No 132 2021

NOTE

THEMATIC MEETING

Joint workshop between Klima 2050 and the Water JPI project EviBAN

Herman Helness and Edvard Sivertsen (Ed.)

KLIMA 2050

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Herman Helness and Edvard Sivertsen, SINTEF
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Thematic meeting

Joint workshop between Klima 2050 and the Water JPI project EviBAN

Workshop Report

Organizing partner:	**SINTEF**
Workshop Place:	**Trondheim, Norway**
Date:	**2021-08-17**
Number of invitees:	**NaN**
Number of registrations:	**26**
Number of guests attending:	**21**

Agenda for the workshop

Joint thematic meeting between Klima 2050 and the Water JPI project EviBAN

Use of grey-green solutions for rooftops, permeable pavements, and rain gardens to manage stormwater at ZEB Laboratoriet – Preliminary results from optimisation and integrated sustainability assessment

Time: August 17th, **09:00 – 12:30**

Location: **Teams**

Program

09:00 Welcome and introduction to the EviBAN-project by Herman Helness (SINTEF)
-project overview and assessment tools under development

09:30 Optimised stormwater management measures at the ZEB Lab. (Edvard Sivertsen, SINTEF)
-results from application of the optimisation tool at the Norwegian case study

10:00 Integrated Sustainability Assessment (ISA) of alternative solutions (Herman Helness, SINTEF)
-framework with criteria and indicators for assessment of stormwater management measures

10:30 On-line exercise with stakeholder input to the ISA framework

11:00 Coffee break

11:15 Testing of the optimisation tool in Finland (Felipe Dasilva, MSc student at Aalto University)

11:45 Modelling of stormwater management measures in Finland
-preliminary results from the case study in Finland (Harri Koivusalo and Ottar Tamm, Aalto University)

12:15 Results from the exercise

12:30 Closure

Objectives

The ZEB Laboratoriet will manage its stormwater through a set of nature-based solutions (NBS) where their efficiency will be documented in a pilot project in Klima 2050. The forthcoming Campus-project at NTNU has proposed some new buildings close to the ZEB Laboratoriet that may affect the stormwater management in the area, in particular at the ZEB Laboratoriet site. The Norwegian case study in the EviBAN-project (Evidence Based Assessment of Natural water retention measures) will assess this effect, where the key question in EviBAN is what the optimal combination of stormwater measures on the new campus site would be to meet both regulations and reduce the risk for flooding at the ZEB Laboratoriet.

The objectives of the meeting are:

- ✓ Bring together key stakeholders, such as property owners and solutions providers
- ✓ Discuss goals, solutions, and capabilities of the NBS
- ✓ Feedback from stakeholders on assessment criteria and weighting

Characterization of the participants

Table 1 shows the number of registrations and actual participants, the respective sector of activity and the level of governance each stakeholder is active in.

Table 1 Overview of stakeholders

Institution / sector	No. of participants (registrations)		
	In total	Male	Female
Authorities	**2 (5)**	**0 (1)**	**2 (4)**
Trondheim Municipality, technical dept.	1 (1)		1 (1)
NVE	0 (3)	0 (1)	0 (2)
Statsbygg	1 (1)		1 (1)
Representatives of companies, other sectors	**10 (12)**	**3 (4)**	**1 (1)**
Asak Miljøstein AS	1 (1)		1 (1)
Avinor AS	0 (1)	0 (1)	
If Skadeforsikring	1 (1)	1 (1)	
Multiconsult	4 (4)	2 (2)	2 (2)
Storm Aqua AS	1 (1)	1 (1)	
ZEB Lab	1 (1)		1 (1)
NTNU	2 (3)	2 (3)	
Internal Stakeholders	**9 (9)**	**6 (6)**	**3 (3)**
SINTEF	3 (3)	2 (2)	1 (1)
VTT	2 (2)	1 (1)	1 (1)
Aalto University	4 (4)	3 (3)	1 (1)

Short summary of the workshop's activities

Due to the corona virus situation, the workshop was conducted as a virtual event using Teams.

The presentations covered the activities of the Norwegian and Finnish research partners in EviBAN connected to modelling and optimizing stormwater management measures, and integrated sustainability assessment (ISA) of alternative solutions.

The presentations can be found in the EviBAN Teams shared project channel in the directory for the local workshop in Trondheim.

The second part was a groupwork exercise. Participants were asked to fill in an on-line questionnaire to give input to measure the sustainability of the different stormwater measures.

The workshop was moderated by Herman Helness (HH) from the EviBAN project.

Group exercise: Input to measure the sustainability of the proposed NWRM

The objective of the group exercise was to provide stakeholder input to the weighting of objectives, criteria, and indicators in the integrated sustainability assessment (ISA) that is being developed as part of the activities in EviBAN. The session was introduced by HH with a short presentation of what an ISA is and what it may be used for. For the latter, some results from the previous SUWAM project were presented as an example.

Thereafter the questionaire and objectives were explained and distributed to each participant who answered individually. Preliminary results from the exercise were presented at the end of the meeting and are included in the slides from the presentation.

EviBAN

Evidence based assessment of NWRM for sustainable water management

Evidence Based Assessment of NWRM for sustainable water management (EviBAN) – a short introduction

Herman Helness

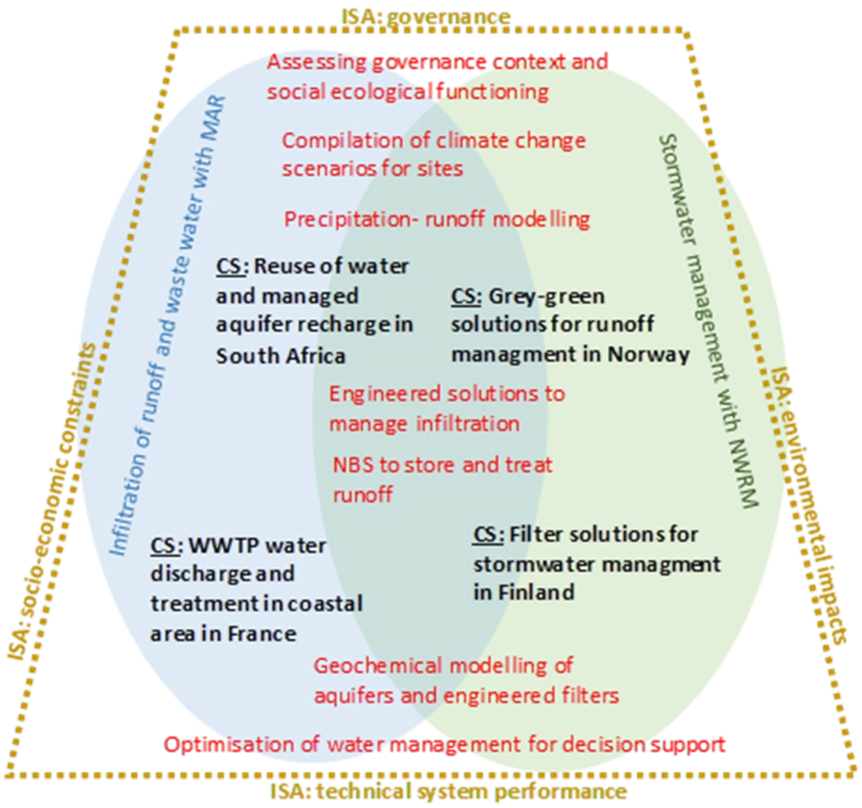
Stakeholder workshop 2021-08-17

International project consortium

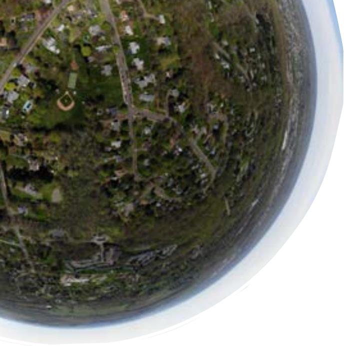
- Water JPI project
  - Promotes international collaboration
  - Each country funds itself
  - EviBAN: Total cost 1,48 Meuro over 3 years
- EviBAN consortium
  - Norway: SINTEF (project coordinator)
  - France: BRGM, Antea Group & ImaGeau
  - Finland: Aalto University & VTT
  - South Africa: Stellenbosch University Water Institute

EviBAN main objectives

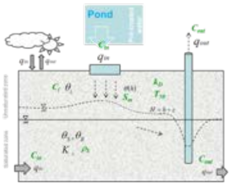
- **Knowledge on NBS for water management to counter negative impacts** of climate change, anthropogenic activities and societal change, and **how NBS should be optimally used** under different conditions to **contribute to progress towards SDGs**.
- **Integrating results** from diverse case studies in South Africa, France, Finland and Norway, in a **toolbox for adaptive water management** - different conditions with respect to climate change, anthropogenic activities and societal change.

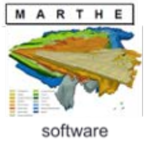


- Case study approach in 4 locations
  - FINLAND and NORWAY: Stormwater management with NWRM
  - FRANCE and SOUTH AFRICA: Infiltration of runoff and wastewater with MAR
  - Common external pressures (*e.g.,* climate change), shared tools (*e.g.*, models such as SWMM, MARTHE, PHREEQC), and shared NBS, such as enhanced infiltration techniques required in MAR and pursued by NWRM
- Integrated Sustainability Assessment (ISA): Performance, environmental impacts, governance, and socio-economic aspects are combined in a holistic assessment



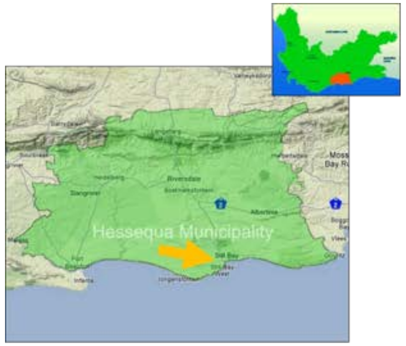
Case studies





+ Phreeq-C

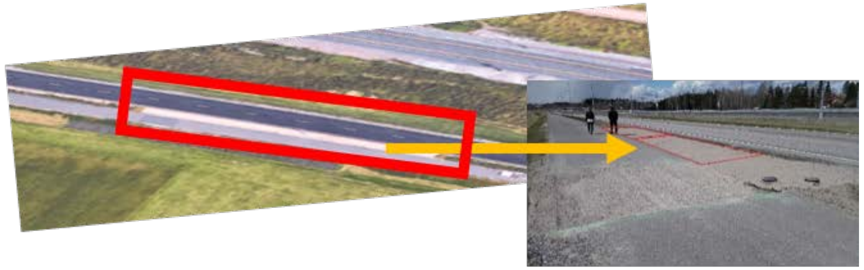
<u>Agon in Normandy, France:</u> **Description:** Tertiary treatment of secondary WWTP effluent (33 500 inh. eq./ BOD5= 2120 kg /day) by reed bed and a sand dune filter. The MAR/SAT system has been chosen to protect the sensitive shellfish production zone on the surrounding estuary. Since 2016, the ImaGeau Subsurface Monitoring System is implemented for real time monitoring of saline intrusion. Water quality and quantity are analysed to develop an ICT tool (BRGM/Géo-Hyd) to assess efficiency of SAT in context of saline intrusion. **Stakeholders** are SAUR (WWTP management for local authorities), Seine Normandy Water Agency (Public Institution with mission is to support water resources protection), ARS (Regional Agency of Health), SMEL and Agon Municipality.
<u>Hessequa Municipal area in the Western Cape, South Africa:</u> **Description:** Water stressed areas relying partly on groundwater for water supply. Pressures on water resources due to drought. Artificial aquifer recharge (AR) in the Goukou River, using flushed water during high rain periods, is a potential water resource. Potential impacts of the AR-process on biodiversity and estuarine health will be a key parameter in the plausibility of using AR. Optimisation of best combination of water sources and NWRM to use. Optimisation tool to be customised for use by local municipal officials. **Stakeholders** are Hessequa Municipality, Cape Nature, National and Provincial departments for water and environment.



Case studies

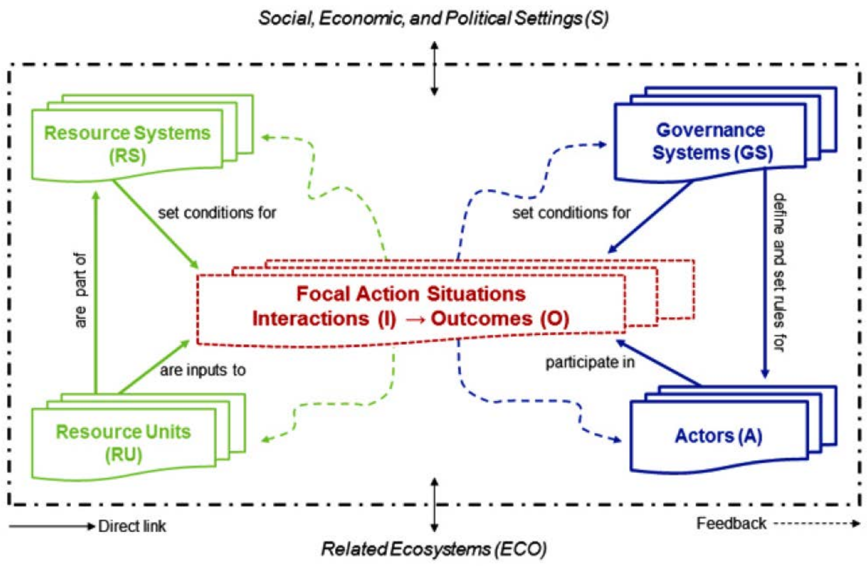
<u>KLIMA 2050 - Høvringen, Vikaune Fabrikker - Sveberg and Storm Aqua – Sandnes, Norway:</u>
Description: Eco-engineered grey-green solutions for rooftops and engineered pervious surface materials for runoff management with respect to quality and quantity. Høvringen consists of 3 large-scale test fields, whereas Sveberg consists of 4 large-scale test fields, hence both sites enable parallel testing of different measures. The sites are in mid Norway. In Sandnes (southern Norway), there are two full-scale installations. One site focuses on infiltration and the other on treatment. All sites are instrumented to measure the water balance and climatic conditions. **Stakeholders** are Storm Aqua and Vikaune Fabrikker (suppliers of grey-green solutions).

<u>Stormwater NBS test sites in Espoo and Vantaa, Finland:</u>
Description: Biofilters and similar NBS to capture and treat stormwater runoff from roads prior to infiltration or discharge to receiving surface waterbodies. Site monitoring and acquisition of data for hydrologic, hydraulic and geochemical performance assessment. Consecutively linked hydrological and hydrogeochemical transport modelling of NBS performance and impact during heavy rainfall/snowmelt events in cold conditions.
Stakeholders are regional and local authorities, local community, landscape designers, suppliers.



System perspective

- Aim to assess the solutions as part of a socio-ecological system (SES)
- Project activities cover different parts of the SES
- Integrated through the toolbox

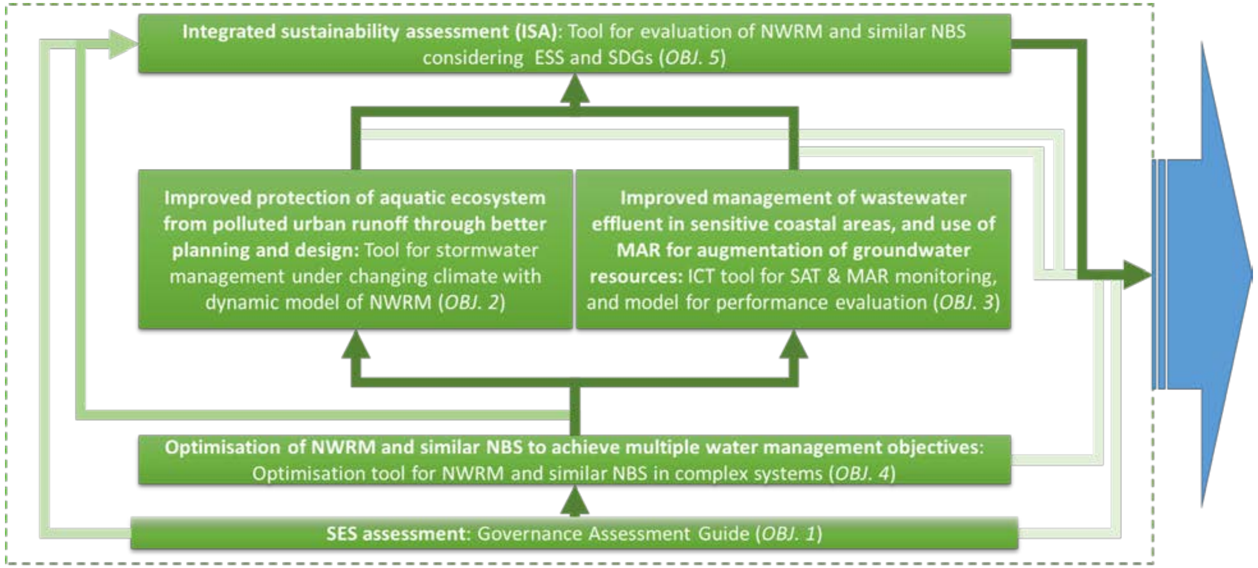


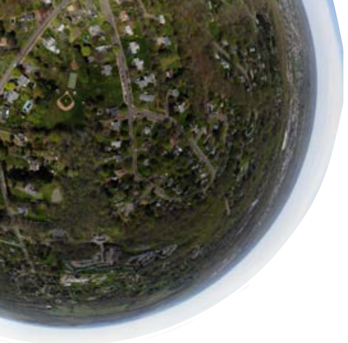
McGinnis and Ostrom (2014)

- Tools to be developed together with local stakeholders
- Interaction between tool development and demonstration
- Dissemination through existing platforms and project web site

Toolbox for assessment of solutions

- Compilation of different assessment tools
  - SES assessment
  - Optimisation
  - Stormwater management
  - Managed aquifer recharge (MAR) and soil aquifer treatment (SAT)
  - Integrated sustainability assessment (ISA)
- Some assessments based on existing tools, e.g., SWMM for stormwater and NORMAN for MAR/SAT, others developed in EviBAN
- Collaboration to utilise synergies with other projects
  - For activities in Norway: Klima 2050, DRENSTEIN, WIDER UPTAKE

