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L'eau dans la ville | Urban water

Impact of urban drainage malfunctions and blue-green measures on urban flooding

Fabian Funke¹, Stefan Reinstaller², Manfred Kleidorfer¹

¹University of Innsbruck

²Graz University of Technology

Introduction

- Engineering expectations



<https://commons.m.wikimedia.org/wiki/File:Feldbach-Rathaus-Leonhardskirche-01ASD.jpg>

06/07/2023

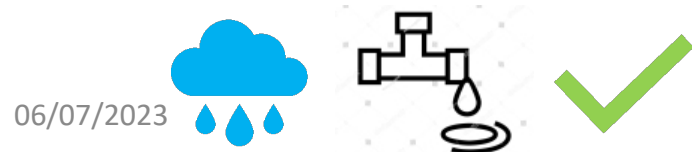


Introduction

- Engineering expectations



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- Reality



Freiwillige Feuerwehr Feldbach (22.08.2020)



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- Reality



Freiwillige Feuerwehr Feldbach (22.08.2020)

- Malfunctions in urban drainage system

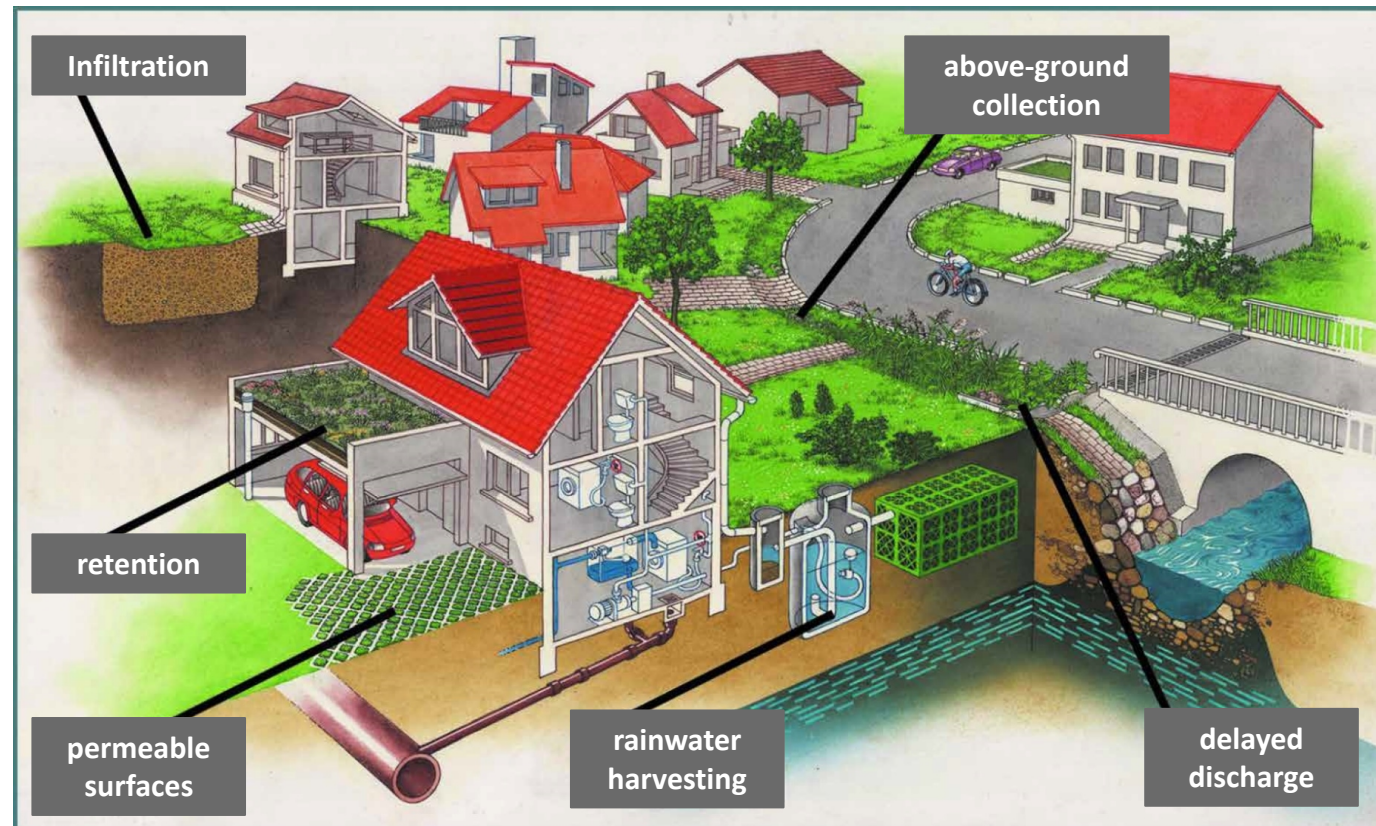


- Events larger than the design event



Introduction

- Blue-green infrastructure



Research questions

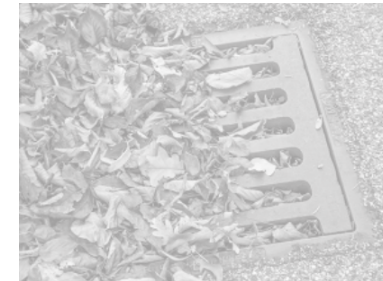
1. How much do urban drainage **malfunctions** and **blue-green measures** **affect the flood risk** during rainfall events of different intensities?
2. Are blue-green measures able to **compensate** for the **additional flood risk** in future rainfall events intensified by **climate change**?

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2. Urban drainage malfunctions and measures



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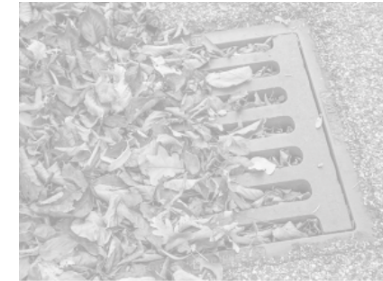


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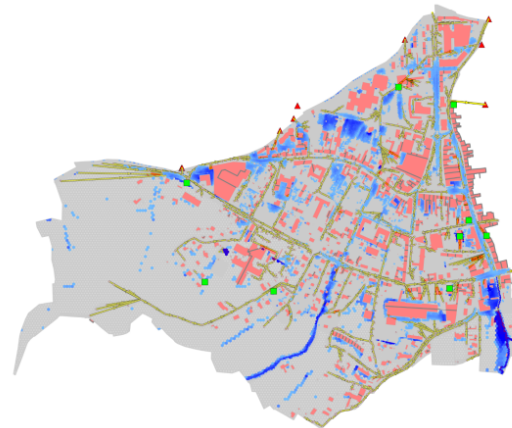
1. Case study Feldbach



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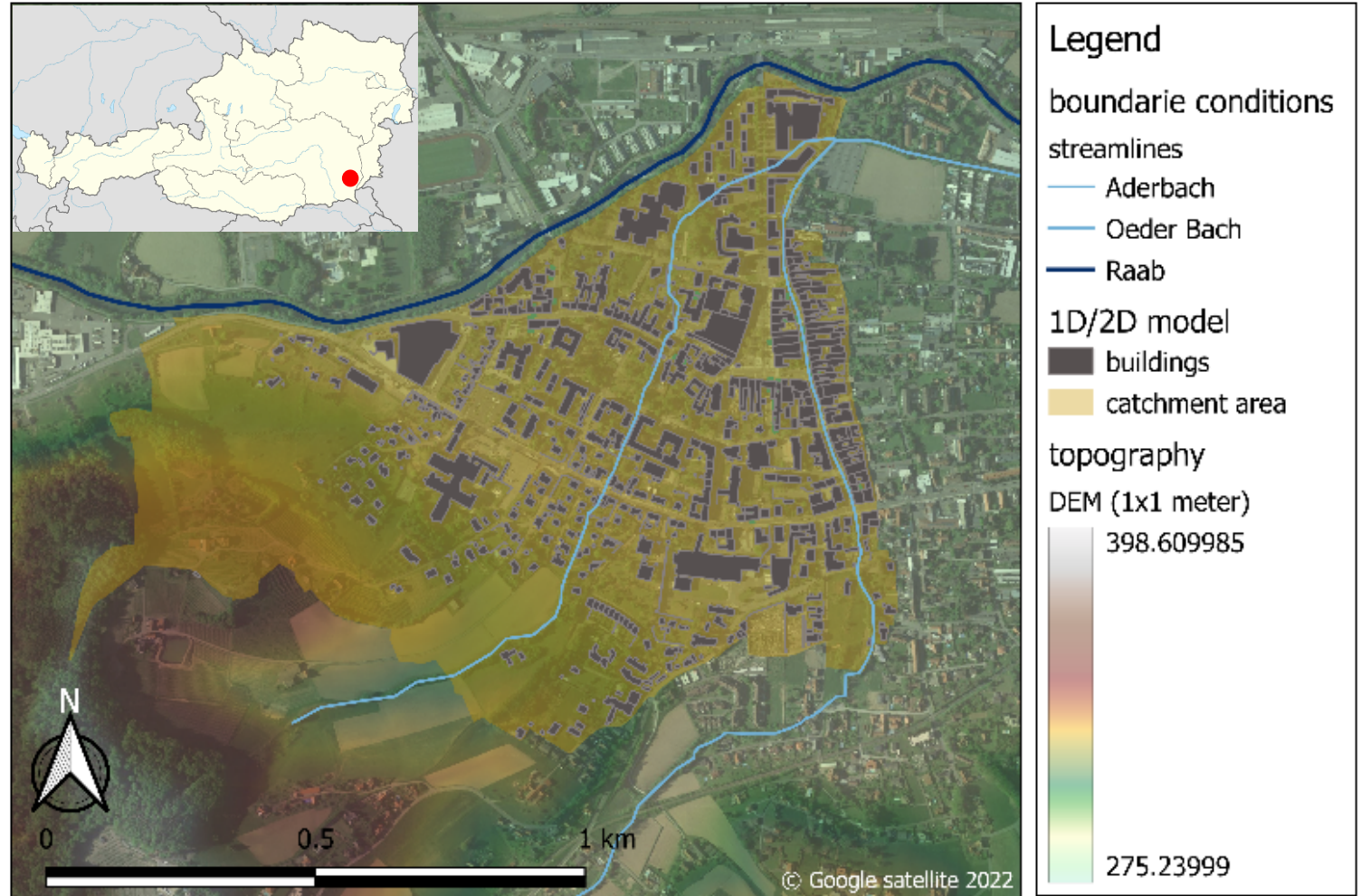


