 Damage risk for waste water treatments plants
B8 HEALTH
B8.1 Health risk for population
B8.2 Damage risk for healthcare facilities
B9 EMERGENCY SERVICES
B9.1 Efficiency risk for civil protection service
B9.2 Efficiency risk for fire brigade
B9.4 Efficiency risk for Emergency medical services
15

C Extreme heat
C1 BUILDINGS
C1.1 Damage risk for residential buildings
C1.2 Damage risk for public buildings
C1.3 Damage risk for commerical buildings
C1.4 Damage risk for industrial buildings
C2 TRANSPORT
C2.2 Damage risk for road transport network
C2.4 Damage risk for bicycle and pedestrian paths
C3 ENERGY
C3.4 Damage risk for Renewable Energy Installations
C3.6 Damage risk for distric heating and cooling systems
C7 ENVIRONMENT & BIODIVERSITY
C7.3 Damage risk for Street Trees
C8 HEALTH
C8.1 Health risk for population
C8.2 Efficiency risk for healthcare facilities
C9 EMERGENCY SERVICES
C9.1 Efficiency risk for civil protection service
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C9.4 Efficiency risk for Emergency medical services
C10 TOURISM
C10.5 Damage risk for touristic attractions
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D Droughts
D4 WATER
D4.1 Damage risk for water treatments plants
D4.2 Damage risk for water supply network
D7 ENVIRONMENT & BIODIVERSITY
D7.1 Damage risk for Urban green spaces
D7.3 Damage risk for Street Trees
D8 HEALTH
D8.1 Health risk for population
D9 EMERGENCY SERVICES
D9.2 Efficiency risk for fire brigade
D9.4 Efficiency risk for Emergency medical services
7

E Storms
E1 BUILDINGS
E1.1 Damage risk for residential buildings
E1.2 Damage risk for public buildings
E1.4 Damage risk for industrial buildings
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
F2.5 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
E8 HEALTH
E8.1 Health risk for population
E9 EMERGENCY SERVICES
F9.1 Efficiency risk for civil protection service
F9.2 Efficiency risk for fire brigade
12

F Wild-fire
F2 TRANSPORT
F2.2 Damage risk for road transport network
F9 EMERGENCY SERVICES
F9.1 Efficiency risk for civil protection service
F9.2 Efficiency risk for fire brigade
3

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
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G9.1 Efficiency risk for civil protection service
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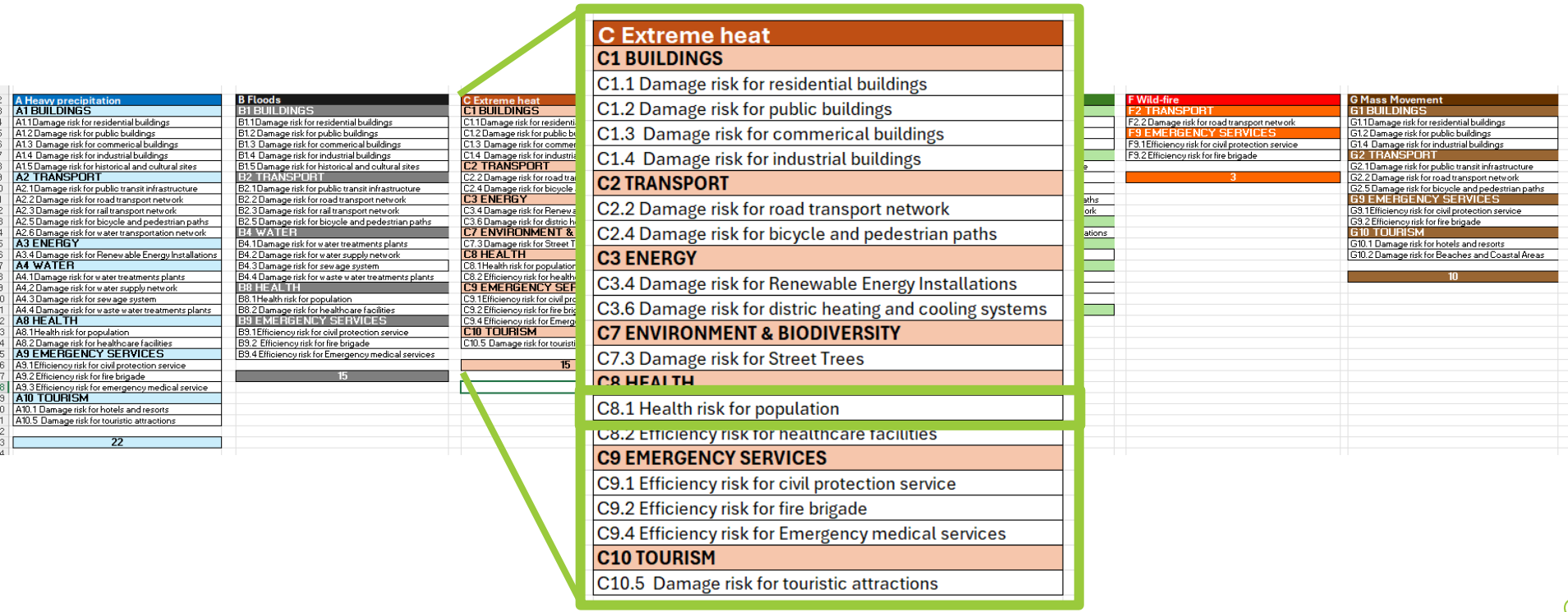
G10.2 Damage risk for Beaches and Coastal Areas
10