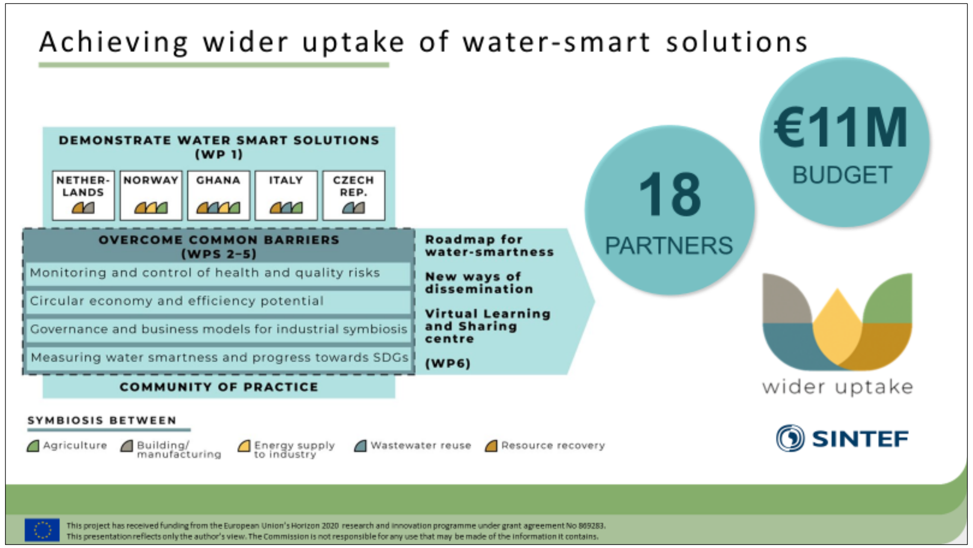




Collaboration and synergies

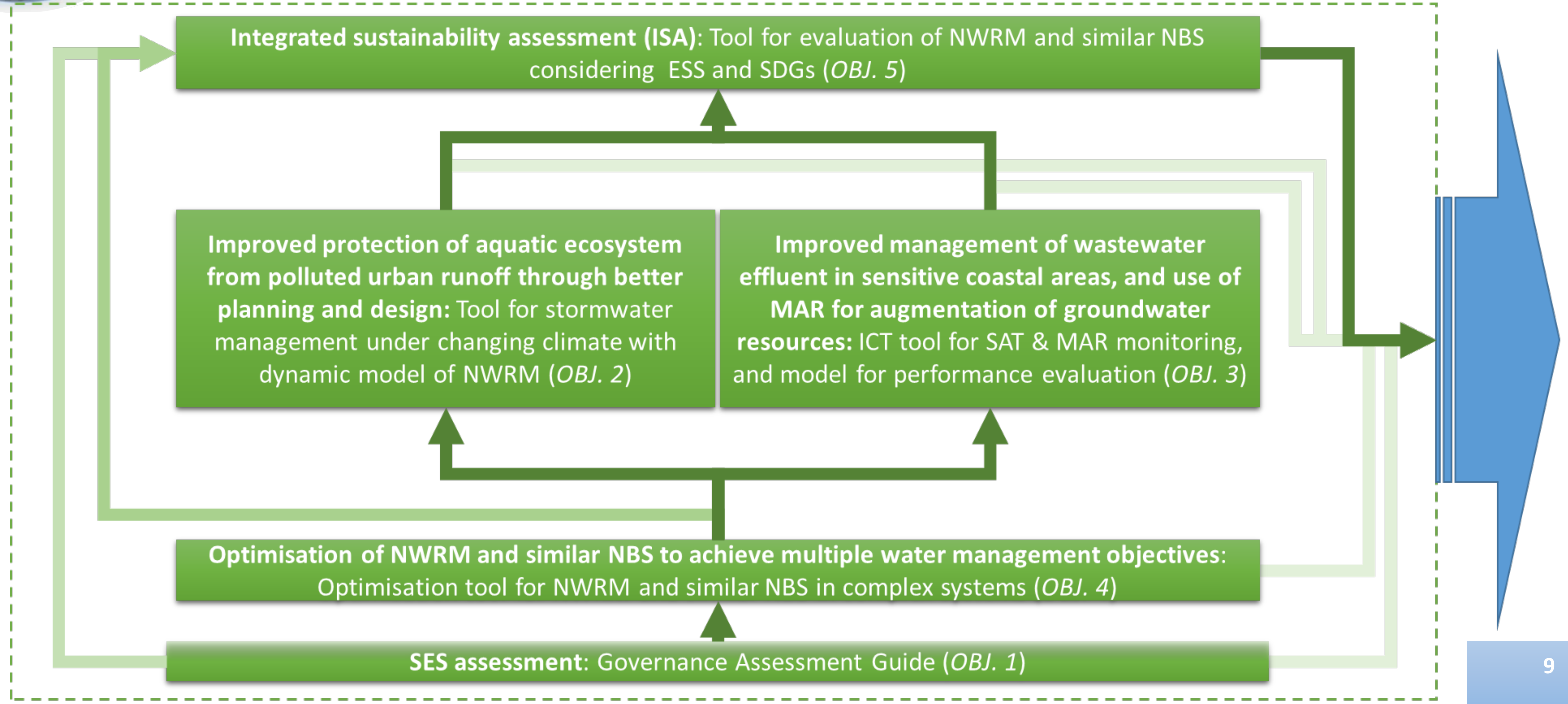
- Methods
- Data
- Stakeholders

as applicable



Toolbox for assessment of solutions

- Several paths depending on level of detail in the assessment



Thank you for your attention

Herman Helness
PhD, Project coordinator

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Eviban
Evidence based assessment of NWRM for sustainable water management

Aalto University School of Engineering
anteagroup
brgm Geoscience for a sustainable Earth
imaGeau
SINTEF
WATER INSTITUTE
VTT

https://www.sintef.no/projectweb/eviban/

EviBAN

Evidence based assessment of NWRM for sustainable water management

Evidence based assessment of NWRM for sustainable water management

Norwegian case study and test of the optimisation tool

Edvard Sivertsen
Thematic meeting with Klima 2050 – August 17th, 2021

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imaGeau
SINTEF
WATER INSTITUTE
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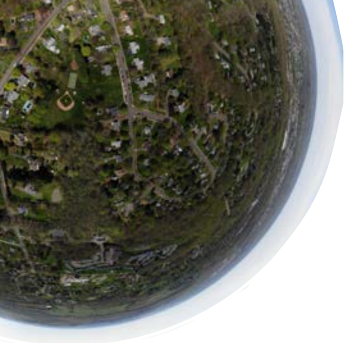
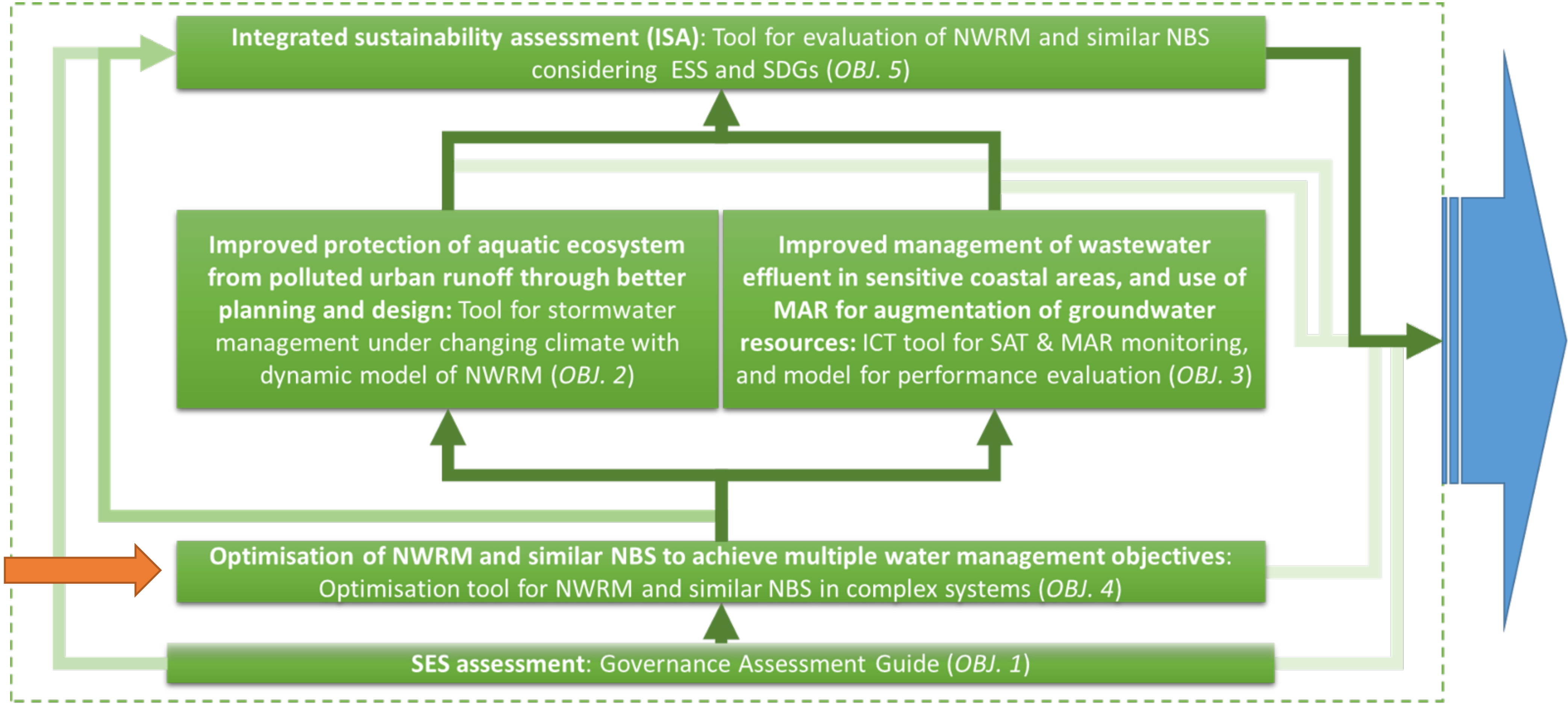
Water JPI

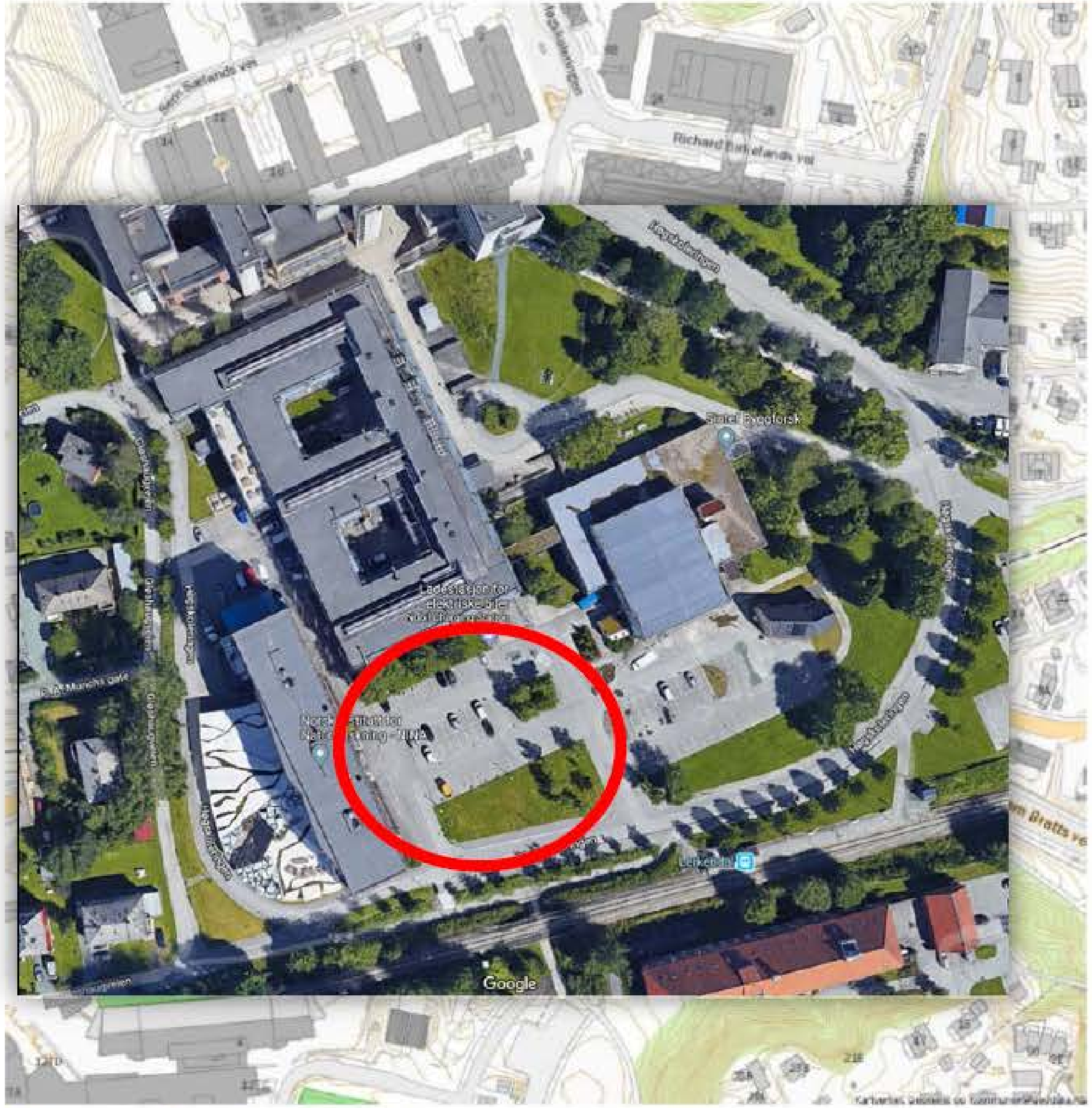


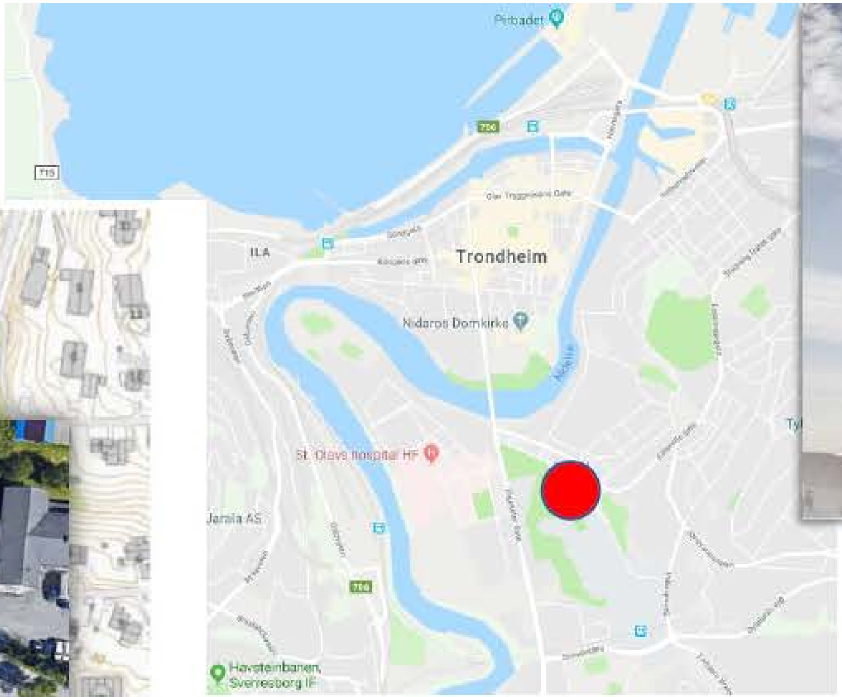
Toolbox for assessment of solutions

A closer look at the **optimisation tool**



The ZEB Laboratory





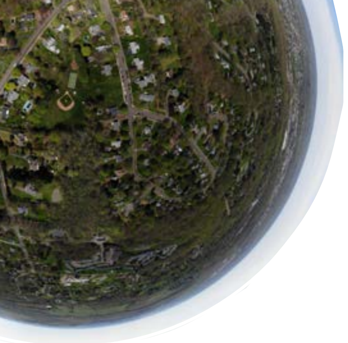
Ill. Veidekke/LINK Arkitektur

- Location: NTNUs campus - Gløshaugen, Trondheim
- 2000 m^2 Living Laboratory i 4 stories
- Budget: 127 MNOK (approx. 12,7 MEuro)
- Financed by
  - NFR: 63 MNOK (approx. 6,3 MEuro)
  - ENOVA: 8 MNOK (approx. 0,8 MEuro)
  - NTNU: 28 MNOK (approx. 2,5 MEuro)
  - SINTEF: 28 MNOK (approx. 2,5 MEuro)

ZEB LABORATORY

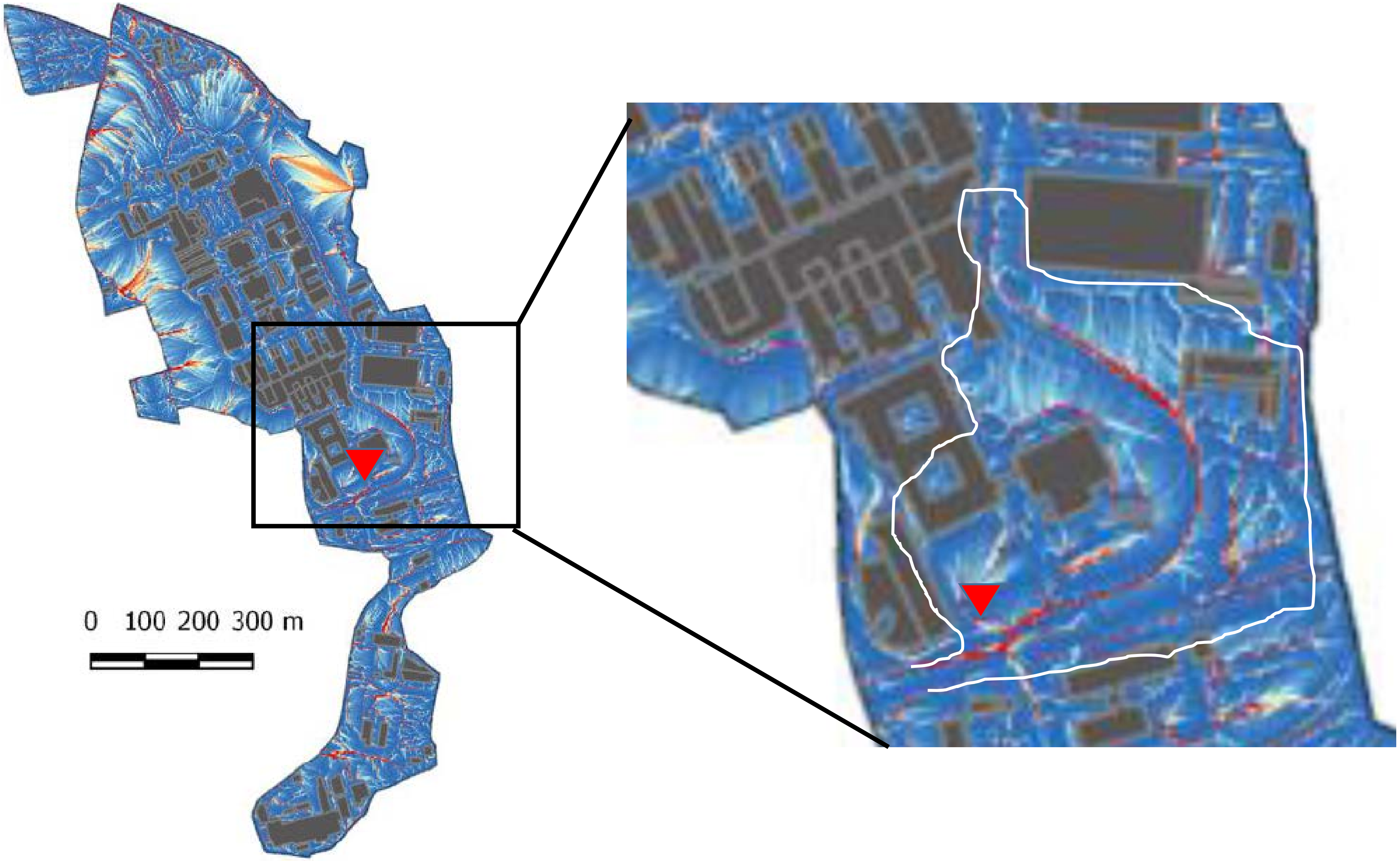
Climate adaptation of a zero emission building

Pilot project in Klima 2050: Stormwater management
Partnere: SINTEF, NTNU, Multiconsult, Isola, Skjævelandgruppen, Trondheim kommune, Statsbygg



NTNU Campus

ZEB Lab



Drainage lines at the NTNU campus

Catchment

Muthanna, T.M, Sivertsen, E, Kliewer, D & Jotta, L: Coupling Field Observations and Geographical Information System (GIS)-Based Analysis for Improved Sustainable Urban Drainage Systems (SUDS) Performance. Sustainability 2018, Vol. 10(12), p. 4683; doi.org/10.3390/su10124683,

