

SuPeRBE Training Material

Macro Area of Expertise:

2 RBE Assessment System

Area of Expertise:

2.1 RBE Method

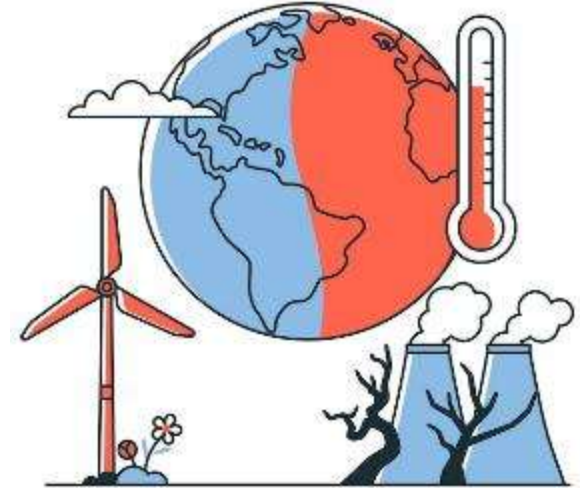
Level of competence: 3

What is the RBE Method?

The RBE Method serves as the methodological foundation of the 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 the RBE Method 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**.



Why is the RBE Method needed?

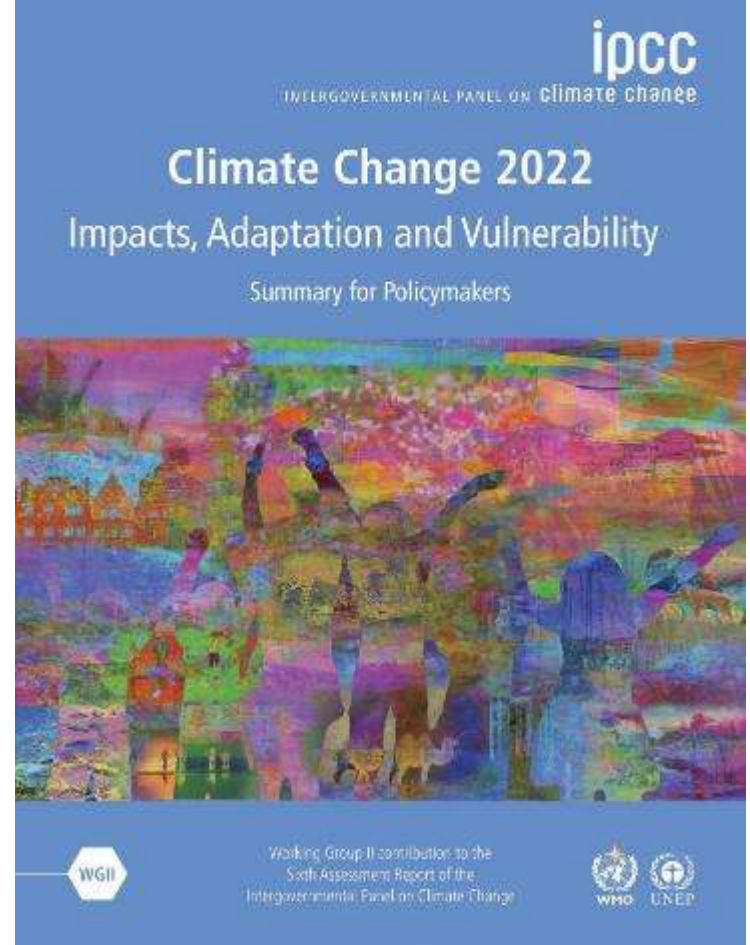
- Lack of climate risk assessment tools at the building and neighbourhood scale.
- Existing sustainability frameworks are not suited for climate risk assessment because not in line with IPCC risk approach.
- Need for comparable, adaptable, and decision-support-oriented tools for climate adaptation.



IPCC AR6

RBE Method is grounded in the IPCC AR6 Risk Concept. The IPCC AR6, or the Intergovernmental Panel on Climate Change Sixth Assessment Report, is the most recent comprehensive assessment of scientific knowledge on climate change.