3. Modeling results



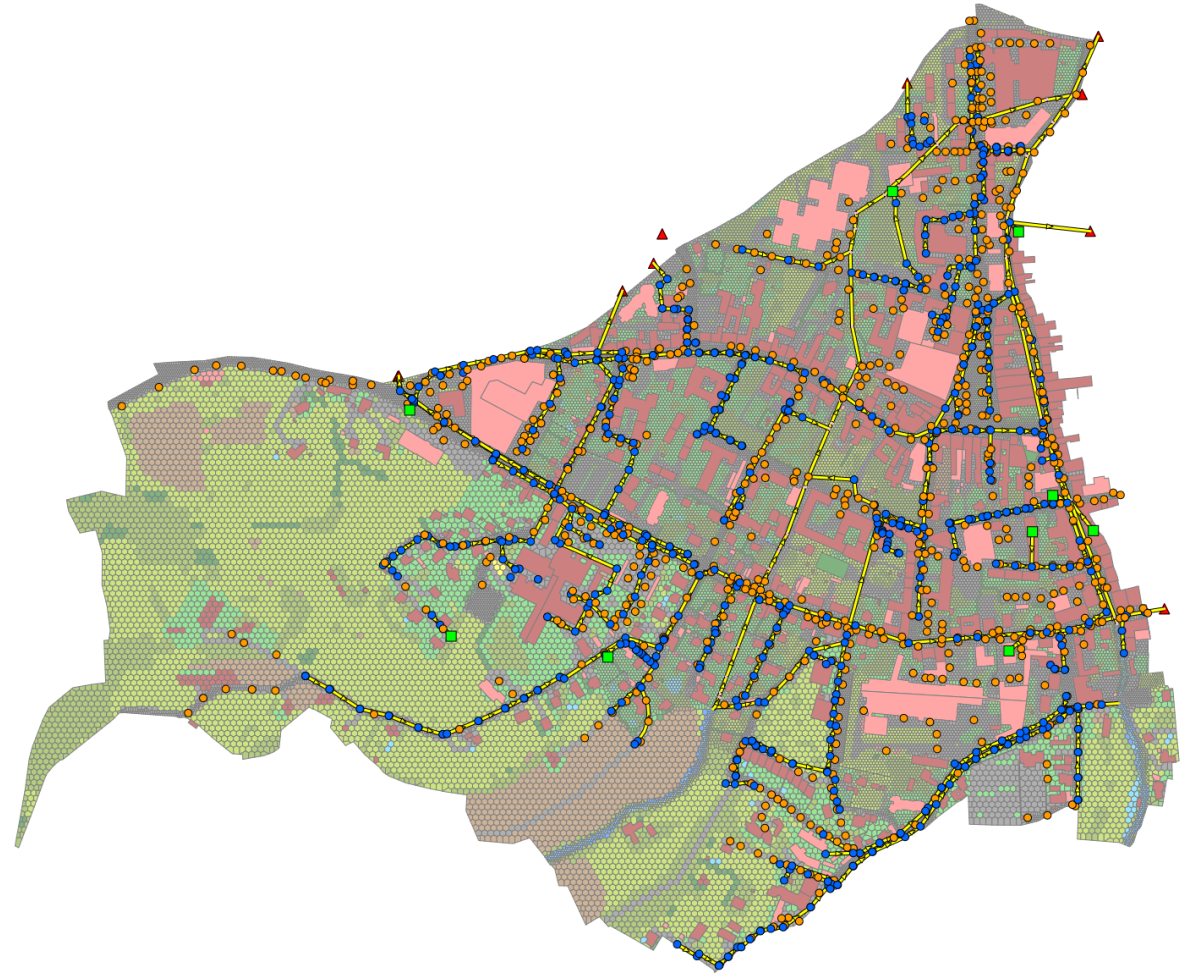
1. Case study Feldbach

- Small city Feldbach (Austria)
- 1.3km²
- Catchment area extends to a hillside (275-400m)
- Two streamlines (piped in the city)
- Poorly permeable soils (no blue-green infrastructure with infiltration)



1. Case study Feldbach

- Combined and separated sewer system
 - 1500 conduits (30km)
 - 500 manholes
 - 850 street inlets
 - 6 storage sewers (241m³)
 - CSO into Raab river
- Few blue-green infrastructure
 - 1 retention basin (hospital)
 - 6 green roofs
 - 3000m² permeable pavement
 - 6 attenuation storage systems
 - Since 2011 rainwater has to be managed on-site (attenuation systems)



1. Case study Feldbach

- 2020 event (60-80mm/1h)
- Caused severe flooding
- 27 documented fire brigade operations
- Combination of sewer surcharge, small river flooding and surface runoff