RNTOOL-CE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C1.1 Damage risk for residenti
C1.2 Damage risk for public bu
C1.3 Damage risk for commer
C1.4 Damage risk for industri
C2 TRANSPORT
C2.2 Damage risk for road tra
C2.4 Damage risk for bicycle
C3 ENERGY
C3.4 Damage risk for Renew
C3.6 Damage risk for distric h
C7 ENVIRONMENT &
C7.3 Damage risk for Street T
C8 HEALTH
C8.1 Health risk for population
C8.2 Efficiency risk for health
C9 EMERGENCY SEF
C9.1 Efficiency risk for civil pro
C9.2 Efficiency risk for fire bric
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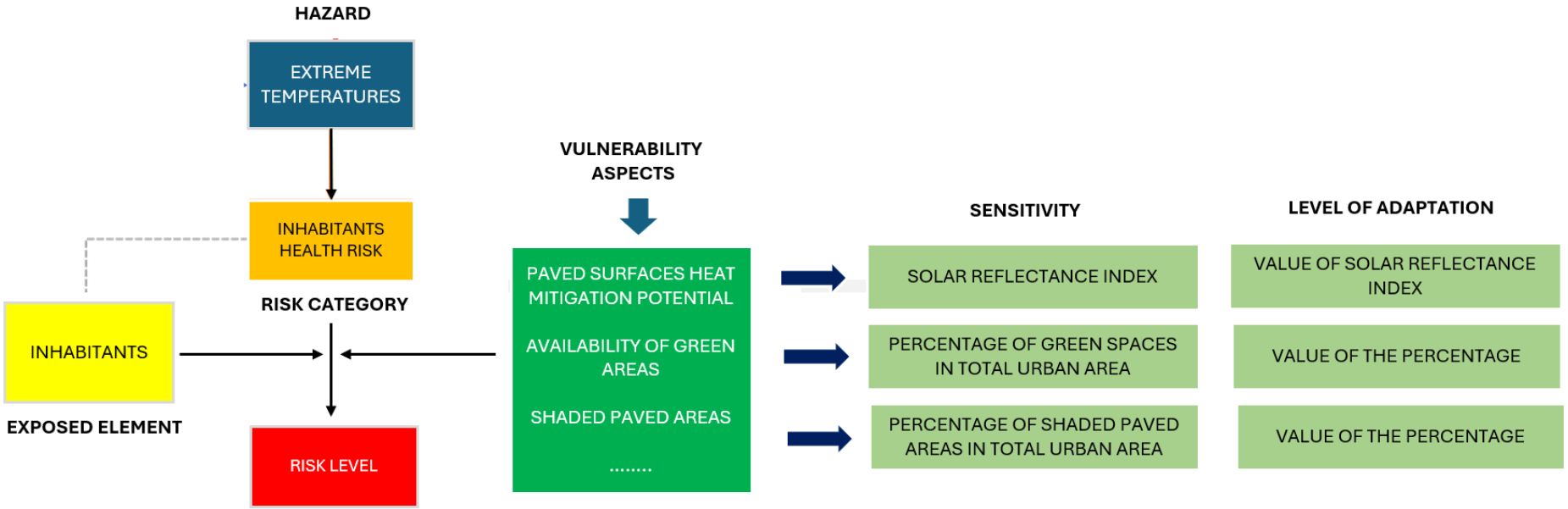
RNTOOL-CE - EXAMPLE