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 but further refines it to account for the complex interactions between climate **hazards, exposure, and vulnerability**.



Risk to Climate Change

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 but further refines it to account for the complex interactions between climate **hazards, exposure, and vulnerability**.

$$R = H \times V \times E \times V \times V$$

RBE Method: Key Features

Cross-Scale

Urban Sectors are harmonised between RNTool and RBTool, enabling consistent data use and coordinated planning across scales. This ensures that building-level measures contribute to urban resilience goals and that neighbourhood strategies are informed by building vulnerabilities.

Measurable

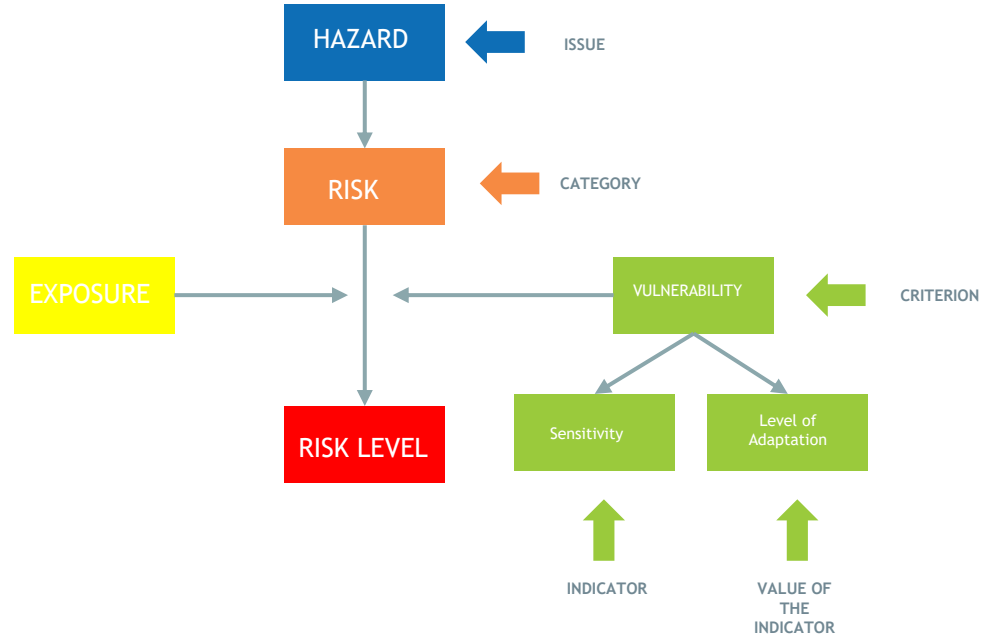
The RBE Method is grounded in clearly defined, measurable criteria and indicators. The method is contextualizable, allowing them to be tailored to local conditions and data availability. This ensures a more accurate and meaningful diagnosis of climate-related risks, supporting evidence-based decision-making.

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.

Impact Chains

RBE 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 (hazard, exposure, vulnerability) is assigned a value.



Three Axes of the Risk Assessment

Hazard

The RBE Method considers both climate-related and non-climate hazards. 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

Exposure describes 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 (IPCC, 2021a).

Vulnerability

Vulnerability is the predisposition of an exposed element to be adversely affected. Vulnerability aspects refer to the criteria that influences the susceptibility of an exposed element to a climatic hazard, potentially increasing or decreasing the associated risk. This criterion may not be a direct characteristic of the exposed element itself but can impact the level of risk