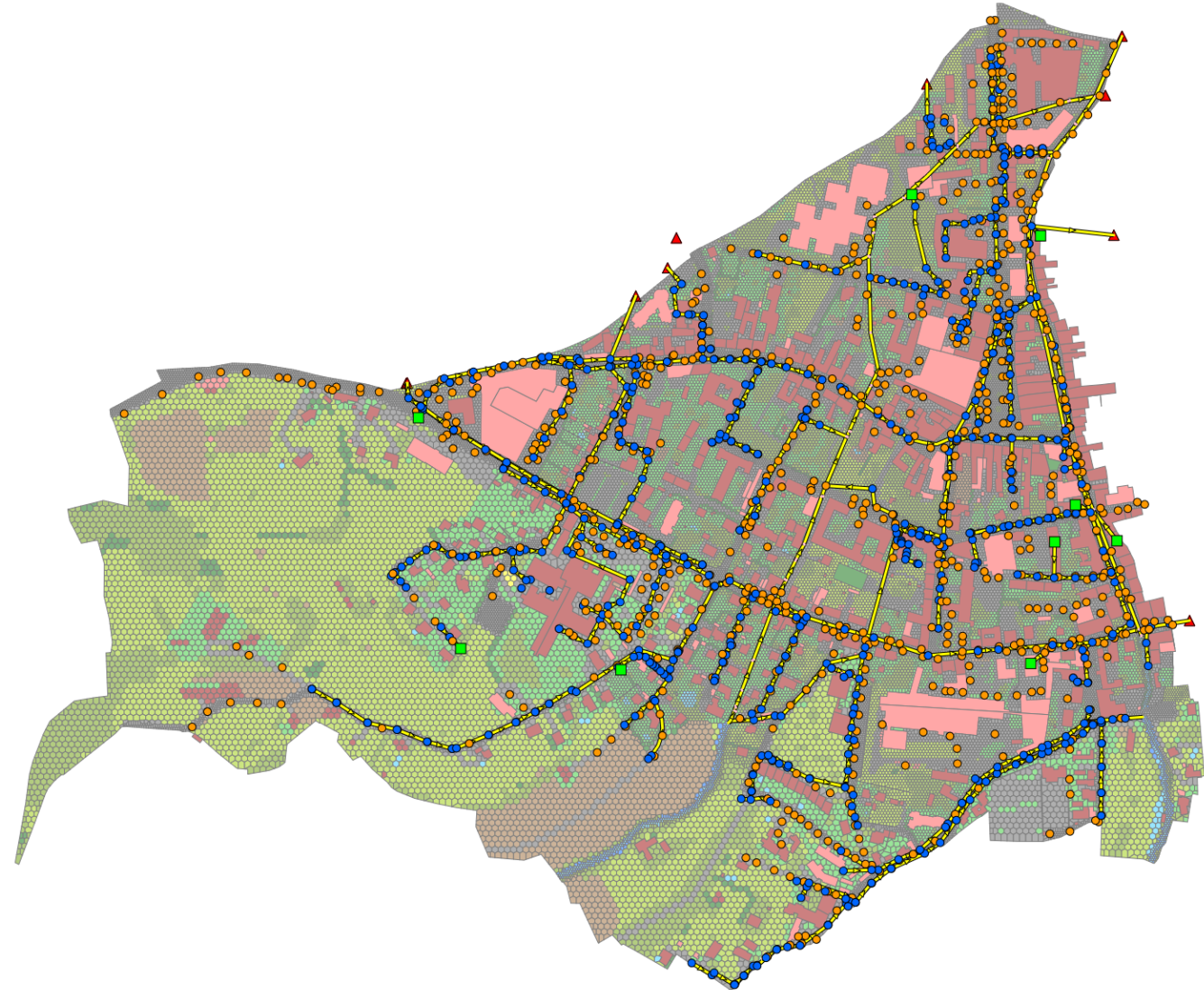


1. Case study Feldbach



PCSWMM

- Physical based model
- Integrated hydraulic 1D-2D Model
- Surface – 2D cells



1. Case study Feldbach



Contents

1. Case study Feldbach



2. Urban drainage malfunctions and measures



3. Modeling results



2. UD malfunctions and measures

- Rainfall Scenarios

Event 1 2009 (40-57mm/h; 5-35a)	Event 2 2020 (57-79mm/h; 20-350a)	Event 3 near future CC 1.5° (67-93mm/h)	Event 4 far future CC 3.0° (77-108mm/h)
Malfunction scenario 1
Malfunction scenario 2
Malfunction scenario 3
Malfunction scenario 4



2. UD malfunctions and measures

- Rainfall Scenarios

Increase of rainfall intensity by 12%/°C

Maraun, D. et al. (2022). A severe landslide event in the Alpine foreland under possible future climate and land-use changes. *Communications Earth and Environment*, 3(1), 1–11. <https://doi.org/10.1038/s43247-022-00408-7>

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2. UD malfunctions

Scenario name	Description	SWMM Parameters	Parameter change
Riverflood	CSO blockage due to river flood	Weir discharge coefficient	1.84 → 0m ³ /s



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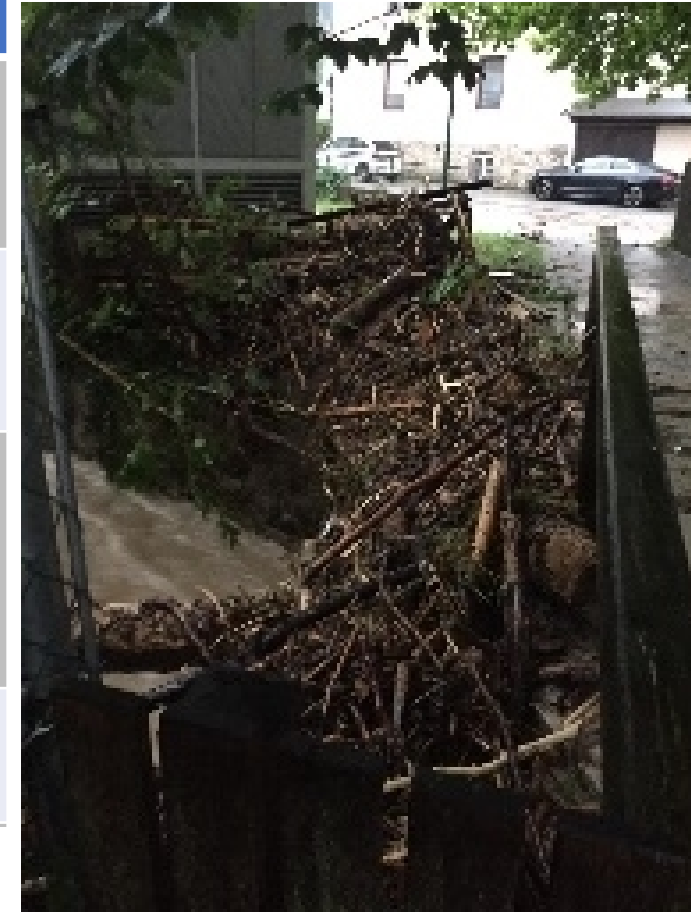
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Stream inlet log jam	Log jam with driftwood at the stream inlets	Conduit flow limit	0 m ³ /s



Michael Reinstaller

2. UD malfunctions

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Retention basin sedimentation	Decrease in retention basin depth due to sediment accumulation and erosion	Depth	*0.25
Misuse of storage units	Decrease in storage depth due to misuse or construction failures	Storage depth	3 → 0.2m



2. Blue-Green measures

Scenario name	Description	Units and area covered
Attenuation storage system	Runoff from all buildings is treated by a storage system with a throttle back to the main sewer	473
Green roof (all roofs)	All roofs in the study area are equipped with an extensive green roof	751 – 203,326m ²
Green roof (flat roofs)	All flat roofs (< 5°) in the study area are equipped with an extensive green roof	154 – 61,419m ²
Permeable pavement	All sealed surfaces in the study area which are not streets or roofs are converted to permeable pavement (e.g. pavements, parking spaces, squares etc.)	169,372m ²

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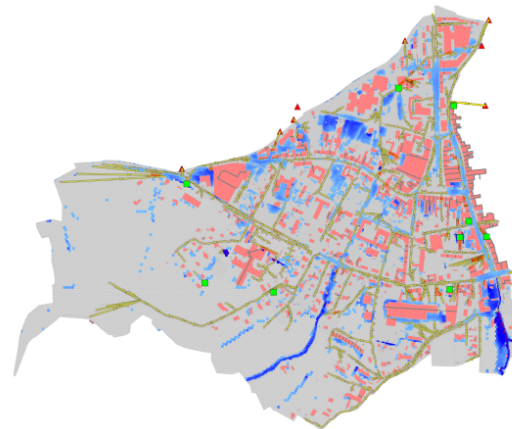
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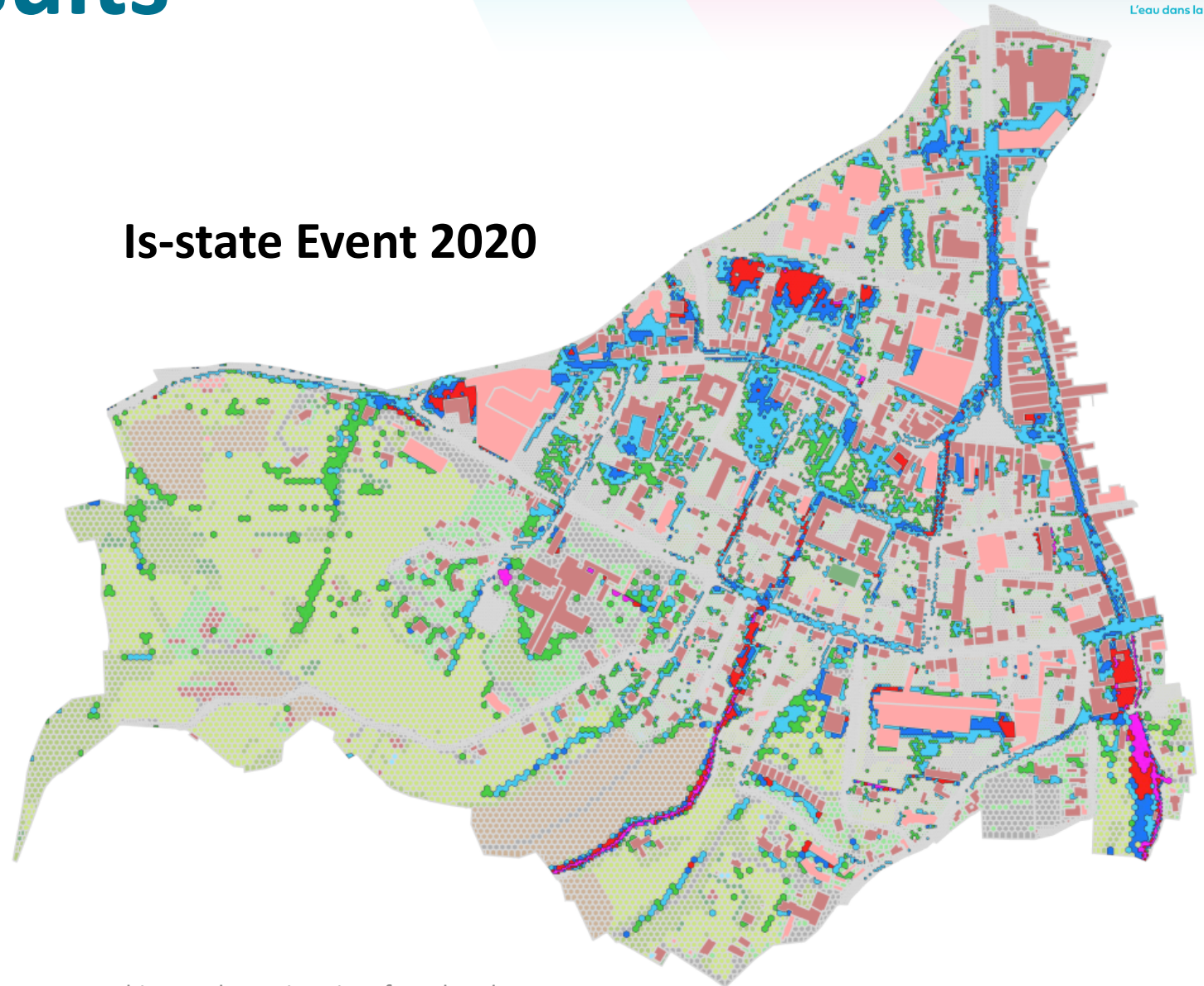
3. Modeling results



