Interreg CENTRAL EUROPE

Co-funded by the European Union

SuPeRBE

SuPeRBE Training Material

Macro Area of Expertise MAE4:

Risk Assessment At Small Urban Scale

Hazard: Floods (B)

Macro Area of Expertise MAE4.1:

Urban Sector: Buildings (B1)

Risk Category: Damage risk for public buildings (B1.2)

Level of competence: 3

Activity 3.2
SuPeRBE Project (CE0200768)

FLOODS

Floods occur when water flow exceeds the capacity of natural or artificial drainage systems. In urban areas, this risk is increased by soil compaction with impermeable surfaces, outdated infrastructure, and changes in snowmelt patterns and river regimes.

Key Characteristics:

- Overbank flow from rivers, streams, or canals leading to floodplain inundation
- Can be slow-onset (prolonged rain/snowmelt) or rapid during extreme events or levee overtopping
- Frequently carries sediments, debris, and contaminants (sewage, hydrocarbons, chemicals)

Trend:

- Urbanization and loss of natural retention (floodplains, wetlands) amplify runoff peaks and exposure
- Where structural defenses exist, residual risk persists from overtopping, failure, and compound events (river + surface runoff + drainage backflow)

MAIN IMPACTS ON BUILDINGS

Direct Impacts:

- Inundation of ground floors, underground levels, and critical rooms (electrical, IT, HVAC)
- Structural damage from hydrostatic pressure, buoyancy (uplift of tanks/floors), erosion and scour around foundations
- Contamination of interiors and building materials with polluted water and sediments
- Damage to site utilities: substations, switchgear, gas meters, heat exchangers, pumps

Indirect Impacts:

- Extended business interruption due to drying, cleanup, and restoratio timelines
- Supply-chain disruption and loss of inventory, archives, or equipment at/near ground level
- Higher insurance premiums, deductibles, or exclusions; increased compliance and maintenance costs
- Devaluation of assets and longer permitting cycles for repairs within f zones

IMPACTS ON PEOPLE AND URBAN SYSTEMS

Human and Social Impacts:

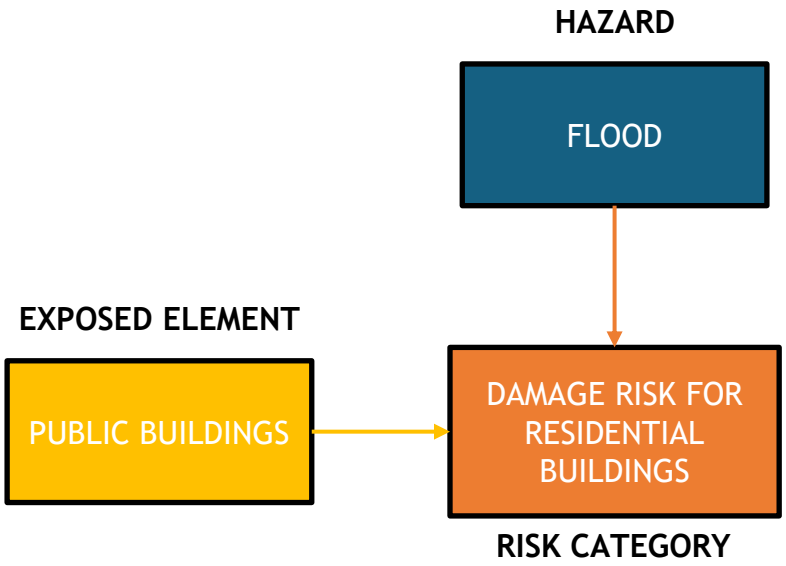
- Risk of injury or fatalities (swift water, submerged hazards, electrical shock)
- Temporary or prolonged displacement of residents/tenants; need for shelters and rehousing
- Health risks from contaminated water, mold growth, and damp indoor environments
- Psychosocial stress and community cohesion impacts during recovery

Urban System Impacts:

- Damage to roads, bridges, embankments, and rail from scour and prol submergence
- Overload or shutdown of wastewater treatment plants; combined sew overflows and environmental pollution
- Disruption of power, district heating, telecoms, and potable water su
- Heavy demand on emergency services, debris management, and recov logistics

RISK ASSESSMENT FOR DAMAGE RISK FOR PUBLIC BUILDINGS

- **Hazard:** Flood
- **Exposed element:** Public Buildings



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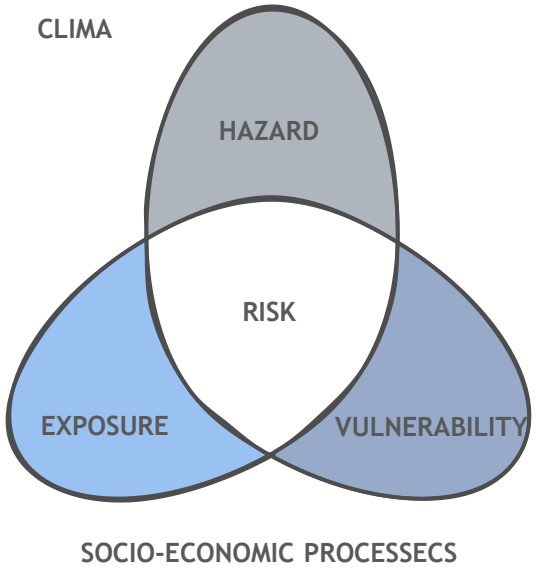
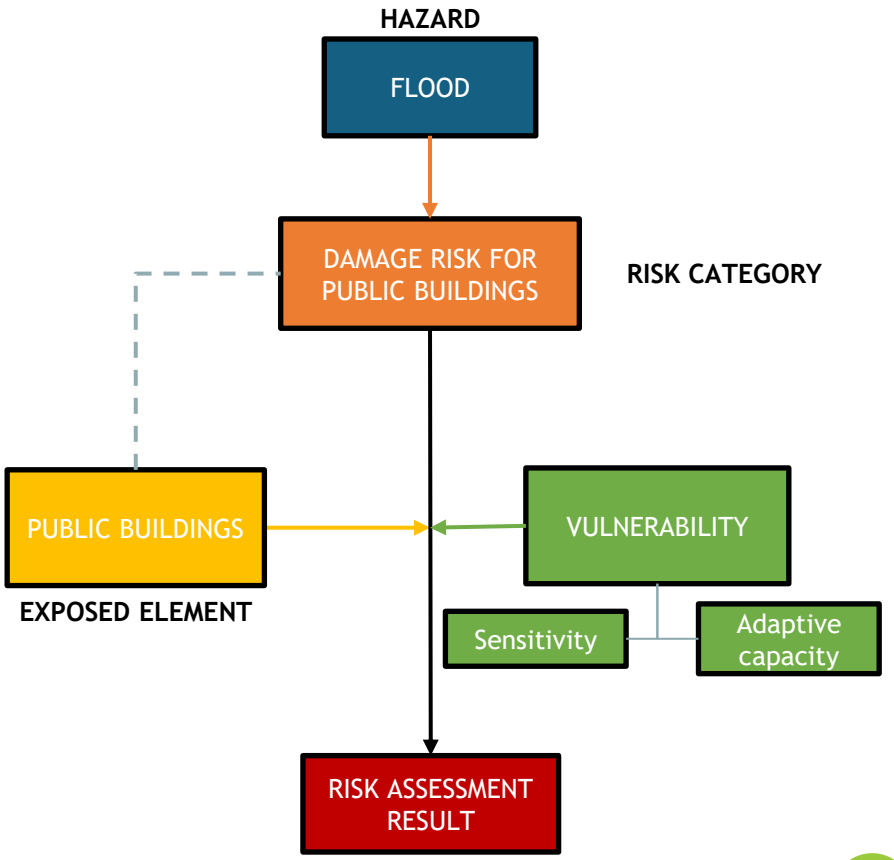
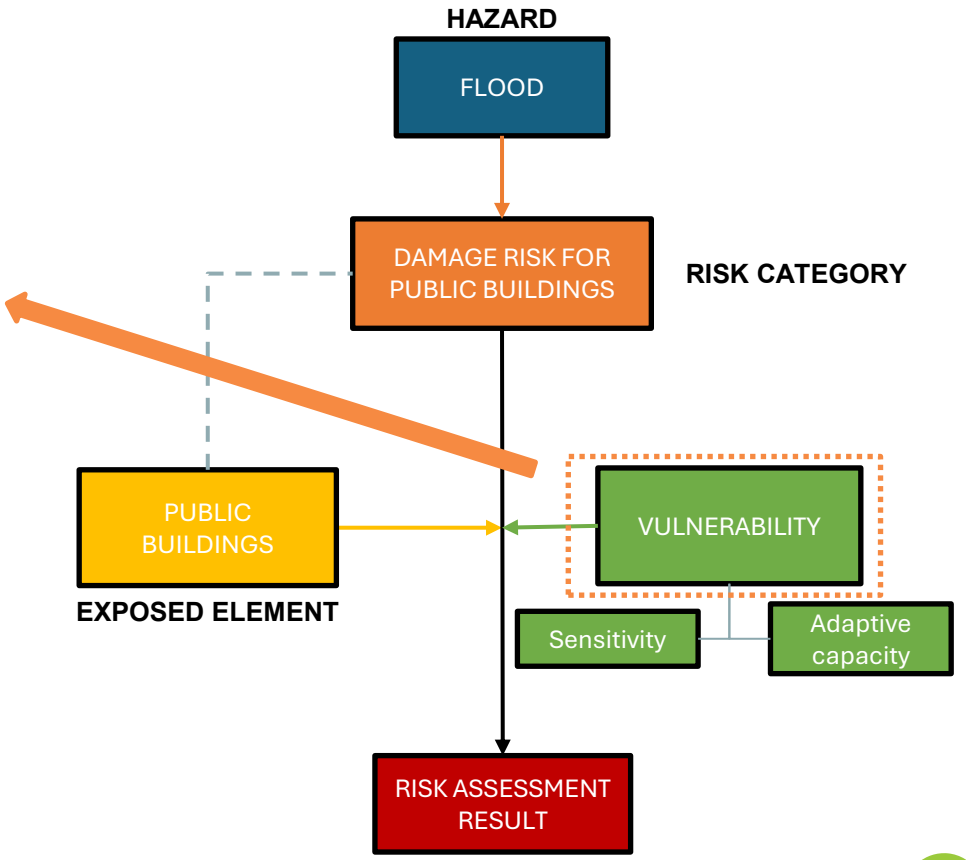


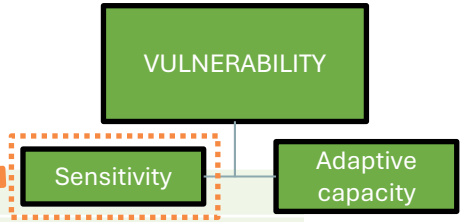


VULNERABILITY CRITERIA

CRITERION
Surface Runoff Potential
Nature-based solutions for flood mitigation
Drainage Capacity
Critical Infrastructure Protection
Building Elevation
Flood-Resilient Construction
Ecological and natural component
Continuity of blue-green infrastructure
Social and institutional preparedness
Emergency Access
Availability of outdoor emergency meeting points



VULNERABILITY ASSESSMENT



CRITERION	INDICATOR
Surface Runoff Potential	Share of permeable surfaces compared to the total site area
Nature-based solutions for flood mitigation	Share of site area covered by nature-based solutions (NBS)
Drainage Capacity	Share of the drainage network using a separate sewer system
Critical Infrastructure Protection	Protection level of critical infrastructure
Building Elevation	Share of buildings with elevated entrance openings above the level of a flood which statistically occurs every 50 years
Flood-Resilient Construction	Share of buildings with flood-resilient materials at or below design flood level
Ecological and natural component	Share of public and private green space relative to total neighborhood area
Continuity of blue-green infrastructure	Functionality of blue-green infrastructure network
Social and institutional preparedness	Existence and completeness of emergency plans and early warning systems (e.g. sirens, SMS alerts, local coordination protocols)
Emergency Access	Share of roads above projected flood level
Availability of outdoor emergency meeting points	Share of emergency assembly points located above projected flood level

B1.2.1 SURFACE RUNOFF POTENTIAL

Description:

This criterion assesses the likelihood of rainwater runoff due to low infiltration across the neighborhood.

Objective:

Determine the urban area‘s ability to retain water and assess critical areas to reduce damage caused by surface runoff.

Relevance:

Surface runoff can lead to a range of environmental and infrastructural issues, as water pollution, soil erosion, and damage to infrastructure. Assessing runoff potential is essential for sustainable urban planning, as it supports the design of blue-green infrastructure.