Hazards

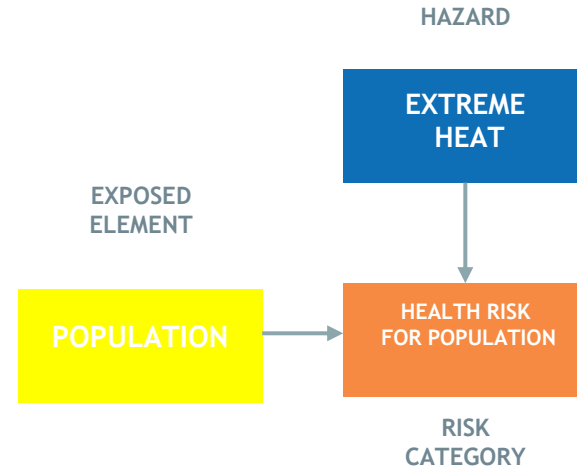
Hazard	Description
Heavy precipitation	A marked precipitation event occurring during a period of 1h, 3h, 6h, 12h, 24h or 48h with a total precipitation exceeding a certain threshold defined for a given location. Sub-hazards: rainstorm, monsoon, heavy snow, fog, hail
Floods	The overflowing of the normal confines of a stream or other body of water, or the temporary rise in the level of the sea or a lake which results in the inundation of dry land. Sub -hazard: Flash/surface flood, river flood, coastal flood, groundwater flood
Extreme Heat	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.
Drought	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
Storms	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
Extreme Cold	Marked cooling of the air or the invasion of very cold air, over a large area
Wildfire	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
Sea level rise	Long-term increase in the average level of the world's seas resulting in a permanent inundation.
Chemical change	Changes in the usual chemical composition of air, water, soil, e.g. change of the CO ₂ atmospheric concentrations, ocean acidification, salt water intrusion
Mass movement	Any type of downslope movement of earth materials. Sub-hazards: landslide, avalanche, rock fall, subsidence, soil degradation, soil erosion
Biological hazards	Exposure to living organisms and their toxic substances or vector-borne diseases that they may carry; examples are venomous wildlife and insects, poisonous plants, mosquitoes carrying disease-causing agents

Urban Sectors

Urban sector	Description
1. Buildings	Refers to any (municipal/residential/tertiary, public/private) structure or 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 (e.g. roads, bridges, hubs, tunnels, ports and airports)
3. Energy	Refers to the energy supply service and related infrastructure (generation, transmission and distribution networks, all energy types).
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, air quality, 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 (e.g. hospitals)
9. Civil protection & emergency	Refers to the operation of the civil protection and emergency services by or on behalf of public authorities (e.g. civil protection authorities, police, fire-fighters, ambulance, paramedic and emergency medicine services)
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.
12. Economic systems	Refers to the set of economic activities, financial infrastructures and trade networks

Risk Categories

A "Risk Category" represents the specific type of risk that arises from the interaction between a defined climatic Hazard and an Exposed Element within an Urban System. For example, the correlation between the hazard "Extreme Heat" and the Exposed Element "Population" results in the Risk Category "Health Risk for Population."



Risk Categories

By defining a specific Risk Category for each combination of hazard and Exposed Element, the RBE Assessment System enables cities to identify exactly *who or what* is at risk and *why*. This targeted approach supports the development of tailored adaptation strategies that can be implemented at different spatial scales, such as buildings, neighbourhoods, and helps to clarify which institution or department is responsible for acting.

Hazard	Urban Systems					
	Built environment		Health		Transport	
	Exposed Elements					
	Residential buildings	Public buildings	Population	Health Care Facilities	Road Network	Rail Network.
Extreme Heat	Risk Category 1	Risk Category 2	Risk Category 3	Risk Category 4	Risk Category 5	Risk Category 6
Heavy Precipitation	Risk Category 7	Risk Category 8	Risk Category 9	Risk Category 10	Risk Category 11	Risk Category 12

RBE Method in Relation to Future Conditions

RBE Method can be used to assess the level of climate risk in relation to future climatic conditions. Selecting Hazard Values that accurately reflects the anticipated changes in climate over time. This involves evaluating potential hazards based on future projections, such as temperature increases, changes in precipitation patterns, and the frequency or intensity of extreme weather events. These projections can be derived from models such as those outlined in the Intergovernmental Panel on Climate Change (IPCC) reports, specifically the Representative Concentration Pathways (RCPs).



Structure of the RBE Method

RBE Method organises its components into nested hierarchical levels (5):

Level 1	Hazard
Level 2	Urban Systems
Level 3	Risk Categories
Level 4	Criteria
Level 5	Indicator

Structure of the RBE Method

Level 1 corresponds to the **Hazards**, translated into a strategic “Issue”. Issues are at top of the hierarchy and contain within them Macro Categories corresponding to the 12 Urban Systems. At the “Issue” level the Hazards are classified based on letters . For example, A. Heavy Precipitation, B. Floods, C, Extreme Heat, D. Drought, etc.