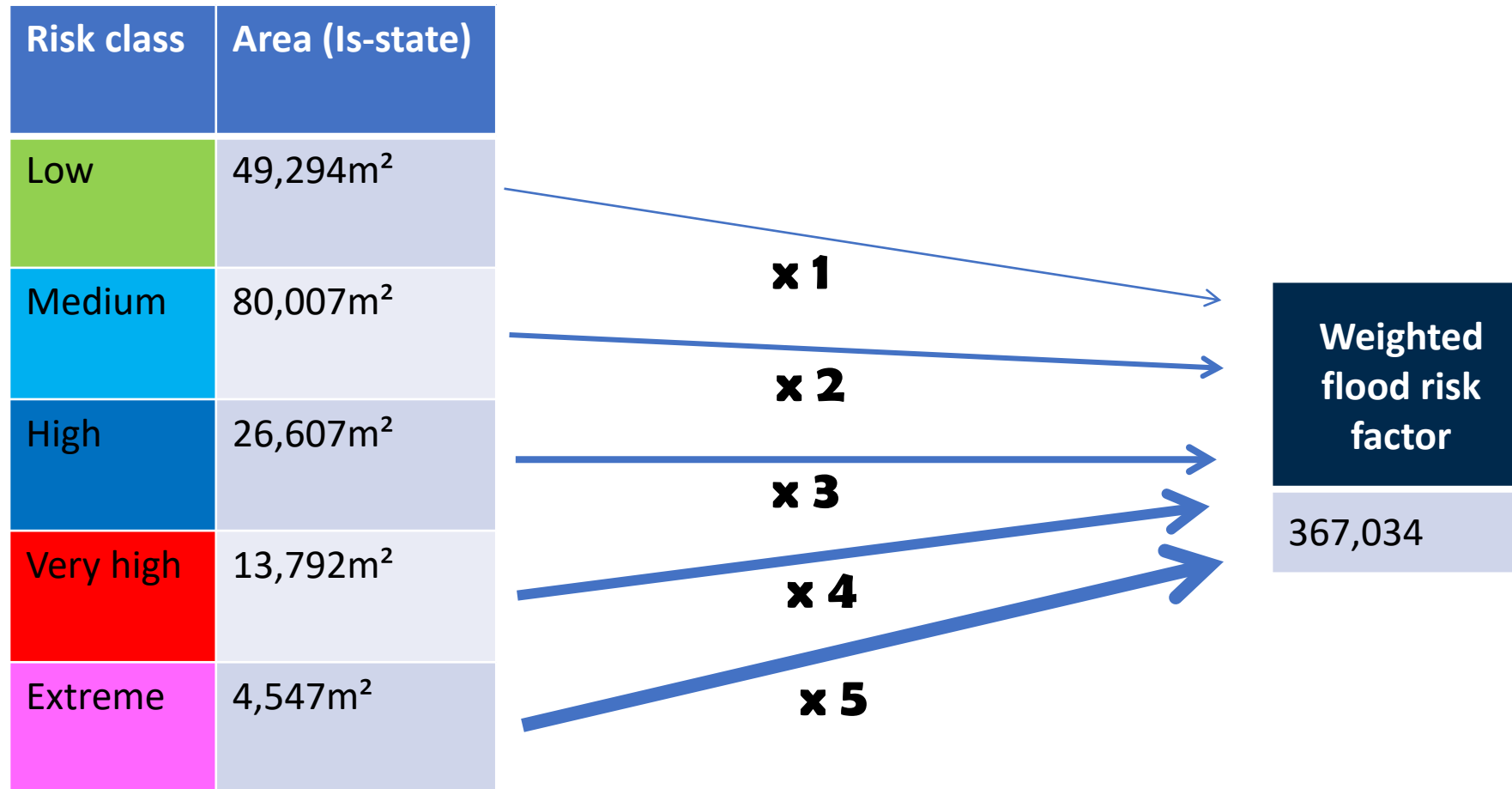
3. Modeling results

Risk class	Water depth in relation to flow velocity			
	< 0,5 m/s	> 0,5 - 1 m/s	> 1 - 2 m/s	> 2 m/s
low	5 - 10 cm			
medium	10 - 30 cm	5 - 10 cm		
high	30 - 50 cm		10 - 30 cm	
Very high	50 - 100 cm		30 - 50 cm	10 - 30 cm
extreme	> 100 cm		50 - 100 cm	30 - 50 cm

Is-state Event 2020

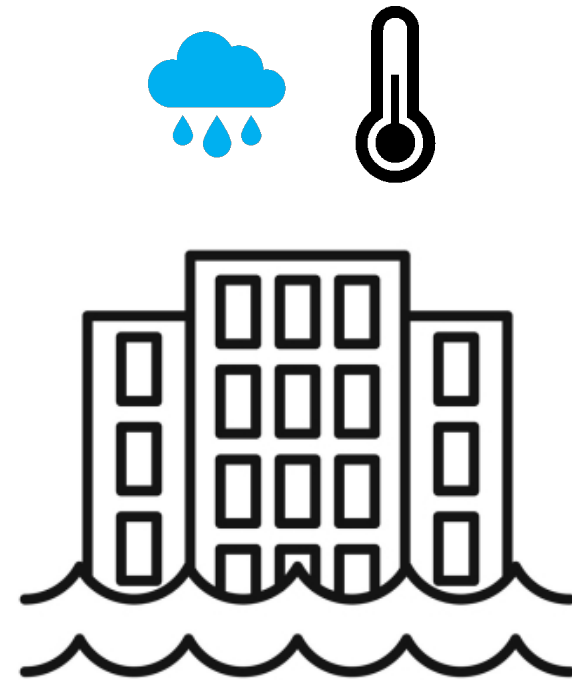


3. Modeling results



3. Modeling results

- How much do **urban drainage malfunctions** and **blue-green measures** affect the **flood risk** during rainfall events of different intensities?