B1.2.1 SURFACE RUNOFF POTENTIAL

Indicator:

Share of permeable surfaces compared to the total site area [%]

Benchmarks: HIB

Critical value (1) = < 40%

Optimal value (0) = ≥ 70%

$$I = (A_{per} / A_{total}) \times 100\%$$

A_{per} = area of permeable surfaces (m^2)
A_{total} = total site area (m^2)

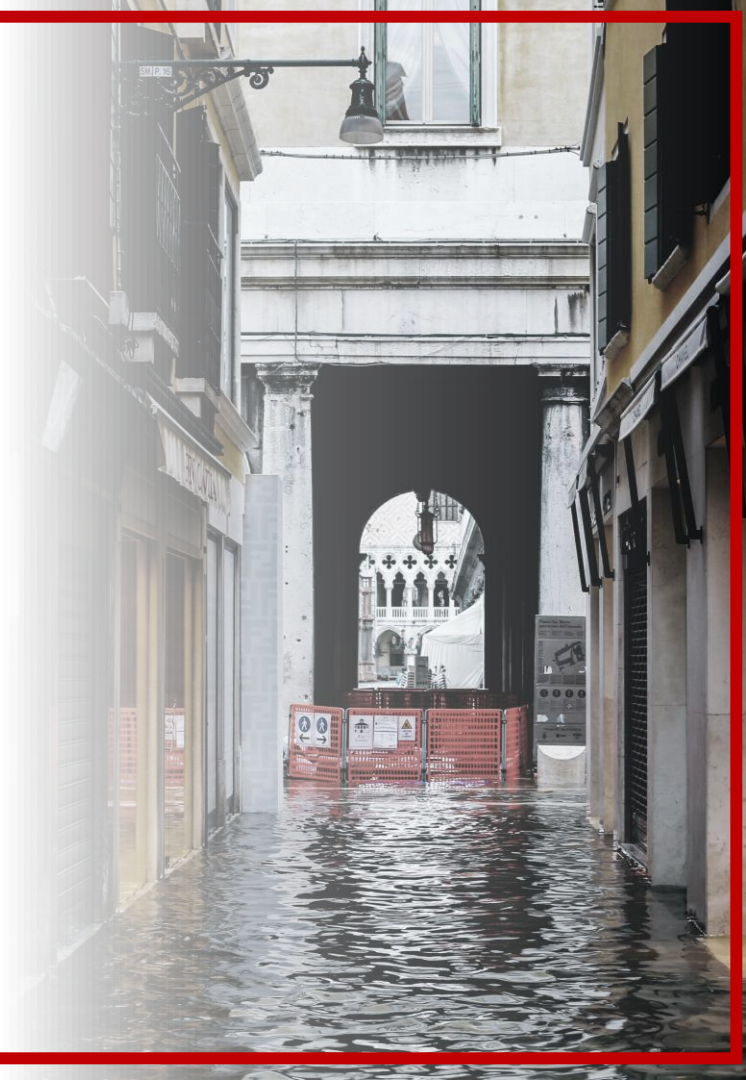
B1.2.1 SURFACE RUNOFF POTENTIAL
CALCULATION STEP-BY-STEP

Step 1 – Gather spatial data on surface types

Collect spatial data describing land cover and materials within the neighborhood boundary.

Data sources:

- GIS data
- orthophotos
- project documentation
- on-site surveys or recent surface condition reports
- cadastral maps and land-use datasets



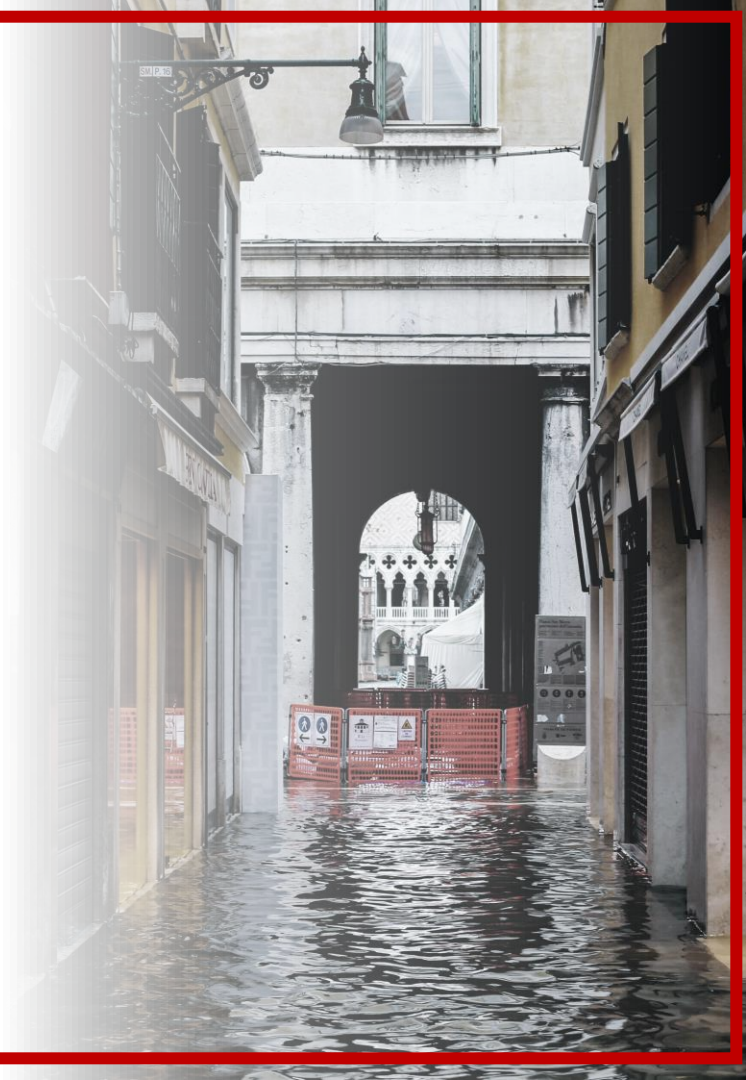
B1.2.1 SURFACE RUNOFF POTENTIAL
CALCULATION STEP-BY-STEP

Step 2 – Identify permeable and impermeable surfaces

Use GIS or CAD tools to classify all visible surface types.

Steps:
- define neighborhood boundary
- classify surfaces by type
- assign “permeable” or “impermeable” attributes
- validate classification through field verification or recent images

Typical categories:
- **Permeable:** vegetation, lawns, gravel paths, permeable pavements, unpaved soils
- **Impermeable:** asphalt, concrete, rooftops, compacted pavements



B1.2.1 SURFACE RUNOFF POTENTIAL
CALCULATION STEP-BY-STEP

Step 3 – Calculate surface areas by category and compute surface share

Measure the total surface area of permeable and impermeable zones.

Indicator : Share of permeable surfaces compared to the total site area [%]

EXAMPLE

A_{per} = 17 000 m²
A_{total} = 30 000 m²

→ I = (17 000 / 30 000) × 100 = **56,7%**

Surface Type	Category	Area (m²)
Grass and vegetation	Permeable	15 000
Gravel pavements	Permeable	2 000
Asphalt roads	Impermeable	8 000
Roofs	Impermeable	5 000
Total site area	-	**30 000**

B1.2.2 NATURE-BASED SOLUTIONS FOR FLOOD MITIGATION

Description:

This criterion assesses the spatial extent of implemented nature-based solutions (NBS) designed to mitigate flooding by increasing water retention, delaying runoff, and enhancing infiltration. These include elements such as bioswales, wetlands, vegetated channels, rain gardens or green roofs.

Objective:

Determine the percentage of the site area covered by NBS to enhance water retention, delay runoff, and improve infiltration.

Relevance:

Understanding the coverage of NBS helps urban planners and policymakers strengthen climate resilience, reduce flood risks, and promote sustainable infrastructure. The findings support the development of effective adaptation strategies and sustainable urban planning.

Source: Voda ve městě, 2022

B1.2.2 NATURE-BASED SOLUTIONS FOR FLOOD MITIGATION

Indicator:

Share of site area covered by nature-based solutions (NBS)

Benchmarks: HIB

Critical value (1) = < 2%

Optimal value (0) = ≥ 10%

Source: Voda ve městě, 2022

$$I = (A_{nbs} / A_{total}) \times 100\%$$

A_{nbs} = area covered by NBS(m^2)
A_{total} = total site area (m^2)

B1.2.2 NATURE-BASED SOLUTIONS FOR FLOOD MITIGATION
CALCULATION STEP-BY-STEP

Step 1 – Gather all required input data

Begin by identify all implemented nature-based flood mitigation elements (e.g. vegetated swales, wetlands, green roofs) within the assessment area.

Data sources:
- GIS landscape and hydrological data
- orthophotos
- on-site surveys
- project documentation
- cadastral maps and land-use datasets
- green infrastructure or stormwater management plans

Source: Voda ve městě, 2022

Tip:
Check whether NBS are engineered for stormwater retention (not purely decorative vegetation).

B1.2.2 NATURE-BASED SOLUTIONS FOR FLOOD MITIGATION
CALCULATION STEP-BY-STEP

Step 2 – Identify Nature-based flood mitigation features

Classify all relevant NBS elements according to their hydrological function.

Typical examples:

- bioswales: linear vegetated channels for surface water conveyance
- rain gardens: landscaped depressions capturing and infiltrating runoff
- constructed wetlands: areas for temporary water storage and purification
- green roofs: absorb rainfall and delay runoff peaks
- retention ponds / basins: designed to detain water during storm events

Tip:
Exclude purely decorative green areas without a stormwater function.

B1.2.2 NATURE-BASED SOLUTIONS FOR FLOOD MITIGATION
CALCULATION STEP-BY-STEP

Step 3 – Measure the surface area of NBS elements

Define the neighborhood boundary. Use GIS tools, CAD drawings, or field surveys to measure the total area occupied by NBS within the site boundary.

Step 4 – Calculate the indicator
Indicator : Share of permeable surfaces compared to the total site area [%]

EXAMPLE

A_{nbs} = 4 500 m²
A_{total} = 40 000 m²

→ I = (4 500 / 40 000) × 100 = **11,25%**

NBS type	Area (m²)	Function
Bioswales	1 200	Conveyance + infiltration
Rain gardens	800	Retention + infiltration
Wetland basin	2 000	Storage + purification
Green roofs	500	Retention + delay runoff
Total NBS area	**4 500**	**-**

B1.2.3 DRAINAGE CAPACITY

Description:

This criterion assesses the capacity of the urban drainage system to manage stormwater runoff during heavy rainfall, based on the presence of separate or combined sewer systems. The drainage system type influences flood risk and pollution levels and is a key factor in climate adaptation.

Objective:

To determinate the share of the drainage network that uses a separate sewer system. The goal is to measure how effectively stormwater runoff is managed during heavy rainfall, reducing flood risks and pollution.

Relevance:

A well-functioning drainage system is crucial for climate resilience and urban sustainability. By analyzing the share of separate sewer systems, we can identify areas at higher flood risk and pollution potential, supporting better stormwater management strategies and climate adaptation planning.

B1.2.3 DRAINAGE CAPACITY

Indicator:

Share of the drainage network using a separate sewer system [%]

Benchmarks: HIB

Critical value (1) = < 50%

Optimal value (0) = 100%

$$I = (A_{sep} / A_{total}) \times 100\%$$

A_{sep} = area with a separate sewer system (m^2)
A_{total} = total serviced area (m^2)

OR

$$I = (L_{sep} / L_{total}) \times 100\%$$

L_{sep} = length of a separate sewer system (m)
L_{total} = total drainage network length (m)

B1.2.3 DRAINAGE CAPACITY
CALCULATION STEP-BY-STEP

Step 1 – Gather all required input data

Begin by obtaining accurate and up-to-date information about the existing sewer infrastructure.

Data sources:
- GIS data
- municipal sewer network maps
- utility provider documentation
- site inspection or field survey

NOTE:
It is crutial to be able to recognize stormwater vs. combined system.

B1.2.3 DRAINAGE CAPACITY
CALCULATION STEP-BY-STEP

Step 2 – Differentiate between separate and combined systems

Identify which parts of the network system are separate (independent storm and sanitary pipes) and which are combined.

Step 3 – Measure the total length (or serviced area) of each drainage system

According to the specific case, it can be measured either the length of the pipes or the serviced area.

Step 4 – Calculate the indicator

Indicator : Share of the drainage network using a separate sewer system [%]

EXAMPLE

System Type	Length (m)
Separate systém (L_{sep})	6 000
Combined system	3 000
Total (L_{total})	**9 000**

→ I = (6 000 / 9 000) × 100 = **67%**

B1.2.4 CRITICAL INFRASTRUCTURE PROTECTION

Description:

This criterion assesses the protection level of critical urban infrastructure (e.g. electrical substations, water treatment plants, hospitals) against climate-related hazards such as floods, heatwaves or power outages. Ensuring their functionality during and after extreme events is essential for neighborhood resilience.

Objective:

The goal is to ensure critical infrastructure functionality during and after extreme weather events, enhancing neighborhood resilience.

Relevance:

Protecting critical infrastructure is essential for maintaining public safety, essential services, and economic stability in the face of climate change. By identifying vulnerabilities and implementing protective measures, cities can reduce risks and ensure continuity of operations during disasters, supporting climate adaptation and disaster resilience strategies.

B1.2.4 CRITICAL INFRASTRUCTURE PROTECTION

Indicator:

Protection level of critical infrastructure [Qualitative]

Benchmarks

Critical value (1) = Not protected critical infrastructure

Optimal value (0) = Protected critical infrastructure

B1.2.4 CRITICAL INFRASTRUCTURE PROTECTION
CALCULATION STEP-BY-STEP

Step 1 – Locate critical infrastructure within the neighborhood

Define the critical infrastructure. It could be helpful to divide it by the main function it serves.

Examples:

- Energy: substations, transformer stations
- Water: treatment plants, pumping stations, reservoirs
- Health: hospitals, emergency clinics, ambulance bases
- Transport: major intersections, public transport hubs

Tip:
Directive (EU) 2022/2557 divides critical infrastructure into eleven categories: Energy, Transport, Banking, Financial market infrastructure, Health, Drinking water, Waste water, Digital infrastructure, Public administration, Space, Production, processing and distribution of food

B1.2.4 CRITICAL INFRASTRUCTURE PROTECTION
CALCULATION STEP-BY-STEP

Step 2 – Evaluate protection system and the criteria

Assess whether each infrastructure asset has physical and operational protection measures in place.

Examples of flood protection:
- elevation
- barriers
- waterproof enclosures
- control systems (according to flood hazard)

Indicator : Protection level of critical infrastructure [Qualitative]

Benchmarks:
Critical value (1) = Not protected critical infrastructure
Optimal value (0) = Protected critical infrastructure

B1.2.5 BUILDING ELEVATION

Description:

This criterion assesses the extent to which buildings in the neighborhood 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.

Objective:

The goal is to determine how well the built environment is protected against flooding, reducing damage risks and enhancing long-term resilience.