A	ISSUE (Hazard)
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Hazard	
A-H1	Hazard Criterion
	Hazard Indicator
A-H2	Hazard Criterion
	Hazard Indicator
A-Hn	Hazard Criterion
	Hazard Indicator

Level 2 corresponds to **Urban Systems**, translated into “Macro Categories”. Macro Categories contain within them the Risk Categories and are organised following a numerical order. For example: A1 Buildings, A2 Transport, A3 Energy, etc.

A	ISSUE (Hazard)
A1	MACRO CATEGORY (Urban System)



Hazard	
A-H1	Hazard Criterion
	Hazard Indicator
A-H2	Hazard Criterion
	Hazard Indicator
A-Hn	Hazard Criterion
	Hazard Indicator

Structure of the RBE Method

Level 3 corresponds to **Risk Categories**. Risk Categories contains within them vulnerability and exposure criteria and are classified based in numerical order. For example: A1.1 Damage Risk for Residential Buildings, A1.2 Damage Risk for Public Buildings, A1.3 Damage Risk for Commercial Buildings, etc.

A	ISSUE (Hazard)
A1	MACRO CATEGORY (Urban System)
A1.1	RISK CATEGORY (Exposed Element)



Hazard	
A-H1	Hazard Criterion
	Hazard Indicator
A-H2	Hazard Criterion
	Hazard Indicator
A-Hn	Hazard Criterion
	Hazard Indicator

Level 4 correspond to assessment **Criteria**. The RBE Method includes three types of criteria: Vulnerability and Exposure criteria, which are associated with Risk Categories, and Hazard criteria, which are associated with Issues.

A	ISSUE (Hazard)
A1	MACRO CATEGORY (Urban System)
A1.1	RISK CATEGORY (Exposed Element)
VULNERABILITY	
A1.1.1	Vulnerability Criterion
EXPOSURE	
A1.1-E1	Exposure Criterion



Hazard	
A-H1	Hazard Criterion
	Hazard Indicator
A-H2	Hazard Criterion
	Hazard Indicator
A-Hn	Hazard Criterion
	Hazard Indicator

Structure of the RBE Method

Level 5 corresponds to **Indicators**. Each indicator is associated with a specific criterion (hazard, exposure or vulnerability) and is used to quantify performance with respect to that criterion. Indicators can be both quantitative and qualitative. A Criterion can be associated to only one indicator.

A	ISSUE (Hazard)
A1	MACRO CATEGORY (Urban System)
A1.1	RISK CATEGORY (Exposed Element)
VULNERABILITY	
A1.1.1	Vulnerability Criterion

Vulnerability Indicator

EXPOSURE	
A1.1-E1	Exposure Criterion

Exposure Indicator



Hazard	
A-H1	Hazard Criterion
	Hazard Indicator
A-H2	Hazard Criterion
	Hazard Indicator
A-Hn	Hazard Criterion
	Hazard Indicator

Structure of the RBE Method

Example:

A	EXTREME TEMPERATURES (Hazard)
A1	BUILDINGS (Urban System)
A1.1	Damage risk for residential buildings (Exposed Element)
VULNERABILITY	
A1.1.1	Surface infiltration capacity
Share of permeable vs impermeable surfaces	
EXPOSURE	
A1.1-E1	Building Density
Number of buildings per km2	



Extreme Temperatures	
A-H1	R20
	Number of Days with Precipitation ≥ 20 mm
A-H2	SDII
	Simple Daily Intensity Index
A-Hn	RX1DAY
	Maximum total precipitation that falls in a single day

RBE Method Assessment Process

The RBE Method assessment process consists of the following steps:

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

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

To calculate the Vulnerability Value of a Risk Category:

- The values of the quantitative indicators are calculated
- The calculated values are normalised in the interval (0,1)
- A normalised score (0,1) is assigned to qualitative indicators
- The scores of quantitative and qualitative indicators are aggregated through a weighted sum.