3. Modeling results

**Is-state
Event 2009**



**Weighted
flood risk
factor**

188,903

**Is-state
Event 2020**



**Weighted
flood risk
factor**

367,034

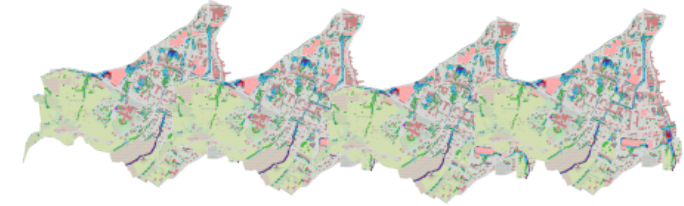
**Is-state
Event CC 3.0°C**



**Weighted
flood risk
factor**

515,173

**Malfunction and Measures
Scenarios**



3. Modeling results

Is-state
Event 2009



Weighted
flood risk
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188,903

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Is-state
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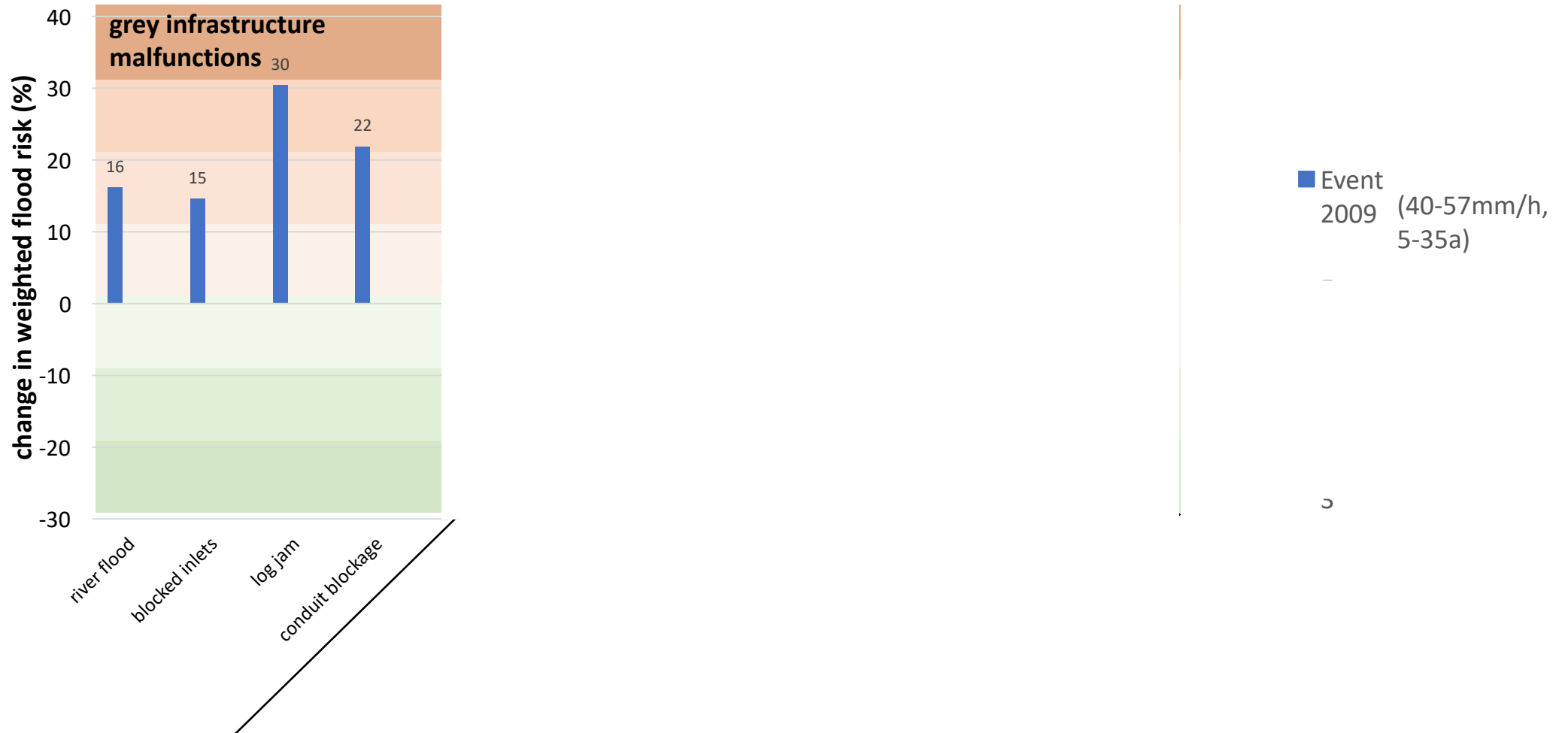
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Log jam scenario



