Coalition Clean Baltic

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EESTI VEEÜHING
ESTONIAN WATER ASSOCIATION

RIVER UNIVERSITY

URBAN FLOOD MANAGEMENT STUDIES IN TALTECH:

URBAN PLUVIAL FLOOD RISK ASSESSMENT METHODOLOGY FOR ESTONIAN CITIES

Murel Truu

11-15 July 2022

Urban cloudburst, Genaro Servín

Funded by

TalTech UWS

Research unit of Urban Water Systems belongs to the research area of **MECHANICS OF FLUIDS AND STRUCTURES RESEARCH GROUP** of Department of Civil Engineering and Architecture of Tallinn University of Technology.

Research interest:

- **Urban Water Infrastructur**e: water supply, sewage, stormwater systems – optimization of performance, design concepts, modelling, sustainability issues;
- **Smart Waterworks**: real-time control, monitoring, smart actuators;
- Water Services and Infrastructures as a part of holistic urban planning;
- Modelling and lab-testing hydraulic systems

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PROJECTS of UWS

- ## Interreg BSR

NOAH

Protecting the Baltic Sea from untreated wastewater spillages during flood events in urban areas
2019-2022 (freshly completed)

- ## DEPART

Decentralized real-time control platform for urban drainage systems in climate proof smart cities
2020-2024

- ## CleanStormWater

Picture here

Testing new storm water treatment solutions for reduction of hazardous substances and toxins inflows into the Baltic Sea
2020-2022

- ## LIFE IP BUILDEST

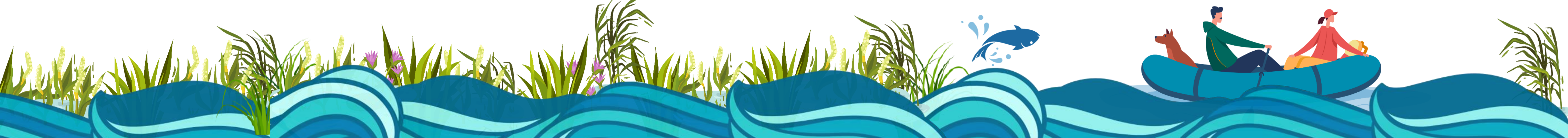
Pursuing national climate ambition through renovation of Estonian building stock and developing its long-term resilience
2022-2028

- ## LIFE LATESTAdapt

Developing and demonstrating portfolio of nature based and smart solutions for improving urban climate resilience in Latvia and Estonia
2022-2027

- ## Reinventing WSDP

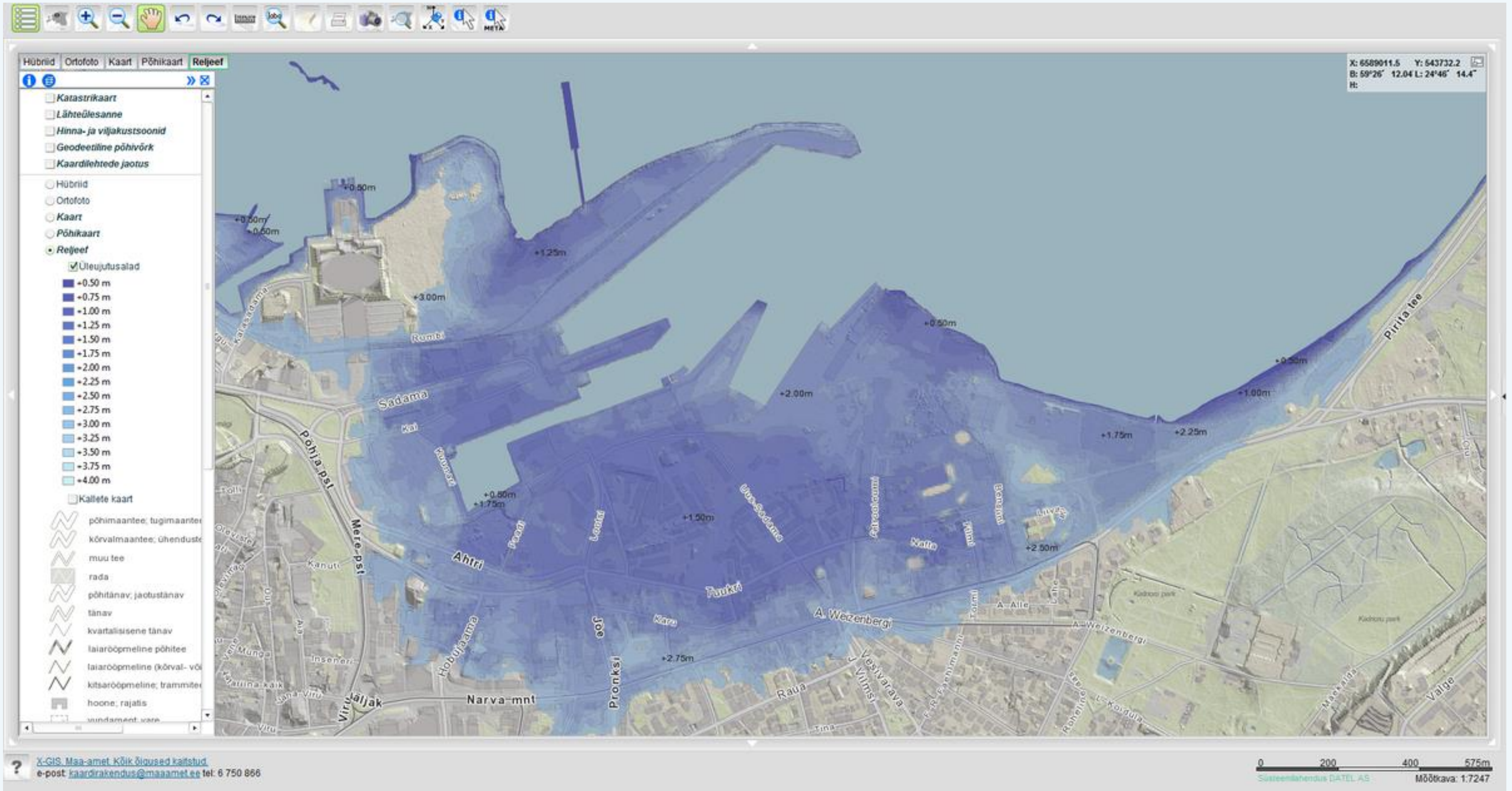
Reinventing the Estonian Public Water and Sewage Management Plans by applying entrepreneurial discovery and rapid realization processes (JRC)
2022-2023



Plan for the presentation

1. Estonian cities' capacity in assessing pluvial floods
2. Baseline for the proposed methodology
3. Methodological framework
4. Rakvere case study
5. Conclusions and followups
6. Risk mitigation
7. Future collaborations

Estonian cities' capacity in assessing pluvial floods (1)



[LINK](#)

MoE carried out comprehensive fluvial flood risk modelling already in 2014, and has since then developed an adequate system assessing coastal flood risks

EC Flood Directive

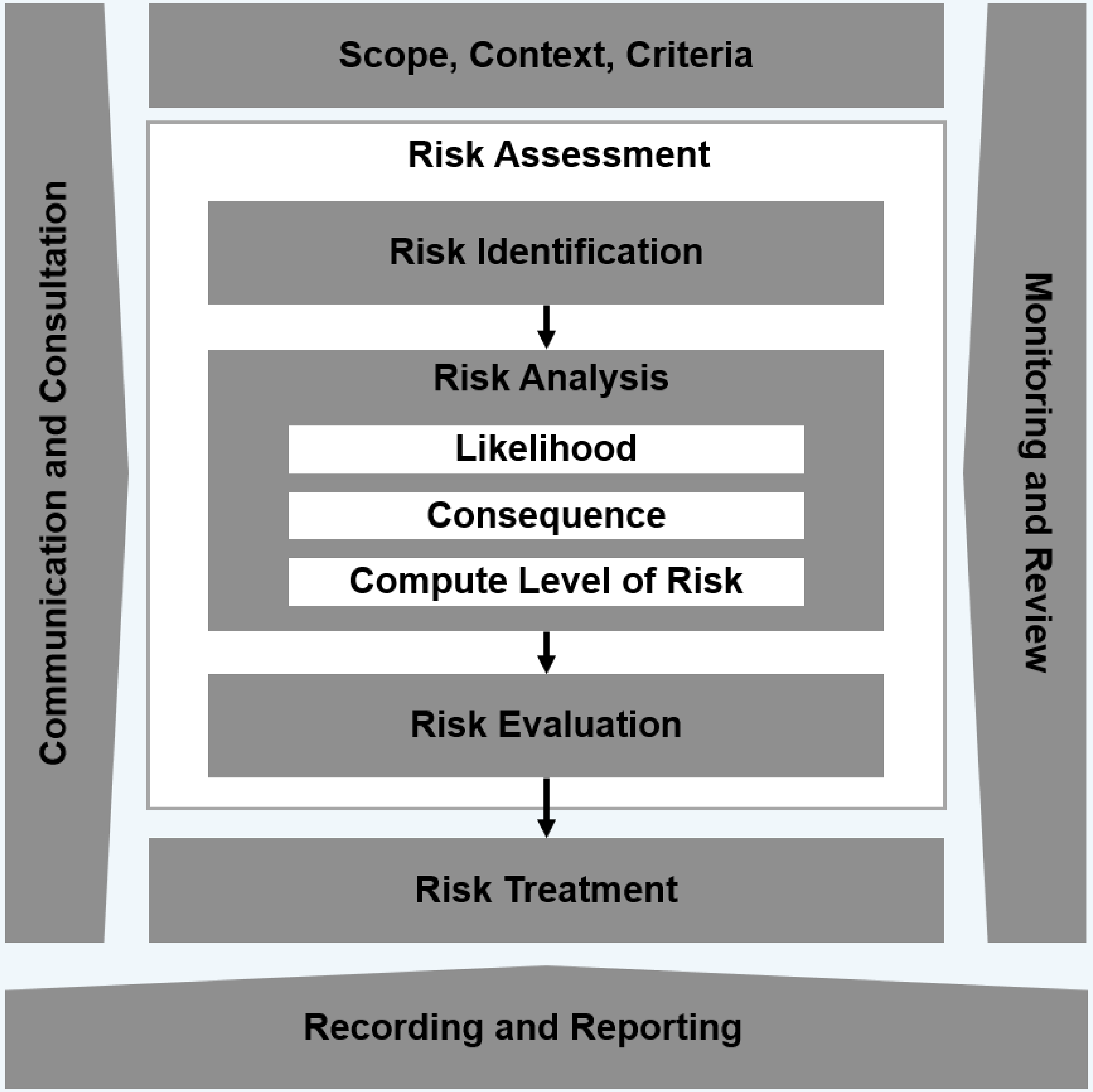
Estonian Water Act

Estonian cities' capacity in assessing pluvial floods (2)

Some background data:

- Pluvial flood risk assessment is currently not required by the Estonian Water Act;
- According to the National Climate Adaptation Development Plan, more the intense precipitations are about to become more frequent;
- Out of the 15 largest cities in Estonia, all have acknowledged the pluvial flood risk concern in their Water Supply and Sewage Development Plans;
- Currently there's no state-approved methodology in place. Cities struggle with lack of adequate baseline data and skillset;
- A few cities in Estonia have participated pilot projects in which they have investigated the pluvial flood risk by hydraulic modelling.