CONTEXTUALISATION OF THE SUPERBE PLATFORM

Definition of contextualised versions for each case study and assessment of predefined building/neighborhood case study

RBTool/RNtool (generic)

LOCAL PRIORITIES

LOCAL CONDITIONS

DATA AVAILABILITY and ACCESSIBILITY

LOCAL and REGIONAL AUTHORTIES' NEEDS

Options that change: **HAZARDS**, **SELECTED CRITERIA/INDICATORS**, and **BENCHMARKS** (e.g., according to the legislation)

RB-IT1	RB-IT2	RB-HR	RB-AT	RB-CZ
Piemonte Region	Veneto Region	Sibenik	Schnifis	Prague

RNTOOL - EXTREME HEAT

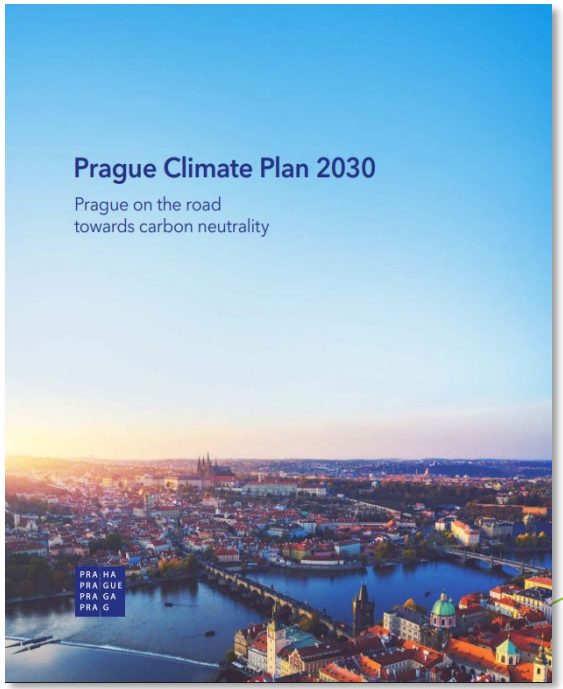
LOCAL VALID BENCHMARKS TO BE ASSIGNED

C	**EXTREME HEAT**									
C1	**BUILDINGS**									
C1.1	**Damage risk for residential buildings**									
VULNERABILITY										
Code	**Criterion**	**Description**	**Indicator**	**Unit**	**Range of values**	**Benchmark (value 0)**	**Benchmark (value 1)**	**Assessment method**	**Data sources**	**References**
C1.1.1	Building Envelope Surface Te	This criterion investigates the thermal behavior of resid	Average surface temperature of bu	°C Degrees	LIB	25	80	To calculate the value of the indicator:• Use infra	Thermal camera surveys, weather sta	ISO 14092:2020 (Adaptation to climate change
C1.1.2	Roof Reflectivity and Emissivi	This criterion assesses the capacity of roofs in the neig	Roof albedo (reflectivity)	n	HIB	0.9	0.1	To calculate the value of the indicator:• Collect d	Roofing material specifications, man	ASTM E903 (Standard Test Method for Solar Ab
C1.1.3	Orientation and Solar Gain	This criterion assesses the exposure of residential build	Share of west-facing façade area	%	LIB	0%	100%	To calculate the value of the indicator:• Calculate	Building plans, site surveys, GIS faça	EN 17037:2018 (Daylight in Buildings); ISO 520
C1.1.4	Dark Surface Exposure	This criterion evaluates the extent of heat-absorbing ma	Share of exposed dark surfaces	%	LIB	no unshaded dark surf	aces are unshaded da	To calculate the value of the indicator:• Calculate	Aerial imagery, GIS land cover analysi	EN 15316-4-3:2017 (Heating systems in buildin
C1.1.5	Material Degradation	This criterion monitors physical damage or accelerated	Façades or roofs showing signs o	Qualitative	-	signs of heat-induced w	isible heat-induced de	To calculate the value of the indicator:• Conduct	On-site building condition surveys, r	N 1990:2002+A1:2005 (Eurocode – Basis of str
C1.1.6	Indoor Temperature Monitori	This criterion determines the capacity of residential uni	Share of residential units with rea	%	HIB	100%	0%	To calculate the value of the indicator:• Identify t	Smart meter datasets, municipal hou	ISO 52016-1:2017 (Energy performance of buil
C1.1.7	Land Surface Temperature	This criterion assesses the overall land surface tempera	Average land surface temperature	°C Degrees	LIB	20°C	60°C	To calculate the value of the indicator:• Use sate	Sentinel-3 satellite data (Copernicus	Copernicus Land Monitoring Service (Urban Atl
C1.1.8	Vegetated vs. Impervious Surf	This criterion measures the balance between vegetated	Ratio of vegetated/permeable to i	Ratio	HIB	egetated/permeable sur	vegetated/permeable su	To calculate the value of the indicator:• Calculate	Urban land cover datasets, municipa	EN 16798-1:2019 (Energy performance of build
C1.1.9	Urban Morphology and Natur	This criterion analyzes the influence of building density	Average building density and heig	H/W ratio	LIB	low buildings, allowing	ets with tall buildings,	To calculate the value of the indicator:• Calculate	Municipal GIS data, cadastral maps,	EN 16798-1:2019 (Energy performance of build