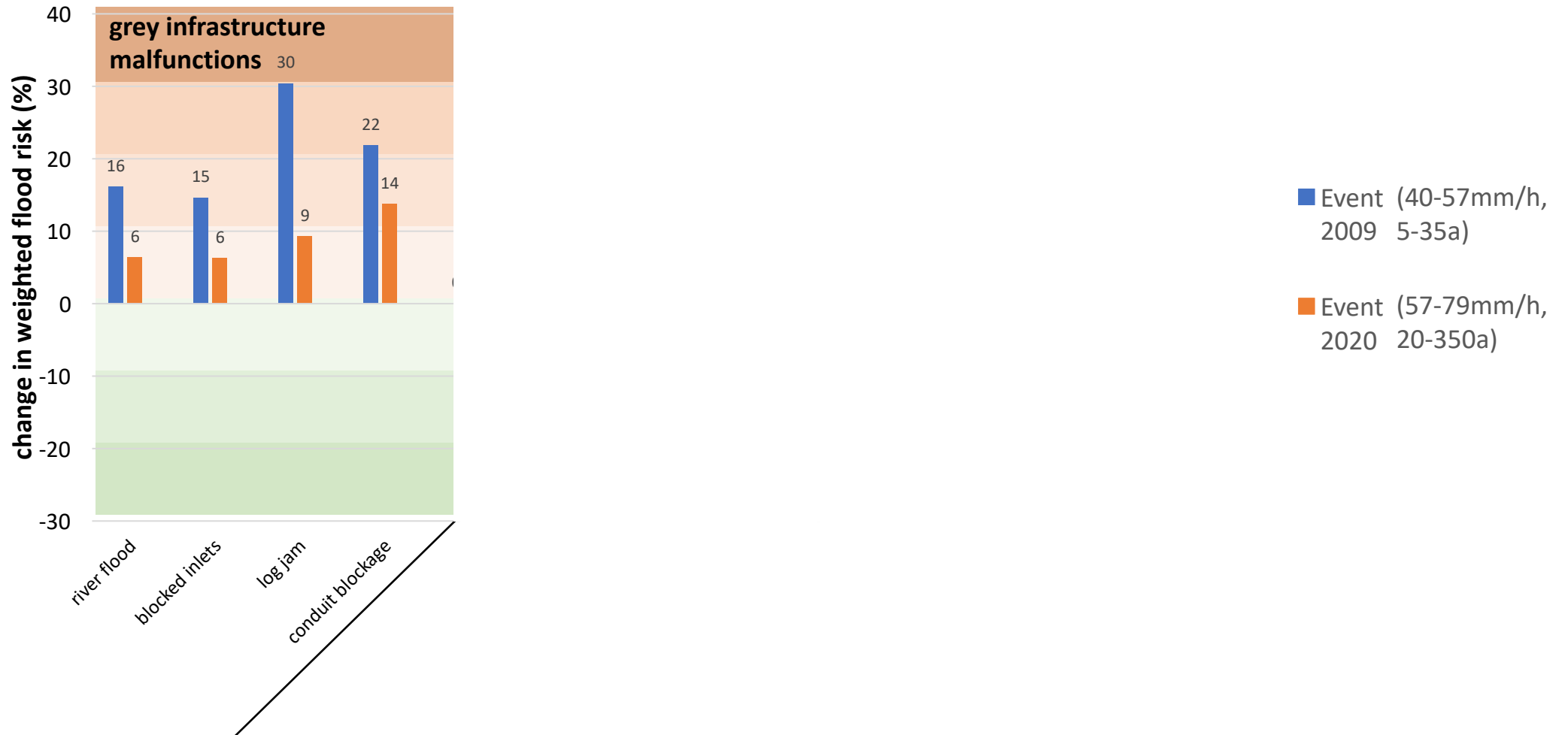
3. Modeling results

Change between Is-states and scenarios in weighted flood risk



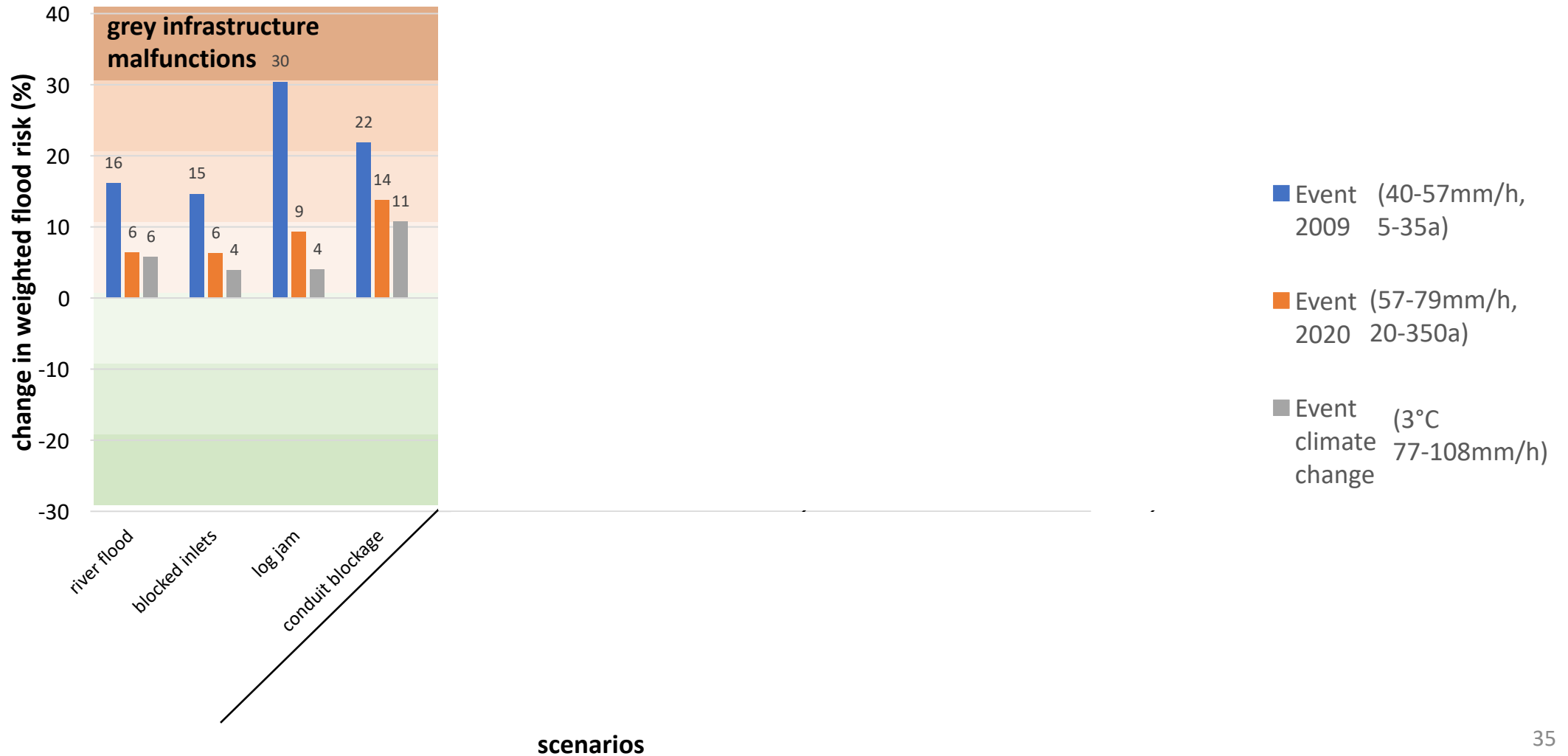
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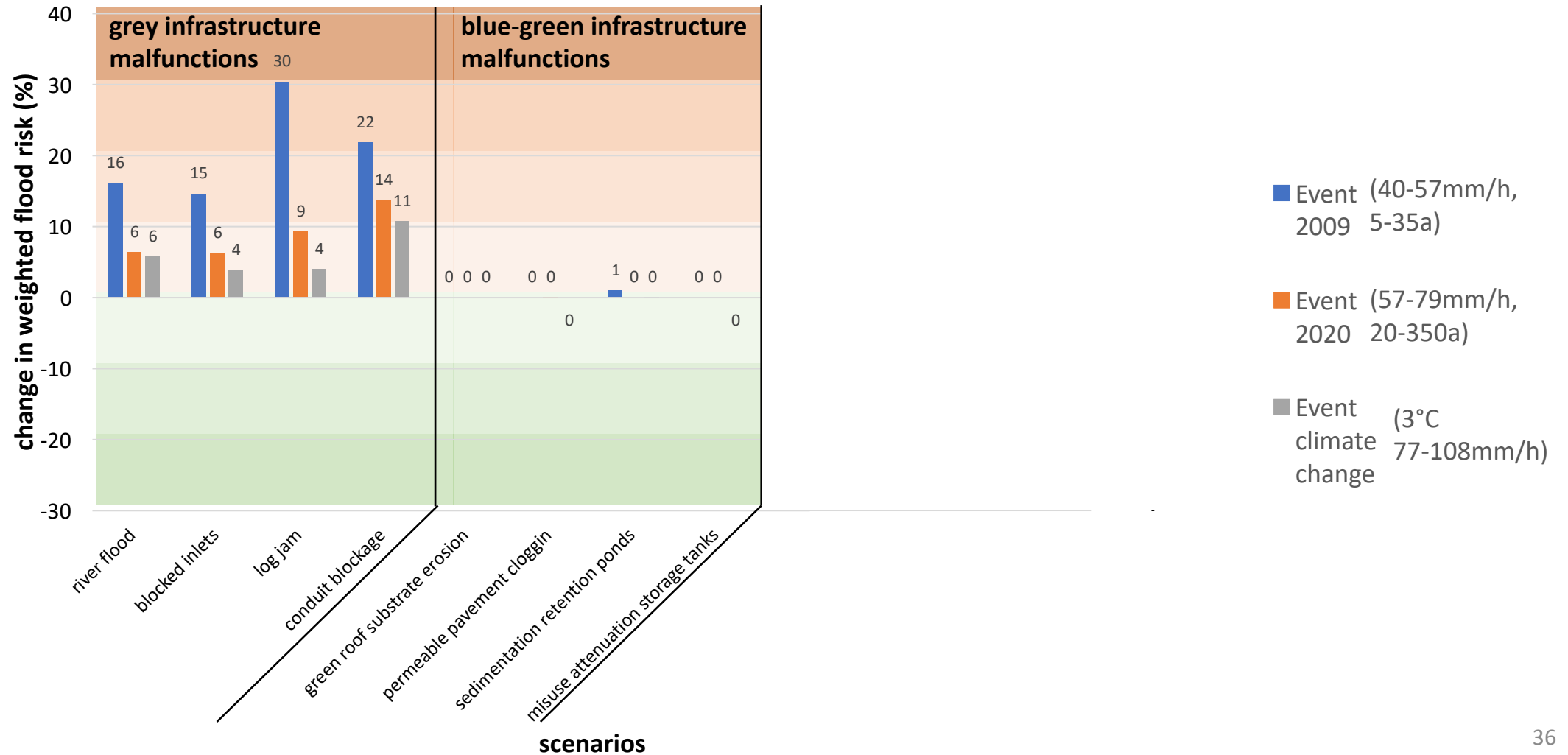
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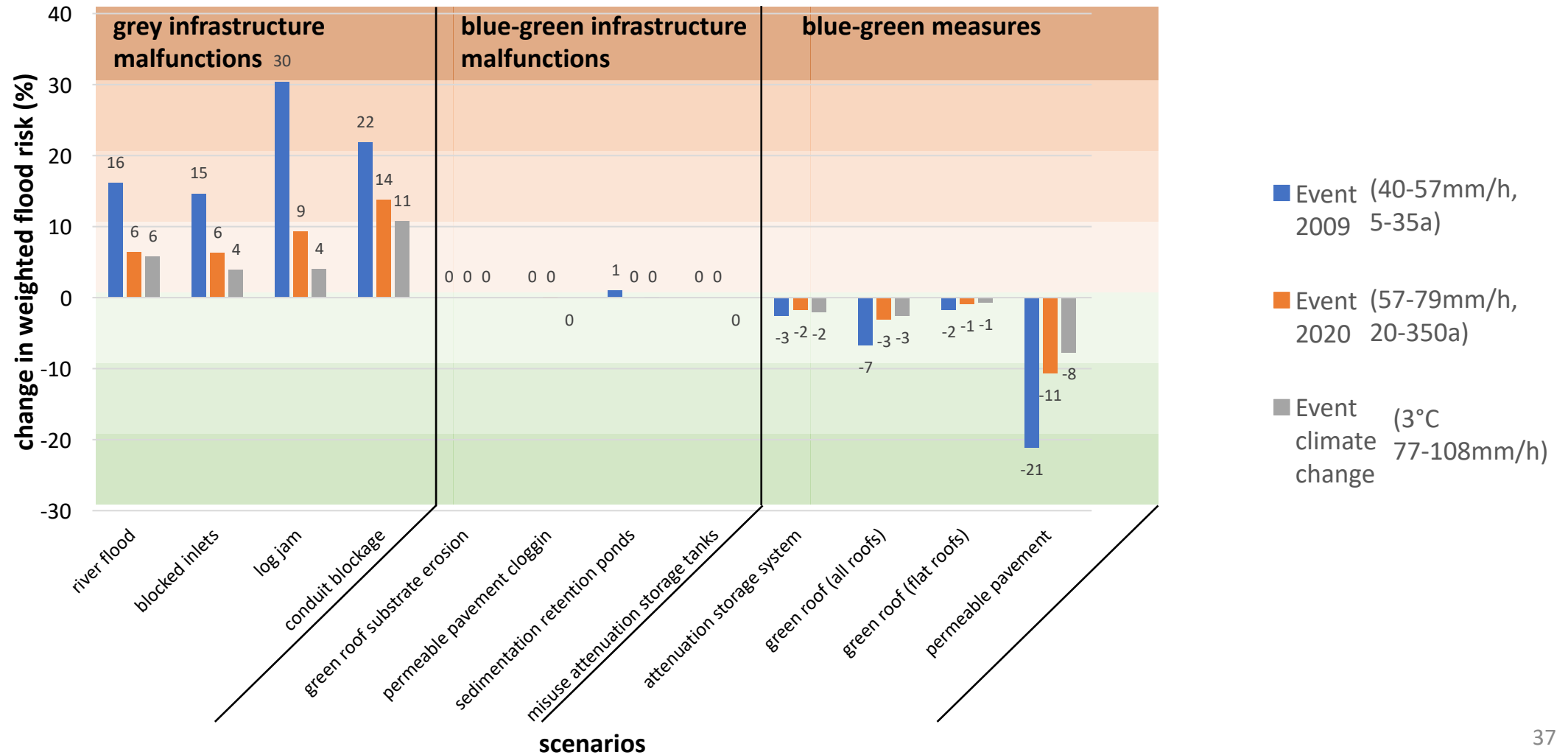
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Change between Is-states and scenarios in weighted flood risk