NTNU Campus

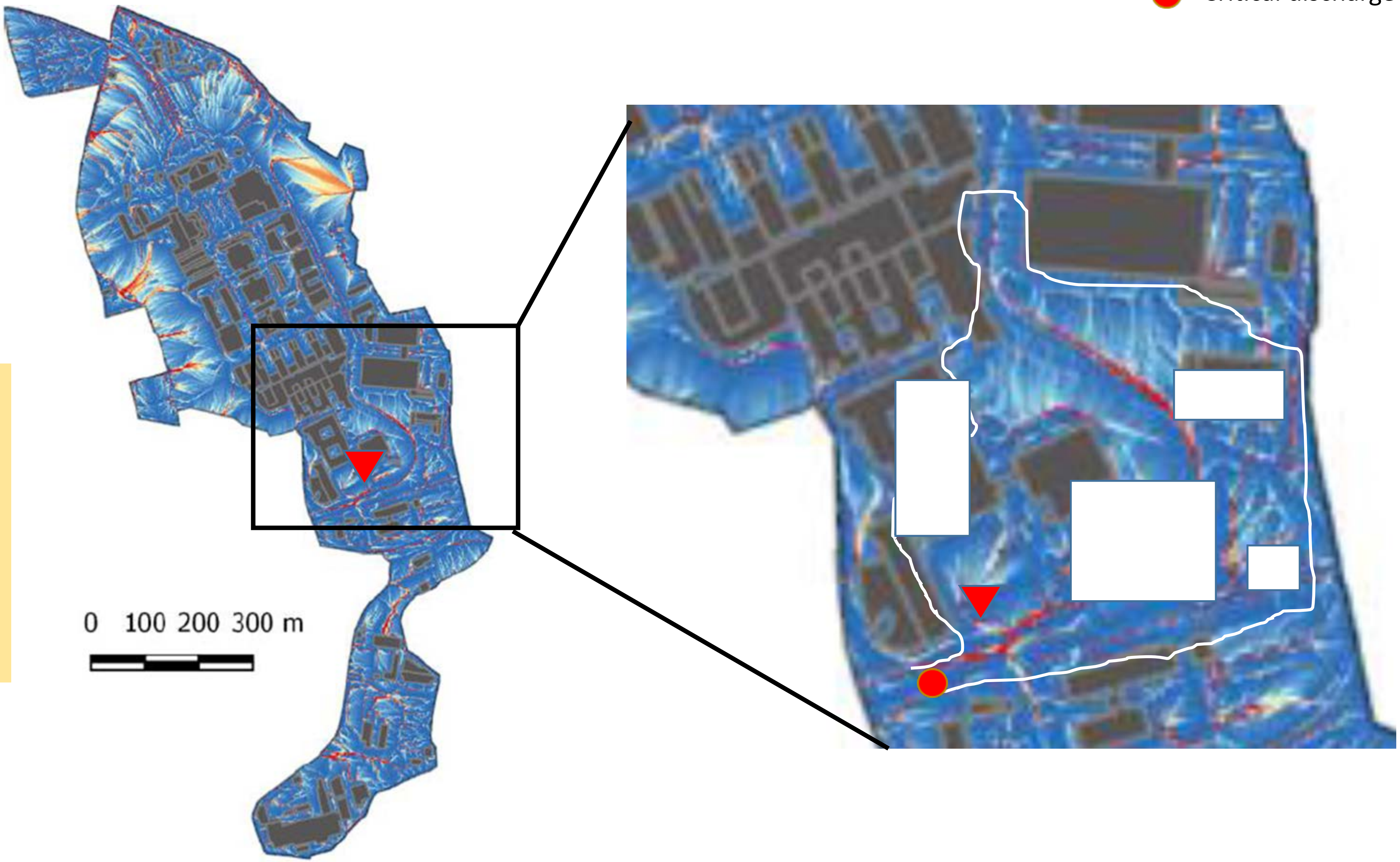
ZEB Lab

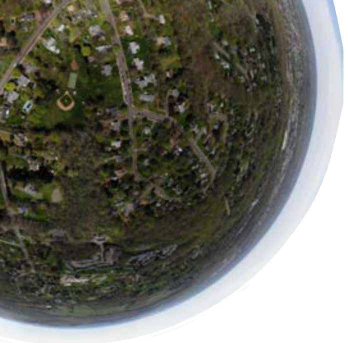
Critical discharge point

Drainage lines at the NTNU campus

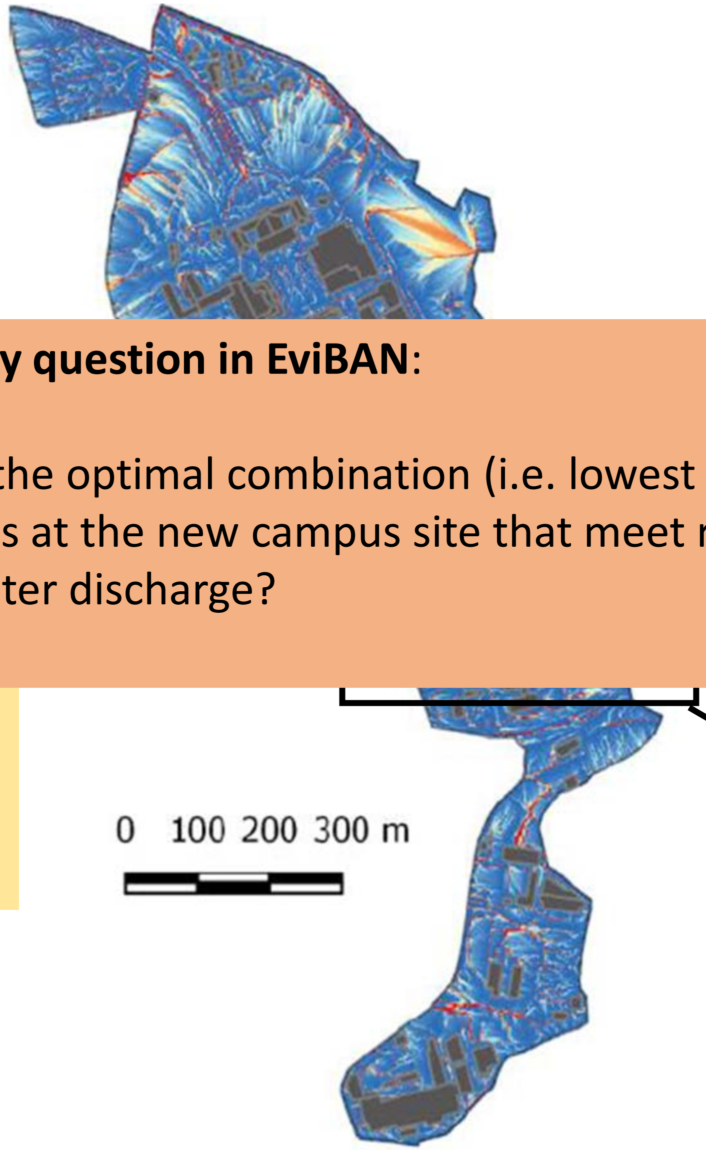
Catchment

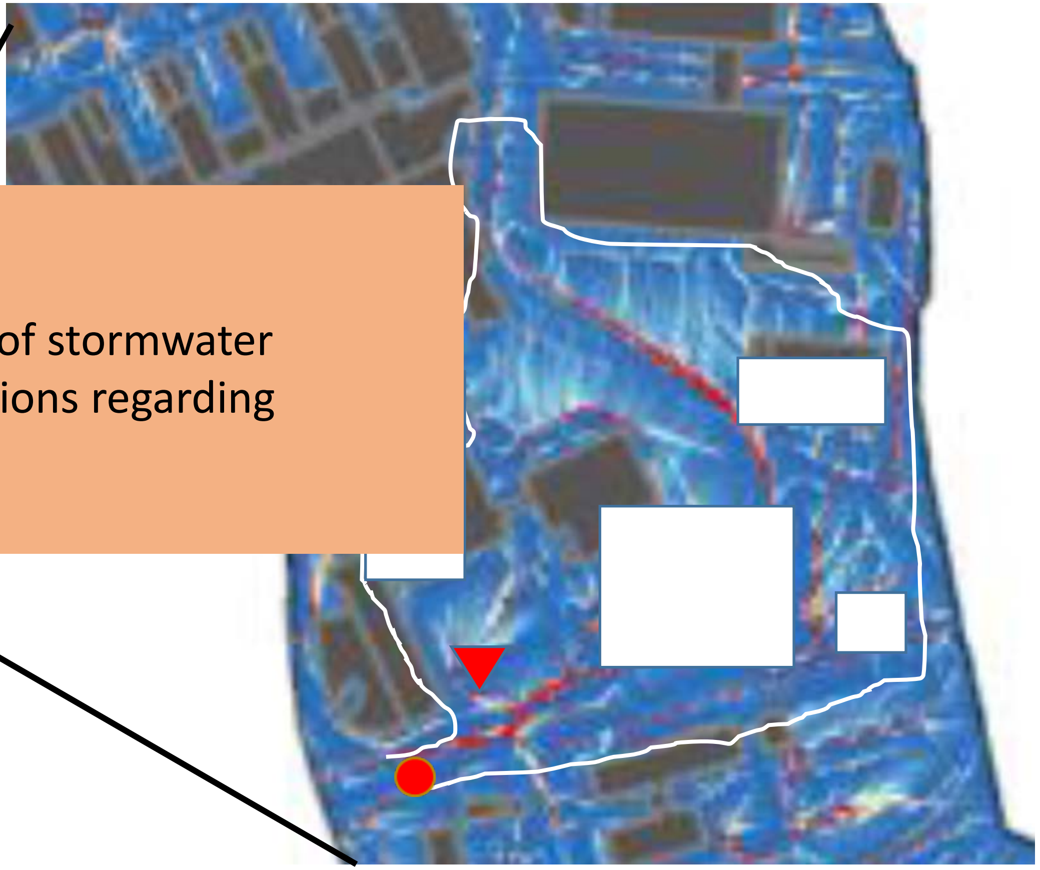
Roughly placement of new buildings





NTNU Campus





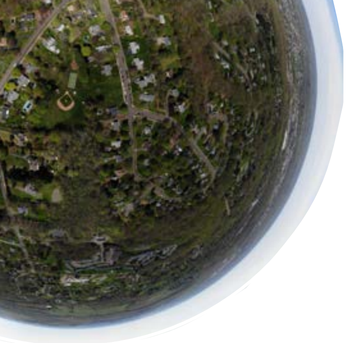
The key question in EviBAN:

What is the optimal combination (i.e. lowest costs) of stormwater measures at the new campus site that meet regulations regarding stormwater discharge?

Drainage li
the NTNU

Catchment

Roughly placement of new buildings



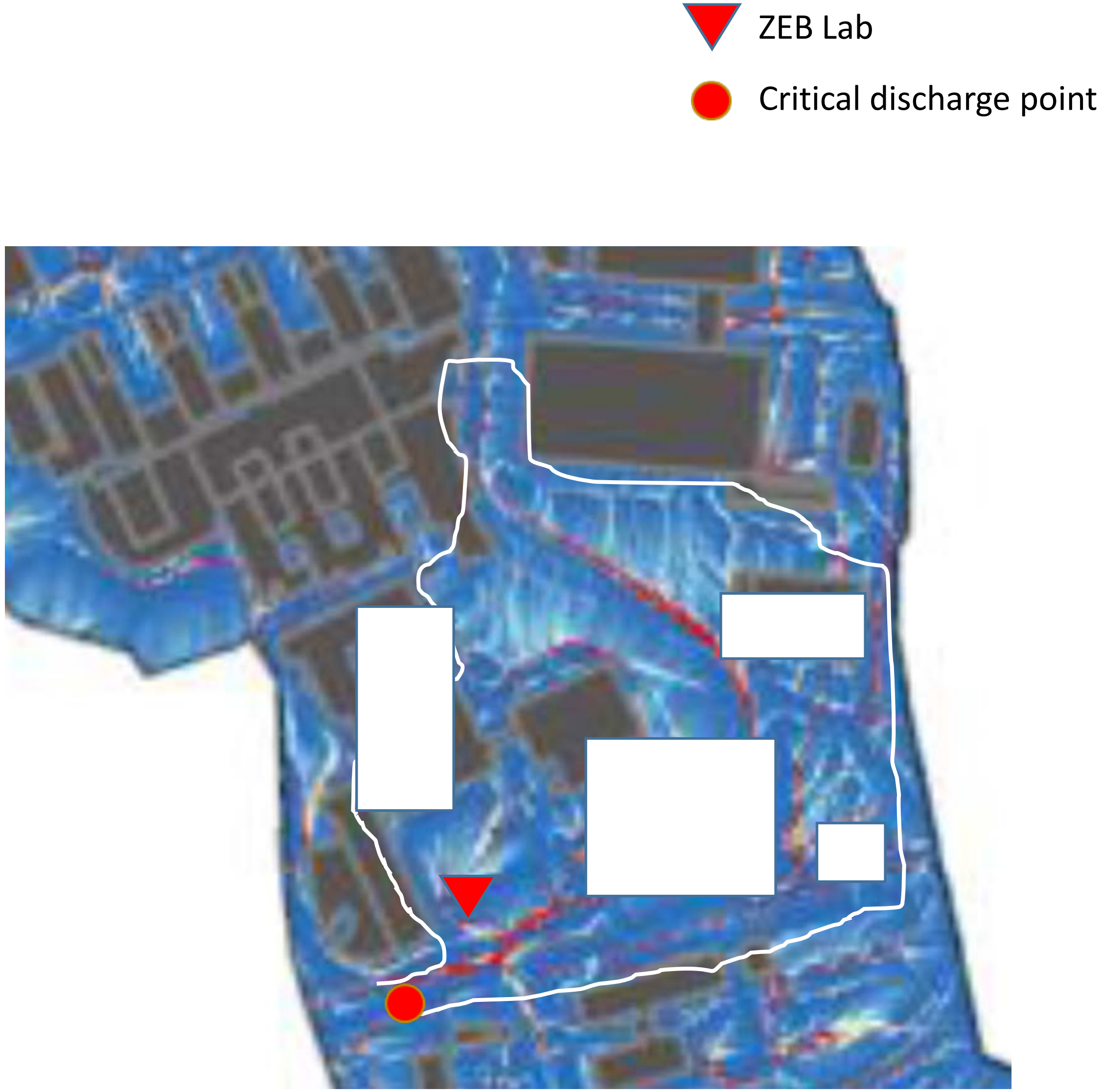
The optimisation tool

Objective:

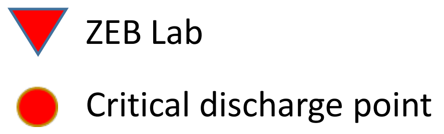
- To screen many possible solutions to find a combination of stormwater measures that meet the discharge regulations
- Serve as basis for more detailed modelling (with e.g. SWWM)

Key facts about the tool:

- Developed in Python
- Three modelling modes:
    - Simulation
    - Optimisation with respect to discharge
    - Optimisation with respect to economy

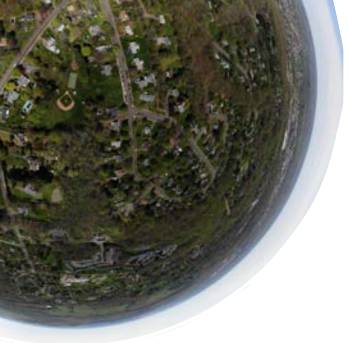


The optimisation tool



Hydrology:

- Simplified rainfall-runoff modelling
- Define a network of nodes
- Define volume split ratio for each node
- Define time of concentration between nodes



The optimisation tool

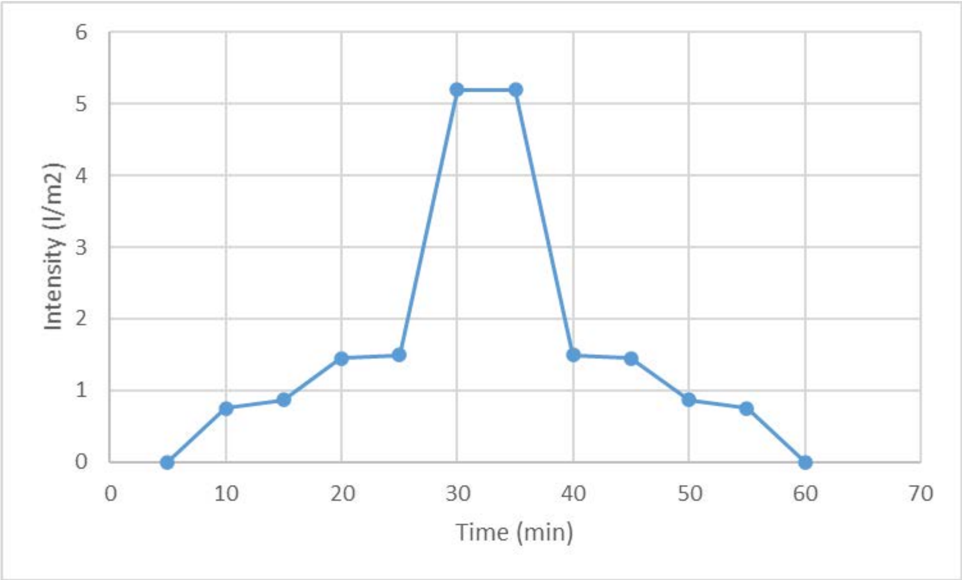
ZEB Lab

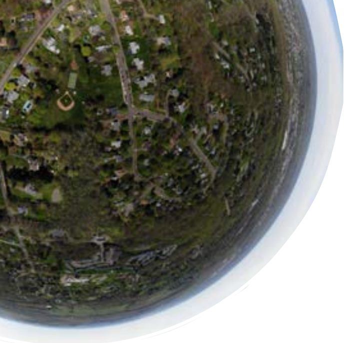
Critical discharge point

Rainfall and water volumes:

- Area of each node must be defined
- Area fraction of each node that is available for NBS
- Different hyetographs may be defined
- Mass balances over each node and time step

Hyetograph from Trondheim (20y/60 min):





The optimisation tool

ZEB Lab

Critical discharge point

Stormwater management solutions:
- Retention (water lost by infiltration or evapotranspiration)
- Detention profile as function of time step
- CAPEX
- OPEX

Tools/measures

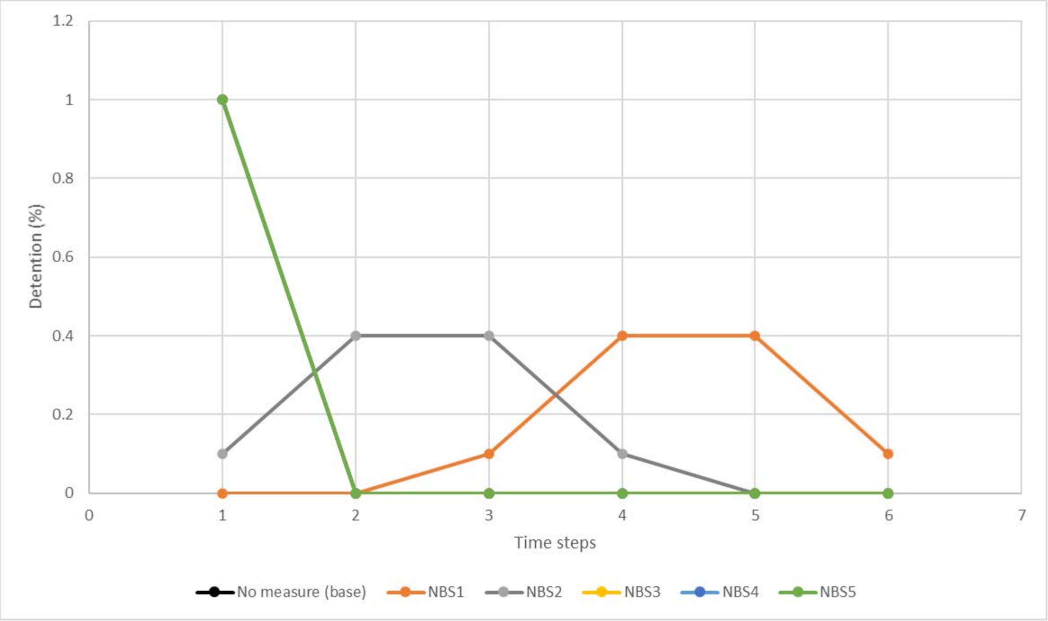
Rain garden

Green roof

Swales

Detention basins

Permeable pavements



NTNU Campus – model with 4 nodes (simulation)