C1.1.10	Green Infrastructure Coverag	This criterion evaluates the presence and extent of gree	Green infrastructure area per bloc	m^2	HIB	ensive green infrastruct	^{2} (no green infrastruct	To calculate the value of the indicator:• Calculate	Municipal green infrastructure plans,	EN 16798-1:2019 (Indoor environmental input
C1.1.11	Indoor Water Use Reduction	This criterion guarantees the adoption of water-efficien	Share of water savings compared	%	HIB	50%	0%	To calculate the value of the indicator:• Compare	Water utility consumption data, build	EN 16941-1:2018 (On-site non-potable water s
C1.1.12	Outdoor Water Use Reductio	This criterion promotes the use of native and drought-t	Availability of native vegetation wi	Qualitative	-	100	0	To calculate the value of the indicator:• Conduct	Municipal landscaping plans, site veg	EN 16941-1:2018 (On-site non-potable water s
C1.1.13	District Cooling	Promote the emplyement of district cooling for space c	Connection to the cooling district	Qualitative	-	100	0	To calculate the value of the indicator:• Verify the	Municipal energy plans, district cooli	CEN/TR 17603:2021 (District Cooling – Guideli
C1.1.14	Renewable Energy Productio	This criterion promotes the onsite production of renew	Share of renewable energy produc	%	HIB	100%	0%	To calculate the value of the indicator:• Calculate	Building energy monitoring systems,	EN ISO 52000-1:2017 (Energy performance of
EXPOSURE										
C1.1-E1	Population Density	This criterion measures the number of residents in the	Number of people in the neighbor	n	n/a	-	-	To calculate the value of the indicator:• Obtain a	Municipal demographic records, nati	Eurostat (Regional and Urban Statistics), Europ
C1.1-E2	Elderly and Sensitive Populat	This criterion measures the share of high-risk groups w	Share of population over 65 / und	%	LIB	of sensitive population	n of sensitive populatio	To calculate the value of the indicator:• Obtain d	Municipal demographic records, nati	WHO Europe (Heat–Health Action Plans), Euros
C1.1-E3	Lack of Cooling Urban Featur	This criterion assesses the availability of urban cooling	Area of cooling infrastructure (gre	m^2/person	HIB	20 m^2/person	0 m^2/person	To calculate the value of the indicator:• Calculate	Municipal green infrastructure maps	WHO Europe (Urban Green Spaces and Health),
C1.1-E4	Proximity to Heat-Intensifying	This criterion assesses the proximity of buildings withi	Distance to major impervious/dar	m	HIB	100 m	0 m	To calculate the value of the indicator:• Measure	GIS land cover data, municipal surfac	European Environment Agency (Urban Heat Isla
C1.1-E5	Distance to Public Cooling Re	This criterion assesses the average distance from resid	Average distance from residences	m	LIB	100 m	1000 m	To calculate the value of the indicator:• Calculate	GIS spatial data, municipal green infr	WHO Europe (Urban Green Spaces and Health),
C1.1-E6	Building Density and Height D	This criterion assesses the building density and height	Average floor area ratio (FAR)	Dimensionless (FAR)	LIB	0.5	5	To calculate the value of the indicator:• Calculate	Municipal cadastral and land use dat	EN 16798-1:2019 (Indoor environmental input
C1.1-E7	Solar Exposure of Public and	This criterion measures the hours of direct sun exposu	Hours of direct sun exposure on r	hours/day	LIB	2 hours/day	12 hours/day	To calculate the value of the indicator:• Conduct	GIS urban morphology data, municip	EN 17037:2018 (Daylight in buildings), Europe