Baseline for the proposed methodology

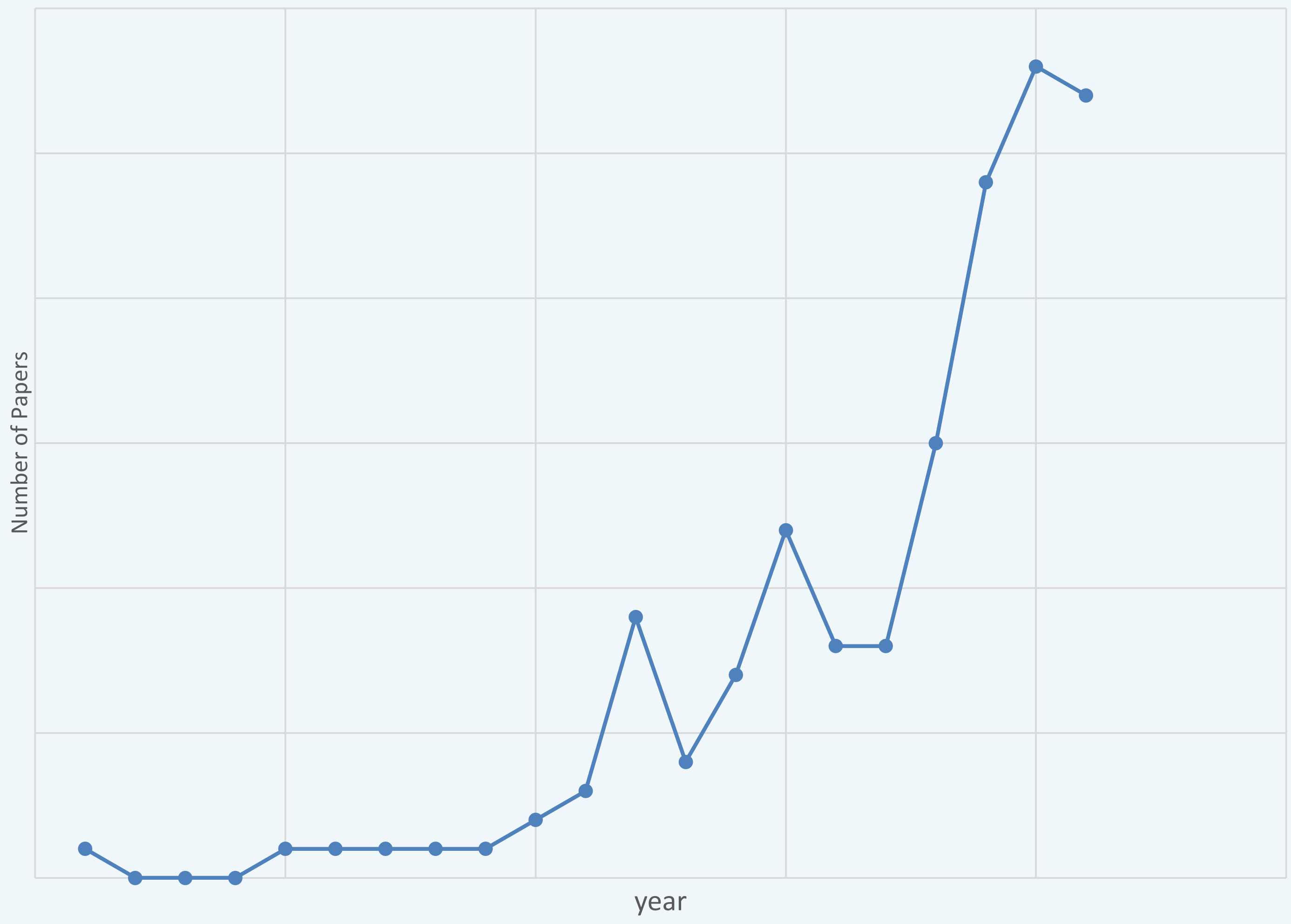


Risk management framework according to ISO 31000

- Risk function of United Nations Disaster Risk Reduction Agency

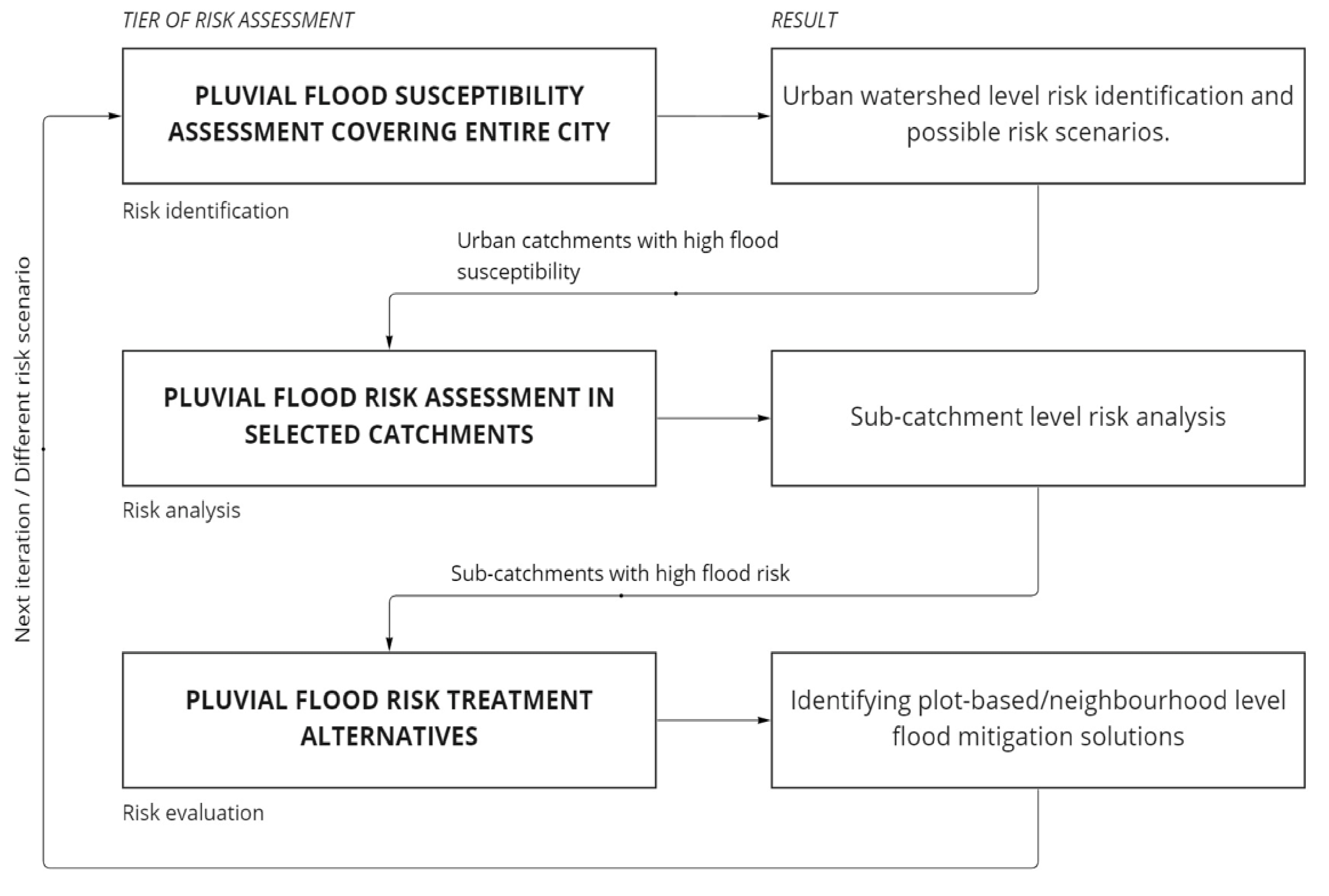
$$Risk = Hazard \; x \; \textbf{Exposure} \; x \; Vulnerability$$

- State of the art methods of pluvial flood risk assessment



Scopus „pluvial flooding “ + „risk assessment“

Previous and ongoing research of UWS, e.g.
https://doi.org/10.3390/w13233340



Methodological framework

Cities need to consider pluvial flood risk for **various operative and strategic decisions**.

The current low capacity is derived due to:

- Pluvial flooding being a dynamic problem, which is in constant change due to changing cityscape and changing climate.
- Limited resources: inadequate baseline data, limited skillset for carrying out complicated analyses (incl. Modelling etc.)