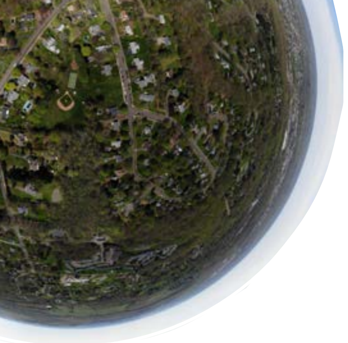
ZEB Lab

Critical discharge point

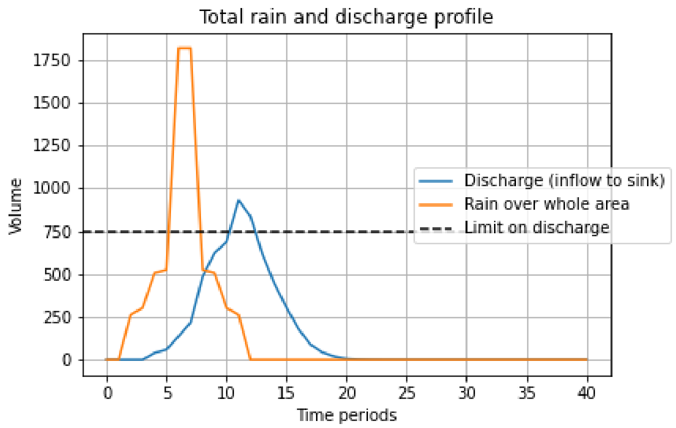
Pre-defined area for each NBS:

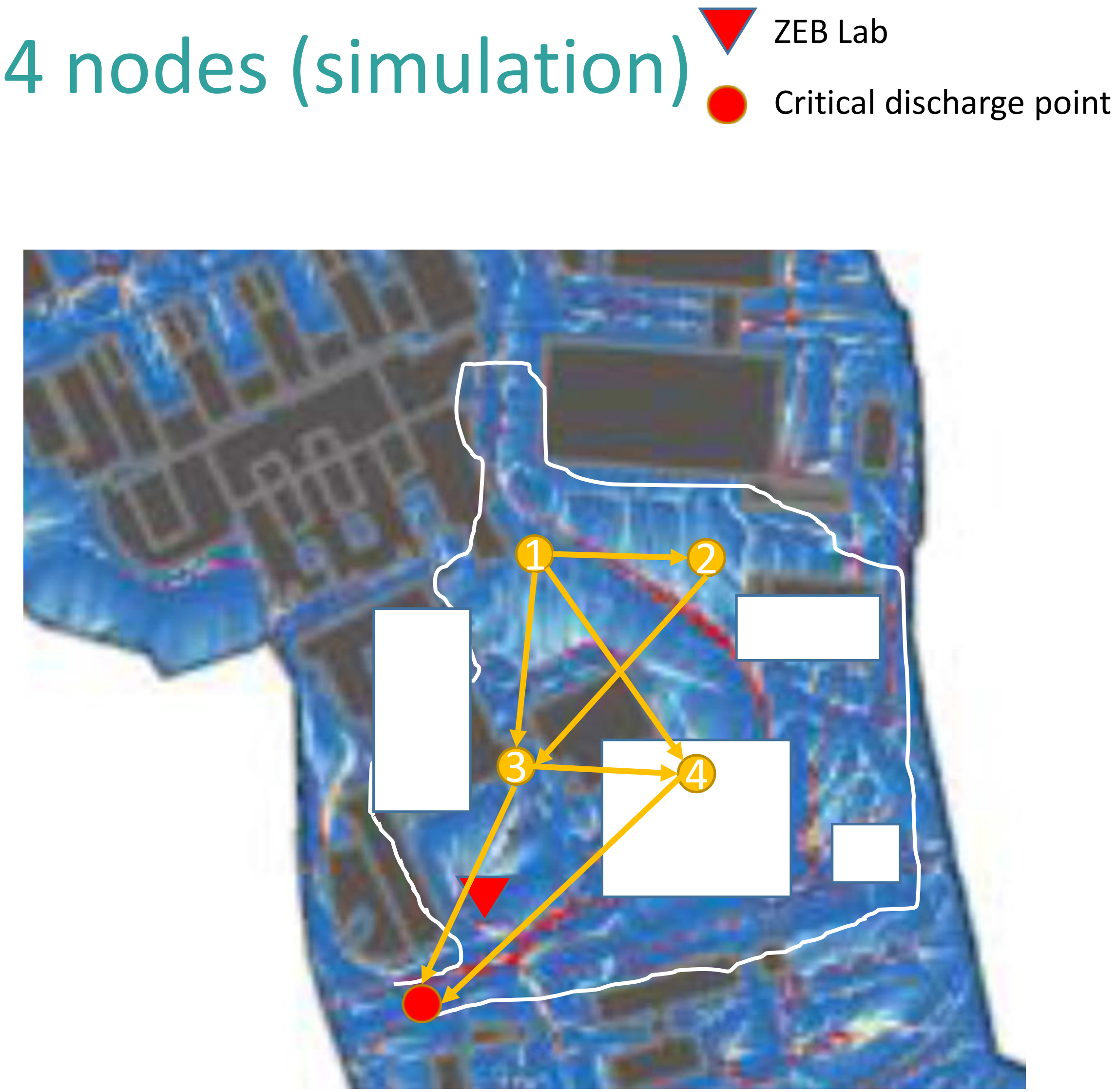
- Install NBS1 in all nodes (30-50% of available area)
- Install NBS4 in node 2 (10% of available area)
- Install NBS5 in node 1 (10% of available area)

	No solution	NBS1	NBS2	NBS3	NBS4	NBS5
Nodes	0	0	0	0	0	0
1	0.5	0.4	0	0	0	0.1
2	0.5	0.4	0	0	0.1	0
3	0.7	0.3	0	0	0	0
4	0.5	0.5	0	0	0	0



NTNU Campus – model with 4 nodes (simulation)





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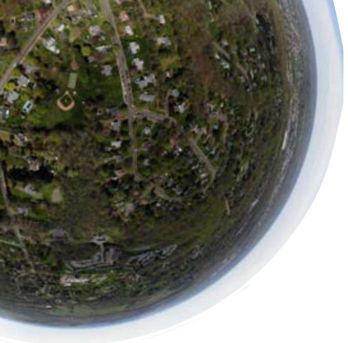
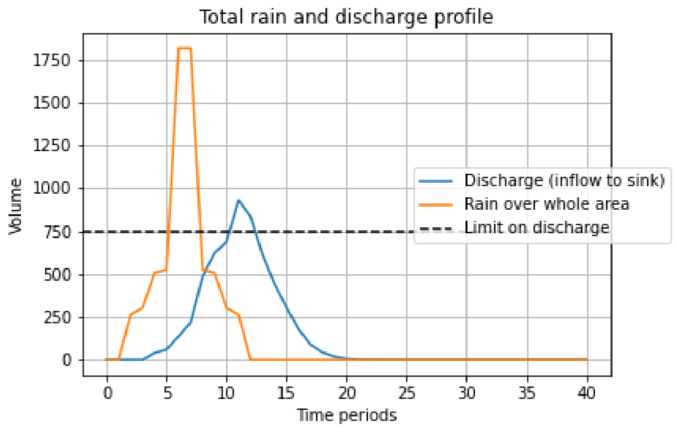
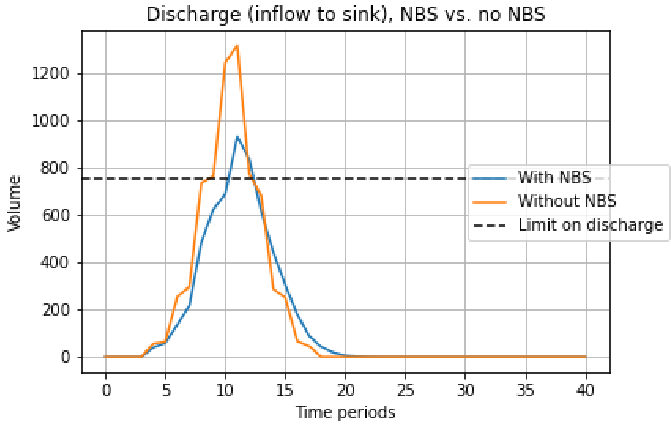
3	0.7	0.3	0	0	0	0
4	0.5	0.5	0	0	0	0



NTNU Campus – model with 4 nodes (simulation)

ZEB Lab
Critical discharge point





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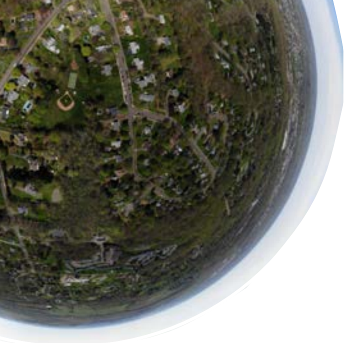
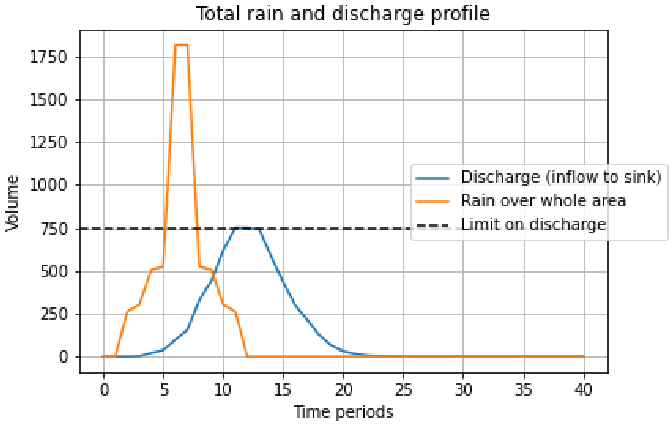
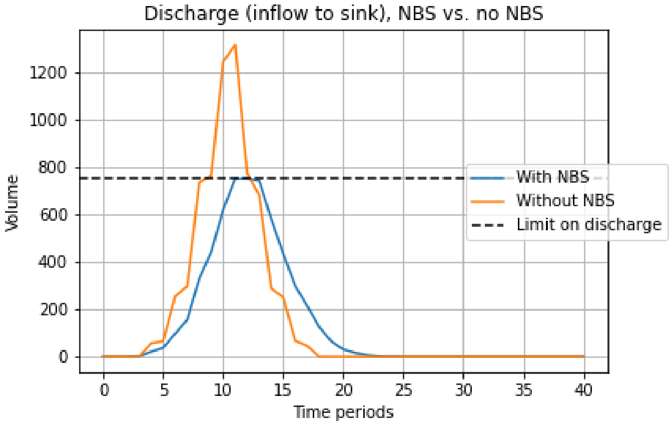
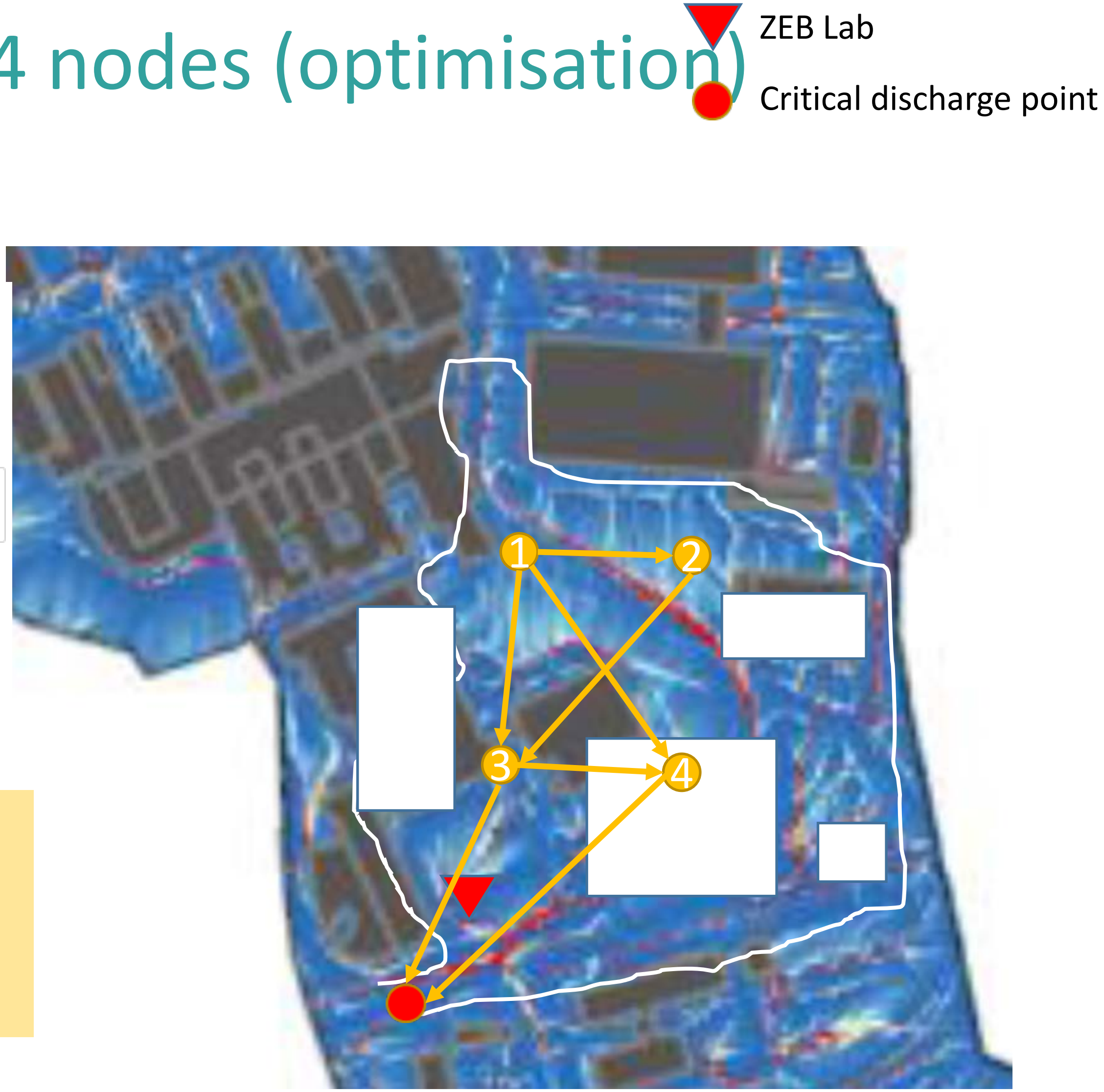
	No solution	NBS1	NBS2	NBS3	NBS4	NBS5
Nodes	0	0	0	0	0	0
1	0.5	0.4	0	0	0	0.1
2	0.5	0.4	0	0	0.1	0
3	0.7	0.3	0	0	0	0
4	0.5	0.5	0	0	0	0

NTNU Campus – model with 4 nodes (optimisation)



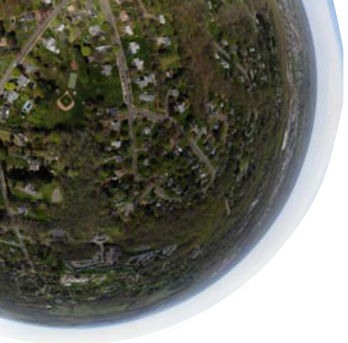




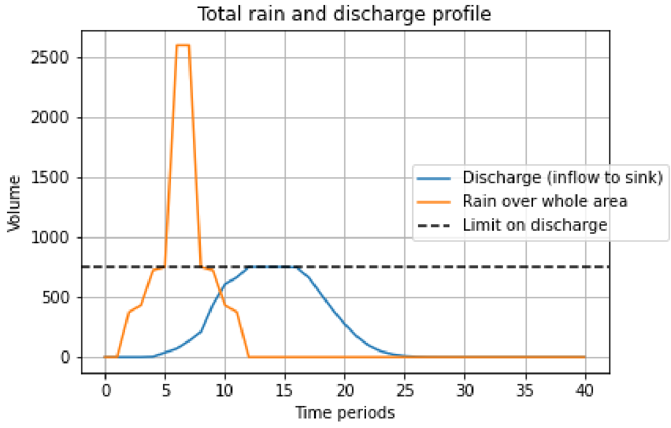


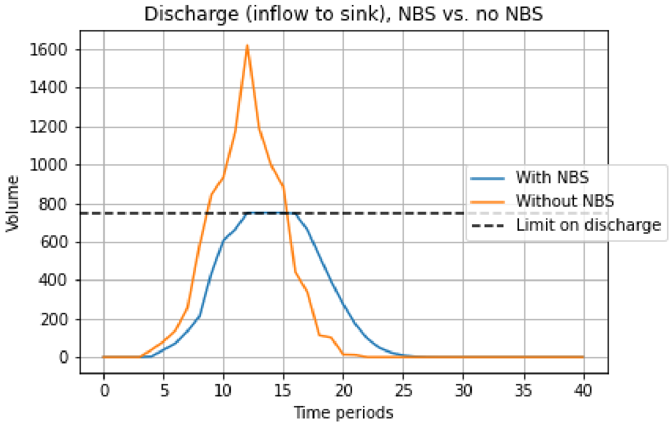
To meet regulation:
- Install NBS2 in node 1 and 3 (40% of available area for that NBS)
- Install NBS3 in node 3 (34% of available area)
- Install NBS5 in node 2

	No solution	NBS1	NBS2	NBS3	NBS4	NBS5
Node	**0**	**1**	**2**	**3**	**4**	**5**
1	0	0	1.00	0	0	0
2	0	0	0	0	0	1.00
3	0.26	0	0.40	0.34	0	0
4	1.00	0	0	0	0	0



NTNU Campus – model with 7 nodes (optimisation)





To meet regulation:

- Install NBS1 in node 6 (36% of available area)
- Install NBS2 in nodes 2, 4, 5, 6 and 7 ...