CONTEXTUALISATION OF THE SUPERBE PLATFORM

List of natural hazards highlighted in the Prague 2030 Climate Plan:

- **Heatwaves and urban overheating**
- **Short-duration heavy rainfall (flash floods)** and river flooding
- Droughts and water scarcity
- Extreme weather events (e.g. windstorms, hail, ice) – storms
- Severe winter conditions (e.g. heavy snowfall, freeze-thaw cycles)



CONTEXTUALISATION OF THE SUPERBE PLATFORM

A-HEAVY PRECIPITATION
A1-BUILDINGS
A1.1 Residential
A2-TRANSPORT
A2.2 Road transport
A2.3 Bicycle and pedestrian paths
A8-HEALTH
A8.1 Health risk for population

C-EXTREME HEAT
C1-BUILDINGS
C1.1 Residential
C7-Environment & biodiversity
C7.3 Street trees
C8-HEALTH
C8.1 Health risk for population

We are seeking experts to help us define the benchmarks of several criteria for the Czech/Prague context for RNTool (neighbourhood scale) – if you are interested in contributing with your expertise, please let us know!

CEN WORKSHOP AGREEMENT

RBE-CE Assessment System is the first of its kind to propose a multi-scale approach implementing the EN ISO14091:2021 "Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment making" at the building, neighbourhood and community scale, so it will be the object of a new CEN Workshop Agreement.

A CEN Workshop Agreement is a reference document (a pre-standard) from the European Committee for Standardization (CEN) that would facilitate the transnational adoption of the RBE Assessment System.

The preparation of the CEN Workshop Agreement will be supported by UNI (Italian National Standardisation Body), and it will start in November 2025.

SUPERBE TRAINING SYSTEM

DECISION-MAKERS: policy-makers and managers in municipalities, regional administrations or other public bodies, investors, developers, etc.

TECHNICAL COORDINATORS: technical officials and technical staff who work in municipalities or other public bodies. They play a key role as an interface between decision-makers and professionals.

PROFESSIONALS: architects, engineers, geologists, etc., who operate in the fields of building design and urban planning.

The skills and knowledge acquired with the SuPeRBE training will be recognized according to the **European TRAIN4SUSTAIN Competence Quality Standard method (CEN Workshop Agreement** - CEN/WA 17939)

A **Skill Passport** describing the acquired level of competence in relation to the different areas of expertise will be issued at the end of the e-course.