Risk assessment tiers

Tier 1: RISK IDENTIFICATIO N

FLOOD SUSCEPTIBILITY

Whole city

Tier 2: RISK ANALYSIS

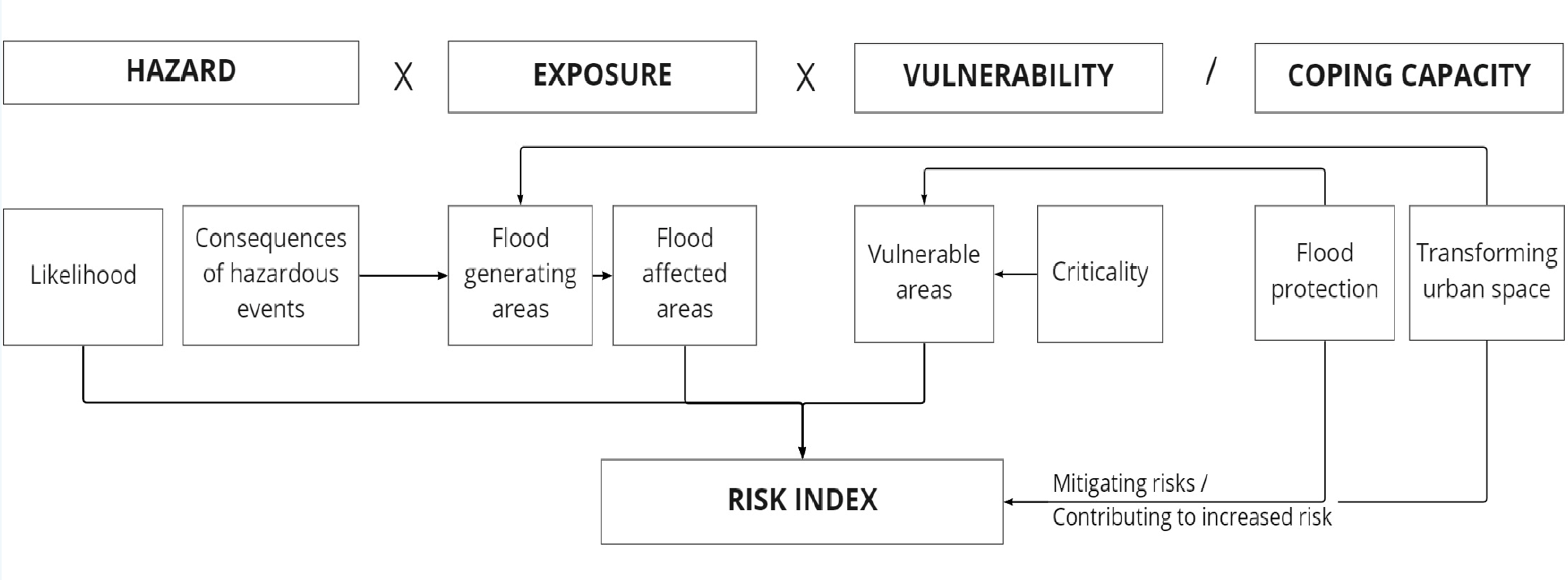
FLOOD DAMAGE

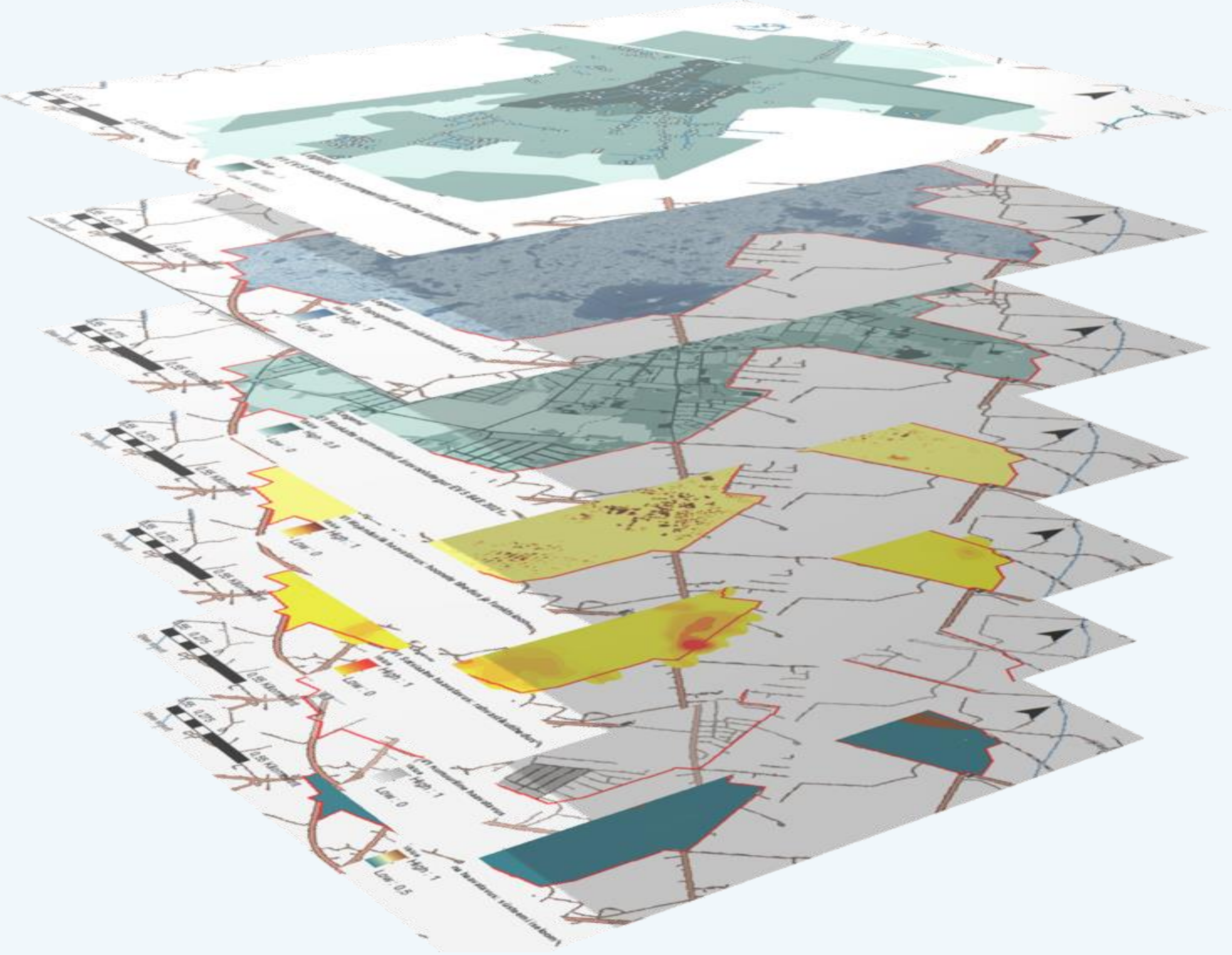
High-risk urban catchments

Tier 3: RISK EVALUATION

FLOOD TREATMENT

High-risk sub-catchments


HAZARD
X
EXPOSURE
X
VULNERABILITY
/
COPING CAPACITY
Likelihood
Consequences of hazardous events
Flood generating areas
Flood affected areas
Vulnerable areas
Criticality
Flood protection
Transforming urban space
RISK INDEX
Mitigating risks /
Contributing to increased risk



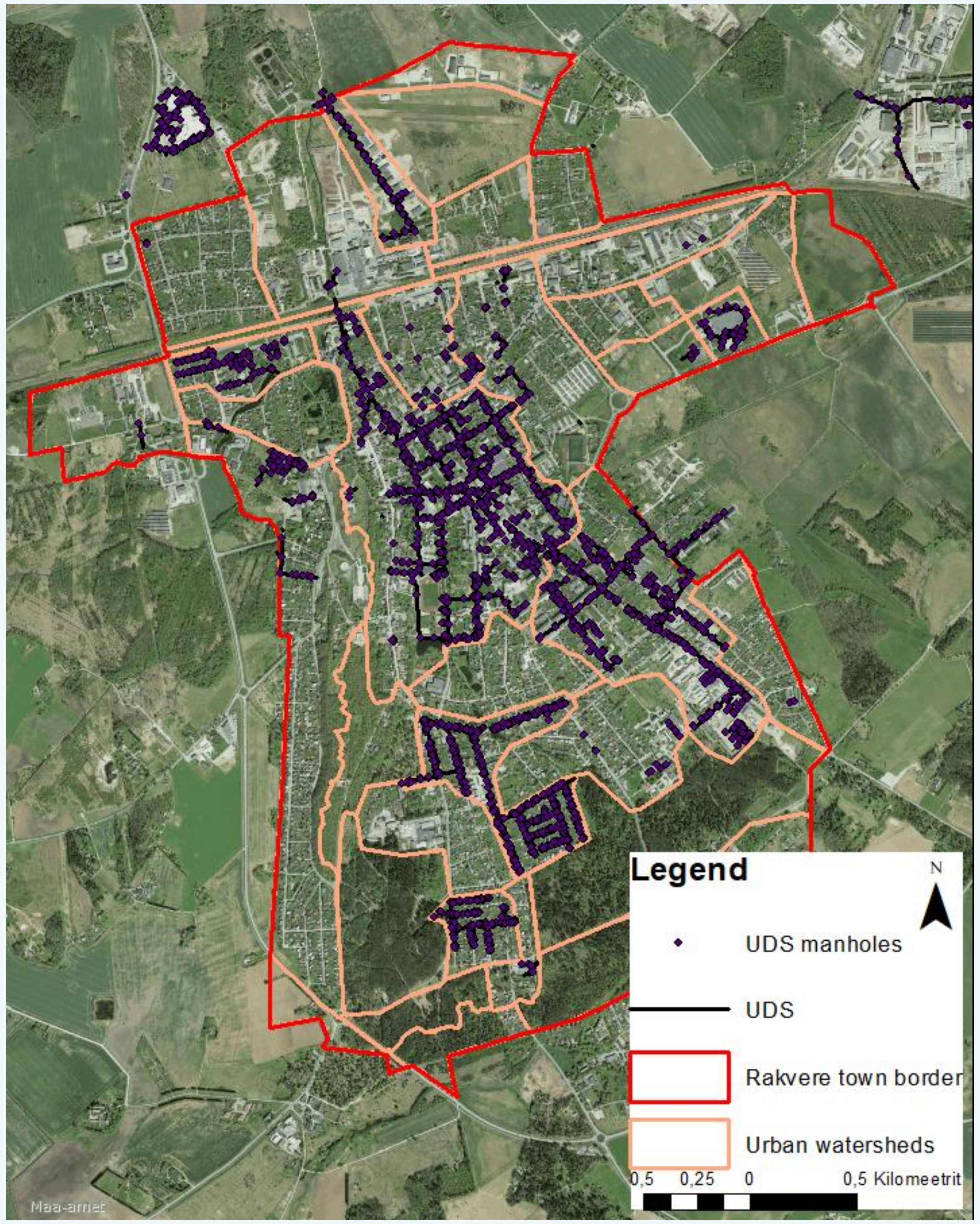
$$Risk_{Tier\ 1} = \frac{\sum(a_i \cdot H_i)\ x \sum(b_j \cdot E_j)\ x\ \sum(c_k \cdot V_k)}{\sum(d_m \cdot CC_m)}$$

$$Risk_{Tier\ 2} = \sum\left(a_i \cdot \frac{H_{E,j}}{CC_j}\right)\ x\ \sum(b_j \cdot E_j)\ x \sum(c_k \cdot V_k)$$