Relevance:

Ensuring that buildings are elevated above flood levels is crucial for minimizing flood damage, protecting property, and safeguarding communities. This assessment supports urban planning, risk management, and climate adaptation strategies, helping cities build more resilient infrastructure.

B1.2.5 BUILDING ELEVATION

Indicator:

Share of buildings with elevated entrance openings above the level of a flood, which statistically occurs every 50 years [%]

Benchmarks: HIB

Critical value (1) = < 50%

Optimal value (0) = ≥ 90%

$$I = (B_{ele} / B_{total}) \times 100\%$$

B_{ele} = number of buildings with elevated entrance opening
B_{total} = total building stock within the assessed area

B1.2.5 BUILDING ELEVATION
CALCULATION STEP-BY-STEP

Step 1 – Determine the design flood elevation

Identify the design flood level for a 50-year return period. Extract flood elevation (MASL).
Data sources:
- flood hazard maps
- municipal flood management plans
- Hydrological or hydraulic models

Step 2 – Collect building-level elevation data
Find out the elevation of the lowest entrance or ground floor opening for each building in the neighborhood.
Data sources:
- municipal building databases
- urban planning or cadastral dataset with elevation dataset
- on-site survey
- LiDAR or drone survey

Note: Ensure all elevations are expressed in the same reference system (MASL) as the flood level data.

B1.2.5 BUILDING ELEVATION
CALCULATION STEP-BY-STEP

Step 3 - Determine compliance of each building

Compare the figure of each building to the 50-year flood level.

Step 4 - Calculate the indicator

Determine the proportion of compliant buildings by dividing their number by the total building stock within the assessed area.

Indicator : Share of buildings with elevated entrance openings above the level of a flood, which statistically occurs every 50 years [%]

EXAMPLE

$B_{ele} = 2$
B_{total} 3

$\rightarrow I = (2/\ 3) \times 100 = \mathbf{66{,}7\%}$

Building ID	Entrance Elevation (MASL)	50-year Flood Level (MASL)	Status
B1	182,3	181,9	Elevated
B2	181,7	181,9	Not elevated
B3	183,0	181,9	Elevated

B1.2.6 FLOOD-RESILIENT CONSTRUCTION

Description:

This criterion assesses the extent to which buildings in the neighborhood are equipped with construction materials or design features that improve resistance to water damage at flood-prone levels. The use of flood-resilient materials (e.g. waterproof finishes, sealed walls, raised utility systems) reduces repair costs and shortens recovery time after flooding.

Objective:

The goal is to determine how well buildings are protected against water damage, reducing repair costs and recovery time after flooding.

Relevance:

This assessment supports urban resilience planning, risk reduction, and climate adaptation strategies, helping cities build more durable and sustainable infrastructure.

B1.2.6 FLOOD-RESILIENT CONSTRUCTION

Indicator:

Share of buildings with flood-resilient materials at or below the design flood level [%]

Benchmarks: HIB

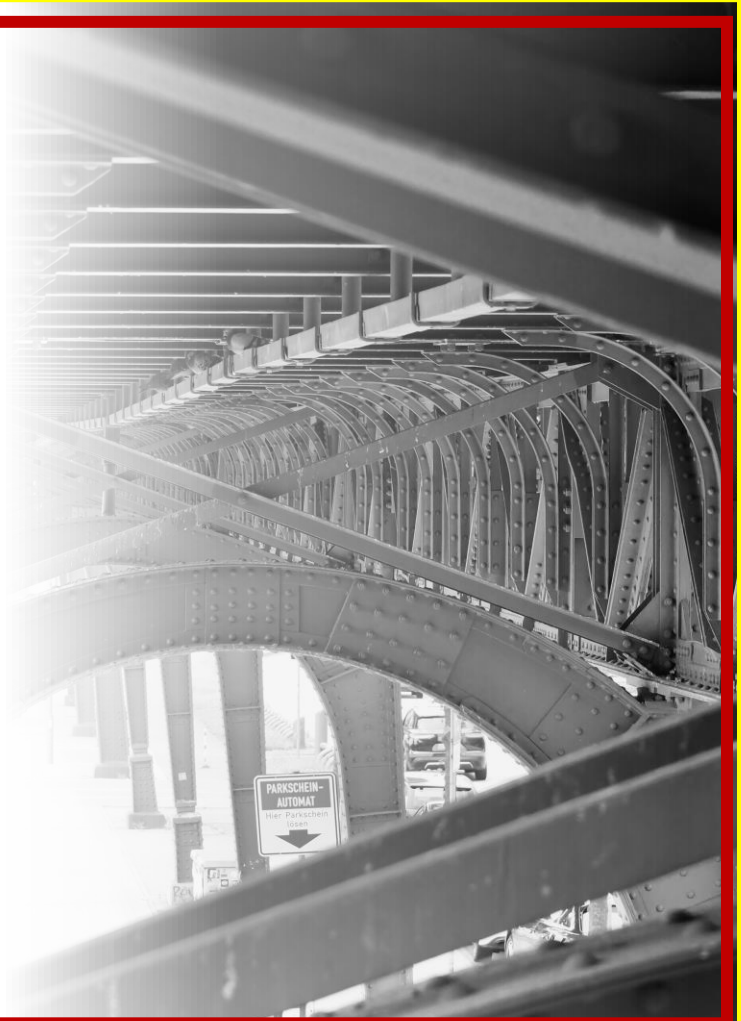
Critical value (1) = < 40%

Optimal value (0) = ≥ 80%

$$I = (B_{frm} / B_{total}) \times 100\%$$

B_{frm} = number of buildings with flood-resilient materials at or below the design flood level

B_{total} = total building stock within the assessed area



B1.2.6 FLOOD-RESILIENT CONSTRUCTION
CALCULATION STEP-BY-STEP

Step 1 – Identify the design flood-exposed building

Identify which buildings are located within the flood hazard zone or below the design flood level.

Data sources:

- flood hazard maps
- municipal flood management plans
- Hydrological or hydraulic models

B1.2.6 FLOOD-RESILIENT CONSTRUCTION
CALCULATION STEP-BY-STEP

Step 2 – Gather building information

Collect documentation and inspection data to determine if buildings include flood-resilient construction measures.

Data sources:
- municipal building and housing databases
- building permit documentation
- post-construction audits or inspection reports
- flood hazard zone mapson-site survey
- interviews with property owners or facility managers

Focus on:
- waterproofing and sealing at the ground level
- type of wall and floor materials
- protection of equipment and electrical installations

B1.2.6 FLOOD-RESILIENT CONSTRUCTION
CALCULATION STEP-BY-STEP

Step 3 – Define flood-resilient features

Identify buildings with flood-resilient features.

Examples:

- Waterproof materials: concrete, ceramics, special plasters
- Sealed walls and joints: use of water-resistant membranes or sealants
- Raised utility systems: sockets, electrical panels, boilers located above flood level
- Backflow preventers: to block sewer water ingress
- Easy-to-dry interiors: removable floor finishes, non-absorbent materials.

Tip:
Ensure the features respond to the hazard situation specific for the location as well as ensure the features are designed functionally and sufficiently.

B1.2.6 FLOOD-RESILIENT CONSTRUCTION
CALCULATION STEP-BY-STEP

Step 4 - Calculate the indicator

Compute the proportion of buildings with flood-resilient materials by dividing their number by the total building stock within the assessed area.

Indicator : Share of buildings with flood-resilient materials at or below the design flood level [%]

Formula:

$$I = (B_{frm} / B_{total}) \times 100\%$$

B_{frm} = number of buildings with flood-resilient materials at or below the design flood level

B_{total} = total building stock within the assessed area

Benchmarks:

Critical value (1) = < 40%

Optimal value (0) = ≥ 80%

EXAMPLE

Building ID	Flood-resilient materials	Status
B1	none	Not resilient
B2	Electricity above the flood level, spaces under the flood level well ventilated, easy to dry out	resilient
B3	none	Not resilient

B_{frm} = 1
B_{total} 3

→ I = (1/ 3) × 100 = **33,3%**

B1.2.7 ECOLOGICAL AND NATURAL COMPONENT

Description:

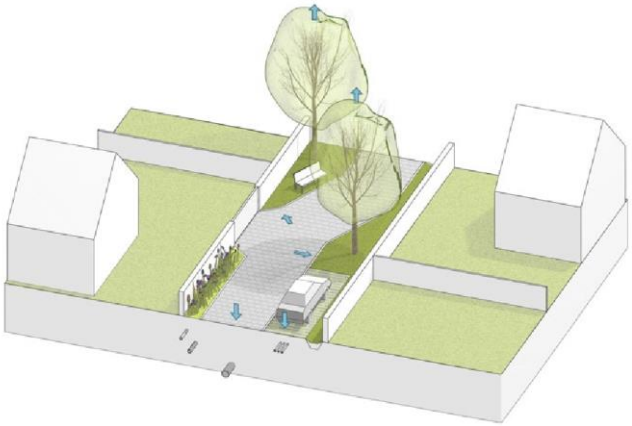
This criterion assesses the share of natural and semi-natural green areas within the neighborhood, including both public and private green spaces.

Objective:

A higher proportion of greenery supports local biodiversity, reduces urban heat, improves water retention and contributes to overall climate resilience.

Relevance:

This assessment helps planners and policymakers prioritize green infrastructure development, improving air quality, mitigating heat islands, and enhancing ecosystem services for healthier, more livable communities.



Source: Voda ve městě, 2022

B1.2.7 ECOLOGICAL AND NATURAL COMPONENT

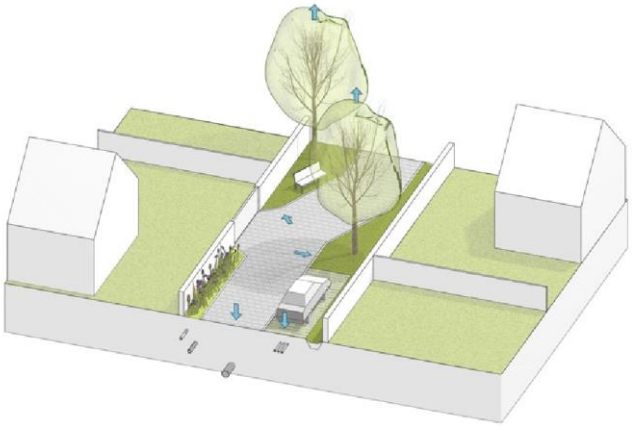
Indicator:

Share of public and private green space relative to total neighborhood area [%]

Benchmarks: HIB

Critical value (1) = < 25%

Optimal value (0) = ≥ 60%



$$I = (A_{gs} / A_{total}) \times 100\%$$

A_{gs} = area of public and private green space (m^2)
A_{total} = total site area (m^2)

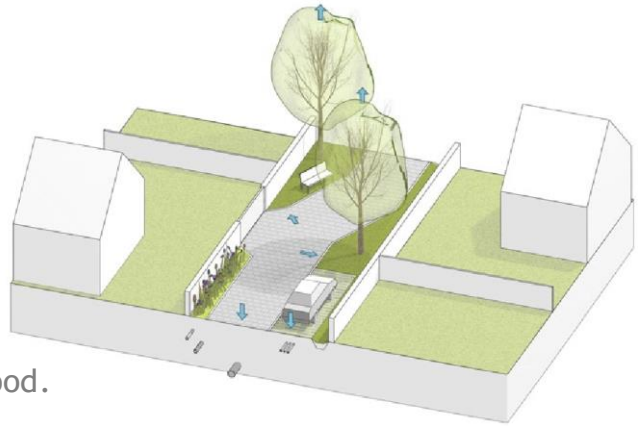
Source: Voda ve městě, 2022

B1.2.7 ECOLOGICAL AND NATURAL COMPONENT
CALCULATION STEP-BY-STEP

Step 1 – Gather all required input data

Collect all available data that describe vegetation and land use within the neighborhood boundary.

Data sources:
- GIS-based land use and vegetation layers
- as-built drawing or landscape design documentation
- municipal cadastral datasets
- on-site verification
- orthophoto



Step 2 – Identify vegetated areas

Identify all types of vegetated and natural surfaces within the neighborhood.

Example:
- Public green areas: parks, community gardens, tree belts
- Private green areas: backyards, courtyards, lawns
- Engineered greenery: green roofs, façades, vegetated swales
- Natural habitats: meadows, riverbanks, or forested areas

Source: Voda ve městě, 2022

B1.2.7 ECOLOGICAL AND NATURAL COMPONENT
CALCULATION STEP-BY-STEP

Step 3 - Measure the surface vegetated area

Define the neighborhood boundary. Use GIS tools, CAD drawings, or field surveys to measure the total area occupied by vegetated area.

Step 4 - Calculate the indicator

Compute the proportion of vegetated area by dividing the sum of all vegetated areas by the total site area.