SKILLS REGISTRY

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European Skills Registry

We aim to enhance the recognition and comparability of qualifications and skills in the construction sector, particularly in relation to sustainable energy, by fostering a common understanding, promoting the TRAIN4SUSTAIN Competence Quality Standard, and facilitating transnational recognition through the Skills Passport.

Registration

Competence Quality Standard

Skills Passport

Courses

Projects

Interreg CENTRAL EUROPE

Co-funded by the European Union

SuPeRBE

Czech Technical University in Prague
University Centre for Energy Efficient Buildings

Pre-registration for the SuPeRBE platform

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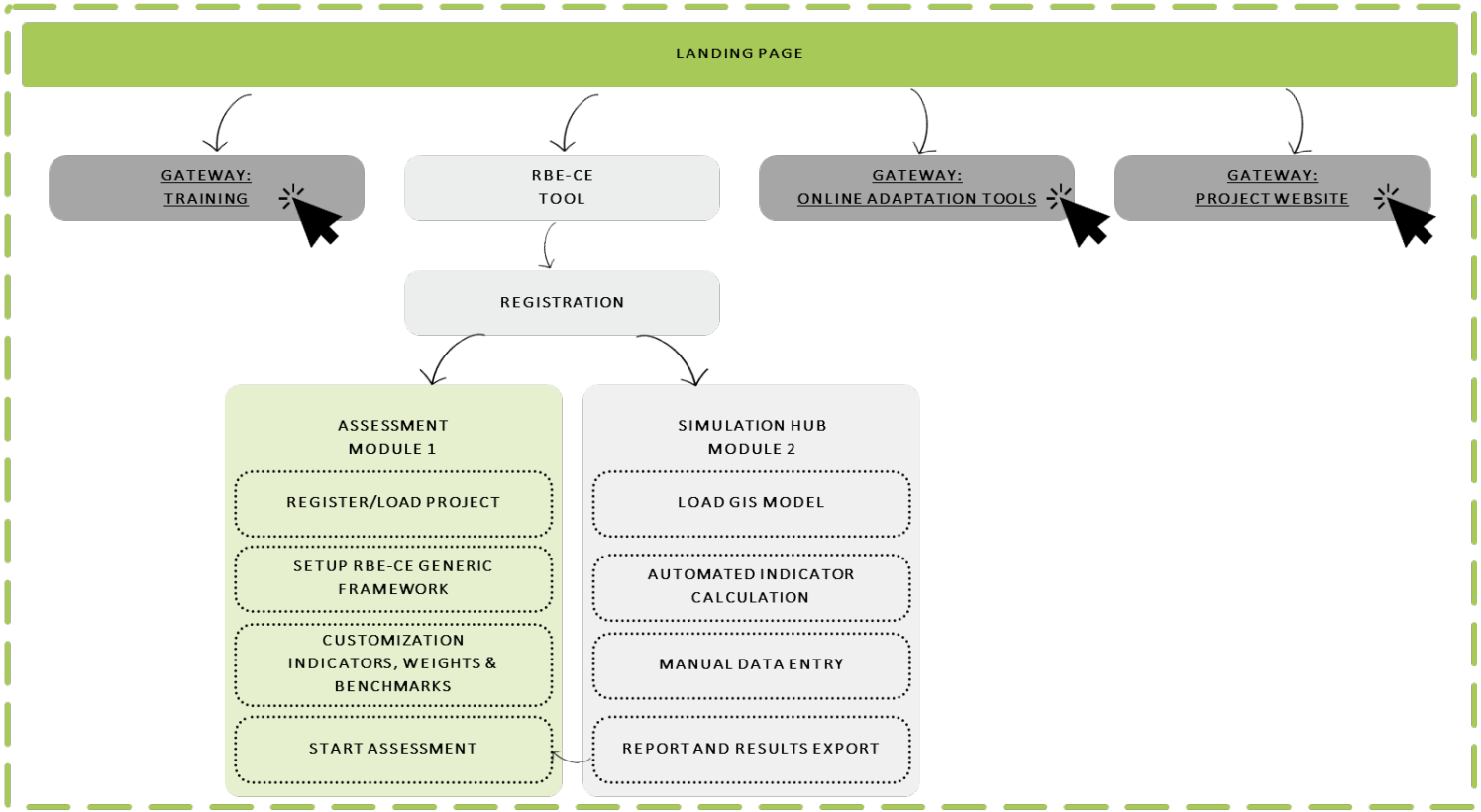
THANKS FOR YOUR ATTENTION!