Data, tools and methods

Tier	Data	Tools and methods	Computing capacity / expert effort requirement
Identification	Public data (open registries)	GIS analysis	Large areas, low effort
Analysis	Site based surveys (geodetic measurements(Technical blueprints Monitoring data	SWMM modelling + GIS analysis	Medium sized areas, high effort
Evaluation	Eelmiste etappide järelmid	Expert decision	Small sized areas, intensive site-by-site evaluation

Rakvere case study



Rakvere is a small town (~11 km^2) located in northern Estonia with a population of approximately 15 000 people. Two small streams, the Soolikaoja creek, and the main Tobia ditch flow through the city and the recreational forest covers approximately 15 % of the city's territory.

The waterbodies in the city are not prone to fluvial flooding. However, the flow rates in the streams affect significantly the capacity and performance of the UDS.

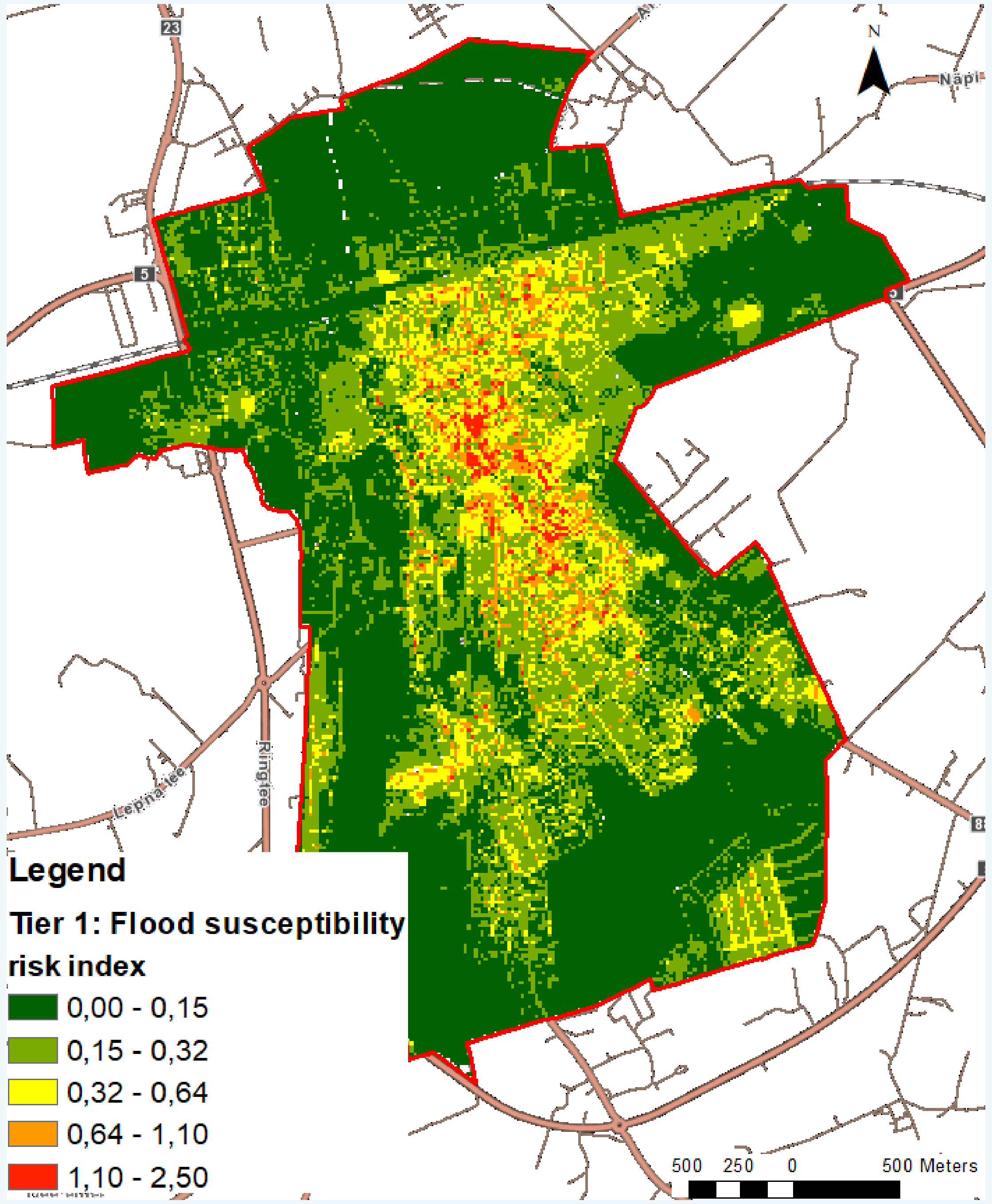
Risk identification (1)

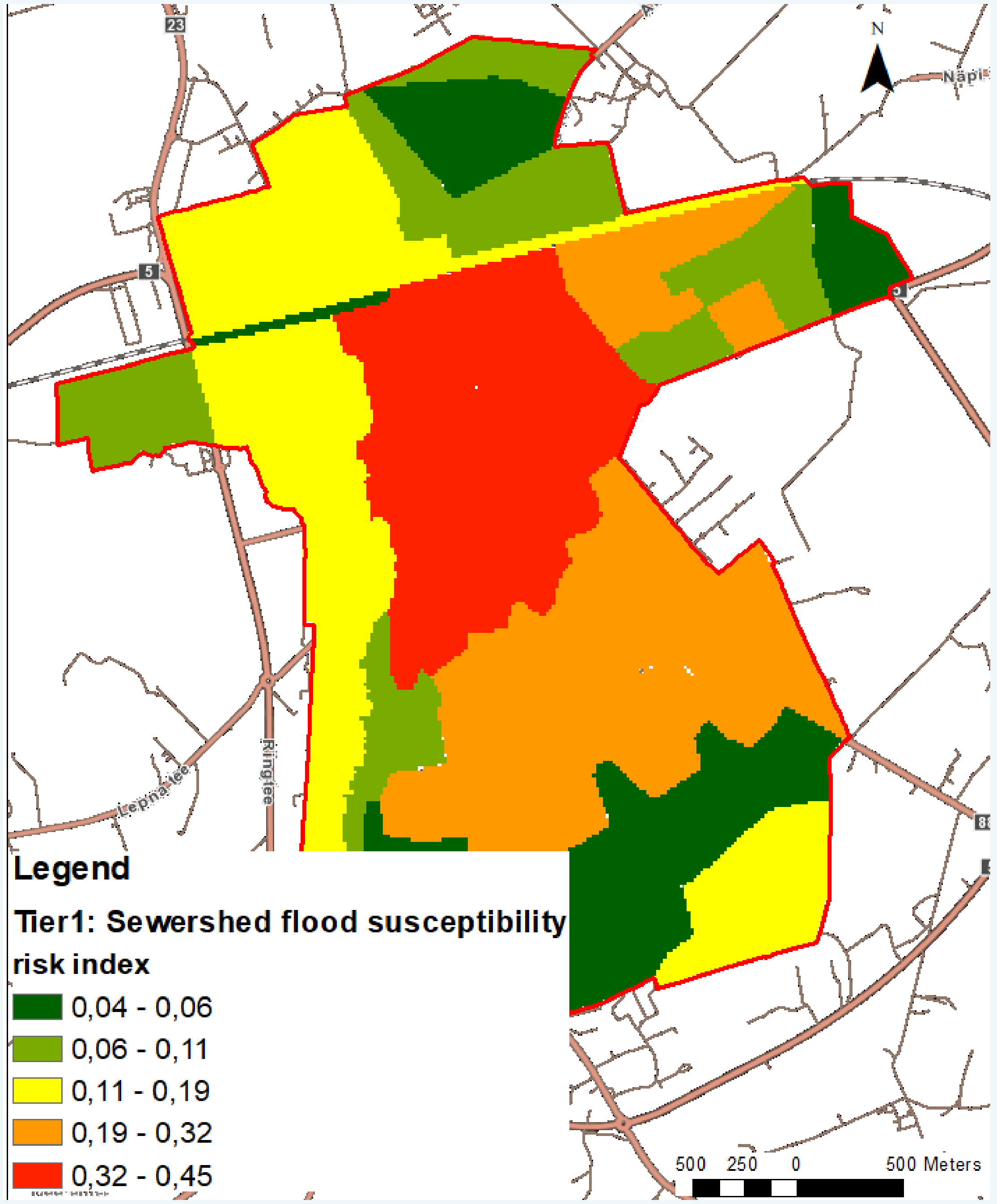
RISK FACTORS

Risk factor	Concept
Hazard	Likelihood of occurrence for extreme precipitation/Variable intensity according to the cityscape. Baseline applied in case study: national design standard [20]
	Concurrent hazards: to be considered in case the pluvial flood is magnified by other natural or manmade hazards (e.g. fluvial floods, system failures)
Exposure	Topographic susceptibility of flood: DEM based surface flow modelling results (TWI, RFS or other) Baseline applied in case study: TWI based on 1x1m DEM [21]
	Infiltration capacity: Landcover based infiltration capacity estimate. Baseline applied in case study: national 1:10 000 base map landcover data [22] combined with national design standard surface runoff rate [20]
Vulnerability	City based estimate. According to the EC Flood Directive the flood risk needs to be assessed against economic, social, environmental and cultural vulnerability [12] Baseline applied in case study (weighing factor): density and value factor of built-up area (1), population density (1), UDS character (0.5), overlay of heritage monuments (0.5)
Coping capacity	Scenario based estimate. Indicators need to show the direction of the impact of the coping measures. Current paper demonstrates the impact of green factor policy to city level flood susceptibility.