Indicator: Share of public and private green space relative to total neighborhood area [%]

Formula:

$$I = A_{gs} / A_{total}) \times 100\%$$

A_{gs} = area of public and private green space (m^2)
A_{total} = total site area (m^2)

Benchmarks: HIB

Critical value (1) = < 25%

Optimal value (0) = ≥ 60%

EXAMPLE

Total area	**35 000 m²**
Green Space Type	**Area (m²)**
Public park	12 000
Private gardens	5 000
Street trees and grass strips	2 500
Green roofs	1 000
Total green area (A_green)	**20 500**

A_{gs} = 20 500 m^2
A_{total} = 35 000 m^2

→ I = (20 500 / 35 000) × 100 = **58,6%**

B1.2.9 CONTINUITY OF BLUE-GREEN INFRASTRUCTURE

Description:

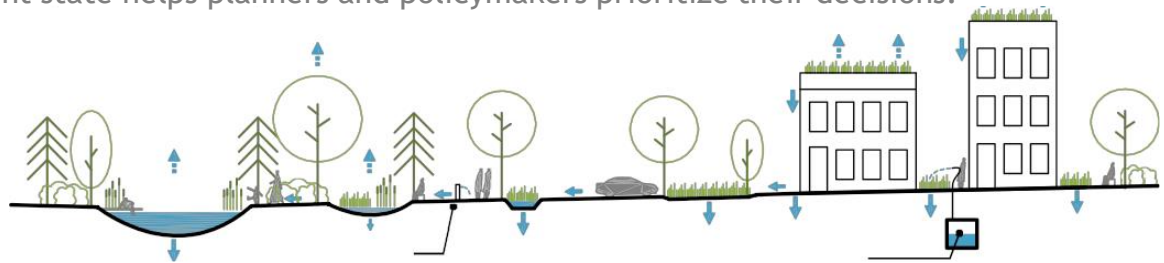
This criterion assesses the functional connectivity of green and water-related elements in the urban fabric. Continuous blue-green networks improve ecological stability, species migration, stormwater retention, and thermal comfort. Fragmentation or isolation of these elements reduces their performance and long-term climate resilience.

Objective:

To determine whether the blue-green infrastructure network in the neighborhood is functionally connected or fragmented. This involves mapping and analyzing green spaces, water bodies, and related features to assess their spatial and ecological linkages.

Relevance:

A well-connected blue-green infrastructure network is crucial for biodiversity conservation, climate adaptation, and urban livability. Mapping the current state helps planners and policymakers prioritize their decisions.



Source: Voda ve městě, 2022

B1.2.9 CONTINUITY OF BLUE-GREEN INFRASTRUCTURE

Indicator:

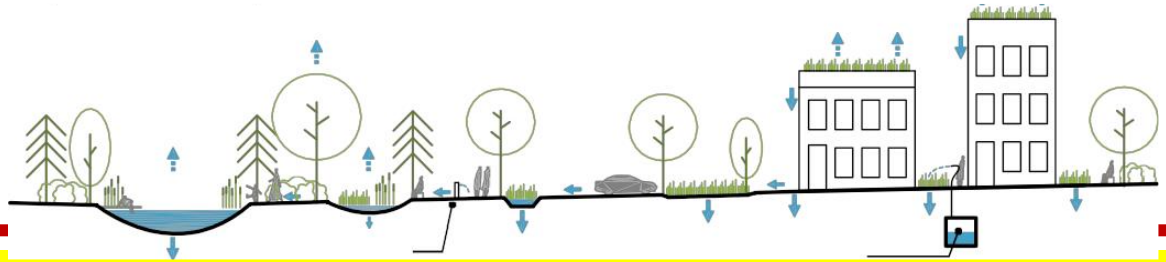
Functionality of blue-green infrastructure network[Qualitative]

Benchmarks: HIB

Critical value (1) = Non functional blue-green infrastructure

Optimal value (0) = Non functional blue-green infrastructure

Source: Voda ve městě, 2022



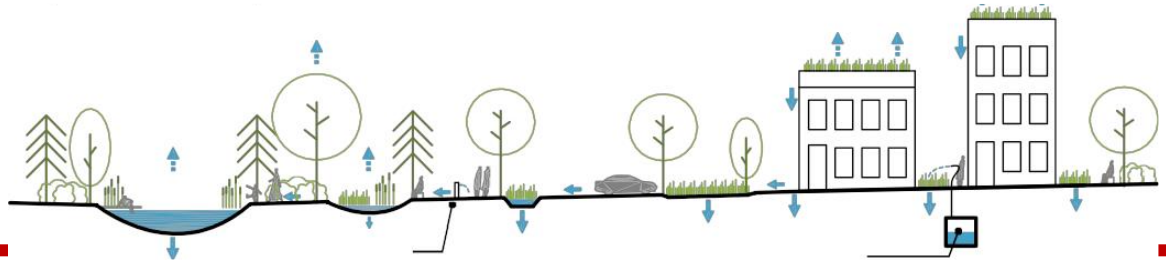
B1.2.9 CONTINUITY OF BLUE-GREEN INFRASTRUCTURE
CALCULATION STEP-BY-STEP

Step 1 – Gather data on green and water-related elements

Map all green and blue infrastructure components, including parks, corridors, streams, ponds, swales, green roofs, etc.

Data sources:
- GIS landscape and hydrological data
- orthophotos
- on-site surveys
- project documentation
- cadastral maps and land-use datasets
- green infrastructure or stormwater management plans

Step 2 – Analyze the functionality of blue-green infrastructure network
Analyze physical continuity and ecological connectivity using GIS or field assessment and Classify the network based on expert judgment as functional (continuous and linked) or not functional (isolated patches).



Source: Voda ve městě, 2022

B1.2.9 CONTINUITY OF BLUE-GREEN INFRASTRUCTURE
CALCULATION STEP-BY-STEP

Step 3 – Evaluate the indicator

Indicator:
Functionality of blue-green infrastructure network[Qualitative]

Benchmarks: HIB

Critical value (1) = Non functional blue-green infrastructure

Optimal value (0) = Non functional blue-green infrastructure

EXAMPLE

Rating	Description	Example
Complete system	Comprehensive emergency plans and functional warning systems covering all major hazards.	Municipal flood and heatwave plans with active SMS alerts.
Partial system	Plans or warning systems exist but lack full coverage or coordination.	Flood plan only; limited communication tools.
Absent system	No formal plans or functioning alert mechanisms.	No local emergency documentation or warning system.

B1.2.10 SOCIAL AND INSTITUTIONAL PREPAREDNESS

Description:

This criterion assesses the existence, coverage and operational readiness of crisis management tools and systems at neighborhood or municipal level. Comprehensive preparedness—including warning systems, emergency plans, and response protocols—is essential for minimizing harm during climate-related events such as floods, storms or heatwaves.

Objective:

The goal is to determine whether the neighborhood or municipality has comprehensive emergency preparedness measures.

Relevance:

Strong social and institutional preparedness is essential for reducing risks, ensuring rapid response, and protecting communities during climate disasters. Effective emergency planning and early warning systems save lives, minimize damage, and enhance overall climate resilience and public safety.

B1.2.10 SOCIAL AND INSTITUTIONAL PREPAREDNESS

Indicator:

Existence and completeness of emergency plans and early warning systems (e.g. sirens, SMS alerts, local coordination protocols) [Qualitative]

Benchmarks: HIB

Critical value (1) = Absence of completed emergency plans and early warning systems

Optimal value (0) = Existence of completed emergency plans and early warning systems

B1.2.10 SOCIAL AND INSTITUTIONAL PREPAREDNESS
CALCULATION STEP-BY-STEP

Step 1 – Collect information

Examine the formal existence and operational scope of emergency preparedness measures. Verify whether official emergency plans are available for the assessed area and whether they address climate-related hazards.

Data sources:
- municipal crisis management documentation
- local civil protection plans
- interviews with local authorities or emergency coordinators
- communication infrastructure inventory
- reports on public awareness and drills

Step 2 – Analyze the complexity and reliability of the preparedness measure

Key evaluation points:
- Is there a real-time warning system in place?
- Are alerts automatic or manually issued?
- Is communication inclusive and accessible to all residents?
- Is the functionality of measures checked regularly?

B1.2.10 SOCIAL AND INSTITUTIONAL PREPAREDNESS
CALCULATION STEP-BY-STEP

Step 3 – Evaluate the indicator

Determine the overall preparedness based on the findings from step 2.

Indicator:
Existence and completeness of emergency plans and early warning systems (e.g. sirens, SMS alerts, local coordination protocols) [Qualitative]

Benchmarks: HIB

Critical value (1) = Absence of completed emergency plans and early warning systems

Optimal value (0) = Existence of completed emergency plans and early warning systems

B1.2.11 EMERGENCY ACCESS

Description:

This criterion assesses the ability of emergency services to access critical areas during flood events. A sufficient share of roads above projected flood levels ensures continuous connectivity for rescue, evacuation and supply operations, and significantly reduces disaster response times.

Objective:

The goal is to determine what percentage of the road network in the neighborhood remains accessible during flooding (based on projected flood levels). This involves analyzing road elevations against flood hazard maps to identify critical access routes.

Relevance:

Ensuring emergency access during floods is crucial for public safety, rapid disaster response, and efficient evacuation. A well-maintained network of flood-resistant roads helps emergency services reach affected areas quickly, minimizing risks and improving resilience in flood-prone urban environments.

B1.2.11 EMERGENCY ACCESS

Indicator:

Share of roads above projected flood level [%]

Benchmarks: HIB

Critical value (1) = < 50%

Optimal value (0) = ≥ 85%

$$I = (L_{rele} / L_{total}) \times 100\%$$

L_{rele} = length of the roads placed above the flood level(km)
L_{total} = total length of the road network in the area(km)

B1.2.11 EMERGENCY ACCESS
CALCULATION STEP-BY-STEP

Step 1 – Collect information

Collect data on the road network and flood history.

Data sources:
- flood hazard maps
- road network GIS data
- digital terrain models or LiDAR datasets
- emergency planning maps or access route documentation

Step 2 – Determine the design flood elevation

Identify the design flood level for a 50-year return period. Extract flood elevation (MASL).

Data sources:
- flood hazard maps
- municipal flood management plans
- Hydrological or hydraulic models

B1.2.11 EMERGENCY ACCESS
CALCULATION STEP-BY-STEP

Step 3 - Determine compliance of a road

Compare the level of a road with the 50-year flood level.

Tip:
Use GIS or modeling tools, overaly road network geometry with flood elevation data.

Step 2 - Determine the indicator

Sum the length of all roads placed above the flood level. Divide this sum by the total length of the road network in the area.

Indicator:
Share of roads above projected flood level [%]

Formula: $I = (L_{rele} / L_{total}) \times 100\%$

L_{rele} = length of the roads placed above the flood level(km)
L_{total} = total length of the road network in the area(km)

EXAMPLE

Total road length		38 km
Road ID	part above flood level	km
X23	0,5 km - 12,4 km	11,9
X23	14,2 km - 15,8 km	1,6
X9	41,1 km - 53,2 km	12,1
	Total length above flood level	25,6

L_{rele} = 25,6 km
L_{total} = 38 m²

→ I = (25,6/38) × 100 = 67,4%

B1.2.12 AVAILABILITY OF OUTDOOR EMERGENCY MEETING POINTS

Description:

This criterion assesses the presence and location of designated outdoor meeting points for use during emergencies. For these places to be functional, they must remain accessible and safe during flood events. Their placement above projected flood levels ensures they can serve as effective evacuation or coordination zones in case of disasters.

Objective:

The goal is to determine what percentage of emergency assembly points in the neighborhood are situated above the design flood level. This involves mapping and analyzing their elevations against flood hazard data to confirm their usability during flooding.

Relevance:

Having accessible and safe emergency meeting points is critical for effective evacuation, coordination, and public safety during floods. Properly located assembly points reduce risks, improve disaster response, and enhance community resilience in flood-prone areas.

B1.2.12 AVAILABILITY OF OUTDOOR EMERGENCY MEETING POINTS

Indicator:

Share of emergency assembly points located above projected flood level

Benchmarks: HIB

Critical value (1) = 0%

Optimal value (0) = 100%

$$I = (P_{eme} / P_{total}) \times 100\%$$

P_{eme} = number of assembly points located above projected flood level
P_{total} = total number of assembly points in the neighbourhood

B1.2.12 AVAILABILITY OF OUTDOOR EMERGENCY MEETING POINTS

CALCULATION STEP-BY-STEP

Step 1 – Collect information

Collect data on all official outdoor emergency meeting points within the neighborhood.

Data sources:

- emergency planning documents
- evacuation route and signage plans
- digital terrain models or LiDAR
- flood hazard maps
- municipal civil protection datasets

Step 2 – Determine the design flood elevation

Identify the design flood level for a 50-year return period.
Extract flood elevation (MASL).

Data sources:

- flood hazard maps
- municipal flood management plans
- Hydrological or hydraulic models

B1.2.12 AVAILABILITY OF OUTDOOR EMERGENCY MEETING POINTS
CALCULATION STEP-BY-STEP

Step 3 - Determine compliance of a meeting point

Compare the level of an emergency assembly points to the 50-year flood level.

Step 4 - Determine the indicator

Determine the proportion of compliant emergency assembly points by dividing their number by the total number of emergency assembly points within the assessed area.