Licia Felicioni and the CTU TEAM

SUPERBE PLATFORM



USER

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CASE STUDIES

Definition of contextualised versions for each case study and assessment of predefined building/neighborhood case study


CHIVASSO [IT]


VENARIA [IT]


LEINI [IT]


GASSINO [IT]


VERONA [IT]


ABANO TERME [IT]


SIBENIK [HR]


SCHNIFIS [AT]


PRAGUE [CZ]

RBE-CE VULNERABILITY VALUE CALCULATION

Calculation of quantitative indicators

The values of the quantitative vulnerability indicators linked to the criteria associated to the Risk Category are calculated. The output consists of a set of quantities expressed in different units of measurement.

Hazard	Extreme Heat	
Risk Category	**Health Risk for Population**	
Vulnerability Criterion	**Indicator**	**Calculated Value**
Capacity of paved surfaces to reflect solar radiation	mean Solar Reflectance Index of paved surfaces in the area	76
Availability of Green Areas	Percentage of green spaces on total urban area surface	15 %
Shading of Paved Surfaces	Percentage of paved surfaces shaded on June 21st at 12:00 PM	5 %

RBE-CE VULNERABILITY VALUE CALCULATION

Normalisation of quantitative indicators' values

The calculated values of quantitative indicators are normalised in the interval (0,1). The term "normalisation" refers to the transformation of indicator values measured in different units into unit-less values on a common scale. The normalisation interval used in RBE Method is a value range from 0 to 1, the most applied in climate risk studies in general. A zero value is defined as "optimal", no improvement necessary or possible and 1 as "critical".

Normalisation values	Description
0-0.2	Optimal (No improvement necessary)
>0.2-0.4	Rather positive
>0.4-0.6	Neutral
>0.6-0.8	Rather negative
>0.8-1	Critical (Could lead to severe consequences)

RBE-CE VULNERABILITY VALUE CALCULATION

Normalisation of quantitative indicators' values

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:

$$X_{norm} = \frac{x_{max} - x_i}{x_{max} - x_{min}}$$

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)

Indicator values worse 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}

For example, if the value (Xi) of the indicator "mean Solar Reflectance Index of paved surfaces in the area" is 14, with the following benchmarks:

- X_{max} (Optimal performance) = 58, benchmark associated to score 0
- X_{min} (Critical performance) = 0, benchmark associated to score 1

The resulting normalised value will be: X_{norm} = 0,76 (rather negative)

RBE-CE VULNERABILITY VALUE CALCULATION

Aggregation of normalised values to calculate the Vulnerability Value of the Risk Category

To calculate the Vulnerability Value (VV) of the Risk Category, the normalized values of the indicators are aggregated using an arithmetic mean. This results in the total Vulnerability Value for the Risk Category:

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

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:ì

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

RBE-CE VULNERABILITY VALUE CALCULATION

Example:

The Risk Category “Health Risk for Population” belonging to the Hazard “Extreme heat” contains 3 criteria. The criterion “Capacity of paved surfaces to reflect solar radiation” has been considered more relevant than the other 2 in the following Table:

Hazard	Extreme Heat		
Risk Category	Health Risk for Population		
Vulnerability Criterion	Indicator	Normalised value	Weight
Capacity of paved surfaces to reflect solar radiation	mean Solar Reflectance Index of paved surfaces in the area	0.65	0.5
Availability of Green Areas	Percentage of green spaces on total urban area surface	0.70	0.25
Shading of Paved Surfaces	Percentage of paved surfaces shaded on June 21st at 12:00 PM	0.40	0.25

The Vulnerability Value (VV) of the Risk Category results to be:

$$VV = (0{,}65 \cdot 0{,}5) + (0{,}70 \cdot 0{,}25) + (0{,}40 \cdot 0{,}25) = 0{,}6$$

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