Risk identification (2)

BASE SCENARIO AND RISK LEVELS





Risk identification (3)

COPING CAPACITY SCENARIO

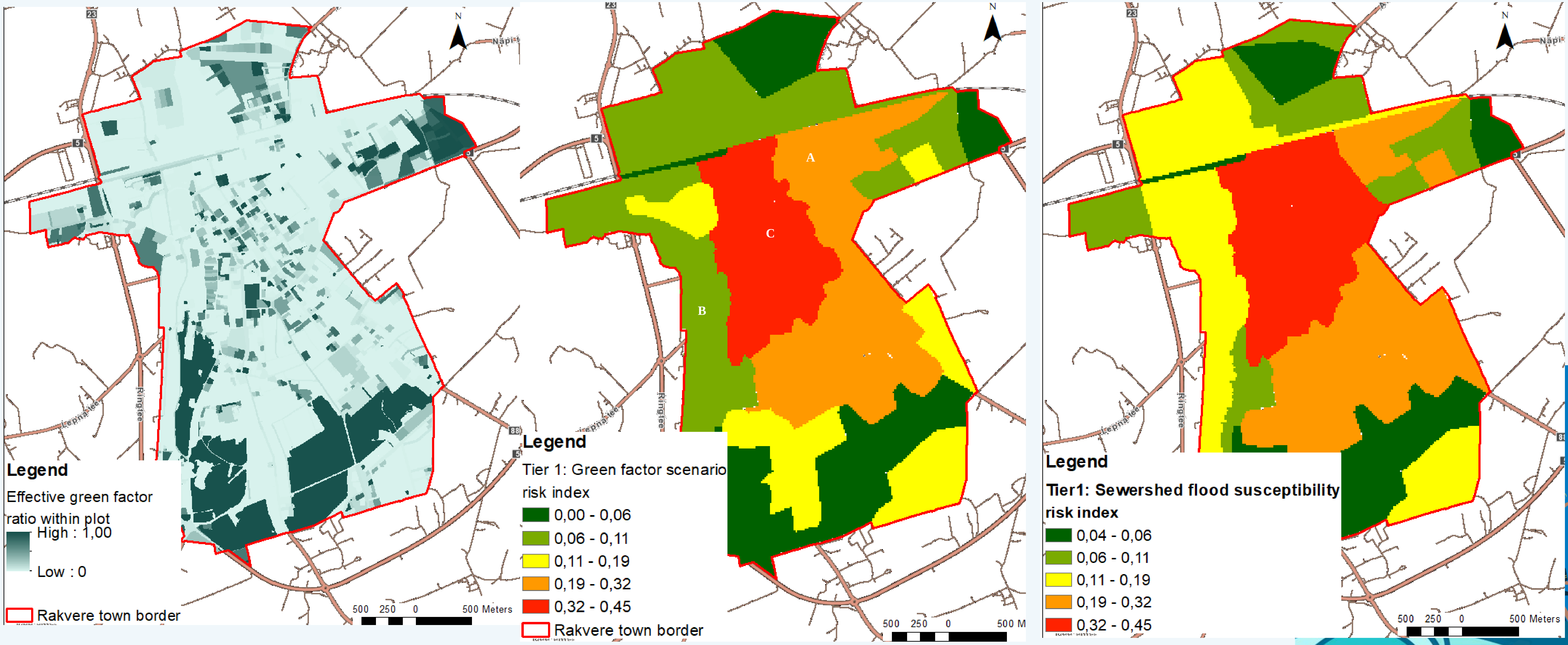
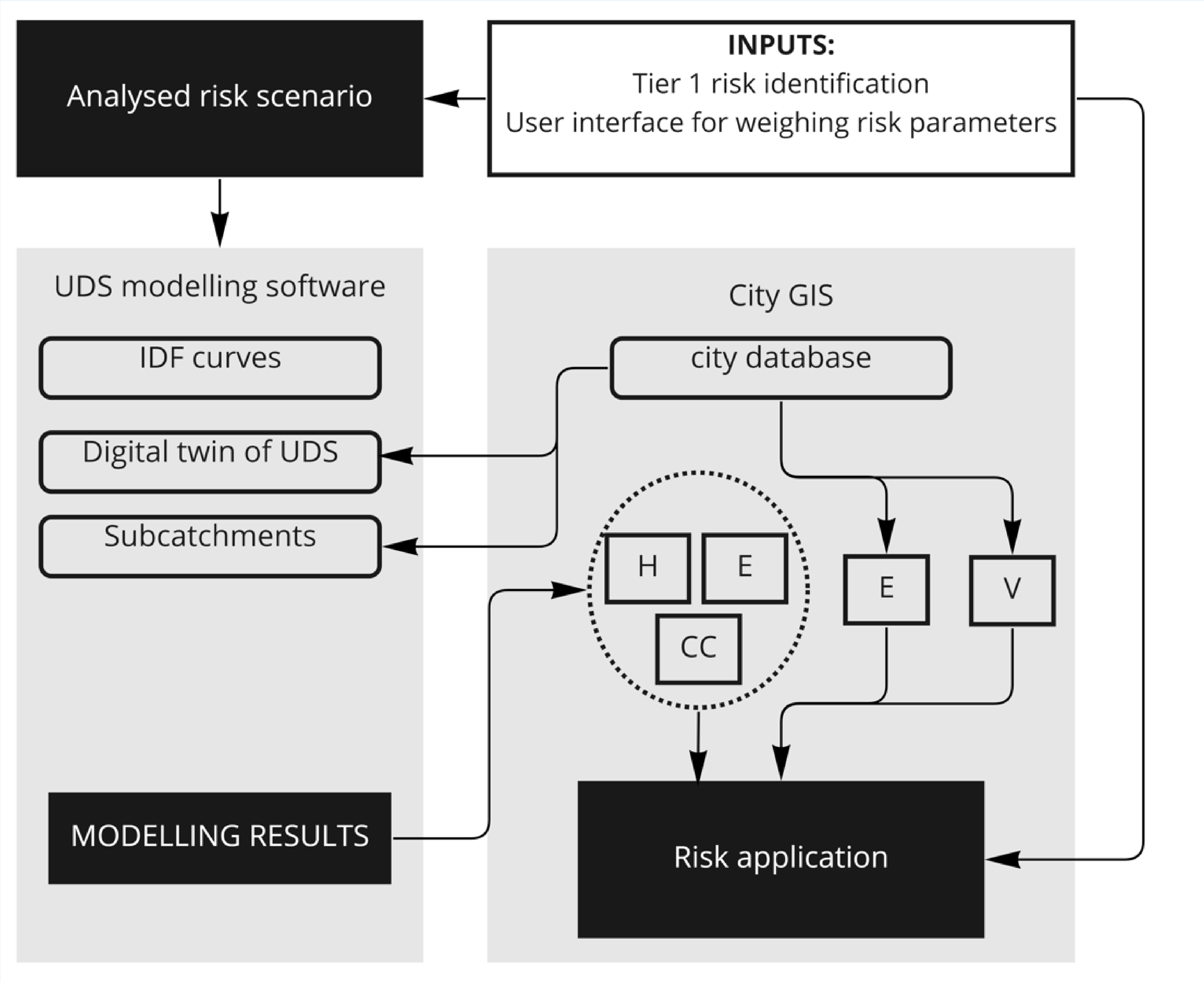


Figure 7 Effective green factor of property plots (Left). The risk level of catchments as policy would be enforced (Right).

Risk analysis (1)