Indicator:
Share of emergency assembly points located above the projected flood level.

$$I = (P_{eme} / P_{total}) \times 100\%$$

P_{eme} = number of assembly points located above projected flood level
P_{total} = total number of assembly points in the neighbourhood

EXAMPLE

Meeting Point	Elevation (MASL)	Flood Level (MASL)	Status
Park A	183.4	182.0	Safe
School Yard B	181.7	182.0	Flood-prone
Square C	182.6	182.0	Safe

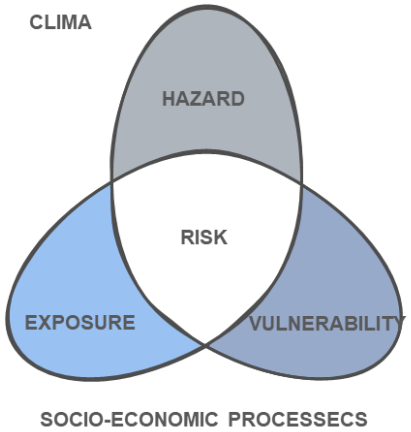
P_{eme} = 2
B_{total} 3

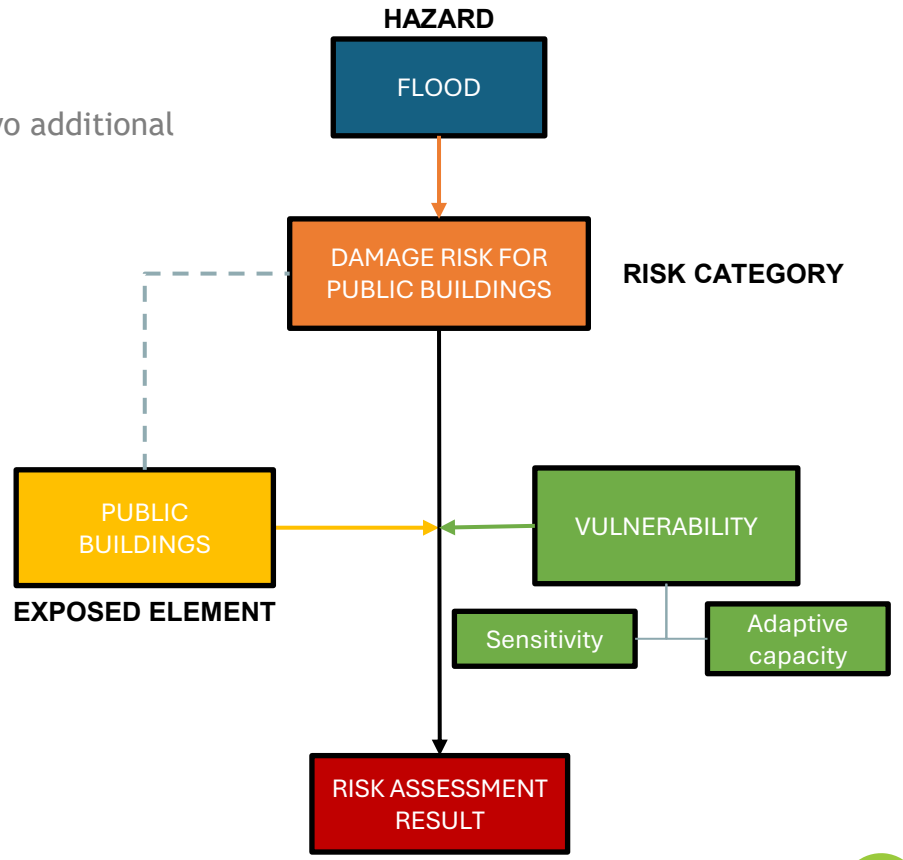
→ I = (2/ 3) × 100 = **66,7%**

EXPOSURE OF PUBLIC BUILDINGS

After assessing vulnerability, it is necessary to quantify two additional factors to determine the level of risk:

- **HAZARD**
- **EXPOSURE**





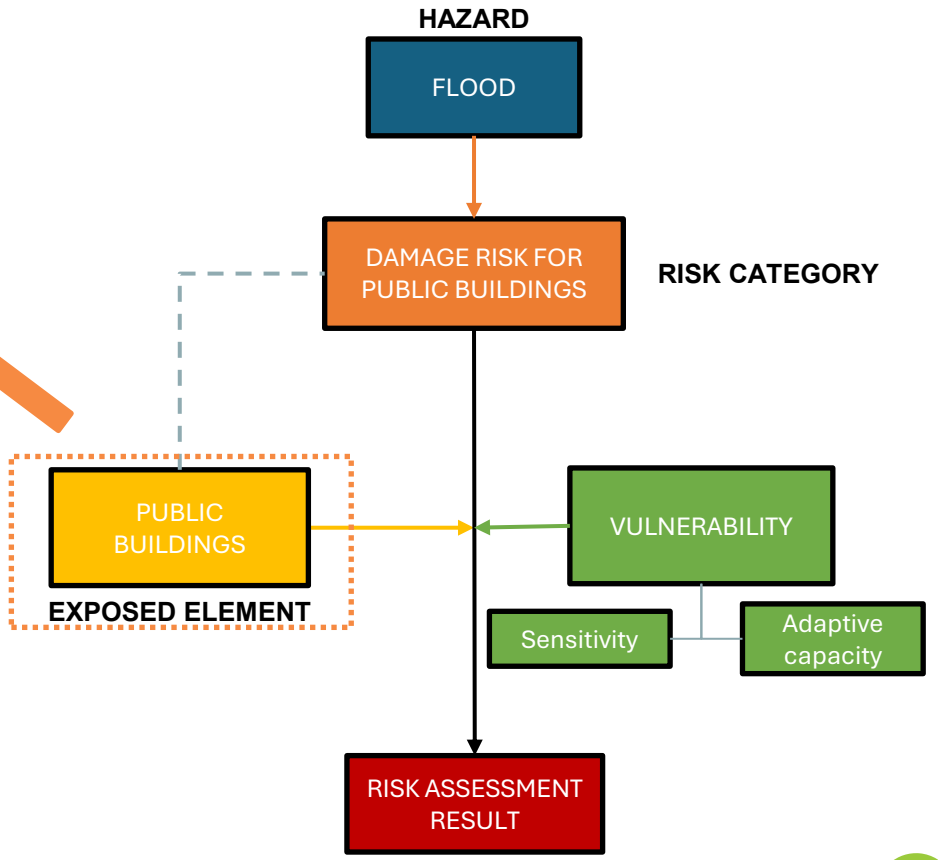
HAZARD LIKELIHOOD

Hazardous event		Slow-on set process		Hazard Value (HV)
Frequent	Likely to occur often in a life time (every 10 years)	Very likely	Very likely to occur in the next 10 years	1 - 0,9
Probable	Likely to occur several times in a lifetime (every 25 years)	Likely	Likely to occur in the next 10 years	0,89 - 0,66
Occasional	Likely to occur some times in a lifetime (every 50 years)	As likely as not	As likely as not to occur in the next 10 years	0,65 - 0,33
Remote	Unlikely but still possible to occur in a lifetime (every 100 years)	Unlikely	Unlikely to occur in the next 10 years	0,32 - 0

Hazard Value (HV) = This information is provided by SECAPs or by experts' judgment

EXPOSURE CRITERIA

CRITERION
Population Exposure
Population Density Exposure
Number of Buildings in flood zones
Building Density in Risk Zone
Hazard level for floods
Flood history
Flood Hazard Exposure
Proximity to Flood Source
Geomorphology of the area
Land Use in Risk Zone
Protective infrastructure
Social vulnerability
Community awareness and engagement



EXPOSURE ASSESSMENT

CRITERION	INDICATOR
Population Exposure	Number of people in flood-prone area
Population Density Exposure	People per square kilometre in flood-prone zones
Number of Buildings in flood zones	Count of buildings within mapped flood zones
Building Density in Risk Zone	Number of buildings per km^2
Hazard level for floods	Share of buildings in official flood hazard zone
Flood history	Number of flood events per decade or per 50 years
Flood Hazard Exposure	Flood depth during a design flood event
Proximity to Flood Source	Average distance to water source (e.g., river, coast, stream)
Geomorphology of the area	Slope gradient, soil type classification
Land Use in Risk Zone	Share of land classified for a development within hazard areas
Protective infrastructure	Type, length or area of protective structures (e.g., dikes, polders, dry basins)
Social vulnerability	Estimated share of vulnerable population
Community awareness and engagement	Frequency and reach of public workshops or drills

OVERALL EXPOSURE (EXPOSURE VALUE - EV)

CRITERION	Normalised value	Weight
Population Exposure	I_1	W_1
Population Density Exposure	I_2	W_2
Number of Buildings in flood zones	I_3	W_3
Building Density in Risk Zone	I_4	W_4
Hazard level for floods	I_5	W_5
Flood history	I_6	W_6
Flood Hazard Exposure	I_7	W_7
Proximity to Flood Source	I_8	W_8
Geomorphology of the area	I_9	W_9
Land Use in Risk Zone	I_{10}	W_{10}
Protective infrastructure	I_{11}	W_{11}
Social vulnerability	I_{12}	W_{12}
Community awareness and engagement	I_{13}	W_{13}

Normalised score Weight

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

Exposure Value (EV) = [0;1]

Critical value = 1

Optimal value = 0

B.1.2-E1 POPULATION EXPOSURE

Description:

The criterion assesses the number of residents living in flood-prone zones, indicating the level of human exposure in risk areas.

Objective:

To evaluate the degree of population vulnerability to flooding and identify areas where human presence intersects with flood risk zones. This supports risk mitigation and urban resilience planning.

Relevance:

Understanding the extent of population exposure to floods is essential for local adaptation strategies and disaster risk reduction. It aligns with the EU Floods Directive, ISO 14091 standards, and supports data-driven decision-making in municipal risk management.

UnSplash

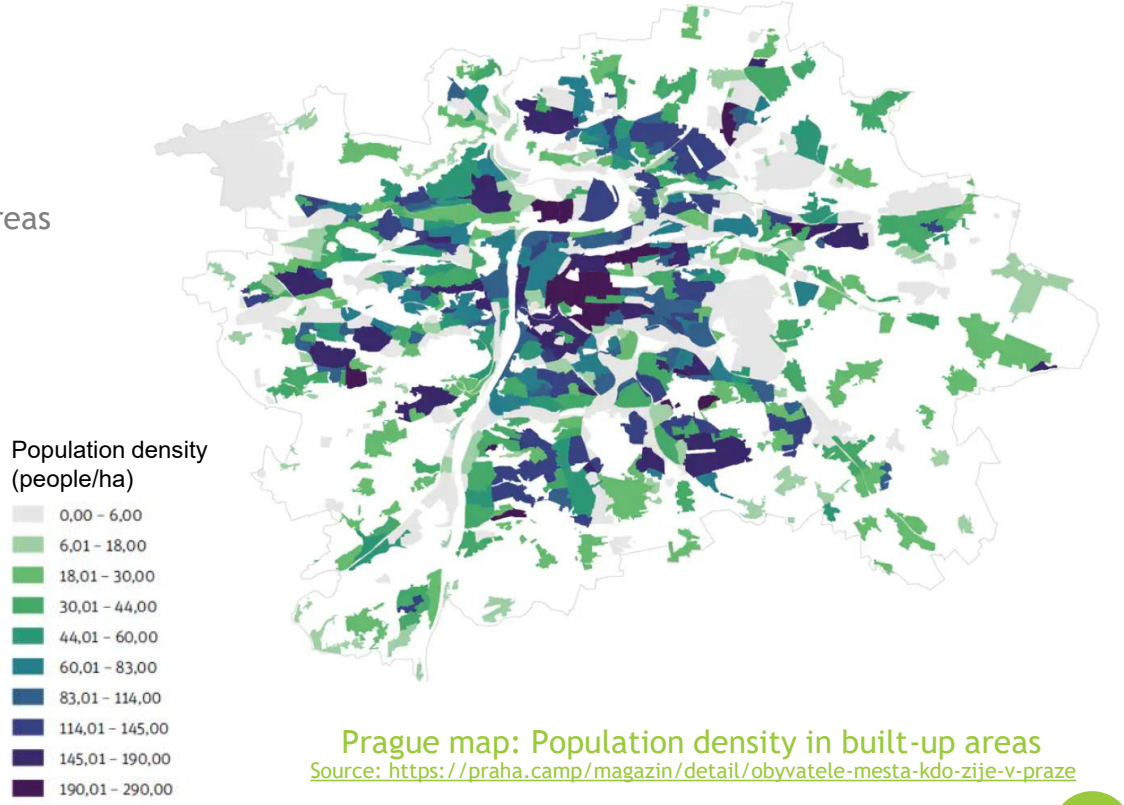
B.1.2-E1 POPULATION EXPOSURE

Indicator:

Number of people residing in flood-prone areas (number).

Benchmarks:

n/a



Prague map: Population density in built-up areas
Source: https://praha.camp/magazin/detail/obyvatele-mesta-kdo-zije-v-praze

B.1.2-E1 POPULATION EXPOSURE

Calculation:

To calculate the value of the indicator, flood hazard maps indicating flood-prone zones under different return periods (e.g., 100-year flood) are obtained and overlaid with population distribution or cadastral residential data in GIS. The number of residents located within flood-prone boundaries is identified. Optionally, results can be normalized by area for comparability between sites of different sizes.

Prague map: flood hazard map

Source: https://iprpraha.cz/stranka/59/zaplavova-uzemi

B.1.2-E1 POPULATION EXPOSURE
CALCULATION STEP-BY-STEP

- Obtain flood hazard maps for relevant return periods (e.g., 100-year flood).
- Overlay flood zones with population distribution or cadastral residential layers in GIS.
- Identify and count residents located within the flood-prone boundaries.

B.1.2-E2 POPULATION DENSITY EXPOSURE

Description:

The criterion assesses the density of people per square kilometre in flood-prone areas, reflecting how concentrated the potentially affected population is within risk zones.

Objective:

To quantify the population density within areas exposed to flood hazards in order to identify locations where large numbers of people could be simultaneously affected by flooding.

Relevance:

High population density in flood-prone areas amplifies potential human, social, and economic impacts during flood events. This indicator supports planning and prioritization of flood protection measures and urban resilience actions in accordance with European and international standards.

B.1.2-E2 POPULATION DENSITY EXPOSURE

Indicator:

Population density in flood-prone zones (people/km^2).

Benchmarks:

Critical value (1): > 1,000 people/km^2

Optimal value (0): 0

Calculation:

To calculate the value of the indicator, flood hazard maps are used to delineate the boundaries of flood-prone zones. Spatially resolved population data (from census blocks or registries) are then used to determine the number of residents within those zones. The total number of people is divided by the area (in km^2) of the flood-prone zone to obtain the population density.

B.1.2-E2 POPULATION DENSITY EXPOSURE
CALCULATION STEP-BY-STEP

- Use flood hazard maps to identify flood-prone boundaries.
- Obtain spatial population data (e.g., census blocks, residential registries).
- Sum the population located within the flood-prone zones.
- Divide the population count by the area (km^2) of the flood-prone zone to derive density.