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-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 Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-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 Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-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:

Where:

X_i : 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 (X_i) 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)

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

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-Normalisation of quantitative indicators' values

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:

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

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)

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

Example: Normalisation of quantitative indicators

If the value (X_i) of the indicator of the indicator “Share of non-permeable surfaces in the area” is 85%, with the following benchmarks:

- X_{min} (optimal performance) = 50 %, benchmark associated to score 0
- X_{max} (critical performance) = 100 %, benchmark associated to score 1

The resulting normalised value will be: $X_{norm} = 0,7$ (rather negative)

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-Normalisation of qualitative indicators

Qualitative indicators specified by categorical values (scenarios) are normalised using a five-level rating scheme

Normalisation values	Description
0.1	Optimal (No improvement necessary)
0.3	Rather positive
0.5	Neutral
0.7	Rather negative
0.9	Critical (Could lead to severe consequences)

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

Example: Normalisation of qualitative indicators

The Table shows the normalised values in relation to the scenarios of the qualitative indicator “Quality of the urban governance”.

During the normalisation phase, the scenario that reflects the actual situation has to be selected and the relative score assigned to the indicator

Normalisation values	Description	Scenario
0.1	Optimal (No improvement necessary)	Exemplary climate governance, with a consolidated and inclusive adaptation strategy integrated into all urban policies. High collaboration between institutions, citizens, private organizations, and the scientific community.
0.3	Rather positive	Well-organized and integrated climate governance in urban planning processes. Strong coordination between all departments and stakeholders. Active participation from the community and stakeholders in planning and implementing adaptation strategies.
0.5	Neutral	Climate plans are present and implemented with a decent level of coordination. Collaboration between different entities exists, but some critical sectors remain neglected. Community and stakeholder involvement occurs only in certain decisions.
0.7	Rather negative	Formal climate plans exist, but with poor coordination between various departments and stakeholders. Little clarity on who is responsible for managing climate risks. Limited or absent community and stakeholder involvement.
0.9	Critical (Could lead to severe consequences)	Fragmented and ineffective climate governance. Lack of clear climate plans or adaptation strategies. Poor collaboration between different entities and absence of citizen involvement.

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-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:

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

RBE Method Assessment Process

Step 1: Calculation of the Vulnerability Value (VV) for Risk Categories

-Example: Aggregation of normalised values to calculate the Vulnerability Value of the Risk Category

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.

RBE Method Assessment Process

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

The RBE Method foresees the assignment of an Exposure Value (EV) to each Risk Category included in the assessment. This value represents the magnitude of the exposed elements, as outlined in the following Table:

Extend of the exposure	Exposure value (EV)
Minor	0,01-0,10
Low	0,11-0,20
Moderate	0,21-0,30
Critical	0,31-0,50
Major	0,51-1

RBE Method Assessment Process

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

-Normalisation of quantitative indicators

To determine the EV of a Risk Category, firstly the value of the associated exposure indicators shall be calculated and normalised in the interval (0,1) applying the procedure indicated below.

Then, EV is calculated using the following formula:

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

Where:

- I_i is the normalised value of the i -th exposure indicator
- W_i is the weight associated with the i -th exposure indicator
- n is the number of exposure indicators considered.

The various weights assigned to exposure indicators may be derived from existing literature, stakeholder information, or experts' weighting. To normalize the indicator, it is necessary to determine the values corresponding to the optimal (0) and critical (1) levels of exposure.

RBE Method Assessment Process

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

-Normalisation of quantitative indicators' values

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:

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

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)

RBE Method Assessment Process

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

Example

Table below illustrates the Exposure Values assigned to Risk Categories, considering one exposure indicator associated to each Risk Category.

Hazard	Risk Category	Exposed element	Exposure indicator	Exposure value
Extreme Heat	Health risk for population	Population	Population density (n/Km2)	0,32 (critical)
	Damage risk for residential buildings	Residential buildings	Percentage of residential buildings over 50 years old (%)	0,7 (major)
Heavy precipitation	Drainage capacity of road networks	Road network	Total length of roads in flood prone zones (Km)	0,18(Low)

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

RBE Method Assessment Process

Step 3: Calculation of the Hazard Value (HV) for Issues

The RBE Method foresees the assignment of a Hazard Value (HV) to each Issue (Hazard) included in the assessment. This value represents the relevance of the hazard in relation to the local context, as defined in the Table below.