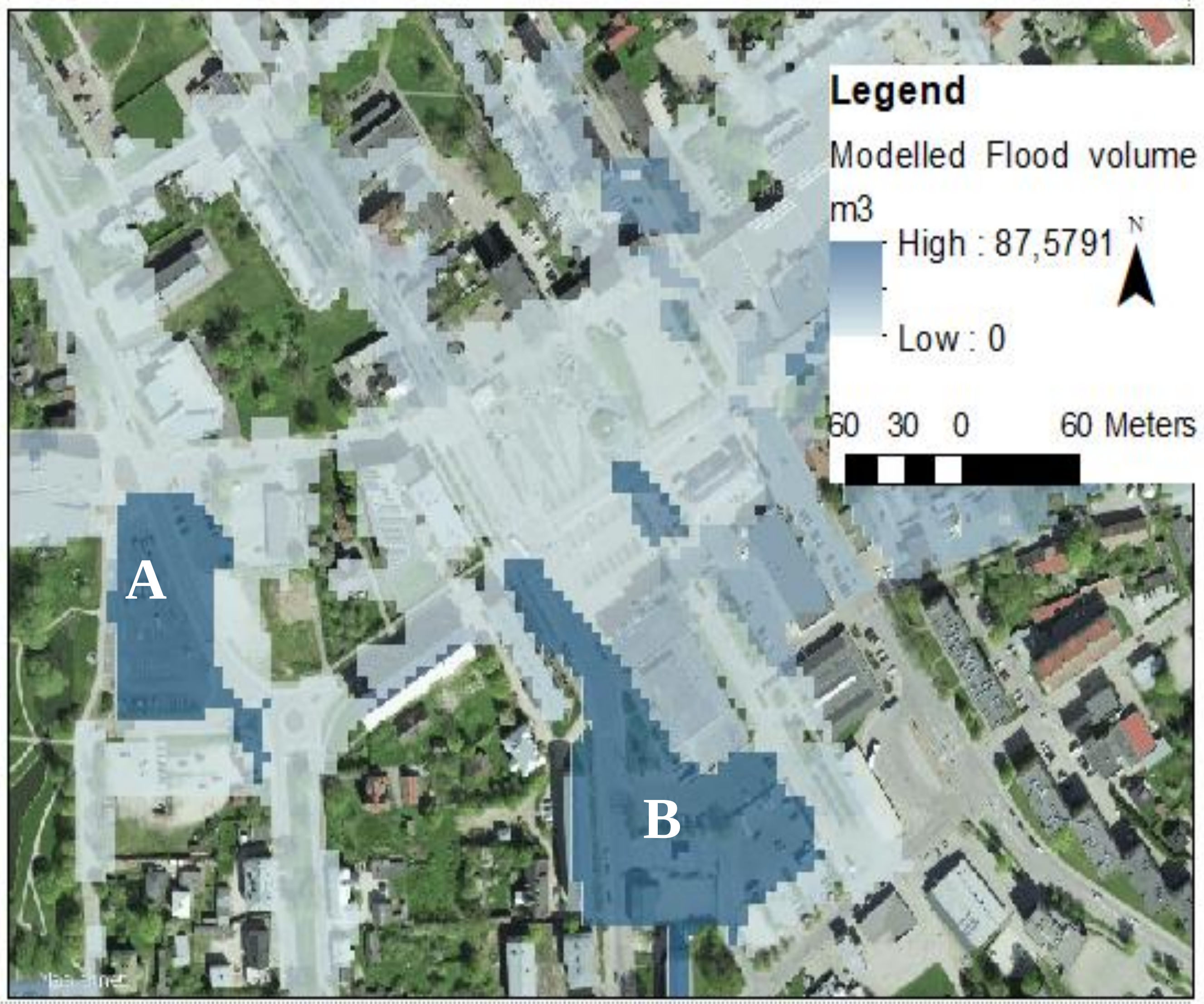
RISK FACTORS

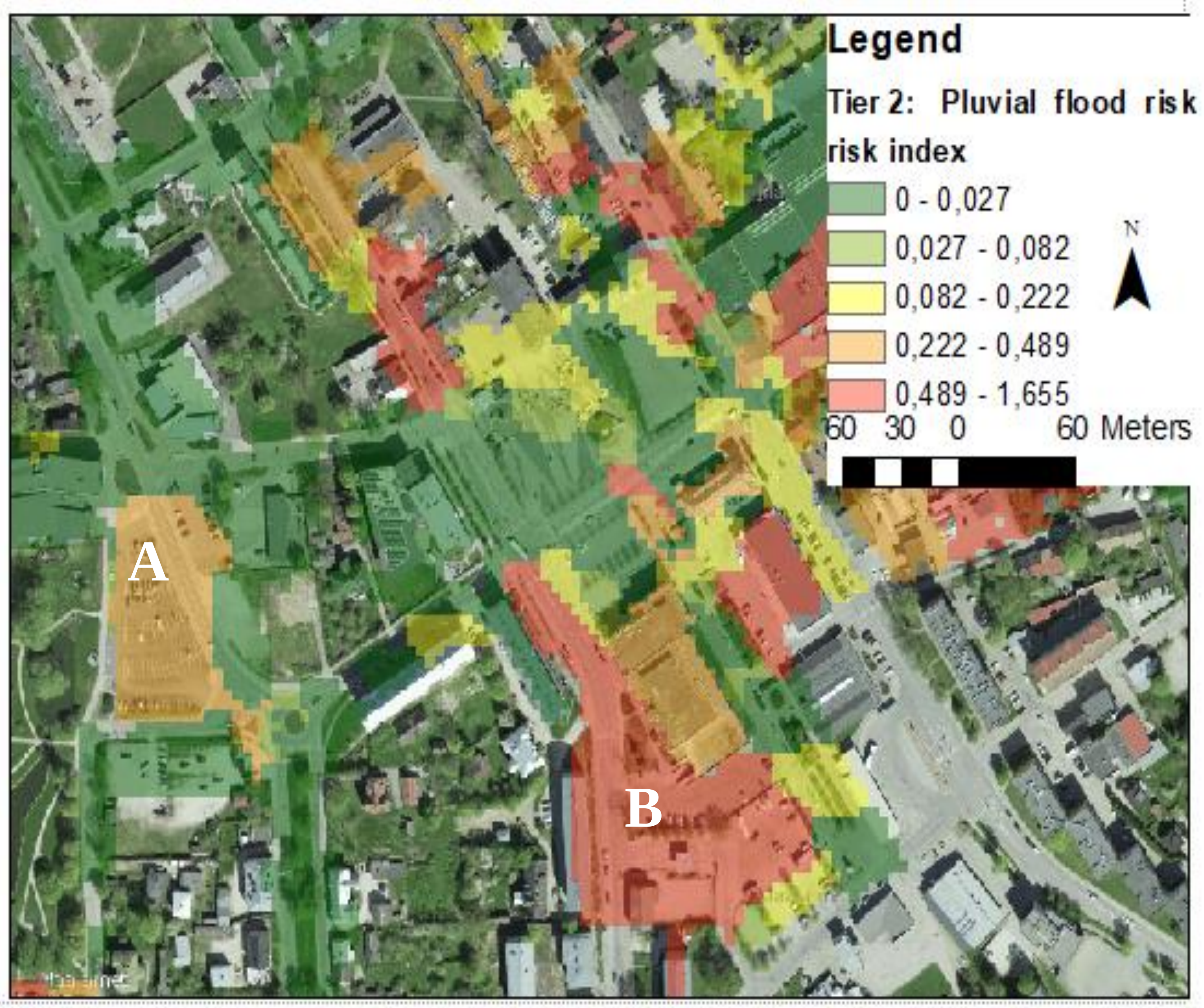


Specific method to analyse the pluvial flood damage in the high-risk catchment is selected by the character of the area. Current presentation will describe application of a solution in which the hazard is modelled using the digital twin of UDS.

Risk identification (2)