EXAMPLE

Flood- pro zone	YES/NO	Yes
Population data	I [people]	10 000
Considered area	A [m2]	2 50
Population density exposure	E[people/m2]	E= 10 000/ 250 = 40

B.1.2-E3 NUMBER OF BUILDINGS IN FLOOD ZONES

Description:

The criterion assesses the number of buildings located within officially designated flood hazard zones, highlighting the physical assets that are directly exposed to flood risk.

Objective:

To quantify the extent of built infrastructure within flood-prone areas, supporting evaluation of potential material damages and prioritization of adaptation or protection measures.

Relevance:

The indicator reflects the spatial overlap between urban development and flood risk zones. Understanding the number of affected buildings is crucial for land-use planning, insurance risk assessments, and climate adaptation strategies consistent with the EU Floods Directive and ISO 14091 standards.

Prague: cadastral map

Source: https://sgi-nahlizenidokn.cuzk.gov.cz/marushka/default.aspx?themeid=3&MarWindowName=Marushka&MarQueryId=6D2BCEB5&MarQParam0=0&MarQParamCount=1

B.1.2-E3 NUMBER OF BUILDINGS IN FLOOD ZONES

Indicator:

Count of buildings within mapped flood zones (number).

Benchmarks: n/a

Critical value (1): -

Optimal value (0): -

Calculation:

To calculate the value of the indicator, official flood hazard maps are overlaid with cadastral or GIS-based building footprint data. The number of buildings intersecting with the flood-prone zones is counted. Results may optionally be normalized by area to enable comparison between different sites.

B.1.2-E3 NUMBER OF BUILDINGS IN FLOOD ZONES
CALCULATION STEP-BY-STEP

- Obtain official flood hazard zone maps based on national or regional flood modelling.
- Acquire geospatial building footprint data from cadastral or municipal GIS databases.
- Overlay building footprints with flood hazard zones in GIS.
- Count the number of buildings located fully or partially within the flood-prone boundaries.

B.1.2-E4 BUILDING DENSITY IN RISK ZONE

Description:

The criterion assesses the density of buildings located within flood-prone zones, expressing how concentrated the built environment is in areas vulnerable to flooding.

Objective:

To determine how intensively the flood hazard areas are developed, providing a basis for evaluating potential physical damage, exposure levels, and the efficiency of spatial planning in risk-prone zones.

Relevance:

High building density in flood-prone areas increases the likelihood of cumulative economic losses and disruptions to infrastructure. The indicator supports sustainable land-use planning, disaster prevention, and urban adaptation strategies that are aligned with the EU Floods Directive and the ISO 14091 framework.

Prague: Schwarzplan

Source: https://www.irozhlas.cz/zpravy-domov/stavby-mapa-obce-urbanismus-gebrian_1902140614_zlo?latlng=50.08614911280705|14.409355085478182|13.369582322945275

B.1.2-E4 BUILDING DENSITY IN RISK ZONE

Indicator:

Number of buildings per km^2 within flood-prone zones (buildings/km^2).

Benchmarks:

Critical value (1): > 50 buildings/km^2

Optimal value (0): 0 buildings/km^2

Calculation:

To calculate the value of the indicator, overlay building footprint data with the boundaries of flood hazard zones using GIS. Count the number of buildings located inside the risk areas and divide this value by the area (in km^2) of the flood zone to obtain the density.

B.1.2-E4 BUILDING DENSITY IN RISK ZONE
CALCULATION STEP-BY-STEP

- Obtain flood hazard maps identifying the extent of flood-prone zones.
- Collect up-to-date building footprint data from cadastral or GIS databases.
- Use GIS tools to overlay building footprints with flood hazard zone boundaries.
- Count all buildings located fully or partially within the flood-prone area.
- Divide the total number of buildings by the area (km^2) of the flood zone to derive the building density.

B.1.2-E5 HAZARD LEVEL FOR FLOODS

Description:

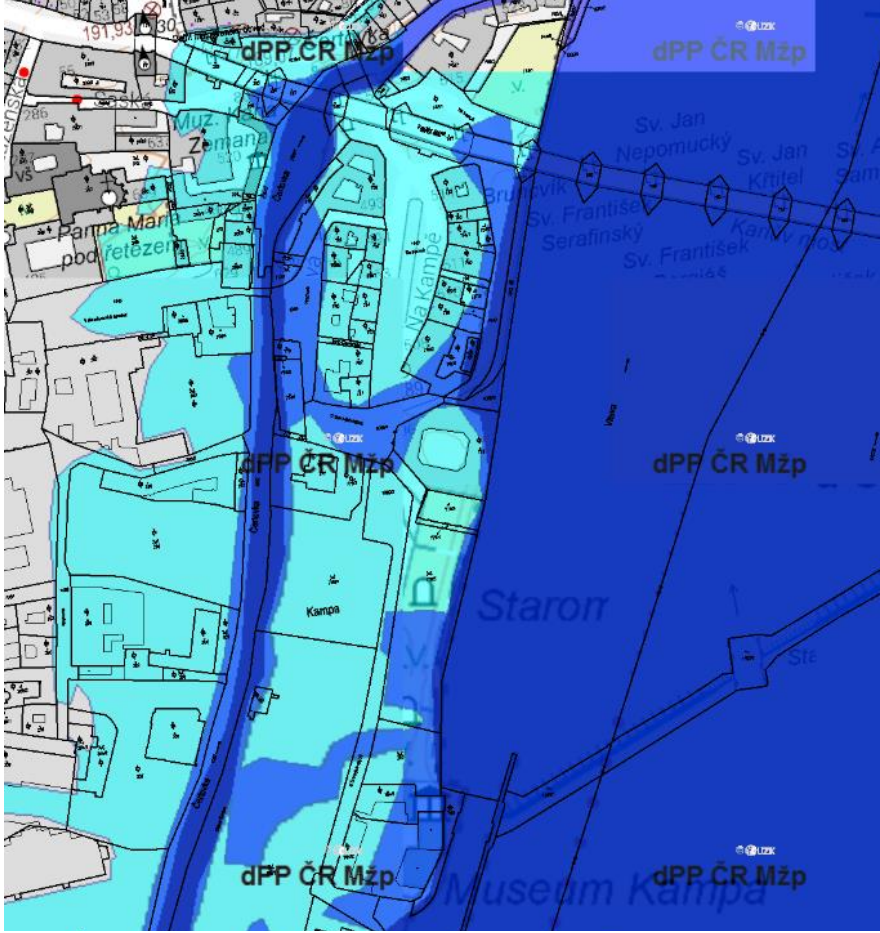
The criterion assesses the classification of neighbourhood or district flood hazard levels based on the frequency and probability of flood occurrence. It reflects how exposed built areas are to varying degrees of flood risk.

Objective:

To determine the relative hazard level of the assessed area by identifying how many buildings are located within different flood frequency zones, providing a basis for flood risk management and spatial planning.

Relevance:

Flood hazard level assessment is fundamental for urban resilience planning and flood risk reduction. It supports prioritization of protective infrastructure, insurance policies, and adaptation actions, aligning with EU Flood Risk Management Plans, ISO 14091, and the EEA Urban Adaptation Support Tool.



Prague: Flood map

Source: https://ikatastr.cz/#kde=50.085208,14.408322,17&mapa=geograficka&vrstvy=zaplavy100
plavy5,parcelybudovy,cislabudov

B.1.2-E5 HAZARD LEVEL FOR FLOODS

Indicator:

Share of buildings located in official flood hazard zones, classified by flood frequency:

- Active flood zone – frequent flooding (10–50 years return period)
- Very high – danger of flooding between 10–50 years
- Medium – danger of flooding between 51–100 years
- Low – danger of flooding between 101–500 years
- Less often or no danger – flooding less frequent or negligible

Benchmarks:

Critical value (1): Majority of buildings located in active or very high flood hazard zones with frequent flooding expected.

Optimal value (0): No buildings located in active or very high flood hazard zones; majority of buildings in low or no-risk zones.

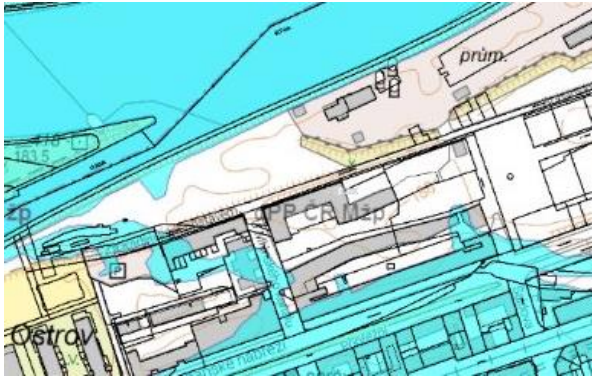
B.1.2-E5 HAZARD LEVEL FOR FLOODS

Calculation:

The indicator is based on a qualitative classification derived from spatial overlap between flood hazard zones and building locations. The share of buildings in each flood frequency category is summarized, and an overall hazard level for the neighborhood is assigned.

EXAMPLE - Prague: Floodmap

Source: https://ikatastr.cz/#kde=50.085208,14.408322,17&mapa=geografickа&vrstvy=zaplavy100,zaplavy20,zaplavy5,parcelybudovy,cislabudov



5-year flood

20-year flood

100-year flood

B.1.2-E5 HAZARD LEVEL FOR FLOODS
CALCULATION STEP-BY-STEP

- Obtain official flood hazard maps that define flood zones by return period (e.g., 50, 100, and 500 years).
- Acquire geospatial building footprint data from municipal or cadastral databases.
- Overlay building footprints with flood zone boundaries in GIS.
- Classify buildings according to the flood frequency zone they fall into.
- Calculate the share of buildings in each category and determine the overall hazard level (qualitative classification).

B.1.2-E6 FLOOD HISTORY

Description:

The criterion assesses the historical frequency of significant flood events in the area, reflecting long-term exposure, accumulated risk, and the recurrence of flood impacts over time.

Objective:

To evaluate the history of flooding in the assessed area in order to understand recurring vulnerabilities and inform future prevention, land-use planning, and adaptation strategies.

Relevance:

Historical flood frequency provides valuable insight into local risk trends and climate-related exposure. It supports data-driven resilience planning, helps identify areas of persistent vulnerability, and aligns with ISO 14091, the EEA Urban Adaptation Support Tool, and the UNDRR Sendai Framework.

B.1.2-E6 FLOOD HISTORY

Indicator:

Number of flood events per decade or per 50-year period (count).

Benchmarks:

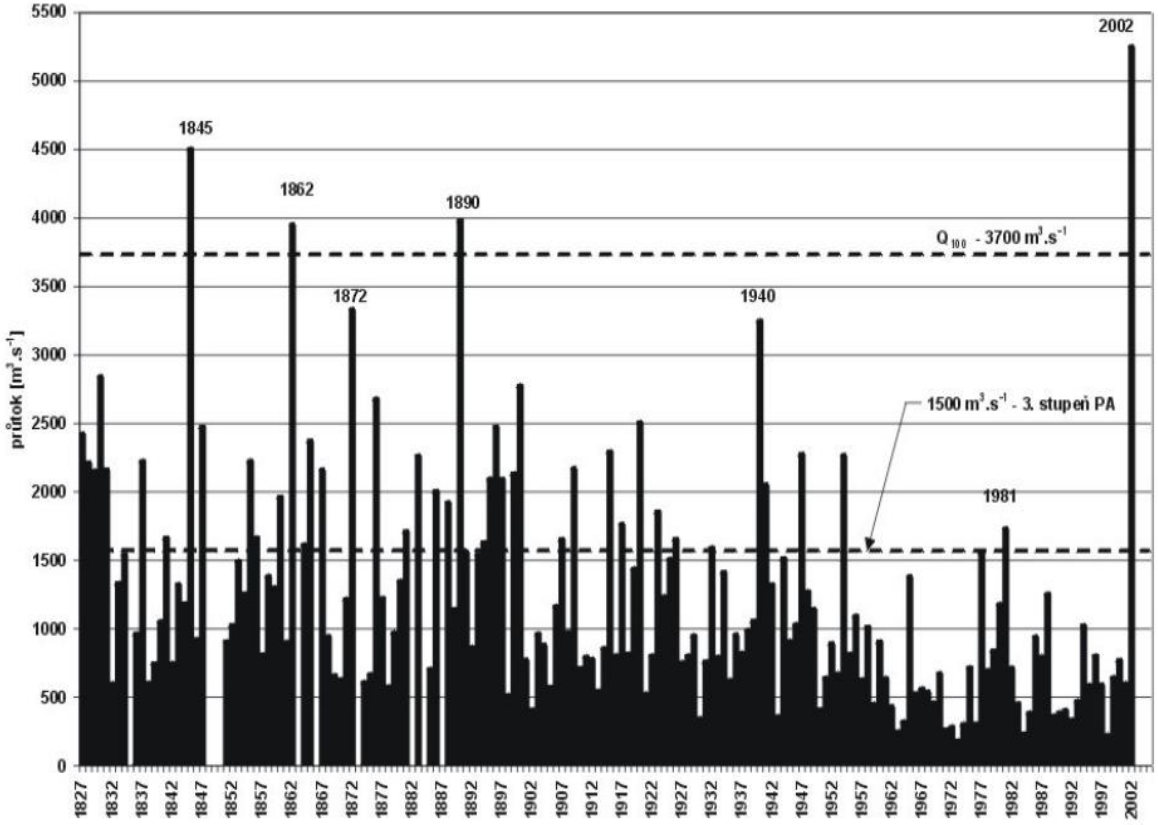
Critical value (1): > 2 flood events per reference period

Optimal value (0): 0 flood events

Calculation:

Collect and verify historical data on flood events from official records, archives, and national or municipal databases. Count the number of significant flood occurrences within or near the assessed area and normalize the result by a defined time interval (e.g., per decade or 50 years).