	No solution	NBS1	NBS2	NBS3	NBS4	NBS5
Node	**0**	**1**	**2**	**3**	**4**	**5**
1	1.00	0	0	0	0	0
2	0.12	0	0.88	0	0	0
3	1.00	0	0	0	0	0
4	0	0	1.00	0	0	0
5	0.77	0	0.23	0	0	0
6	0.53	0.36	0.11	0	0	0
7	0	0	1.00	0	0	0

Summary

- Developed an optimisation tool that take into account **hydrological** as well as **economic** properties of stormwater management solutions
- To be used for screening of potential combination of solutions prior to more detailed hydrological modelling
- Flexible with respect to number of solutions assessed

Next step for the Norwegian ZEB Lab/campus case:

- Define "real" properties for a selection of stormwater solutions
- Define a network/nodes that give a representation of the area of interest
- Optimise

Thank you for your attention

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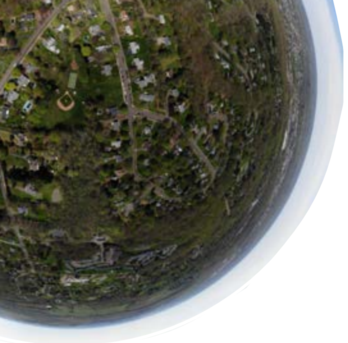
Eviban Evidence based assessment of NWRM for sustainable water management

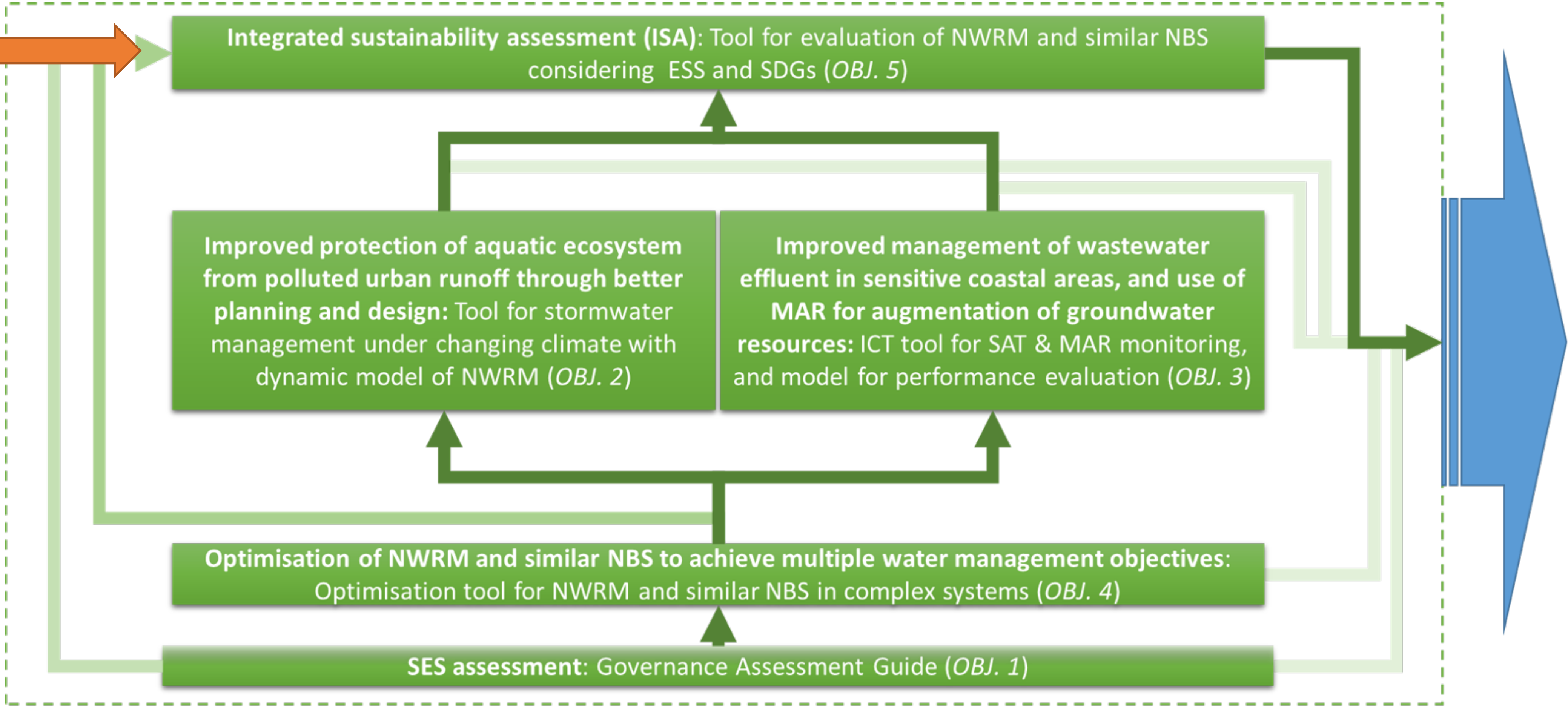
Aalto University School of Engineering · brgm Geoscience for a sustainable Earth · SINTEF · SWATER INSTITUTE · VTT · Water JPI

https://www.sintef.no/projectweb/eviban/



Toolbox for assessment of solutions

A closer look at the **ISA tool**



EviBAN

Evidence based assessment of NWRM for sustainable water management

Integrated sustainability assessment (ISA) – introduction and on-line exercise

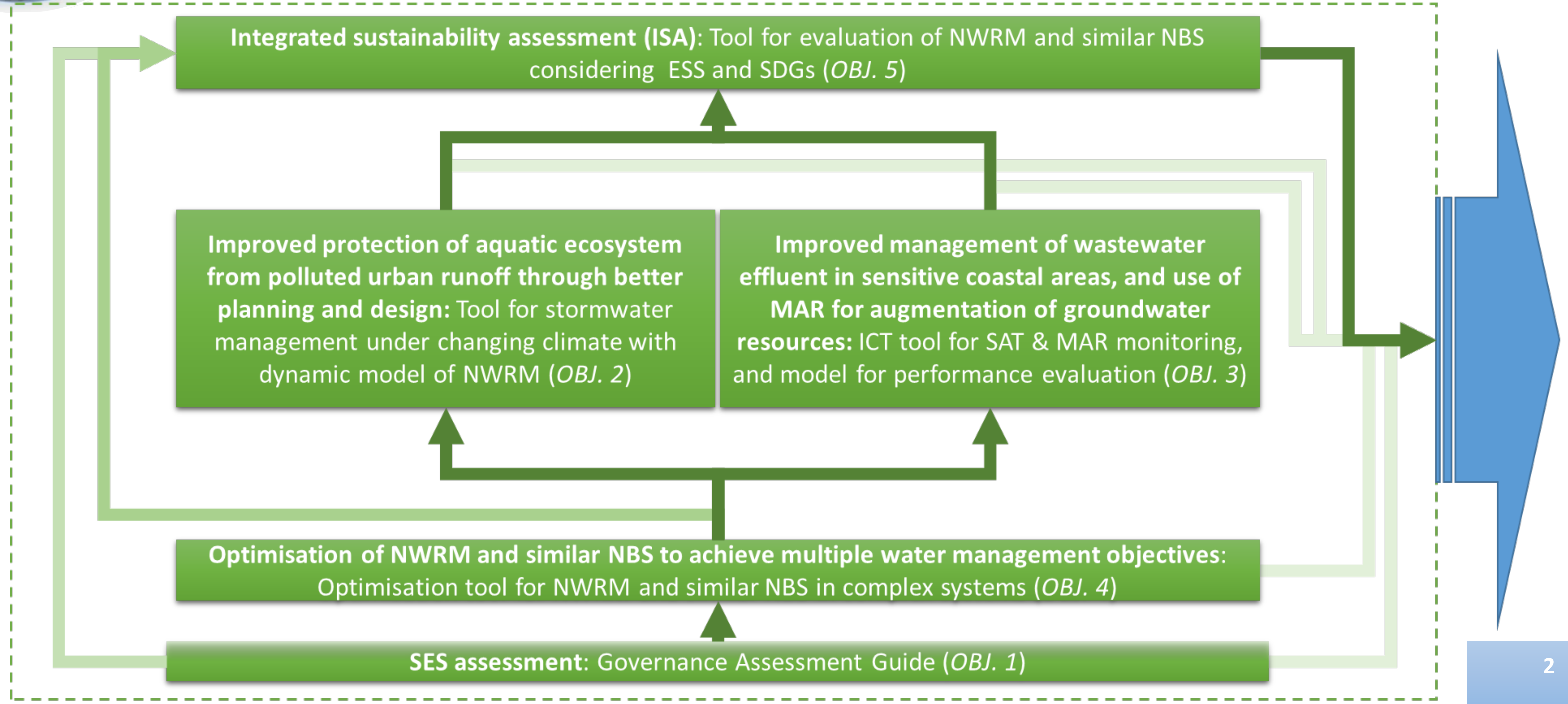
Herman Helness

Stakeholder workshop 2021-08-17

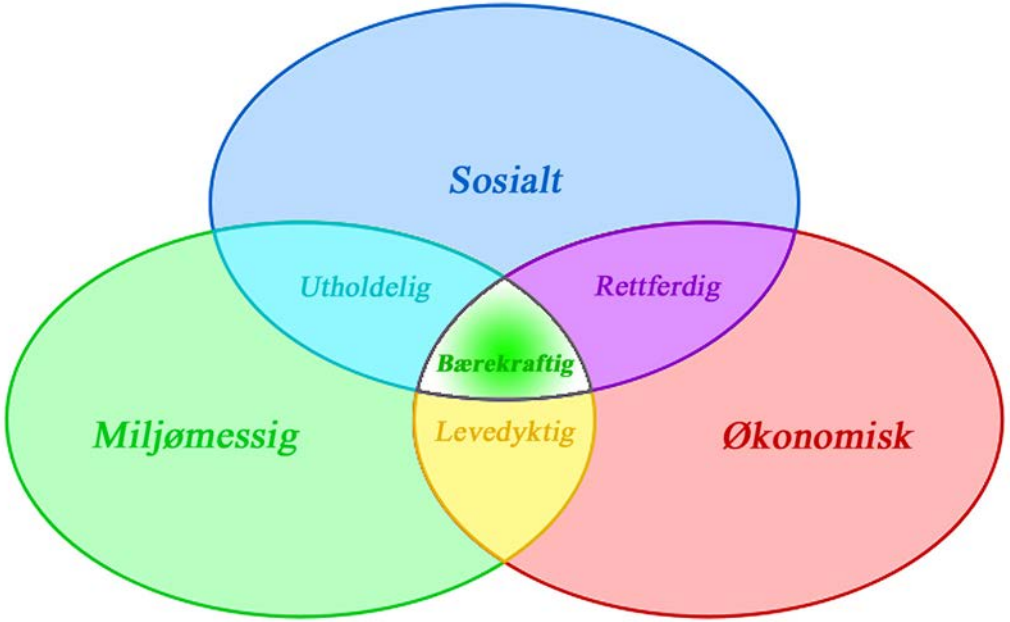
Aalto University School of Engineering
anteagroup
Geoscience for a sustainable Earth brgm
imaGeau
SINTEF
WATER INSTITUTE
VTT
Water JPI

Toolbox for assessment of solutions

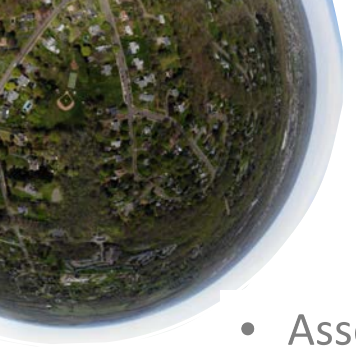
- Several paths depending on level of detail in the assessment



Sustainability and different dimensions



- Sustainability assessment
  - Always holistic – if not it is an MCA
- "What" is sustainable?
  - Need to differ between society and a technical solution, e.g., properties of a water treatment process can not be linked directly to all sustainability dimensions
- SDGs are a goal
  - A systems contribution to progress towards the SDGs – relative to alternatives, easier to assess



What is an ISA?

- Assessing sustainability requires a holistic perspective
  - Include environment, society, economy, technical performance, …, for several alternatives in different scenarios for future conditions
  - Quickly becomes comprehensive and you lose overview
- With ISA you split "the big picture" in parts assessed separately
  - Social: Objectives and criteria from social science
  - Economy: Objectives and criteria from economics
  - Environment: Objectives and criteria from environmental science
  - Technical performance: Objectives and criteria from technological science
- Results from sub-assessments are integrated in a second step
  - The integration is pure mathematics

→ If you agree to the sub-assessment results and the weighting you should☺ agree to the conclusion

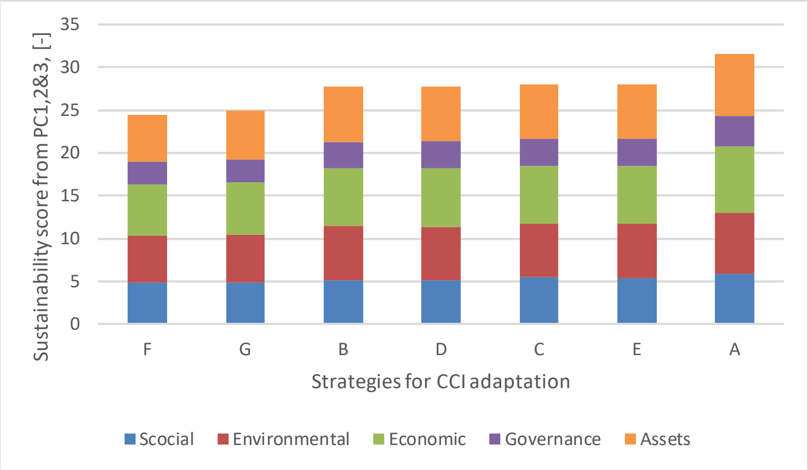
- Requires collaboration between disciplines and with end-users and stakeholders

	Actors involved	Communicative events	LoS - water supply.	LoS - sanitation.	Share of increased availability to community	Compliance with quality standards	Acceptability of the strategic alternative	Awareness of climate change	Overall hydraulic reliability	Biodiversity	Water for plants and animal feed	Non renewable resource use	Energy consumption per hhl	CO2 footprint, potable water use
A	10	10	10	10	10	10	3.333333	10	0	0	6	10	0	7.5
B	9	9	10	10	8.5	10	0	8	3.309271	10	2	10	0	10
C	0	0	6.666667	10	0	10	5.555555	0	10	0	10	10	0	7.5
D	4	4	10	10	8.5	10	1.111111	4	4.742999	0	3	10	0	7.5
E	2	2	6.666667	0	0	0	10	0	8.584616	0	6	6.622854	1.666667	6.25
F	10	10	0	10	0	9	0	8	5.808933	0	0	0	10	0
G	6	6	3.333333	10	0	0	0	8	7.205956	0	2	3.333333	6.666667	2.5

	Flow downstream Riversdale	Hydraulic reliability, irrigation	Total cost for WS&S per hhl	Pot. Inc. employment in agri.	Extent of irrigation	Water beyond basic needs	Compliance with 'drops'	Fraction of billed water	Impact on governance	Hydraulic reliability, water supply	Infrastructure for WS&S	O&M, WS&S infrastructure	Total operating costs cost per m3	Water loss	Reduced potential for flooding
A	0	2.666667	0	10	10	0	10	10	10	0	10	10	0	0	10
B	3.309271	0	10	0.75	0	8.215323	10	10	5	8.215323	0	10	10	0	0
C	10	10	10	0.75	0	6.843531	10	10	5	6.843531	10	10	0	0	10
D	4.742999	1.269841	0	0	7.5	9.079045	10	10	5	9.079045	10	10	0	0	10
E	8.584616	5.925926	10	10	10	10	7.5	7.5	0	10	5	5	10	1.666667	10
F	5.808933	5.925926	6	10	10	5.595369	10	10	10	5.595369	2.5	0	6	10	10
G	7.205956	5.925926	4	10	10	7.812254	0	0	10	7.812254	10	10	4	10	10

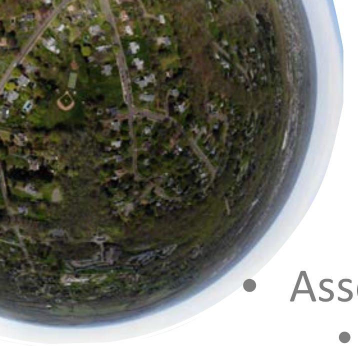
- Even evaluation of only 1 CC scenario and 6 strategic options to adapt or mitigate these gives a table with 174 indicator values….

- Final evaluation with MVA to keep overview



- Ranking of alternatives point to F and G: Reduce water loss and improve demand management, but relatively small differences – several strategies should be evaluated further.

- Importance of criteria show the importance of the criteria with respect to the difference between the alternatives – not absolute importance!

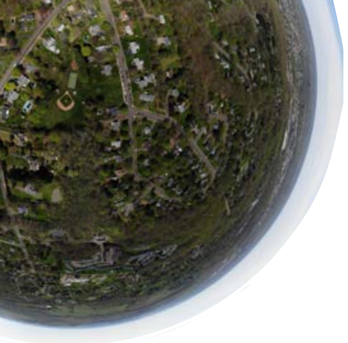


Example of ISA-framework from previous project

- Assess options in a sustainability perspective
  - Climate change time frame
  - Strategic level
  - Aligned with Hessequa Key Performance Areas
  - Related to methodology from EU project TRUST, also in eg. Blue Cities, DESSIN and RWH4Gana
- Dimensions:
  - Social
  - Environmental
  - Economic
  - Governance
  - Assets
- Objectives:
  - 8 objectives linked to KPA in IDP
- Criteria:
  - 29 criteria to measure compliance with the objectives
- Users participate in defining objectives and criteria, and weights for the criteria
- Local data should be used as much as possible

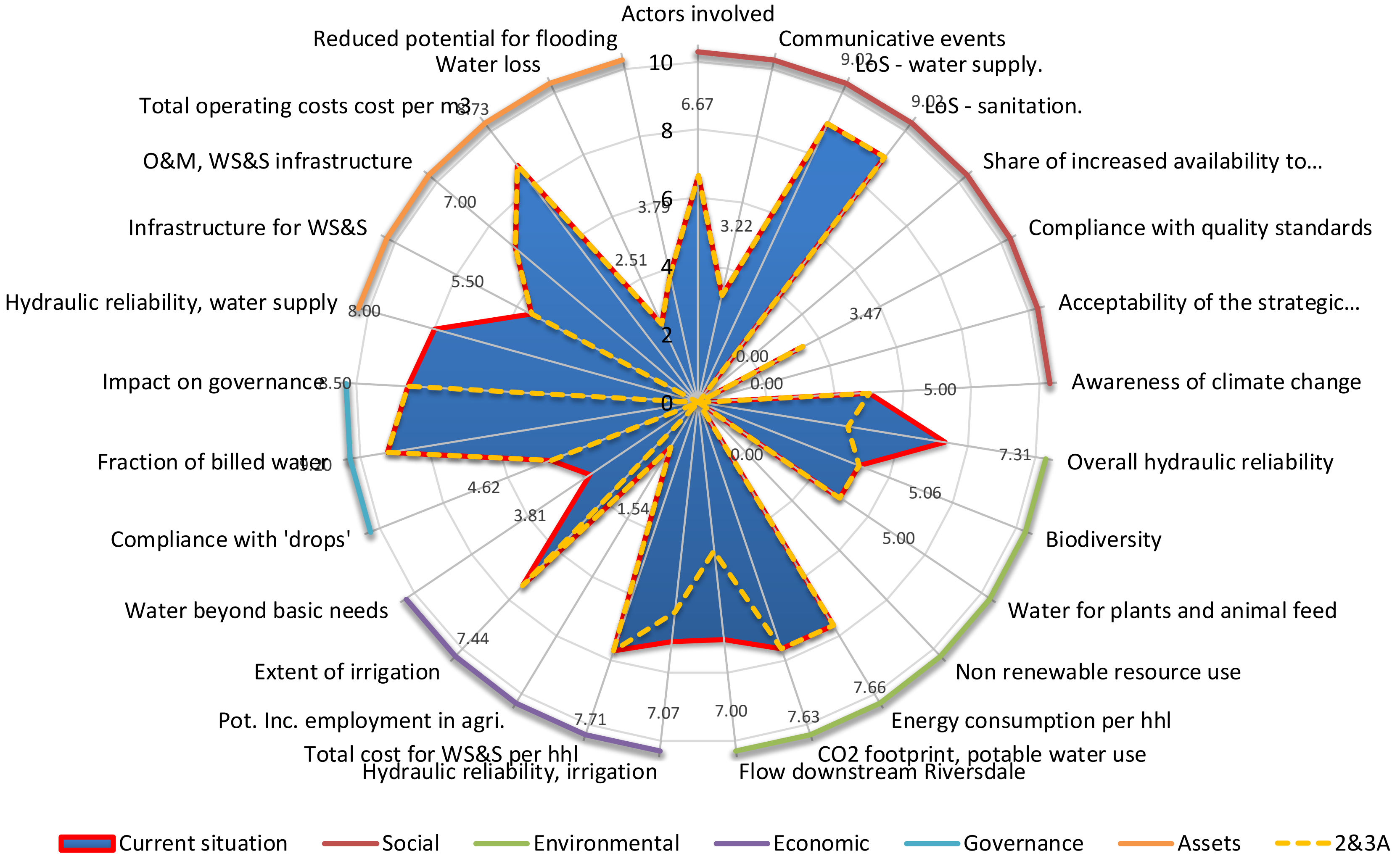
Sustainability Assessment Framework for options in Integrated Water Management - Case Riversdale in Hessequa municipality