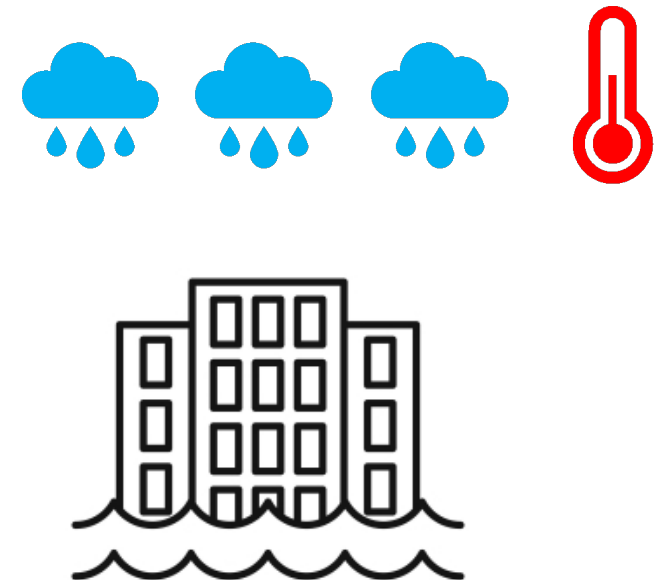
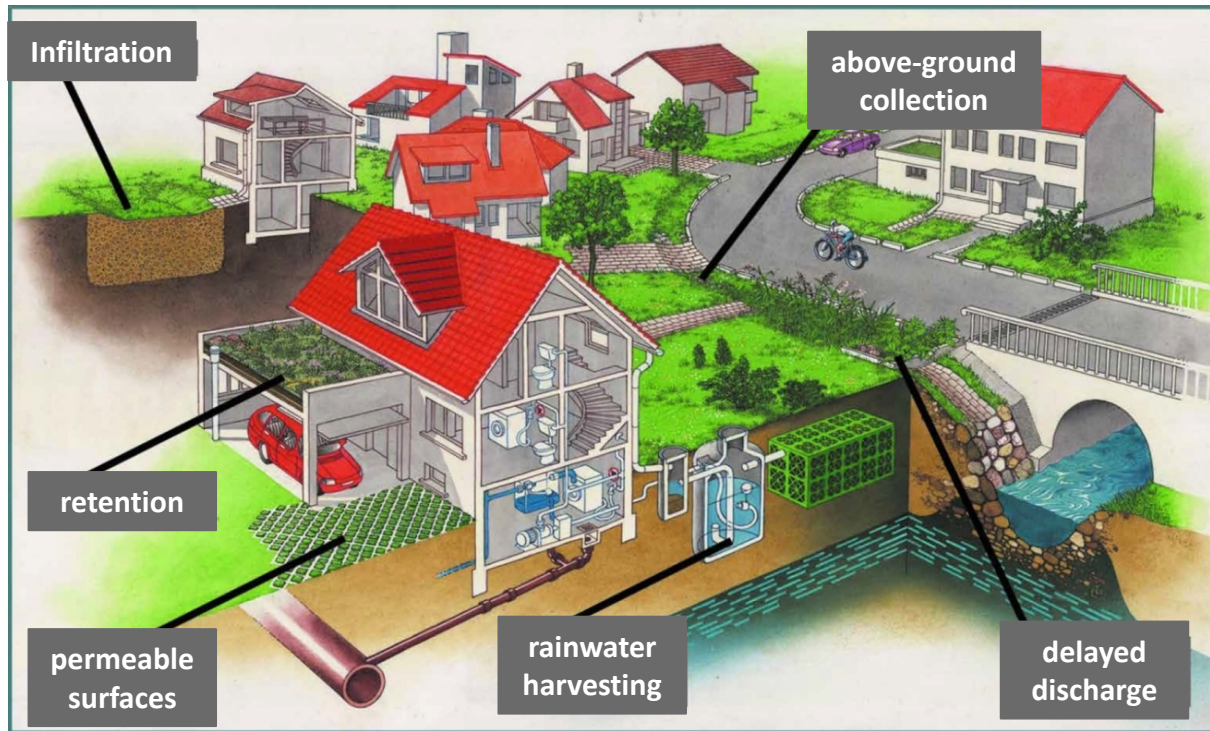
3. Modeling results

Change between Is-states and scenarios in weighted flood risk



3. Modeling results

- Are blue-green measures able to **compensate** for the **additional flood risk** in future rainfall events intensified by **climate change**?



3. Modeling results

**Is-state
Event 2020**



**Weighted
flood risk
factor**
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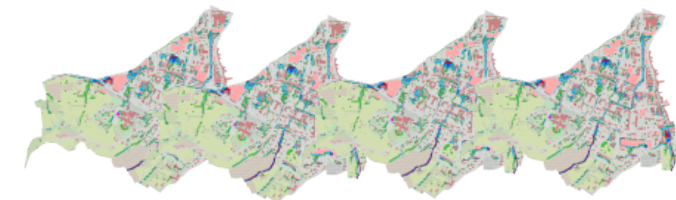
Measures Scenarios