EXAMPLE - Prague: Major Floods between 1827-2002



Source: https://bezpecnost.praha.eu/clanky/povodne

B.1.2-E6 FLOOD HISTORY
CALCULATION STEP-BY-STEP

- Gather historical records of flood events from national disaster databases, municipal archives, or civil protection sources.
- Identify events that affected the area within the chosen time frame (e.g., past 50 years).
- Verify flood events based on documented impacts (damages, evacuations, or official reporting).
- Count the total number of relevant flood events.
- Normalize the result over a consistent time basis (e.g., per decade or per 50-year period) for cross-location comparability.

B.1.2-E7 FLOOD HAZARD EXPOSURE

Description:

The criterion assesses the degree of physical exposure to floodwaters by measuring the expected flood depth in a defined design flood scenario. It represents the potential inundation level that could affect buildings, infrastructure, and people.

Objective:

To determine the depth of flooding expected under a standardized design flood event (e.g., 100-year flood) and use this as a proxy for assessing local flood hazard severity and resilience requirements.

Relevance:

Flood depth is a key determinant of potential damage to assets, safety of residents, and effectiveness of flood protection measures. This indicator supports flood risk mapping, spatial planning, and climate adaptation policies in line with the EU Floods Directive and ISO 14091 framework.

B.1.2-E7 FLOOD HAZARD EXPOSURE

Indicator:

Flood depth during a design flood event (m).

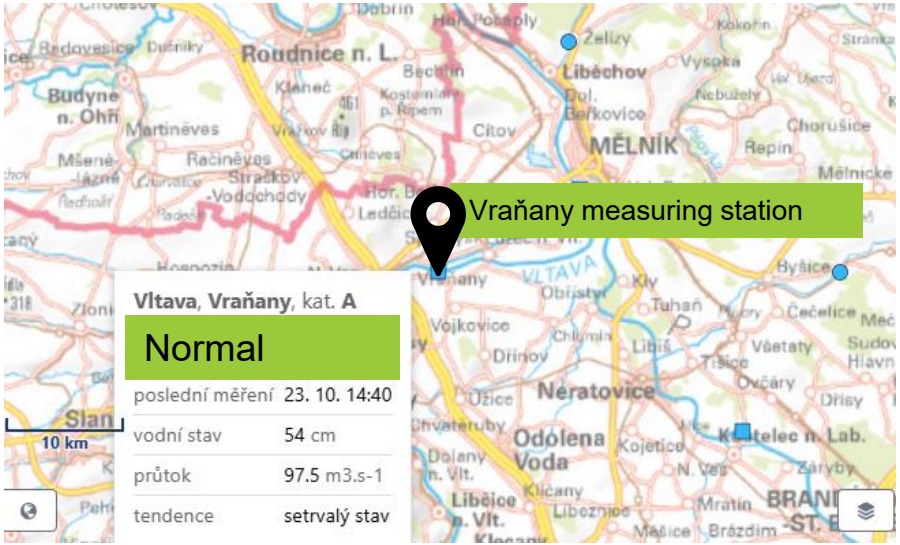
Benchmarks:

Critical value (1): > 1.0 m

Optimal value (0): ≤ 0.3 m

Calculation:

To calculate the value of the indicator, use hydraulic or hydrodynamic modeling results or official flood hazard maps to determine the expected flood depth for the target area under the design flood scenario. The average or maximum flood depth is then derived, depending on planning needs and risk tolerance.



Limits for flood activity levels	
Flood activity stage	Water level
Drought	10 cm
Level 1 Flood activity (Alertness)	370 cm
Level 2 Flood activity (Readiness)	510 cm
Level 3 Flood activity (Danger)	610 cm
Level 3 Flood activity (Extreme Flood)	787 cm

B.1.2-E7 FLOOD HAZARD EXPOSURE
CALCULATION STEP-BY-STEP

- Obtain flood hazard maps or hydraulic model outputs for the selected design flood (e.g., 100-year flood).
- Extract flood depth values for the assessed neighborhood or parcels from spatial datasets.
- Compute either the average or maximum depth within the area of interest.
- Visualize the distribution of flood depth zones using GIS for further analysis and communication.

B.1.2-E8 PROXIMITY TO FLOOD SOURCE

Description:

The criterion assesses the average distance between buildings or population centres and the nearest flood source, such as rivers, streams, or coastal zones. It provides an estimate of the potential exposure to flooding based on spatial proximity.

Objective:

To evaluate how close urban structures and populations are to potential flood sources, offering insight into exposure levels and the need for protective infrastructure or buffer zones.

Relevance:

Proximity to flood sources significantly affects the likelihood and severity of flood impacts. This indicator supports flood risk mapping, urban zoning, and the design of green or nature-based buffers, consistent with ISO 14091 and the EEA Urban Adaptation Support Tool.

B.1.2-E8 PROXIMITY TO FLOOD SOURCE

Indicator:

Average distance to the nearest water source (m).

Benchmarks:

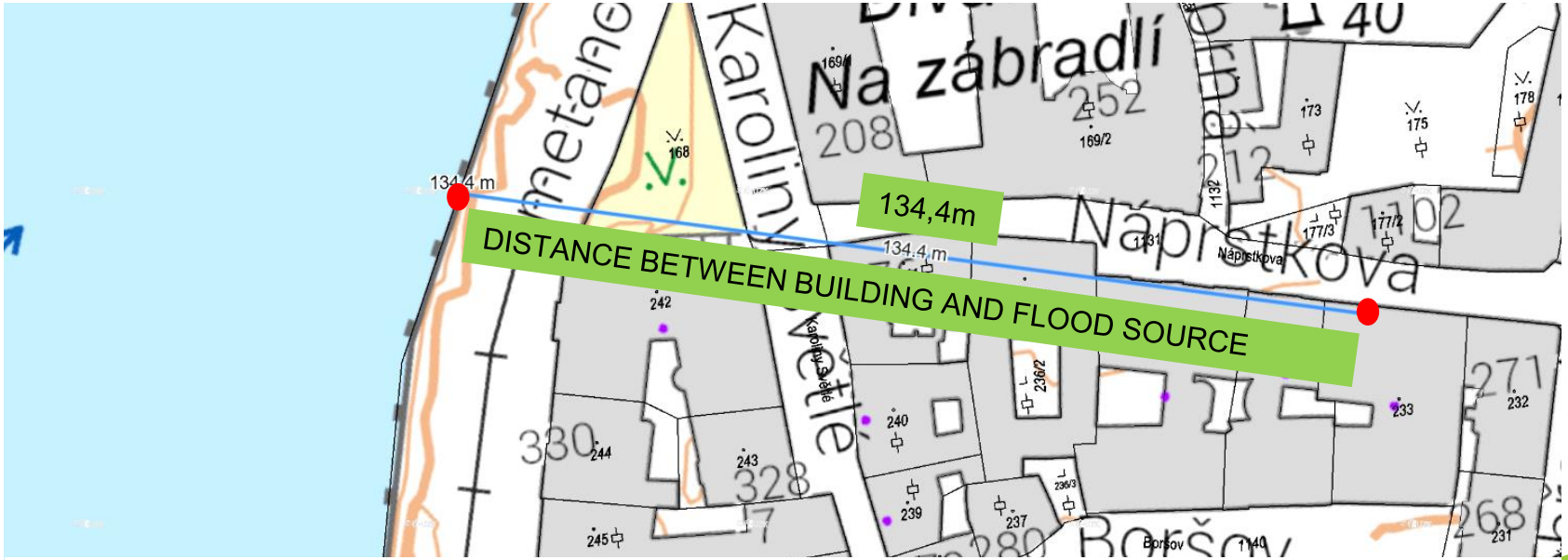
Critical value (1): > 500 m

Optimal value (0):< 100 m

B.1.2-E8 PROXIMITY TO FLOOD SOURCE

Calculation:

To calculate the value of the indicator, determine the average Euclidean distance between buildings (or population centroids) and the nearest flood source using GIS spatial analysis tools.



Source: https://ikatastr.cz/#kde=50.085208,14.408322,17&mapa=geograficka&vrstvy=zaplavy100,zaplavy20,zaplavy5,parcelybudovy,cislabudov

B.1.2-E8 PROXIMITY TO FLOOD SOURCE
CALCULATION STEP-BY-STEP

- Identify and map primary flood sources such as rivers, streams, and coastal boundaries using hydrological or GIS datasets.
- Map the centroids of buildings or population blocks in the assessed area.
- Use GIS to calculate the Euclidean distance from each centroid to the nearest flood source.
- Compute the average distance across the entire neighborhood or study area.

B.1.2-E9 GEOMORPHOLOGY OF THE AREA

Description:

The criterion assesses the geomorphological characteristics of the area—such as slope gradient and soil type—which determine flood pathways, runoff behavior, and water infiltration capacity.

Objective:

To evaluate how terrain morphology and soil composition influence flood dynamics, infiltration potential, and erosion risks within the assessed area.

Relevance:

Geomorphological conditions strongly affect local hydrology and flood susceptibility. Understanding slope and soil characteristics supports sustainable urban drainage, soil conservation, and adaptation strategies consistent with ISO 14091 and the European Soil Data Centre (ESDAC).

Source: https://content.satimagingcorp.com/static/galleryimages/Pleiades-1A-2M-DEM-Dubai_International-Airport.jpg

B.1.2-E9 GEOMORPHOLOGY OF THE AREA

Indicator:

Slope gradient, soil type classification

Benchmarks:

Critical value (1): Steep slopes combined with impermeable or compacted soils (e.g., clay); high runoff risk and erosion susceptibility

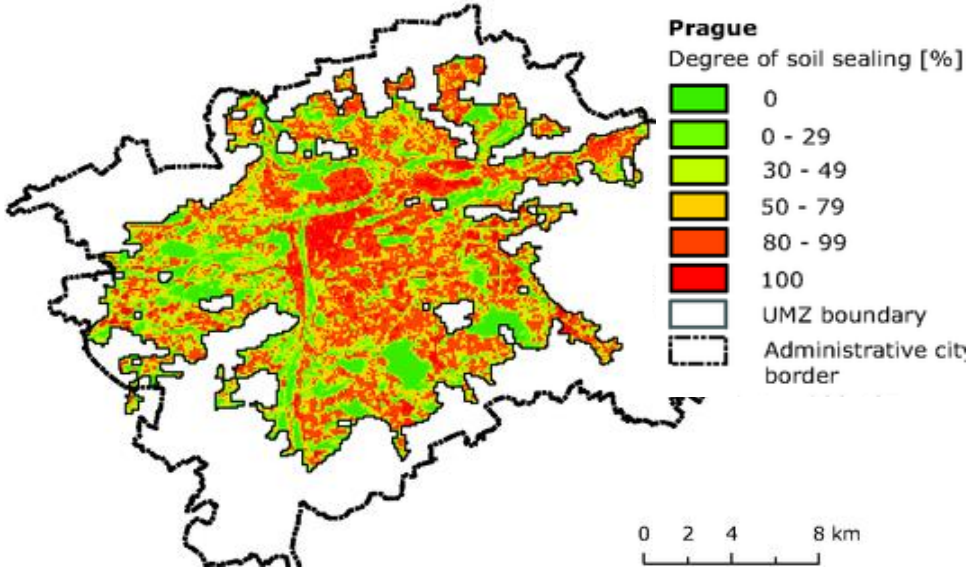
Optimal value (0): Flat to gently sloping terrain with permeable, well-draining soils (e.g., sandy loam); low runoff potential and high infiltration

Source: https://content.satimagingcorp.com/static/galleryimages/Pleiades-1A-2M-DEM-Dubai_International-Airport.jpg

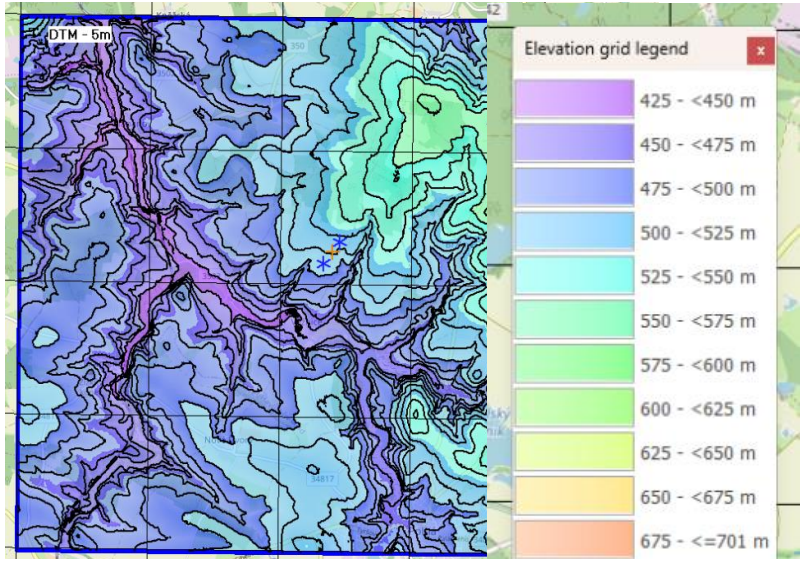
B.1.2-E9 GEOMORPHOLOGY OF THE AREA

Calculation:

To calculate the value of the indicator, analyze digital elevation models (DEMs) and soil data to classify terrain slope and soil permeability. The combination of slope gradient and soil hydrological class determines the overall runoff potential and flood susceptibility of the area.



Source: https://www.eea.europa.eu/data-and-maps/figures/soil-sealing-in-the-capitals/prague-eps-file/image_large



Source: https://help.emd.dk/mediawiki/images/1/1e/20240110_CzechRepublic_DTM-5m-20m.png

B.1.2-E9 GEOMORPHOLOGY OF THE AREA
CALCULATION STEP-BY-STEP

- Use digital elevation models (e.g., Copernicus EU-DEM, SRTM) to calculate slope gradients across the study area.
- Classify slope categories (e.g., flat: 0–5%, moderate: 6–15%, steep: >15%).
- Obtain soil type maps and identify hydrological soil groups (A–D) based on permeability.
- Combine slope and soil data in GIS to determine runoff potential and infiltration capacity.
- Interpret the geomorphological classification qualitatively (low, medium, high runoff risk).