Dimention	KPA #	Alignment with Hessequa Municipality's focus areas	ID	Criteria for sustainability assessment of options in IWM	ID	Proposed indicators	Comments to indicators
Social (S)	1	EFFECTIVE COMMUNICATION AND PARTICIPATION.	S1	Increased participation in water management	S11	Actors involved in water resource management	
					S12	Forums and arenas for discourse on water resource management	
					S13	Awareness/knowledge of water preservation	
	4	DEVELOPMENT OF SAFE AND INTEGRATED HUMAN SETTLEMENTS.	S2	Equitable access to reliable water supply and acceptable sanitation	S21	Level of service: Fraction of system with design levels for indigene; low; high; industry	Need spatial resolution, per area, per settlement, per capita
					S22	Water consumption	Also need allocation to ecosystem, farming and city.
					S23	User complaints	
	5	HUMAN DEVELOPMENT INITIATIVES TO ENHANCE THE SOCIAL WELL-BEING OF ALL OUR RESIDENTS.	S3	Water management solutions that enhance good health, knowledge-building and social integration	S31	Compliance with quality standards	Inverted, calculate as percentage of non-compliance
					S32	Awareness	
					S33	Training/knowlede building	
Environment (En)	2	TO LIMIT THE IMPACT OF OUR PRESENCE IN THE NATURAL ENVIRONMENT AND REESTABLISH A HERITAGE OF PRESERVATION.	En1	Preserve water resources and water related ecosystem services	En11	Water abstraction/Water resource	Overall hydraulic reliability
					En12	Indicator on ESS?, Biodiversity	Can be a relative value compared to 1A
					En13	Water resources provisioning of plants and animal foodstuffs	Can be a relative value compared to 1A
					En14	Non renewable resource use of WCS	Should indicate degree of water recirculation. Inverted, calculated as the fraction of users without recycling.
			En2	Minimisation of other environmental impacts	En21	Energy consumption per household	Data exist at the municipality but must be processed. Use SWC as fist estimate. Better with per hhld. than m3,
					En22	CO2 footprint	Based on energy, but should differ from En21
					En23	Flow downstream Riversdale for different needs	Specific needs must be defined. Can be total yearly flow and be given as relative to 1A as initial estimate.
Economic (Ec)	6	TO STIMULATE ECONOMIC GROWTH FOR THE BENEFIT OF ALL COMMUNITIES.	Ec1	Stimulate economic growth and entrepreneurship through better access to water resources and improved water cycle services	Ec11	Ec11 Hydraulic reliability for irrigation channel (demand/supply)	Hydraulic reliability for the farmers
					Ec12	Savings at household level	Costs relative to 1A as an initial estimate
					Ec13	Employment	
					Ec14	Extent of land and/or number of farms that can be irrigated	Hectars that can be irrigated based on specific value for weath and other grains
					Ec15	Water beyond basic needs	Can be a relative value compared to 1A. Will be equal to En12
Governance (G)	7	AN ACCOUNTABLE LOCAL AUTHORITY WITH A FIT FOR PURPOSE WORKFORCE AND TRANSPARENT FINANCIAL PRACTICES.	G1	Deliver services in alignment with prevailing standards for good governance in water management	G11	Compliance with Blue drop; Green drop; No drop	
					G12	Income, metering, billing, linked to WCS	
					G13	Impact in terms of roles and networks, distribution of resources in the implicated institutions, transparancy	
Assets (A)	3	MAINTENANCE AND DEVELOPMENT OF ALL INFRASTRUCTURE AND SERVICES	A1	Maintain adequate infrastructure for water supply and sanitation, with optimal impact on other infrastructure and services	A11	Hydraulic reliability for Riversdale WS (demand/supply), currently 1.4 Mm3/(7.8-5.8) Mm3.	Can this be made for different users and classes: Domestic use; Industry; Agricultural?
					A12	Coverage of water supply, currently 100%	Inverted, calculated as 100-coverage-%
					A13	Coverage of sanitation	Inverted, calculated as 100-coverage-%
					A14	Total cost per m3, data exist but must be processed.	Cost items (infrastructure, operational, maintenance, labour) per m3 are also interesting.
					A15	Percent water loss, data exist but must be processed	
					A16	Impact on other infrastructure (street network, storm water network...)	



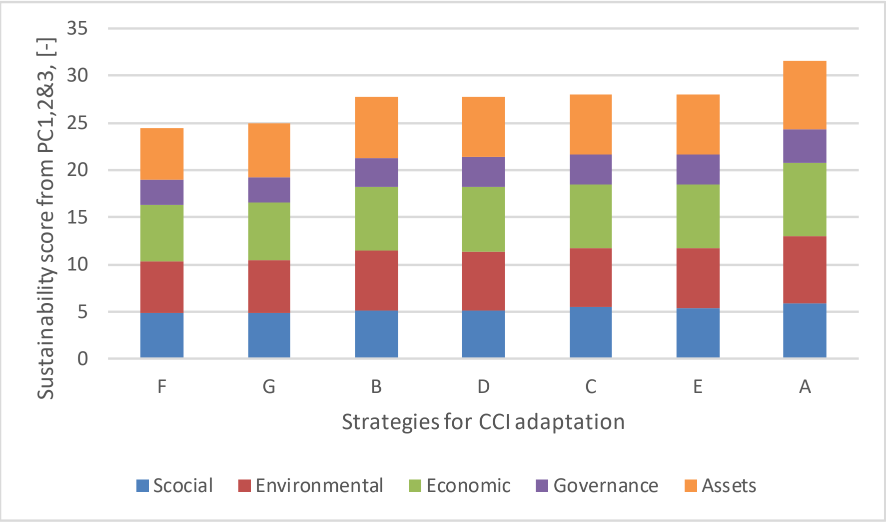
Visualizing different dimensions of sustainability

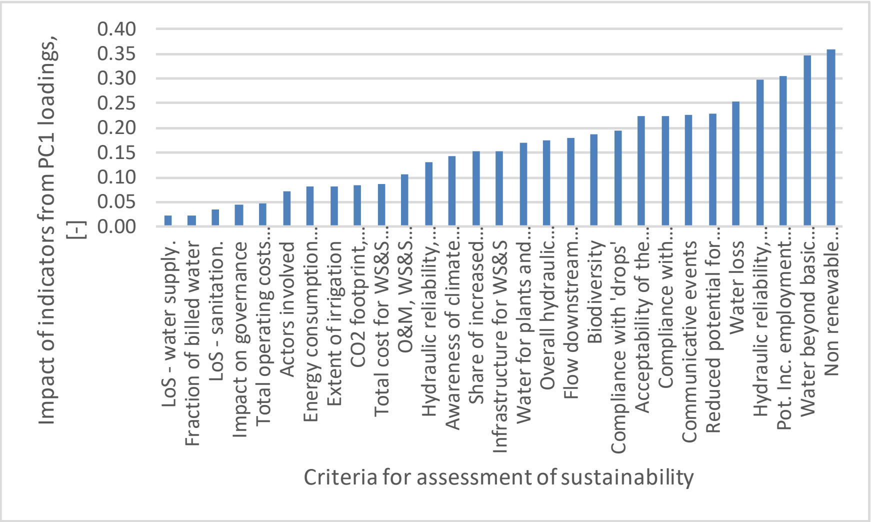
- Results for Riversdale showing current and expected future situation if no measures are implemented
  - Available water resources decrease by 10% (scenario 2&3A)



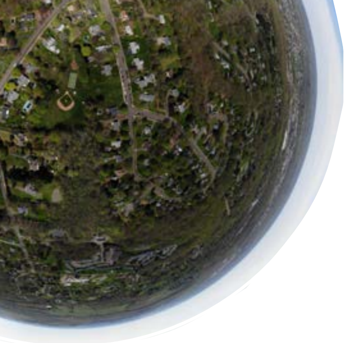
Multivariate analysis to rank alternatives and assess criteria

- Even evaluation of only 1 CC scenario and 6 strategic options to adapt or mitigate these gives a table with 174 indicator values….
- Final evaluation with MVA to keep overview in a holistic assessment.





- Ranking of alternatives point to F and G: Reduce water loss and improve demand management, but relatively small differences – several strategies should be evaluated further.
- Importance of criteria show the importance of the criteria with respect to the difference between the alternatives – not absolute importance!



Integrated sustainability assessment (ISA) tool

INPUT

Case specific input from stakeholders:
- Define the case
- Define NWRM alternatives
- Relevant SDGs
- Local objectives
- Local adaptation of criteria and indicators

Input from other tools in the toolbox:
- Governance assessment tool…
- Optimisation…
- Stormwater or MAR/SAT…

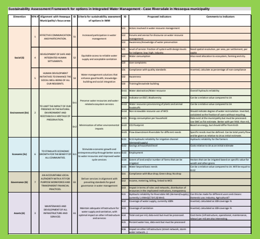
Pre-defined input in the ISA tool:
- List of (selected?) SDGs
- List of standard objectives for NWRM
- List of standard criteria and indicators

ISA TOOL

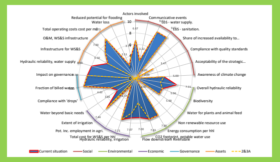
- Sets up evaluation matrix:
  - Objectives
  - Criteria
  - Indicators
- Defines scenarios to be assessed at least with respect to:
  - Water quantity
  - Water quality
- Calculates values of indicators and populate evaluation matrix for all alternatives and scenarios
- Prepares results:
  - Sustainability score
  - Comparison of alternatives

OUTPUTS

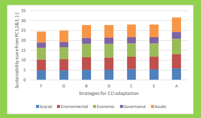
ISA matrix

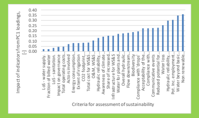


Radar plot(s)

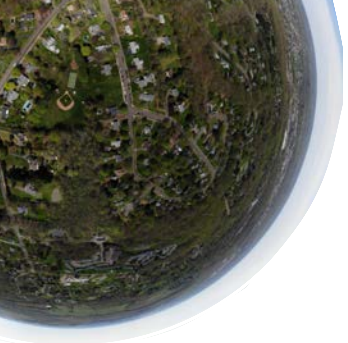


Sustainability score:



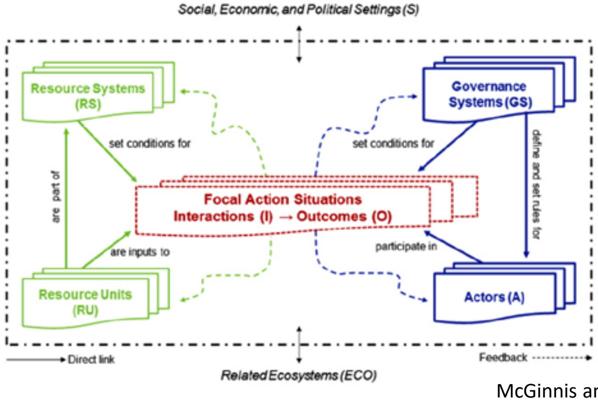


- Collaborate on cases and input from tools
- Develop pre-defined input in the ISA tool, the tool calculations and the tool outputs

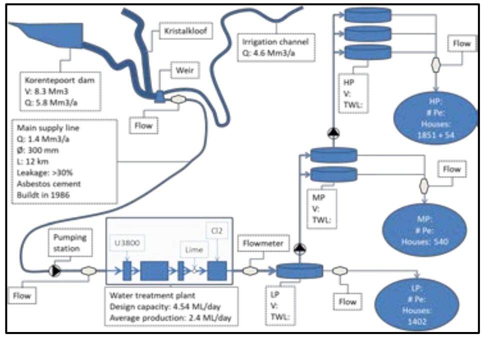


Assessment in 5 dimensions

- Aim to assess the solutions as part of a socio-ecological system (SES)
- Describe key aspects of the solution in 5 dimensions
  - Social (S)
  - Environmental (En)
  - Economic (Ec)
  - Governance (G)
  - Technical Performance (TP)
- Co-development with stakeholders



McGinnis and Ostrom (2014)

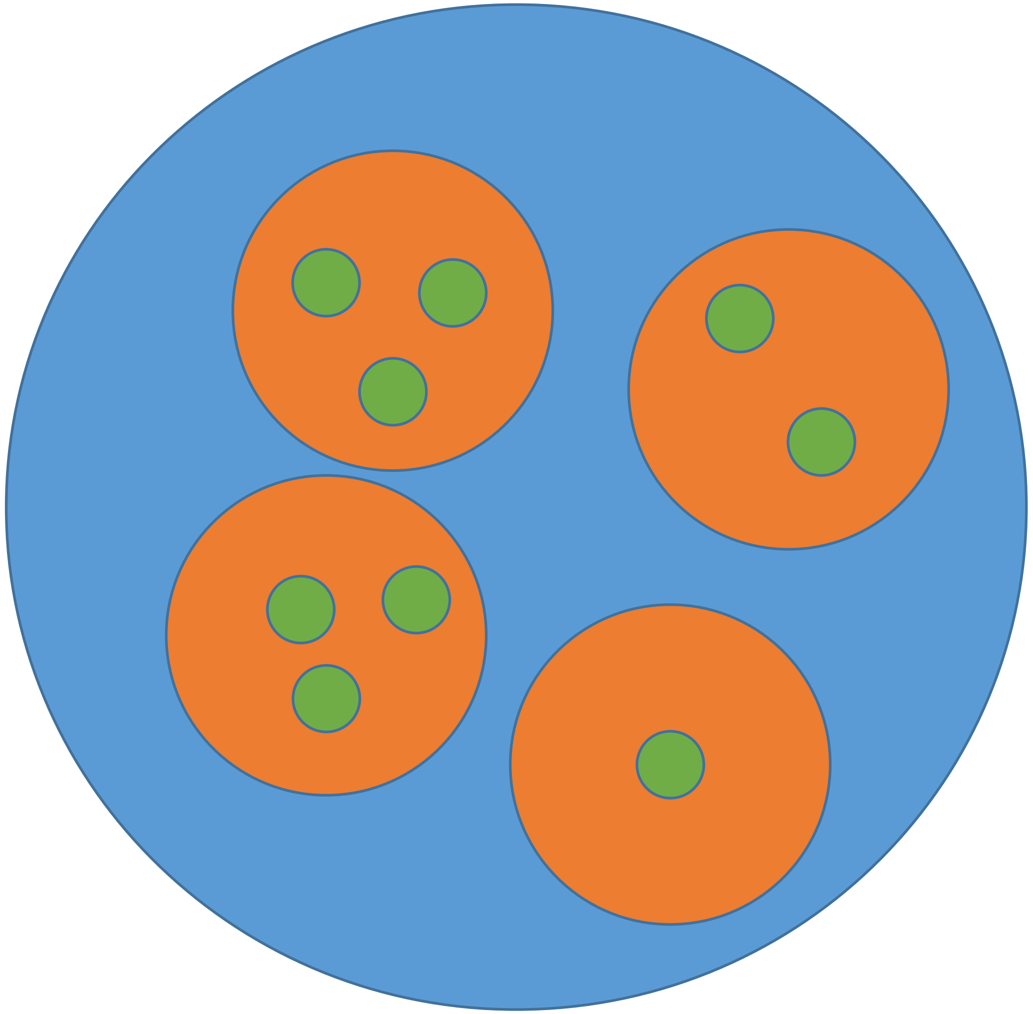


Water Cycle Services related to water supply in Riversdale, Hessequa Municipality, Helness et al., (2017)

3-level structure for each dimension

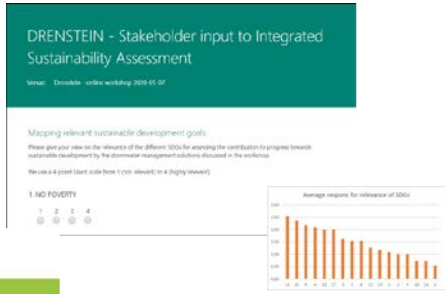
- ***OBJECTIVES*** should cover the whole SES
- **CRITERIA** should cover the essential properties to assess compliance/achievement
- INDICATORS should cover a representative selection of properties

  and be SMART
  - **S**pecific
  - **M**easurable
  - **A**chievable
  - **R**ealistic
  - **T**ime-bound
- Be informed by previous studies
  - "Don't reinvent the wheel"



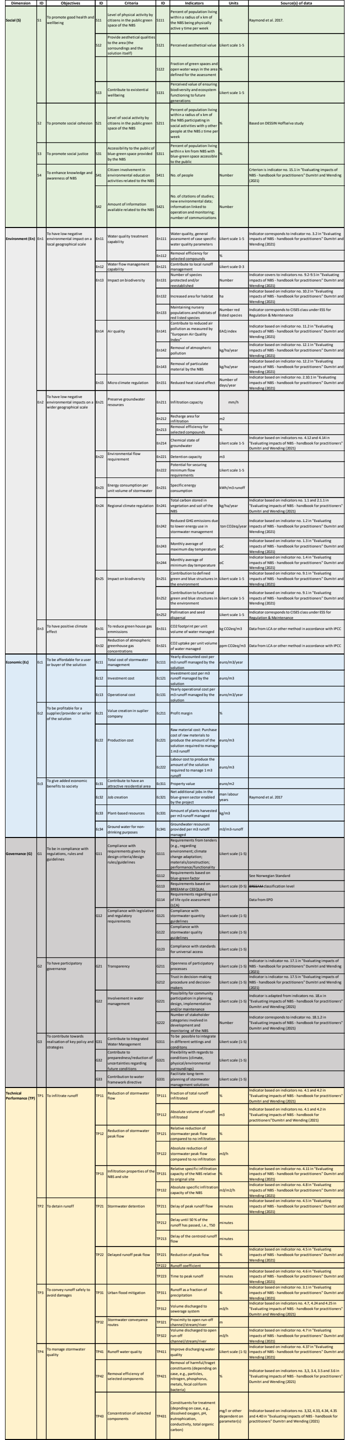
Previously in EviBAN

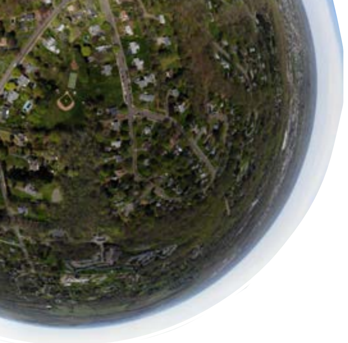
- Relevance of SDG
- Initial set of objectives and criteria
- Discussed in workshops with local stakeholders in each case
- Supplemented with literature/results from other studies
- Organised in 3 levels
  - OBJECTIVES => CRITERIA => INDICATORS
- To be discussed with stakeholders from all case studies again before preparing final version



Status ISA framework

- Objectives and criteria sorted according to stakeholder feedback from previous workshops
- Aim is one common framework to assess NWRM and similar NBS applied for stormwater or MAR
  - Common OBJECTIVES
  - Standard CRITERIA with options for local adaptation
  - Same for INDICATORS, but more choices
- Current version:
  - 17 OJECTIVES => 45 CRITERIA => 77 INDICATORS
- Too comprehensive?
  - Key will be data availability and additional work





Exercise using MS Forms

- Several sections:
  1. Application area and type of stakeholder
  2. Social dimension
  3. Environmental dimension
  4. Economic dimension
  5. Governance dimension
  6. Technical performance dimension
  7. Free text comments

EviBAN - DRENSTEIN - Stakeholder input to weighting of Integrated Sustainability Assessment

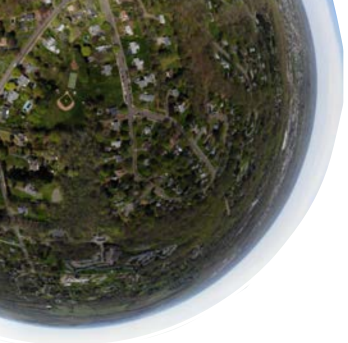
Venue: EviBAN, Klima 2050 - online workshop 2021-08-17

...