Hazards event		Hazard Value (HV)	
Frequent	Likely to occur in a lifetime (every 0-10 years)	Very likely	1-0,9
Probable	Likely to occur several times in a lifetime (every 0-25 year)	Likely	0,89-0,66
Occasional	Likely to occur sometime in a lifetime (every 0-50 years)	As like as not	0,65-0,33
Remote	Unlikely but still possible to occur in a lifetime (0-100 years)	Unlikely	0,32-0,0

RBE Method Assessment Process

Step 3: Calculation of the Hazard Value (HV) for Issues

The Hazard Value shall be assigned using the information provided in the SECAPs. If information is not available:

- the Hazard Value (HV) is assigned by experts
- the Hazard Value (HV) is assigned through the calculation, normalisation and aggregation of specific Hazard criteria.

Regarding the second option, the Table shows an example of Hazard Criteria for the Issue “Extreme Heat”.

Issue	Extreme heat
Hazard criteria	Indicators
SU25(summer days)	Number of days per year with a daily maximum temperature greater than 25°C
SU30 (warm days)	Number of days per year with a daily maximum temperature greater than 30°C
TMAX	Daily maximum temperature °C
TR20 (tropical nights)	Number of days per year with a daily minimum temperature greater than 20°C
HW	Number of days per year with a daily maximum temperature greater than 30°C

RBE Method Assessment Process

Step 3: Calculation of the Hazard Value (HV) for Issues

To determine the HV for an Issue, the value of the associated hazard indicators shall be calculated and normalised in the interval (0,1). Then HV is calculated using the following formula:

Where:

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

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

The various weights assigned to hazard indicators may be derived from existing literature, stakeholder information, or experts' weighting.

RBE Method Assessment Process

Step 3: Calculation of the Hazard Value (HV) for Issues

Example

Supposing to conduct the risk assessment evaluation for a Central European city, the Table below reports the Hazard Values assigned after the consultation of its SECAP.

Hazard	Hazard value (HV)
Extreme heath	0,8(High)
Heavy precipitation	0,6 (Moderate)
Storms	0,5(Moderate)

The output of this step is a set of Hazard Values (EV), one per Issue.

RBE Method Assessment Process

Step 4: Calculation of the Category Risk Value

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

- a Hazard Value (HV)
- an Exposure Value (EV)
- a Vulnerability Value (VV)

The last 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

RBE Method Assessment Process

Step 4: Calculation of the Category Risk Value

$$\text{Category Risk value} = (HV^{w_{HV}} \times EV^{w_{EV}} \times VV^{w_V})^{1/\sum w}$$

Where:

-HV is the hazard value

-EV is the exposure value

-VV is the vulnerability value

Whv is the weighted associated to HV

Wev is the weighted associated to EV

Wv is the weighted associated to VV

Assuming that the weighting fulfills the following properties:

$$0 \leq w_i \leq 1$$

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

$$\text{Category Risk value} = HV^{w_{HV}} \times EV^{w_{EV}} \times VV^{w_V}$$

RBE Method Assessment Process

Step 4: Calculation of the Category Risk Value

Example

To calculate the risk value of the risk category “health risk for inhabitants” the following values are used:

Hazard value (HV) = 0,68

Whv = 0,25

Exposure value (EV) = 0,35

Wev = 0,25

Vulnerability value (VV) = 0,6

Wv = 0,5

The value of the risk category “Health risk for inhabitants” results to be:

$$\text{Category risk value} = (0,68^{0,25} \times 0,35^{0,25} \times 0,6^{0,5}) = 0,54$$

RBE Method Assessment Process

Step 5: Aggregation of Risk Category Values to Calculate the Risk Value of Macro-Categories (Urban Systems)

In this step the risk value of Risk Categories calculated in the previous step are aggregated to produce a risk value at Macro Category level. This value represents the specific risk of Urban Systems in relation to the Hazards.