Event 2020

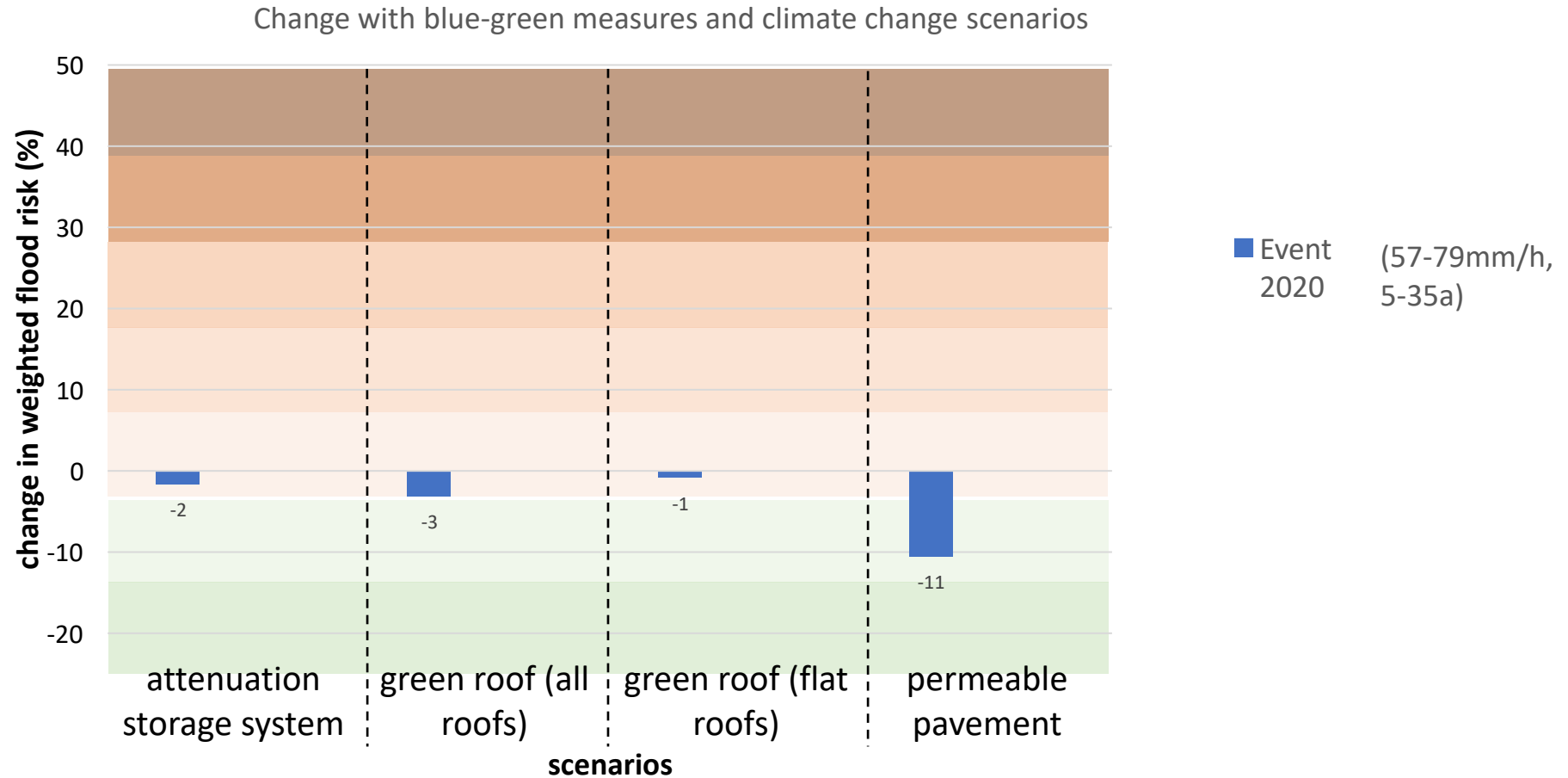


**Event
CC 1.5**

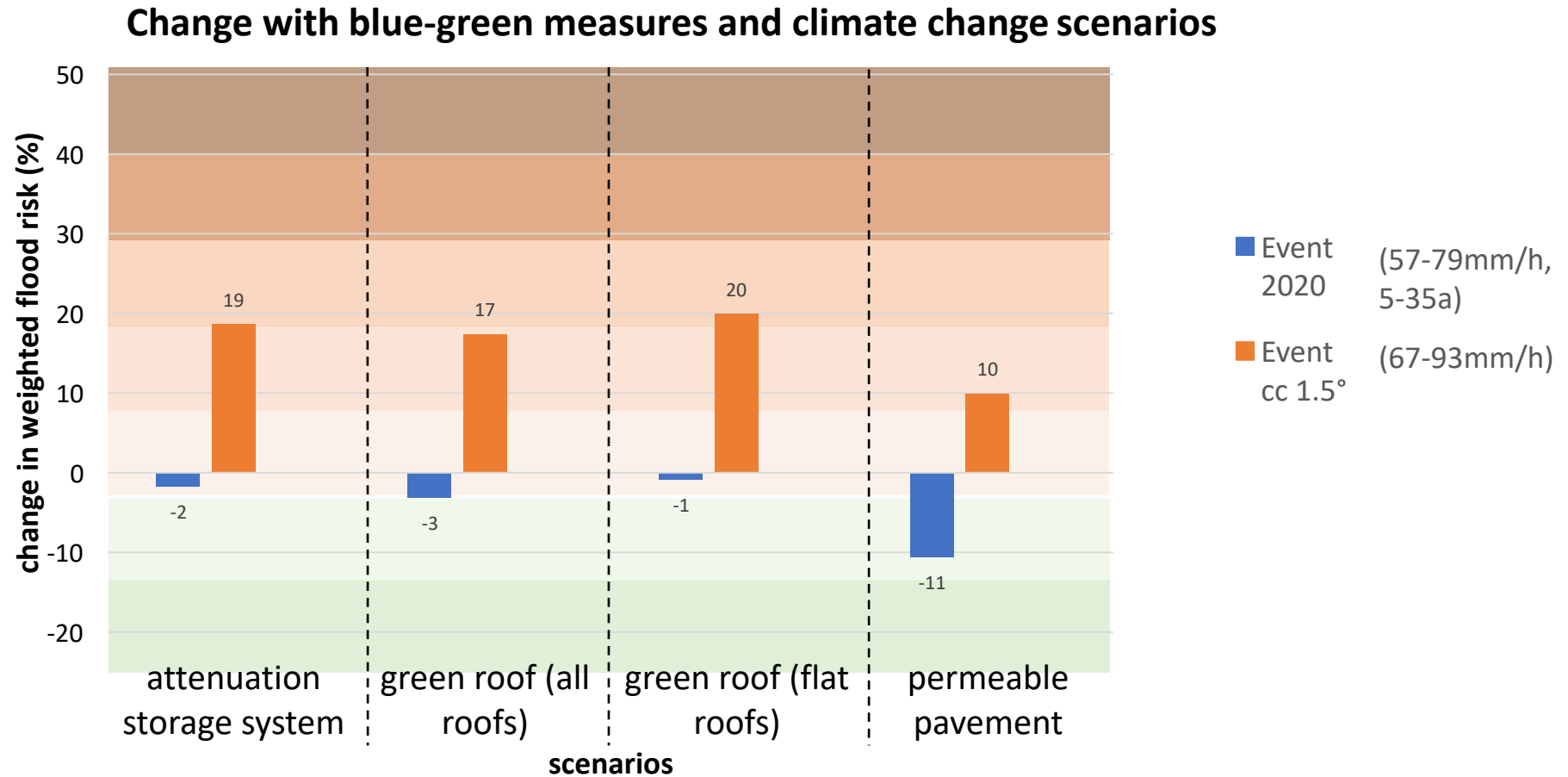


**Event
CC 3.0**

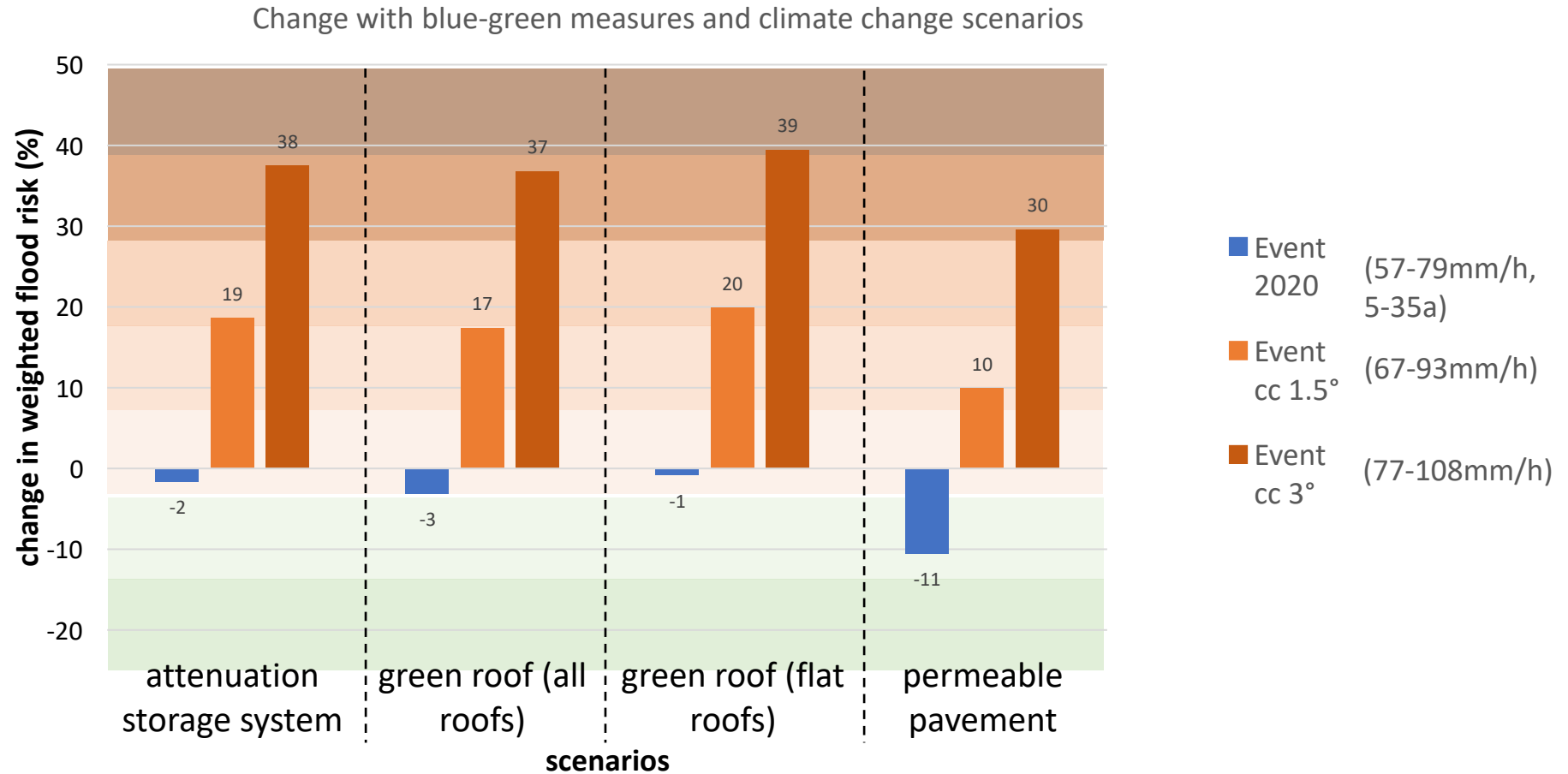
3. Modeling results



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Conclusion

- Coupled 1D-2D hydraulic models (PCSWMM) **are able** to model urban drainage malfunctions and blue-green measures

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Conclusion

- Coupled 1D-2D hydraulic models (PCSWMM) **are able** to model urban drainage malfunctions and blue-green measures
 - Malfunctions in grey infrastructures have an **much greater impact** than in blue-green infrastructures
 - With increasing rainfall intensities **the impact** of malfunctions and blue-green measures **decreases**
 - Widespread implementation of blue-green measures **can not compensate** for future rainfall events intensified by climate change
- Combination of different measures and a „Safe to Fail“ approach is necessary

Thank you for your attention!

Questions?