Technical performance dimension

Please weight the objectives, criteria and indicators presented below.

Use a 4-point Likert scale from 1 (not important for my application) to 4 (very important for my application).



Importance of ***<u>OBJECTIVES</u>***, **CRITERIA** and INDICATORS

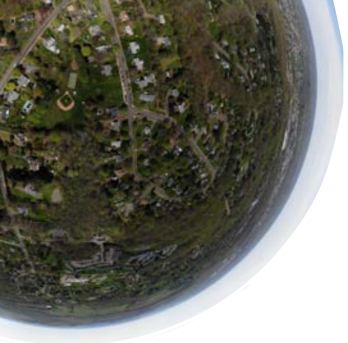
- Separate sections for each sustainability dimension
- ***<u>OBJECTIVE</u>***
- **CRITERIA** (one or several)
- INDICATORS (one or several)
- Scoring using Likert scale(1-4) according to importance for your application area
  - 1: not important;
  - 2: somewhat important;
  - 3: important;
  - 4: very important

52. ***<u>OBJECTIVE: To infiltrate runoff</u>***

1	2	3	4
○	○	○	○

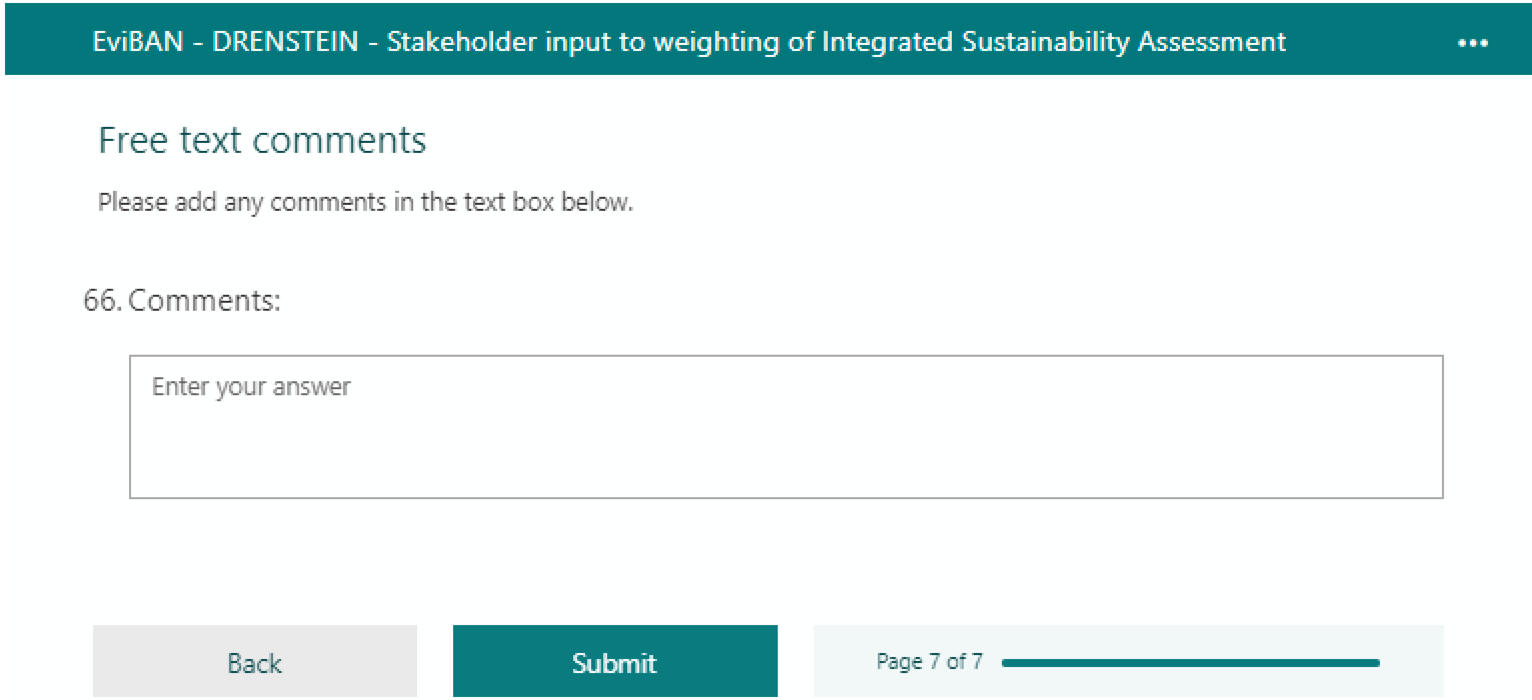
53. Please weight the **CRITERION** and INDICATOR(S) presented below

	1	2	3	4
CRITERION: Reduction of stormwater flow	○	○	○	○
INDICATOR: Fraction of total runoff infiltrated, [%]	○	○	○	○
INDICATOR: Absolute volume of runoff infiltrated, [m3]	○	○	○	○



Final section of the exercise

- Stakeholder comments
  - Free text answer



EviBAN - DRENSTEIN - Stakeholder input to weighting of Integrated Sustainability Assessment

Free text comments

Please add any comments in the text box below.

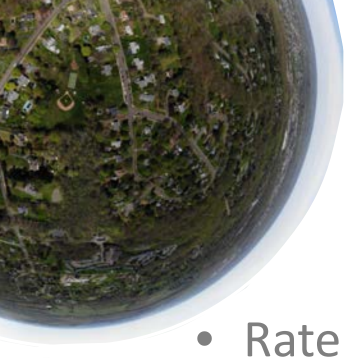
66. Comments:

Enter your answer

Back | Submit | Page 7 of 7

Submit when finished

- We will end with a discussion of the average results



Some points for consideration before we begin

- Rate versus weight?
  - In a concrete assessment of a given case one would set up the ISA adapting criteria and indicators to the specific case and weighing would be on indicator level so one could say that 'rate' would be better than 'weight' for today's exercise.
  - The important issue is that we are NOT asking for a ranking – it is OK to respond that several objectives/criteria/indicators have the same importance.

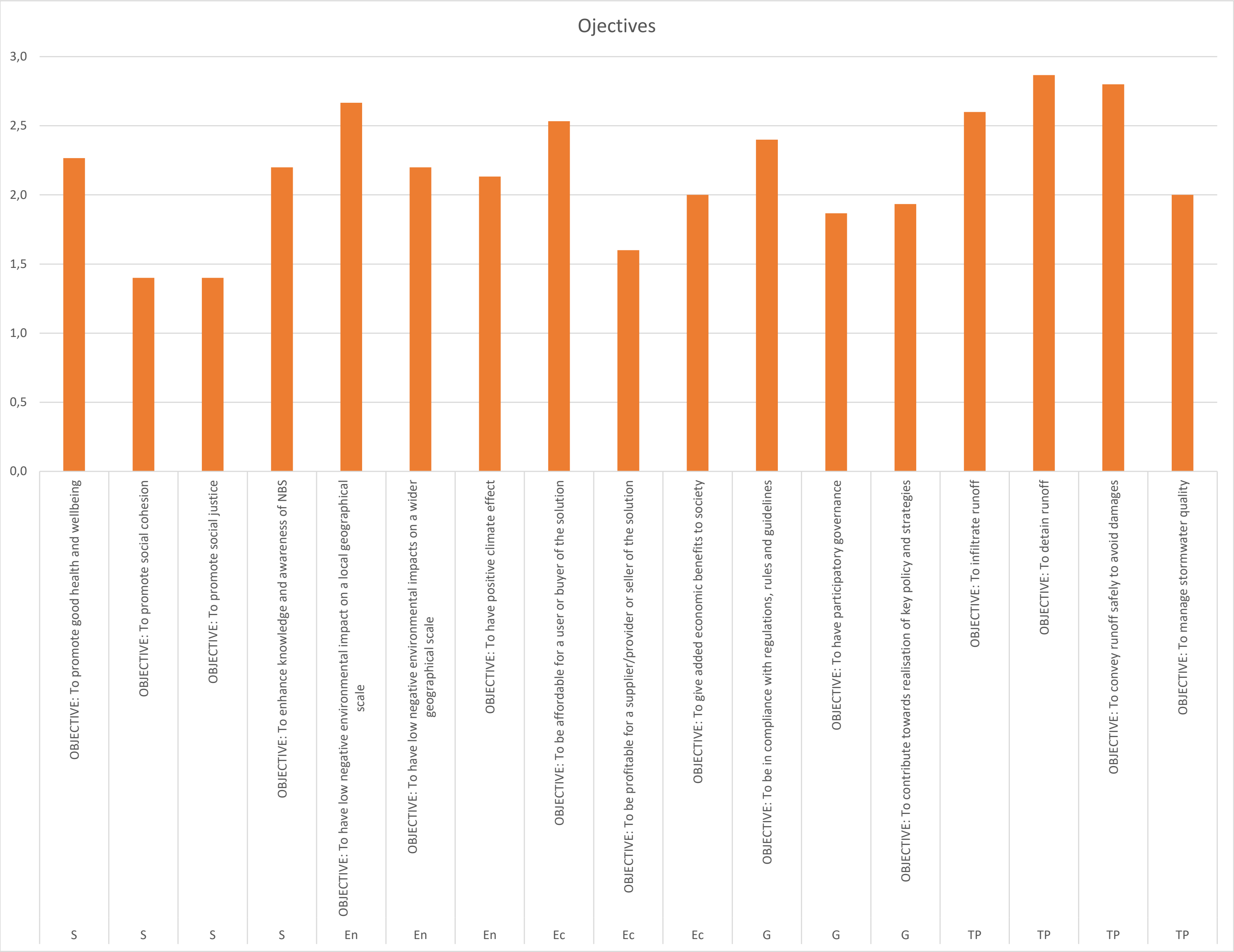
- Should the answers for a sequence of ***<u>OBJECTIVE</u>*** => **CRITERION** => INDICATOR(s) be linked?
  - Not necessarily, it is OK to find that a criterion has higher importance than the objective.
  - … same for indicator versus criterion

- Note that some indicators need to be specified according to a specific case
  - e.g., **x** people lining within y km from the NBS

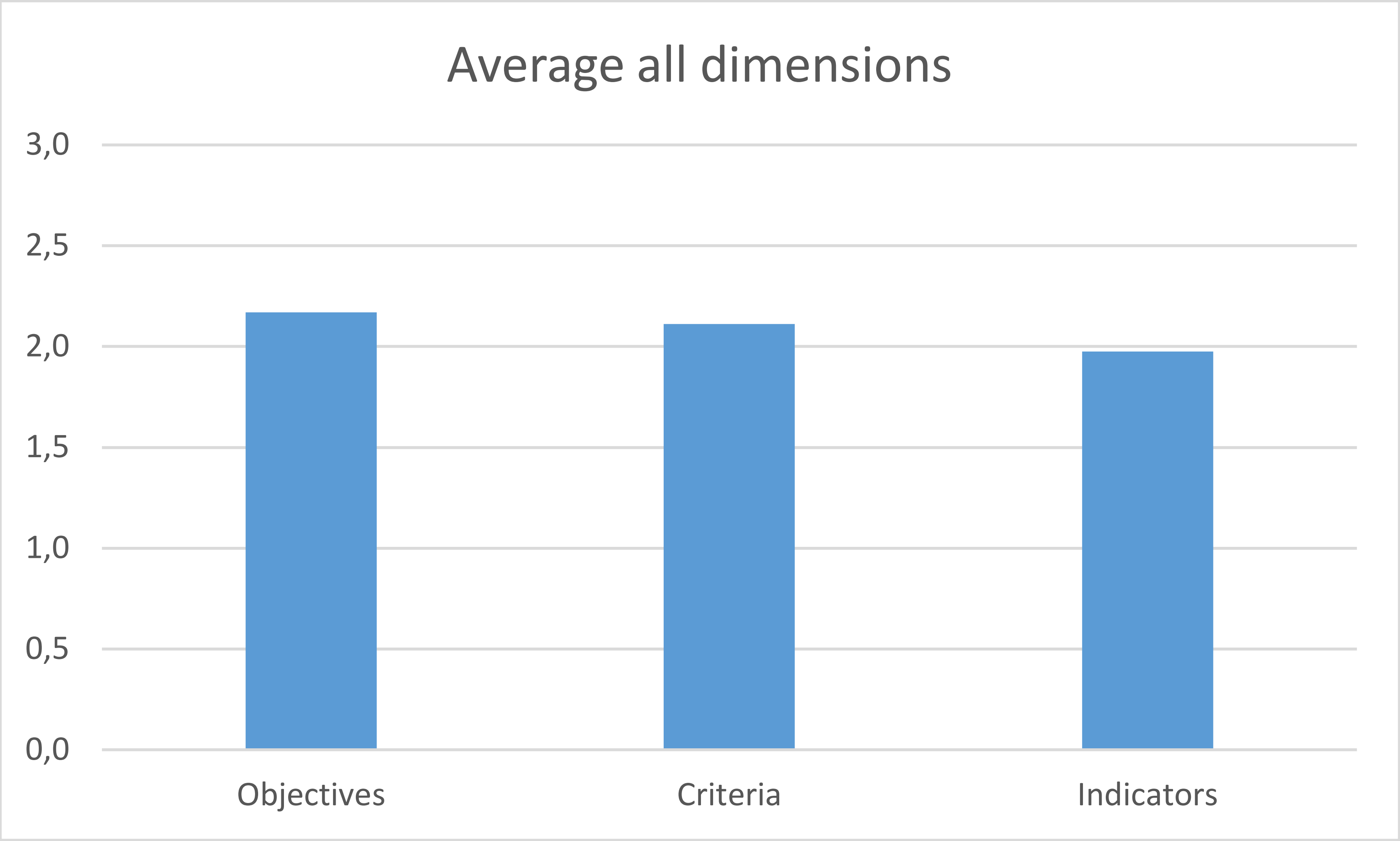
Preliminary results from on-line exercise

PRELIMINARY RESULTS: Average score for 'OBJECTIVES'

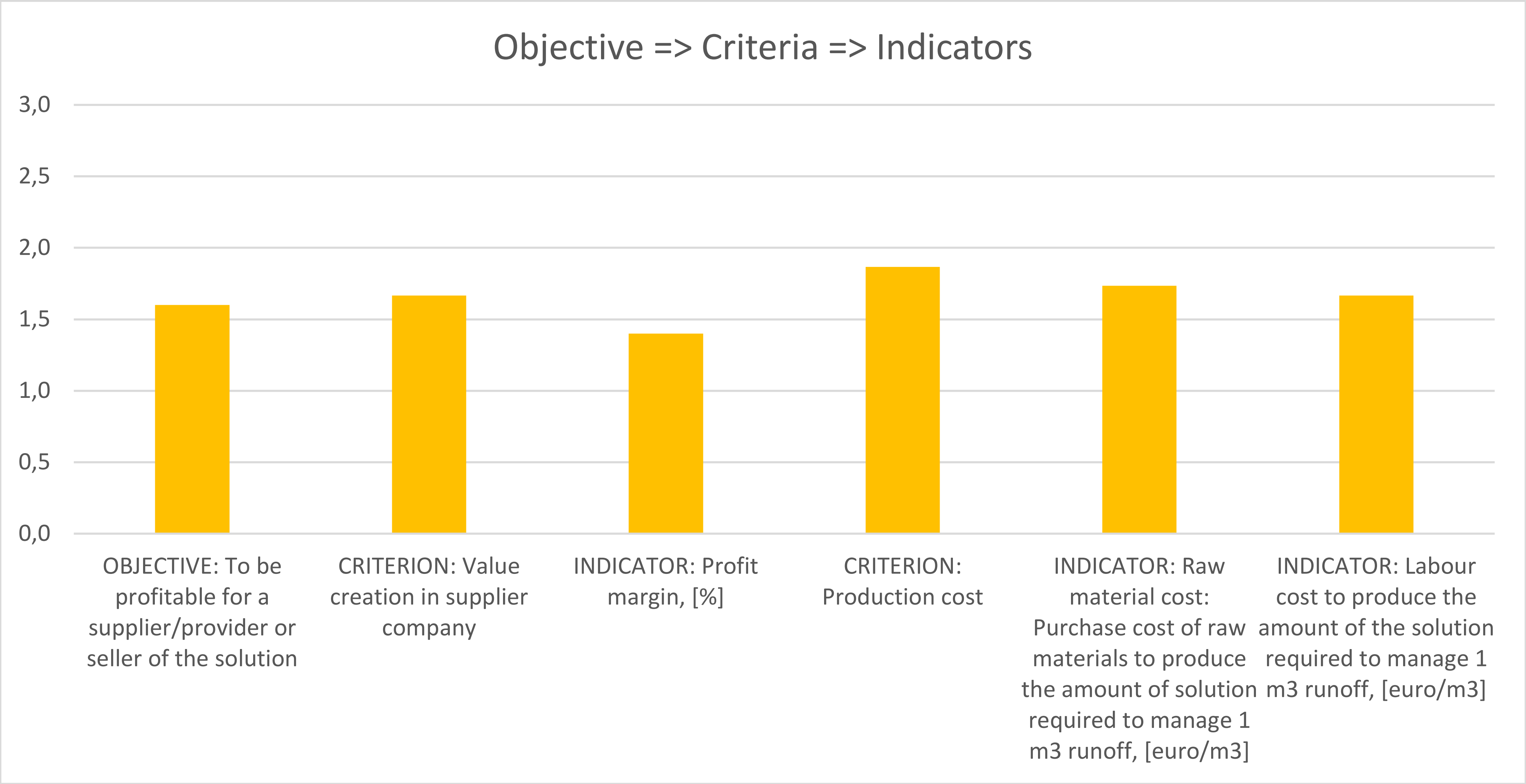
- Averages according to dimension:
- Social:
  - 1,8
- Environmental:
  - 2,3
- Econnomy:
  - 2,0
- Governance:
  - 2,1
- Technical performance:
  - 2,6



PRELIMINARY RESULTS: Average overall scores for 'OBJECTIVES', 'CRITERIA' and 'INDICATORS'



PRELIMINARY RESULTS: Average scores for a selected sequence of 'OBJECTIVES' => 'CRITERIA' => 'INDICATORS'



Thank you for your attention

Herman Helness

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Aalto University School of Engineering · anteagroup · brgm – Geoscience for a sustainable Earth · imaGeau · SINTEF · Water Institute · VTT

https://www.sintef.no/projectweb/eviban/

Evidence based assessment of a Nature-Based Solutions Optimizer

WAT Master's Thesis Seminar – Final Presentation – August 18, 2021

Felipe da Silva
Supervisor: Harri Koivusalo
Advisor: Adrian Werner, Ambika Khadka

Outline

- Context, team & stakeholders
- Objectives
- Methods
- Results
- Findings
- Recommendations for further development
- Questions/Comments

Project in context

Current world challenges

Increase of urbanization

Changes in stormwater runoff volume and quality

Changes the hydrological systems and the natural environment

Project team & stakeholders

- Harri Koivusalo: Professor in water resources engineering
- Ambika Khadka: Doctoral research at water and environmental engineering research group

- Adrian Werner: A research scientist at SINTEF who helped designed the NBS optimizer

Sven Hallinin tutkimussäätiö

Research gaps

- Wider costs and benefits at different scales
- The conditions under which NBS perform best
- How they are best combined with other measures

EviBAN tool

Excel input data file and output results file

Python code to run simulation and optimization

EviBAN tool

- Optimizes the most cost-effective NBS combinations to meet desired peak flow attenuation.