B.1.2-E10 LAND USE IN RISK ZONE

Description:

The criterion assesses the proportion of developed or developable land located within flood-prone zones, illustrating how urbanisation contributes to exposure and potential flood impacts.

Objective:

To quantify how much of the area at risk of flooding is already occupied or designated for development, supporting informed spatial planning and sustainable urban growth management.

Relevance:

High levels of development in flood-prone zones increase potential damage, service disruption, and recovery costs during floods. This indicator supports land-use policies and resilience strategies aligned with the EU Floods Directive, ISO 14091, and the UNDRR Land Use Planning Guidelines for Disaster Risk Reduction.

Source: https://iprpraha.cz/stranka/3866/a-new-neighbourhood-to-rise-up-next-to-karlin-will-have-one-of-the-biggest-parks-in-prague-an-exhibition-at-camp-reveals-the-future-for-rohan-island

B.1.2-E10 LAND USE IN RISK ZONE

Indicator:

Share of land classified for development within hazard areas (%).

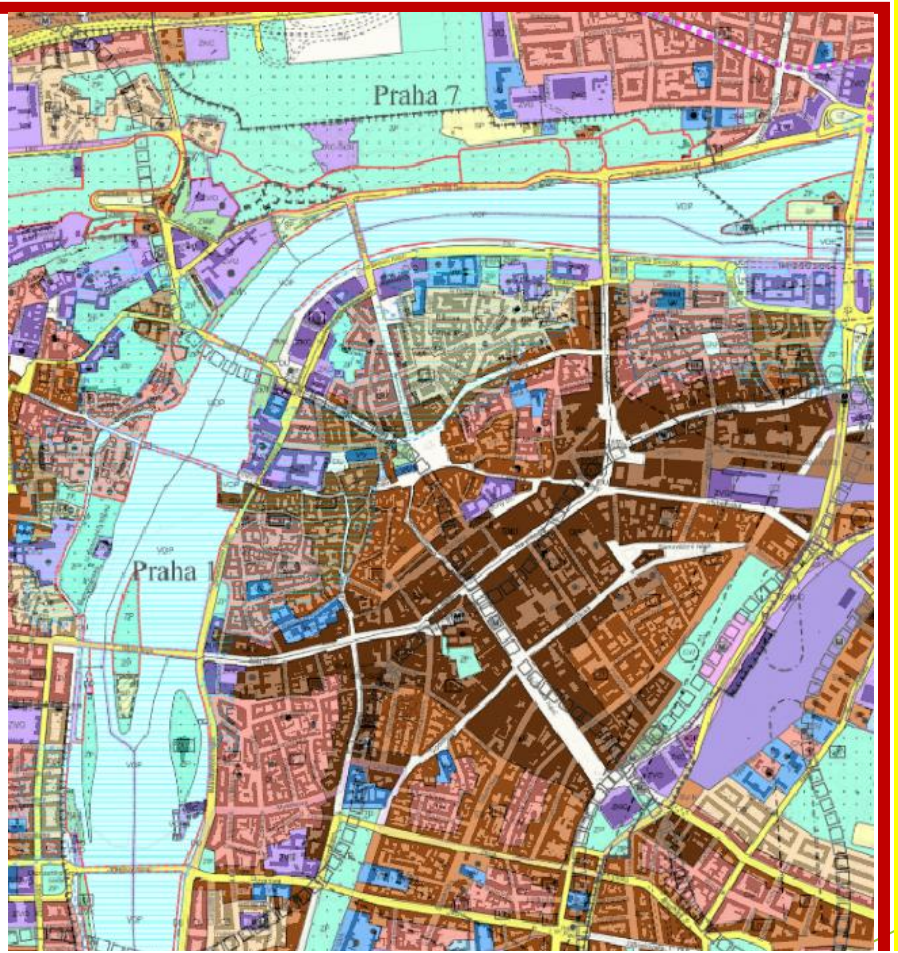
Benchmarks:

Critical value (1): > 20%

Optimal value (0): 0%

Calculation:

To calculate the value of the indicator, overlay land use or zoning maps with official flood hazard maps using GIS tools. Determine the portion of land classified as developed or developable within flood-prone zones and express it as a percentage of the total area.



EXAMPLE - Prague: Land use plan drawings

Source: https://app.iprpraha.cz/apl/app/vykresyUP/

B.1.2-E10 LAND USE IN RISK ZONE
CALCULATION STEP-BY-STEP

- Obtain official flood hazard maps defining flood-prone zones.
- Acquire up-to-date land use or zoning maps showing areas classified for development.
- Overlay land use layers with flood hazard zones in GIS.
- Calculate the total area designated as built-up or developable within flood-prone zones.
- Divide this value by the total land area of the neighborhood (or the flood-prone section) and multiply by 100 to obtain the percentage share.

B.1.2-E11 PROTECTIVE INFRASTRUCTURE

Description:

The criterion assesses the presence, type, and quality of structural flood protection measures, such as levees, dikes, retention basins, and other engineered systems designed to mitigate flood impacts.

Objective:

To evaluate the extent and effectiveness of existing structural flood defense systems protecting the assessed area, identifying both coverage and potential protection gaps.

Relevance:

The existence and maintenance quality of flood protection infrastructure significantly influence the level of flood resilience in urban areas. This indicator supports flood risk management and adaptation strategies in line with the EU Floods Directive, ISO 14091, and UNDRR flood risk reduction frameworks.

Source: https://cs.wikipedia.org/wiki/Polder_%28n%C3%A1dr%C5%BE%29

B.1.2-E11 PROTECTIVE INFRASTRUCTURE

Indicator:

Type, length, or area of protective structures (e.g., dikes, polders, retention basins) (m^2).

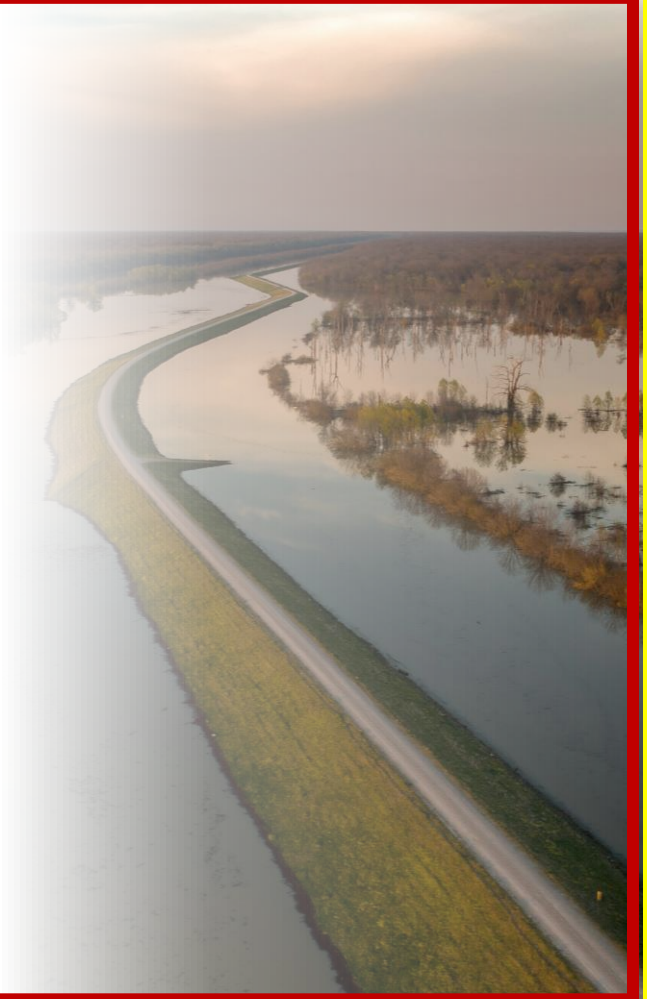
Benchmarks:

Critical value (1): < 3,000 m^2

Optimal value (0): > 10,000 m^2

Calculation:

To calculate the value of the indicator, identify all structural flood protection elements within or adjacent to the study area, measure their spatial extent or coverage, and assess their functional condition using engineering or GIS data.



B.1.2-E11 PROTECTIVE INFRASTRUCTURE
CALCULATION STEP-BY-STEP

- Inventory all relevant flood protection structures (e.g., levees, dikes, retention or dry basins).
- Use GIS data or engineering documentation to measure the protected area or length of infrastructure.
- Review engineering reports or inspection data to evaluate structural type, condition, and design capacity.
- Map the spatial distribution of protective measures and identify any unprotected or residual-risk zones.

B.1.2-E12 SOCIAL VULNERABILITY

Description:

The criterion assesses the share of socially vulnerable groups—such as the elderly, low-income households, and people with disabilities—who are likely to be disproportionately affected by flood events due to limited adaptive capacity or mobility.

Objective:

To evaluate the extent of social vulnerability within the community, identifying population groups that may require targeted support during flood preparedness, response, and recovery efforts.

Relevance:

Flood impacts are not distributed evenly across populations. Understanding the concentration of socially vulnerable groups supports equitable adaptation planning, risk communication, and the prioritization of protective measures in line with the Sendai Framework, ISO 14091, and the EEA Urban Adaptation Support Tool.

B.1.2-E12 SOCIAL VULNERABILITY

Indicator:

Estimated share of socially vulnerable population (%).

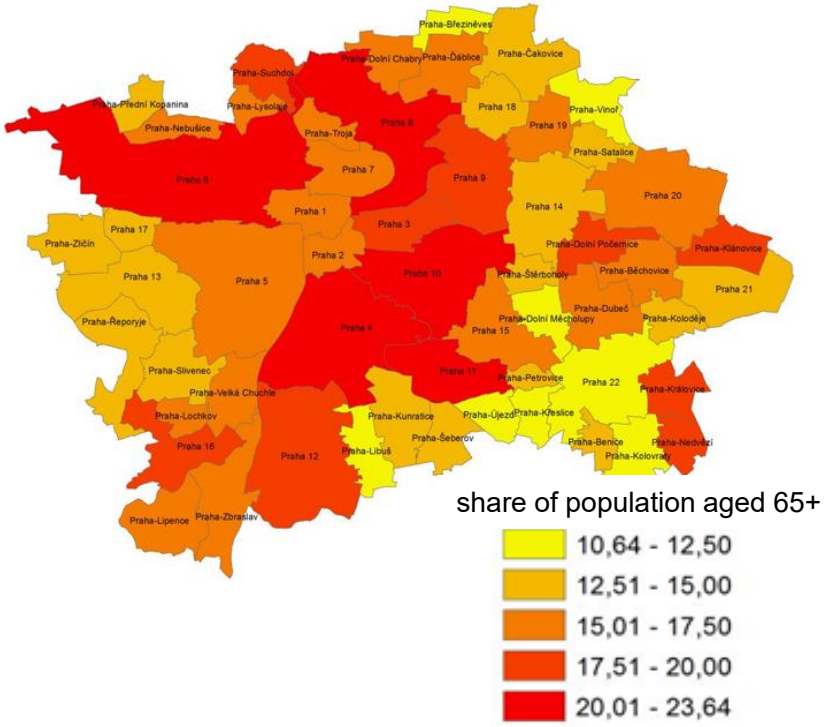
Benchmarks:

Critical value (1): > 30%

Optimal value (0): 10%

Calculation:

To calculate the value of the indicator, collect disaggregated demographic and socioeconomic data to identify the share of residents belonging to defined vulnerability categories. The total number of vulnerable individuals is divided by the total population and expressed as a percentage.



Source: https://share.google/images/7eZQJEXFXgnuwMHfU

B.1.2-E12 SOCIAL VULNERABILITY
CALCULATION STEP-BY-STEP

- Gather demographic and socioeconomic data at the neighborhood or census-block level.
- Define vulnerability categories (e.g., people aged 65+, persons with disabilities, low-income households below the poverty line).
- Count the number of individuals within these categories.
- Divide the total number of vulnerable individuals by the overall population.
- Multiply by 100 to express the result as a percentage.

B.1.2-E13 COMMUNITY AWARENESS & ENGAGEMENT

Description:

The criterion assesses the level of community awareness and engagement in flood preparedness through activities such as public education, awareness campaigns, and participation in flood drills or training exercises.

Objective:

To measure how actively local communities are informed and involved in flood preparedness initiatives, ensuring that residents understand risks and are capable of responding effectively in emergency situations.

Relevance:

Public awareness and engagement are key components of disaster risk reduction and climate resilience. Frequent and inclusive communication builds social preparedness and supports community self-reliance, in line with ISO 22395, ISO 14091, and UNDRR guidance on public education for disaster risk reduction.

B.1.2-E13 COMMUNITY AWARENESS AND ENGAGEMENT

Indicator:

Frequency and reach of public workshops or drills (events/year).

Benchmarks:

Critical value (1): 0 events/year

Optimal value (0): ≥ 4 events/year

Calculation:

To calculate the value of the indicator, review official records of public education activities, training exercises, and awareness campaigns conducted by municipal authorities, NGOs, or civil protection services, and determine their frequency and inclusiveness.

B.1.2-E13 COMMUNITY AWARENESS AND ENGAGEMENT
CALCULATION STEP-BY-STEP

- Collect records of flood-related workshops, drills, and awareness campaigns from relevant municipal, NGO, or civil protection sources.
- Count the total number of distinct public events conducted in the target area over a one-year period.
- Include both in-person and digital engagement efforts (if supported by participation data).
- Evaluate whether these initiatives effectively reached diverse and vulnerable population groups.