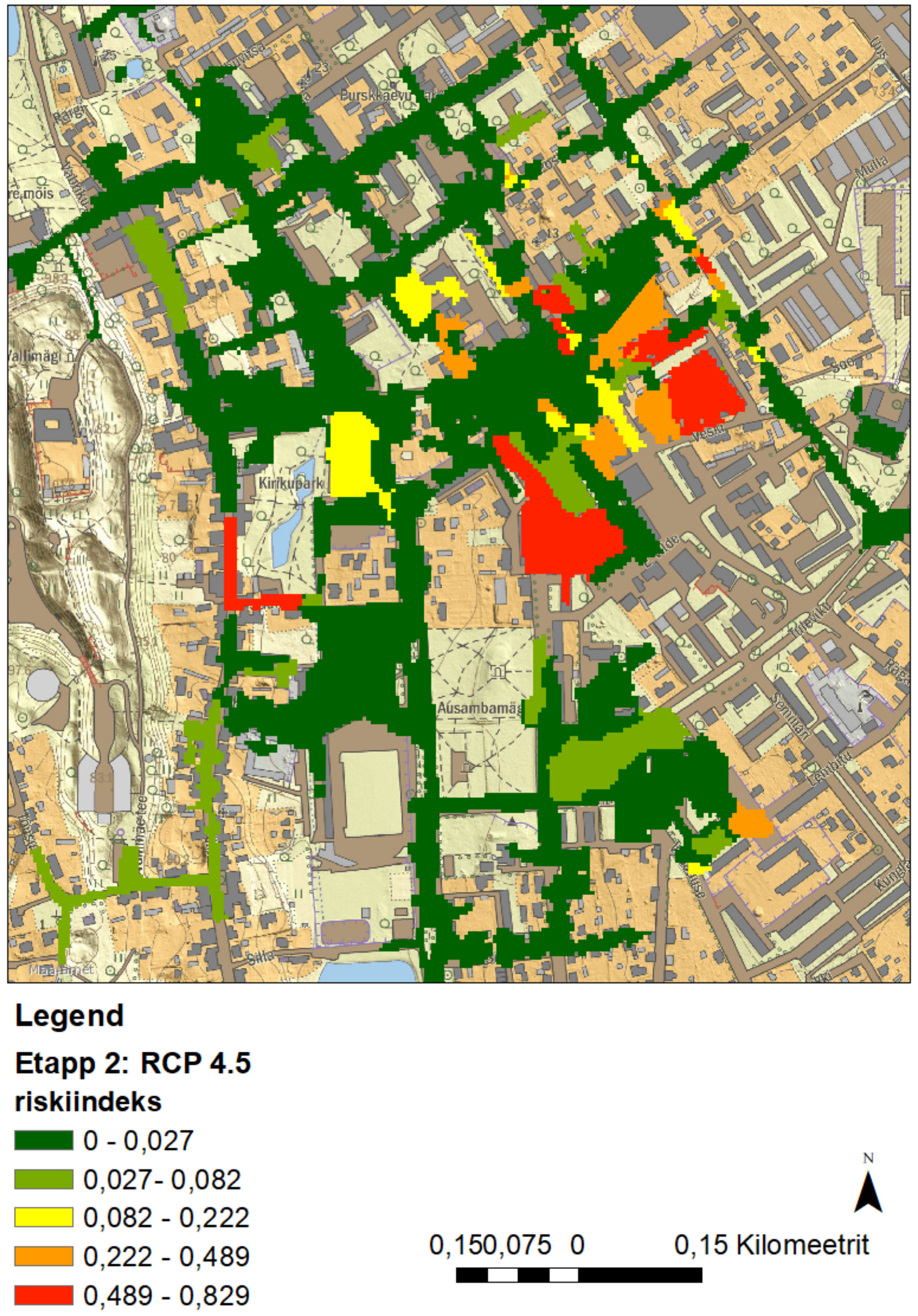
BASE SCENARIO AND RISK LEVELS

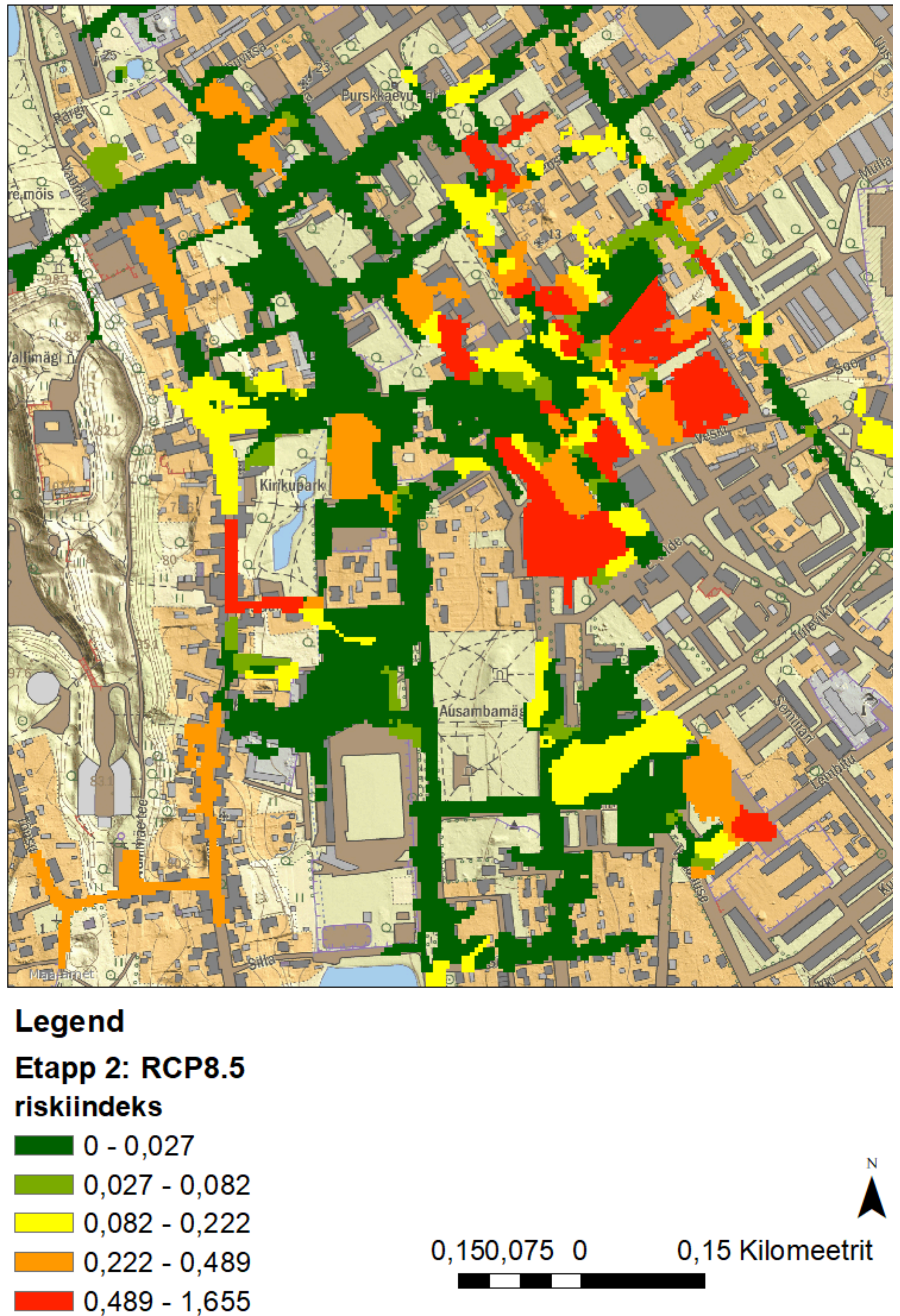




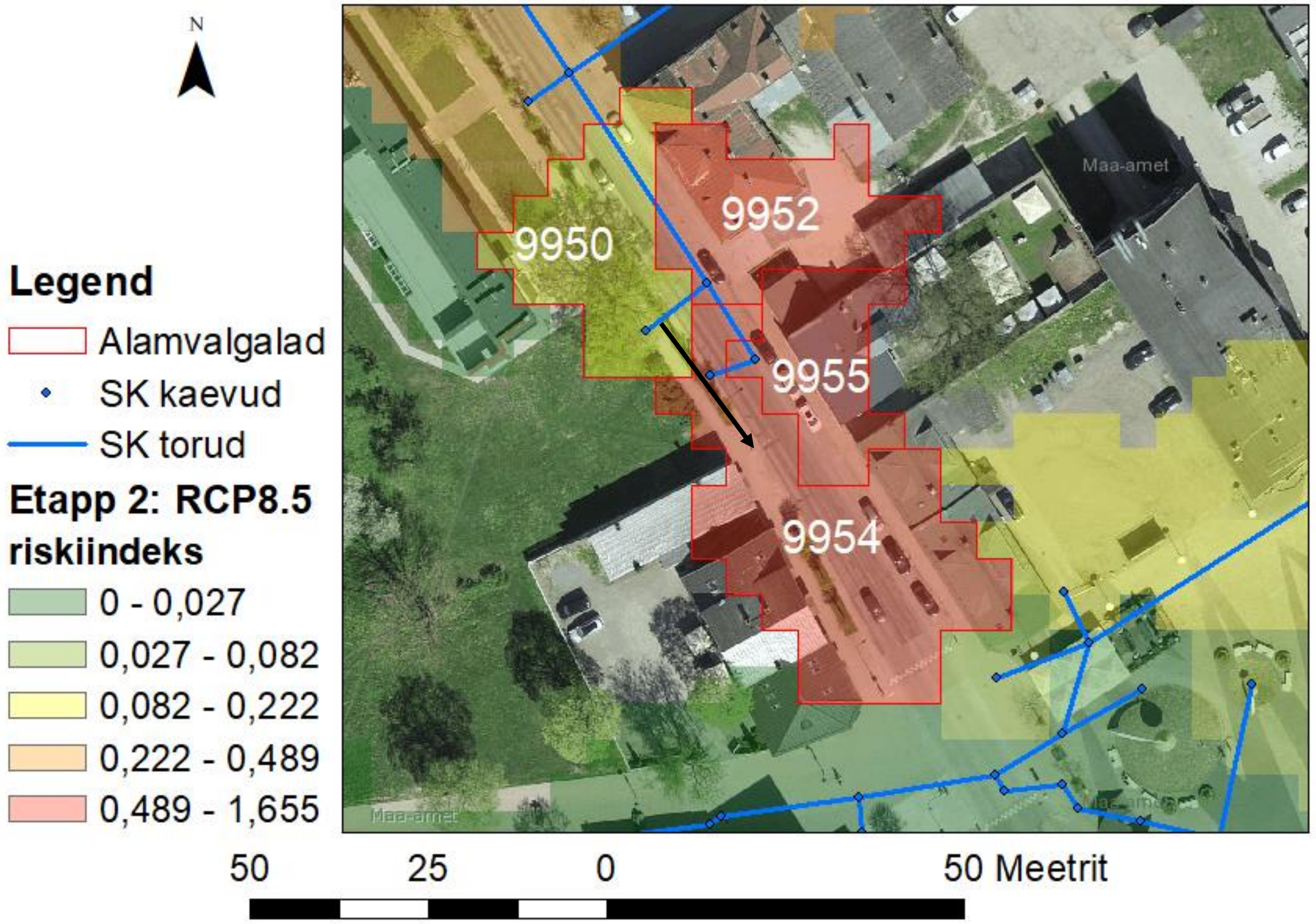
Risk identification (3)

ALTERNATIVE CLIMATE SCENARIOS





Risk evaluation (1)



Risk evaluation (2)

Sub-catchment (NodeID)	9954		9955		9952		9950	
Risk level	4	5	2	5	4	5	1	3
Risk index	0,284	0,549	0,004	0,517	0,477	0,888	0,001	0,206
Scenario ID	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Likelihood for the scenario	42%	12%	42%	12%	42%	12%	42%	12%
Hazard character: flood duration (minutes)	19,02	35,90	0	30,65	6,30	11,84	0	22,23
Hazard character: flood võlume (m3)	3,56	8,27	0	3,36	18,62	35,22	0	0,90
Buildings exposed to floods (building registry code)	108008548 108008557 108008547		108008554 120577740		108008551		108011723 108008551	
Population density (in/ha)	min 50 in/ha		min 75 in/ha		min 100 in/ha		min 100 in/ha	
Environmental vulnerability	Separate sewage		Separate sewage		Separate sewage		Separate sewage	
Cultural vulnerability	Heritage protection area		Heritage protection area		Heritage protection area		Heritage protection area	
Riski evaluation	Treatment needed (T)		Treatment needed(T)		Treatment needed (T)		Acceptable (A)	