RBE Method Assessment Process

Step 5: Aggregation of Risk Category Values to Calculate the Risk Value of Macro-Categories (Urban Systems)

Being a multi-risk approach, the aggregation of the risk categories scores take place through an arithmetical mean.

$$\text{Macro category risk value} = \sum_{i=1}^n (C_i \times W_i)$$

Where:

- 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:

$$0 \leq W_i \leq 1$$

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

RBE Method Assessment Process

Step 5: Aggregation of Risk Category Values to Calculate the Risk Value of Macro-Categories (Urban Systems)

Example

The Macro-category “Health” has 2 risk categories. In the next table there are the risk values for each one of them and their respectively weight.

Risk Category	Risk Value	Weight
Health of inhabitants	0,61	0,60
Efficiency risk for healthcare facilities	0,28	0,20

The score for the Macro-Category in relation to the Hazard “Extreme Temperatures” is =
 $(0,61 \cdot 0,60) + (0,28 \cdot 0,40) = 0,48$ (neutral)

RBE Method Assessment Process

Step 6: Aggregation of Macro Category Values to calculate the Risk Value of Issues (Hazards)

In this step the risk values of Macro Categories are further aggregated to produce a risk value for issues (Hazards).

Being a multi-risk approach, the aggregation of the Macro Categories' scores take place through an arithmetical mean.

RBE Method Assessment Process

Step 6: Aggregation of Macro Category Values to calculate the Risk Value of Issues (Hazards)

In this step the risk values of Macro Categories are further aggregated to produce a risk value for issues (Hazards). Being a multi-risk approach, the aggregation of the Macro Categories' scores take place through an arithmetical mean.

$$\text{Issue Risk Value} = \sum_{i=1}^n (C_i \times W_i)$$

where:

- 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:

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

RBE Method Assessment Process

Step 6: Aggregation of Macro Category Values to calculate the Risk Value of Issues (Hazards)

Example

The Issue “Extreme Heat” includes 3 Macro Categories. In the following Table is reported the risk value of each and the relative weight.

Macro category	Risk value	Weight
Health	0,54	0,7
Energy	0,32	0,15
Transports	0,23	0,15

The Issue score in relation to the hazard “Extreme heat” results to be:
Hazard risk level= $(0,54 \times 0,7) + (0,32 \times 0,15) + (0,23 \times 0,15) = 0,46$ (neutral)

RBE Method Assessment Process

Step 7: Aggregation of Issues Values to calculate the Overall Risk Value

Finally, the overall risk value is calculated as arithmetical mean of Issue's risks values:

$$\text{Overall Risk Value} = \sum_{i=1}^n (I_i \times W_i)$$

- 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:

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

RBE Method Assessment Process

Step 7: Aggregation of Issues Values to calculate the Overall Risk Value

Example of risk values and weight factors associated to issues

Issue	Risk value	Weight
Extreme heath	0,46	0,5
Heavy precipitation	0,73	0,2
Storms	0,65	0,1

The overall risk value results to be:

$$\text{Overall risk value} = (0,46 \times 0,5) + (0,73 \times 0,2) + (0,65 \times 0,1) = 0,44 \text{ (neutral)}$$

Assessment Results

Risk Categories

The risk values of Risk Categories provide a clear understanding of which elements within the urban systems are most at risk and highlight areas that require priority in adaptation strategies.

Macro Categories

The risk values (0,1) of Macro Categories provide a clear understanding of which urban sectors are most at risk and highlight areas that require priority in adaptation strategies.

Issues

The RBE Method allows for an aggregated view of how each hazard affects the overall risk profile. Hazards with higher risk values indicate a greater vulnerability to climate impacts and thus require immediate and sustained efforts to mitigate these risks.

RBE Method Results

Overall Risk

RBE method provides a clear metric to gauge the effectiveness of current adaptation measures and the urgency for additional interventions. The interpretation of results is crucial for informing climate adaptation strategies and underscore the importance of integrating these findings into broader urban planning and policy frameworks.