Conclusions

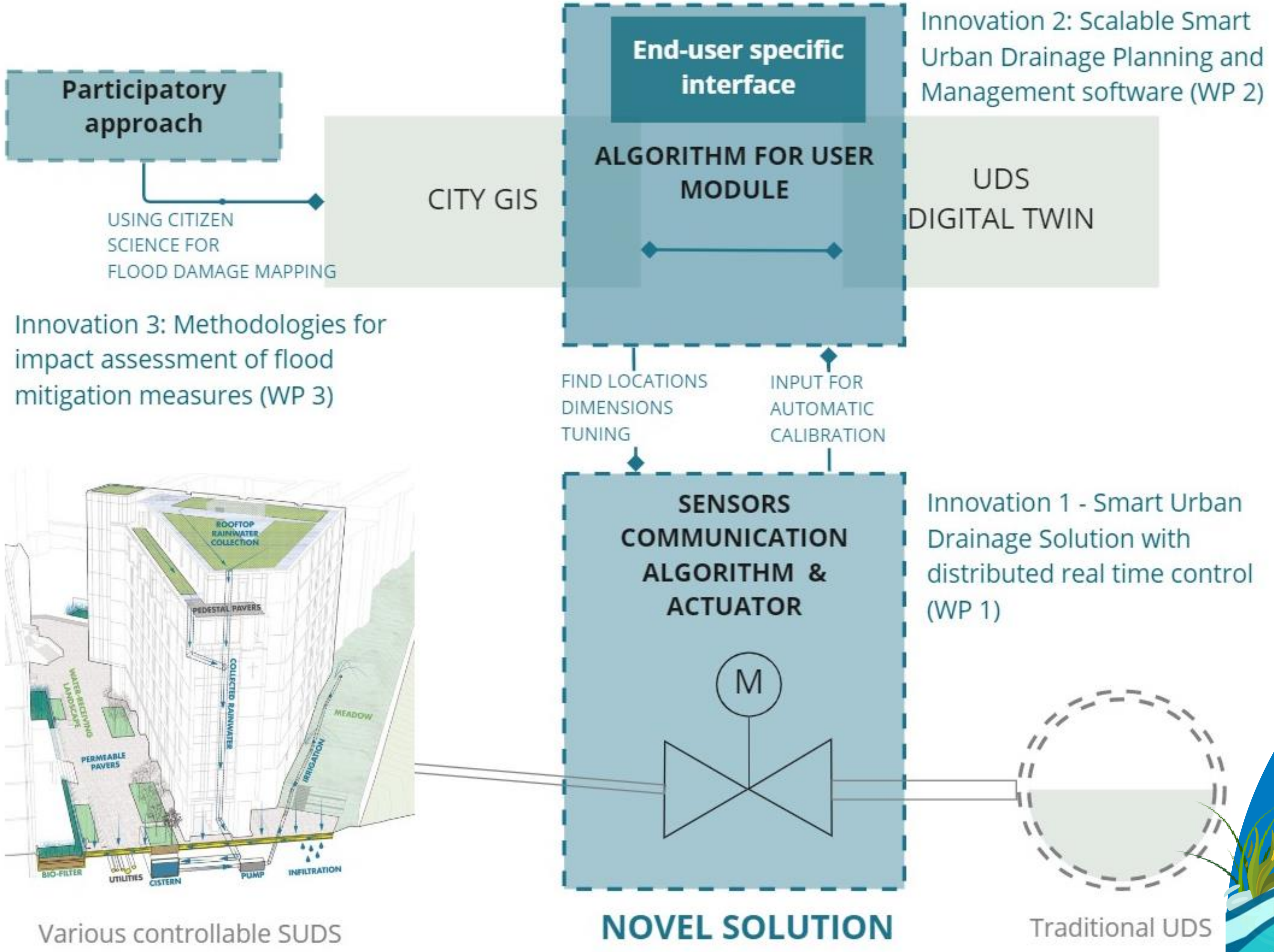
The proposed methodology

- Has high automation potential as can be linked with public registries and municipal GIS
- Makes it possible to assess pluvial flood risk in diferent scales and scopes
  - analyse the combined effect of floods to different vulnerabilities of the City
  - specialize the analysis to specifc vulnerabilities (buildings, sensitive groups, heritage areas etc).
- Allows to update the analysis at request or upgrade used methods as capacity advances.
- Improves cities capacity for data-based decision making in pluvial flood risk managment and optimize the resources foreseen for analyses.
- Allows to apply risk based management decisions to alleviate the potential flood damages.

Risk mitigation

SOLUTIONS FOR COMBINED STORMWATER MANAGEMENT

- Risk concious planning and precautionary principle in urban design
- Model predictive site selection and design criteria definition
- Real-time and model-predictive control systems (actuators and algorithms)
- Design of Nature Based Solutions



Follow-ups

Fine-tuning the methodology to increase the climate resilience of Estonian building stock (capacity building of nationa renovation wave):

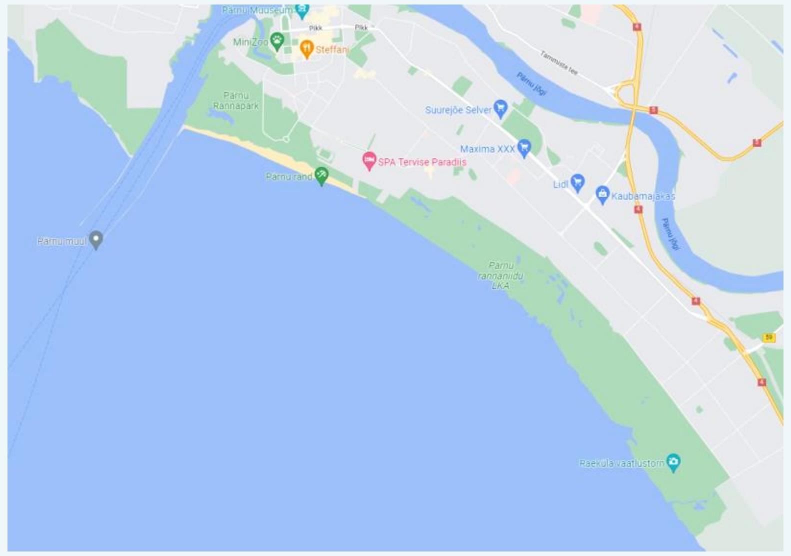
- Fine-tuning vulnerability factors of buildings;
- Advancing plot-based risk evaluation methods that assist also to identify mitigative solutions to floods
- Collaborating MoE for developing a practical guideline for municipalities to implement the methodology

Any joint challenges for the future?

LIFE URBANCOWS https://www.facebook.com/profile.php?id=100064856013706
2012-2016

EU priority habitats - Coastal meaow (HD 1630*) and coastal lagoon (HD 1150*) restoration in urban settings with community engagement and visitor management

Results: 250 ha of priority habitat complex restored, awarded visitor destination, preserved flood control zone at a coasline



Pärnu Postimees

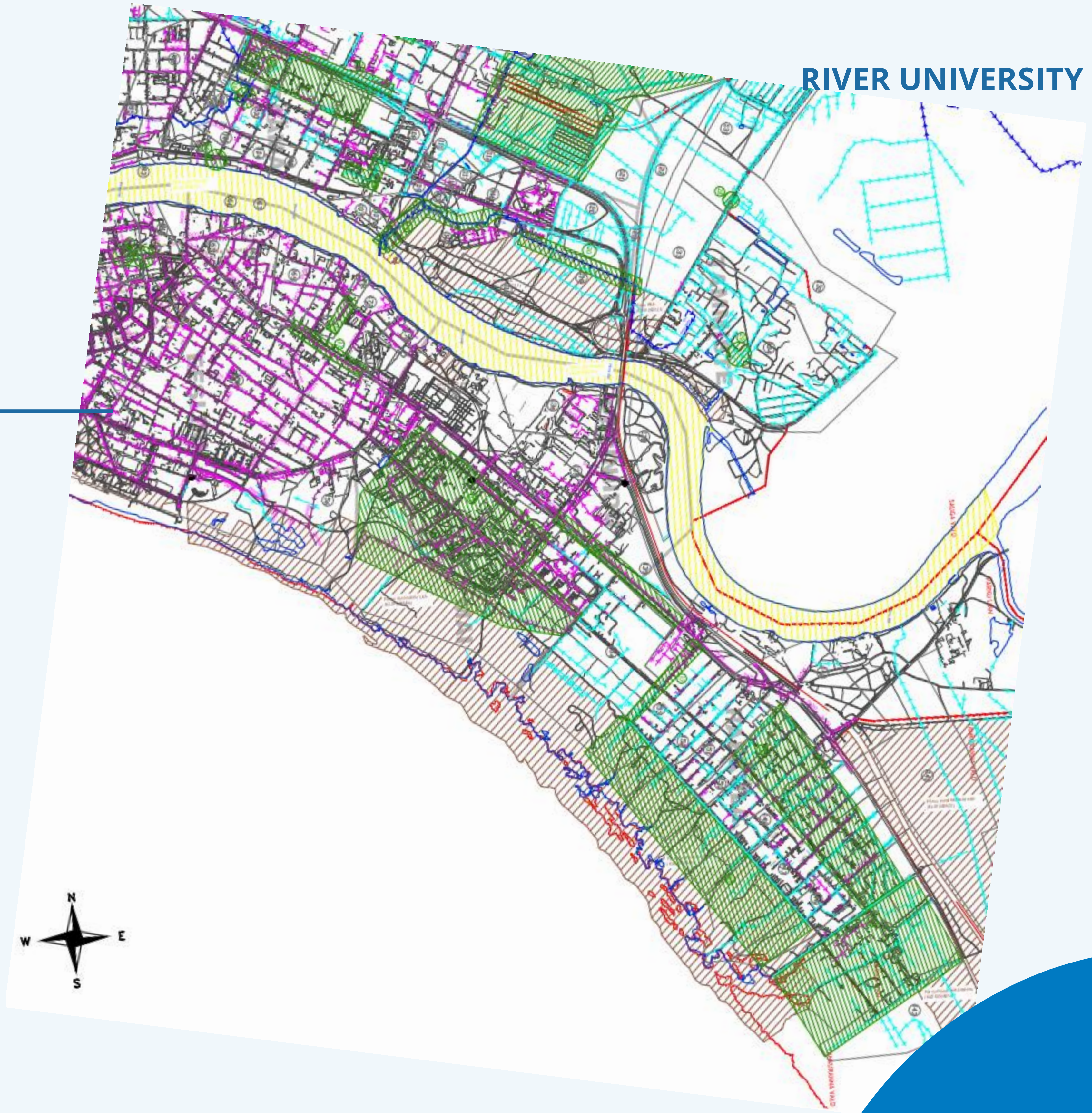
Uuring kinnitab: randade suplusvett reostavad rannaveised

Lauri Mutso, Ajakirjanik
10. jaanuar 2022, 15.48

High concentration of E. coli in the bathing water is blamed on grazing, however the sampling has been carried out only in the bay (not in the outflows of stormwater sewage) and the E. coli concentration has been also high during periods where the cattle is not in site and no floods have occurred in the pastures.

https://parnu.postimees.ee/7426768/uuring-kinnitab-randade-suplusvett-reostavad-rannaveised

LIFE Environment proposal?



Planned actions (Pärnu)

- Environmental DNA analyses combined with remote sensing monitoring techniques in stormwater drainage system to identify the causes of pollution;
- Developing/designing solutions
- Stormwater retention system to the residential area and biofiltration system in the coastal forest – smart control combined with nature based solutions.
- Policy work in the residential zone – identification of illegal outflows, assistance with joining the local wastewater sewage system;

Planned actions (Estonia)

- developing designs/solutions for areas with similar challenges (TbD)
- Testing novel methods for bathing waters quality monitoring and developing a national methodology and Toolset for it.

Planned partnership:

Pärnu City
Tallinn University of Technology
Environmental Agency of Estonia

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ESTONIAN WATER ASSOCIATION

THANK YOU

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