Thesis objectives & deliverables

Parameterize

Develop a transparent way to parameterize the EviBAN optimization tool.

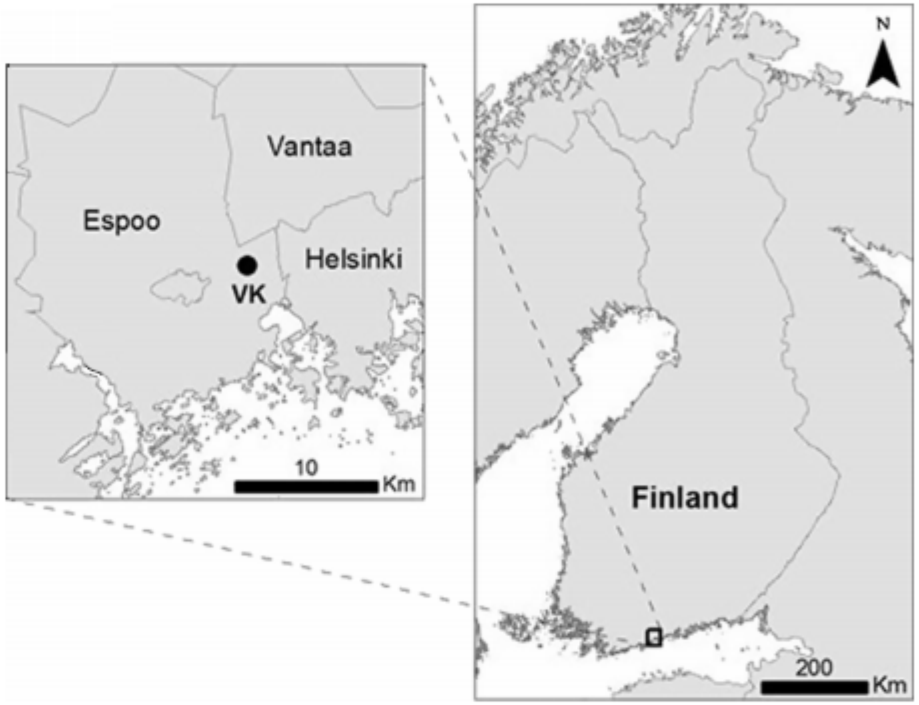
Validate

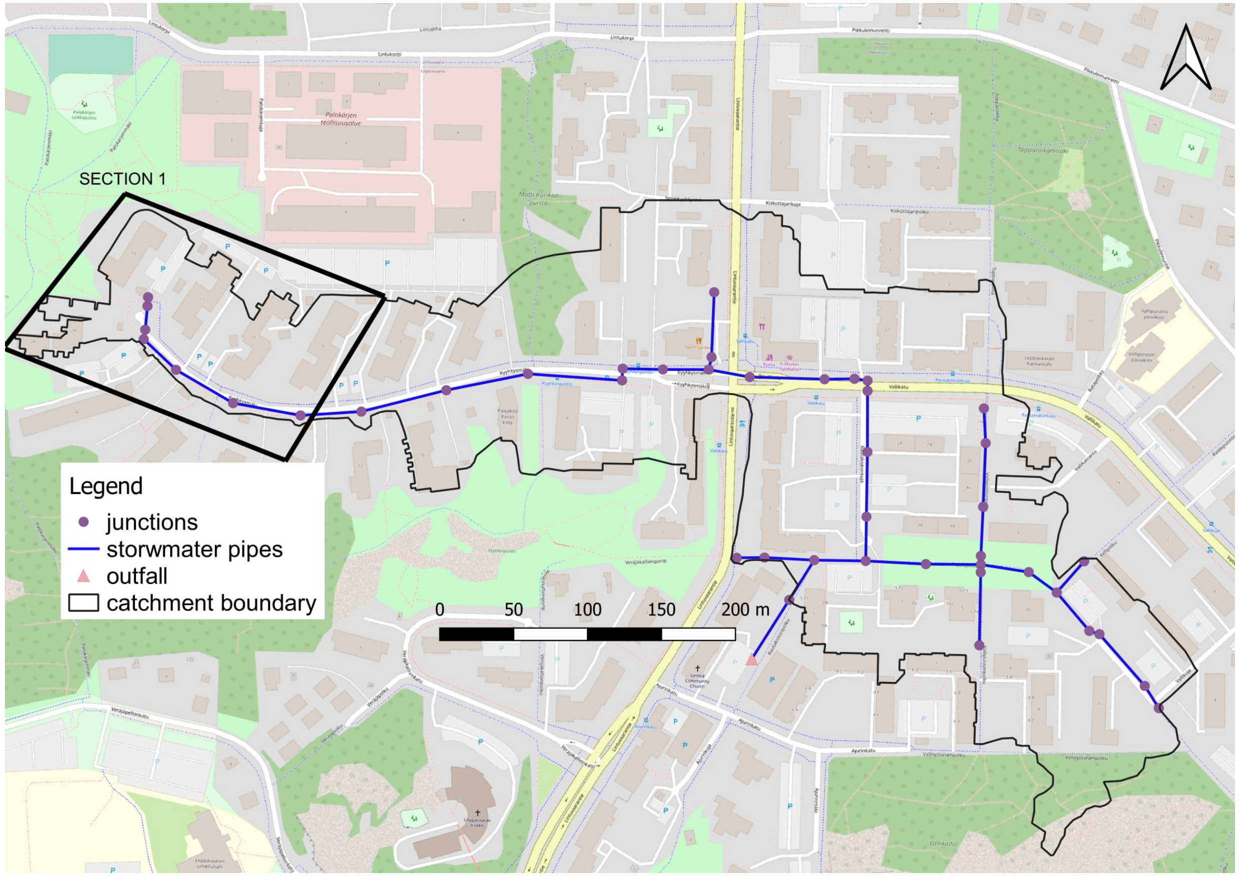
Determine how the results of the optimizer compare to the SWMM results of the optimized NBS combination scenario.

Suggest

Suggest ways to further develop the optimizer.

Vallikallio Espoo Finland





Nodal areas (m^2)

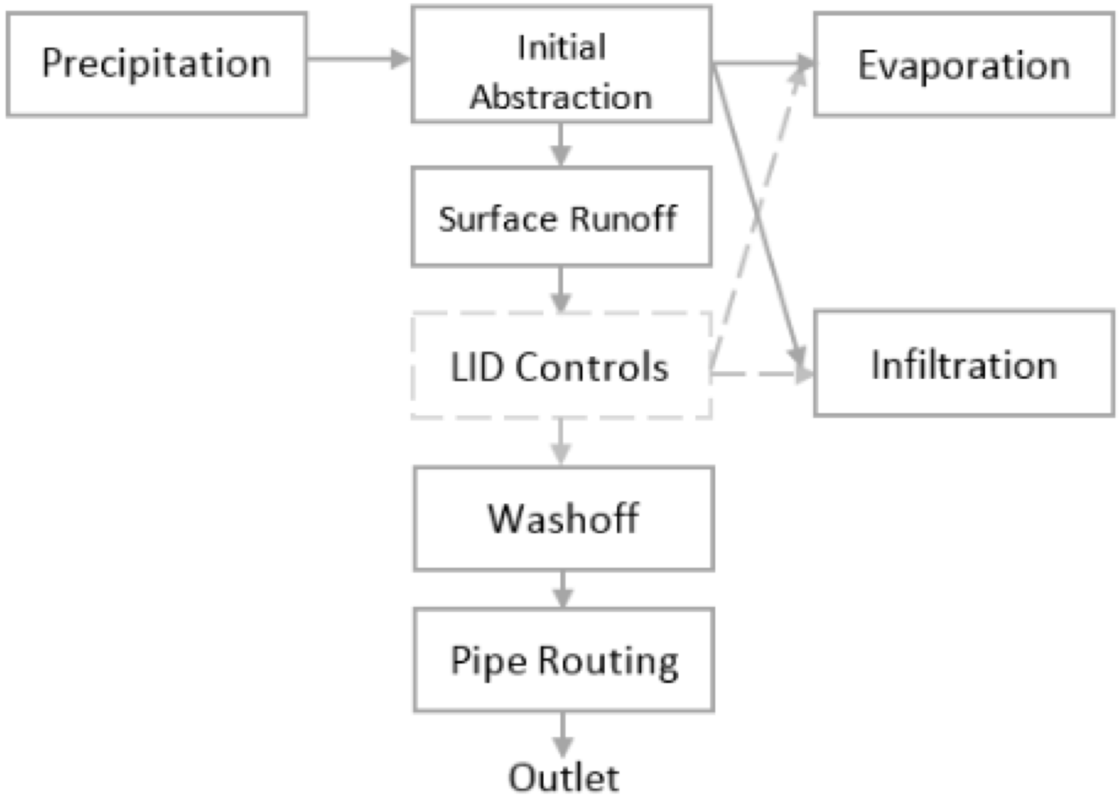
Node	1	2	3	4	5	6	7	Total
Roof	785	46	17	602	1,038	1,142	1,081	4,710
Walkway	302	274	110	0	485	577	629	2,377
Parking	634	0	962	0	142	145	0	1,882
Road	0	0	233	0	177	264	264	937
Pavers	0	0	0	0	49	95	0	144
Sand	0	0	27	0	74	226	86	413
Rock	0	0	0	0	0	48	49	97
Vegetation	554	527	343	0	645	945	329	3,343
Impervious	73 %	36 %	74 %	100 %	71 %	66 %	82 %	72 %
Pervious	27 %	64 %	26 %	0 %	29 %	34 %	18 %	28 %
Total Area	2,275	846	1,692	602	2,608	3,442	2,437	13,903

SWMM

Industry standard to model runoff volume and quality in large catchments.

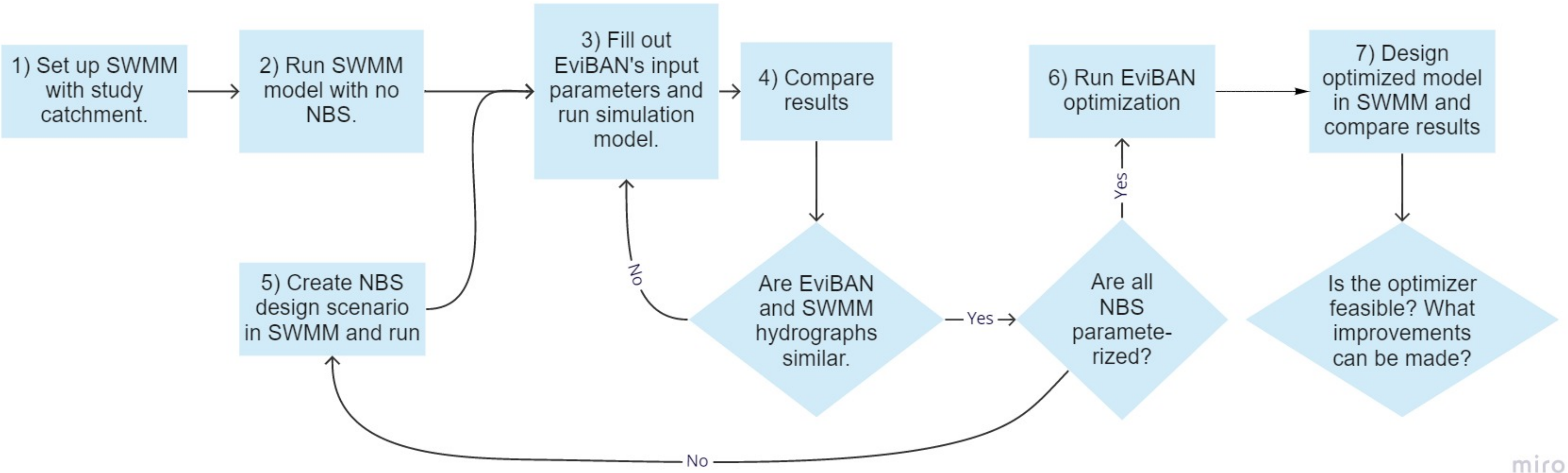
USEPA (US environmental protection agency)

Open source



(Tuomela, 2017)

Methods flow diagram



Results

Parameterization of 25-year storm model

	Retention Losses	Detention (time step) total time = 74 min					
Measure		1	2	3	4	5	6
No NBS	0.28	0.4	0.3	0.2	0.1	0	0
Rain garden	1.00	0.4	0.2	0.2	0.1	0.1	0
Green roof	1.00	0.4	0.2	0.2	0.1	0.1	0
Swales	0.56	0.4	0.2	0.2	0.1	0.1	0
Permeable pavements	1.00	0.4	0.2	0.2	0.1	0.1	0

Scenario	Rainfall (time step) (mm/2 min)									
	1	2	3	4	5	6	7	8	9	10
25-year	0	0	0	0	0	2.94	2.94	2.94	2.94	2.94

Parameterization of 50-year storm model

	Retention Losses	Detention (time step) total time = 74 min					
Measure		1	2	3	4	5	6
No NBS	0.28	0.4	0.3	0.2	0.1	0	0
Rain garden	0.92	0.4	0.2	0.2	0.1	0.1	0
Green roof	0.83	0.4	0.2	0.2	0.1	0.1	0
Swales	0.46	0.4	0.2	0.2	0.1	0.1	0
Permeable pavements	0.92	0.4	0.2	0.2	0.1	0.1	0

Scenario	Rainfall (time step) (mm/2 min)									
	1	2	3	4	5	6	7	8	9	10
50-year	0	0	0	0	0	3.38	3.38	3.38	3.38	3.38

Cost scenarios

	Option 1		Option 2		Option 3		Option 4	
Measure	Capital cost per m2 (EU)	O&M cost per year (%)	Capital cost per m2 (EU)	O&M cost per year (%)	Capital cost per m2 (EU)	O&M cost per year (%)	Capital cost per m2 (EU)	O&M cost per year (%)
Rain garden	501	0.10	20	0.10	10	0.10	21	0.10
Green roof	564	0.07	30	0.07	10	0.10	20	0.07
Vegetated swale	371	0.06	38	0.06	10	0.10	18	0.06
Permeable paver	252	0.04	45	0.04	10	0.10	22	0.04

Option 1 (Ruan), Option 2 (Ambika), Option 3 LID performance with similar costs, Option 4 arbitrary to further test optimization tool

Optimized solutions

Option 1

Node	NO NBS	Rain Garden (€501)	Green Roof (€564)	Swale ($371)	Permeable Paver (€252)
1	59 %	0 %	0 %	0 %	41 %
2	68 %	0 %	0 %	0 %	32 %
3	75 %	0 %	0 %	0 %	25 %
4	100 %	0 %	0 %	0 %	0 %
5	74 %	0 %	0 %	0 %	26 %
6	76 %	0 %	0 %	0 %	24 %
7	74 %	0 %	0 %	0 %	26 %

Option 2

Node	NO NBS	Rain Garden (€20)	Green Roof (€30)	Swale (€38)	Permeable Paver (€45)
1	48 %	52 %	0 %	0 %	0 %
2	100 %	0 %	0 %	0 %	0 %
3	100 %	0 %	0 %	0 %	0 %
4	100 %	0 %	0 %	0 %	0 %
5	67 %	33 %	0 %	0 %	0 %
6	62 %	38 %	0 %	0 %	0 %
7	83 %	17 %	0 %	0 %	0 %

Optimized solutions

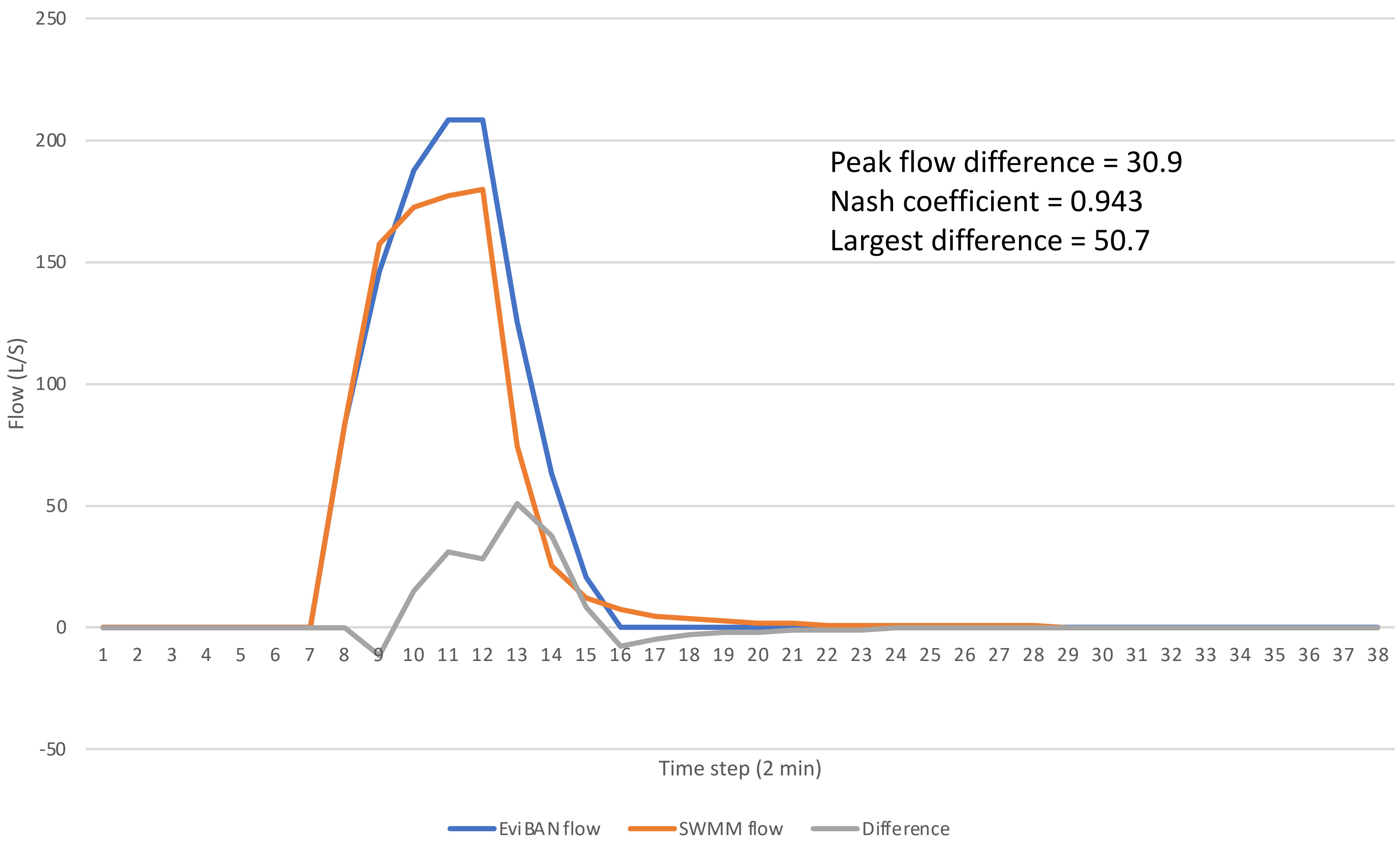
Option 3

Node	NO NBS	Rain Garden (€10)	Green Roof (€10)	Swale (€10)	Permeable Paver (€10)
1	100 %	0 %	0 %	0 %	0 %
2	62 %	0 %	5 %	0 %	32 %
3	99 %	0 %	1 %	0 %	0 %
4	100 %	0 %	0 %	0 %	0 %
5	47 %	28 %	0 %	0 %	26 %
6	72 %	4 %	0 %	0 %	24 %
7	57 %	17 %	0 %	0 %	26 %

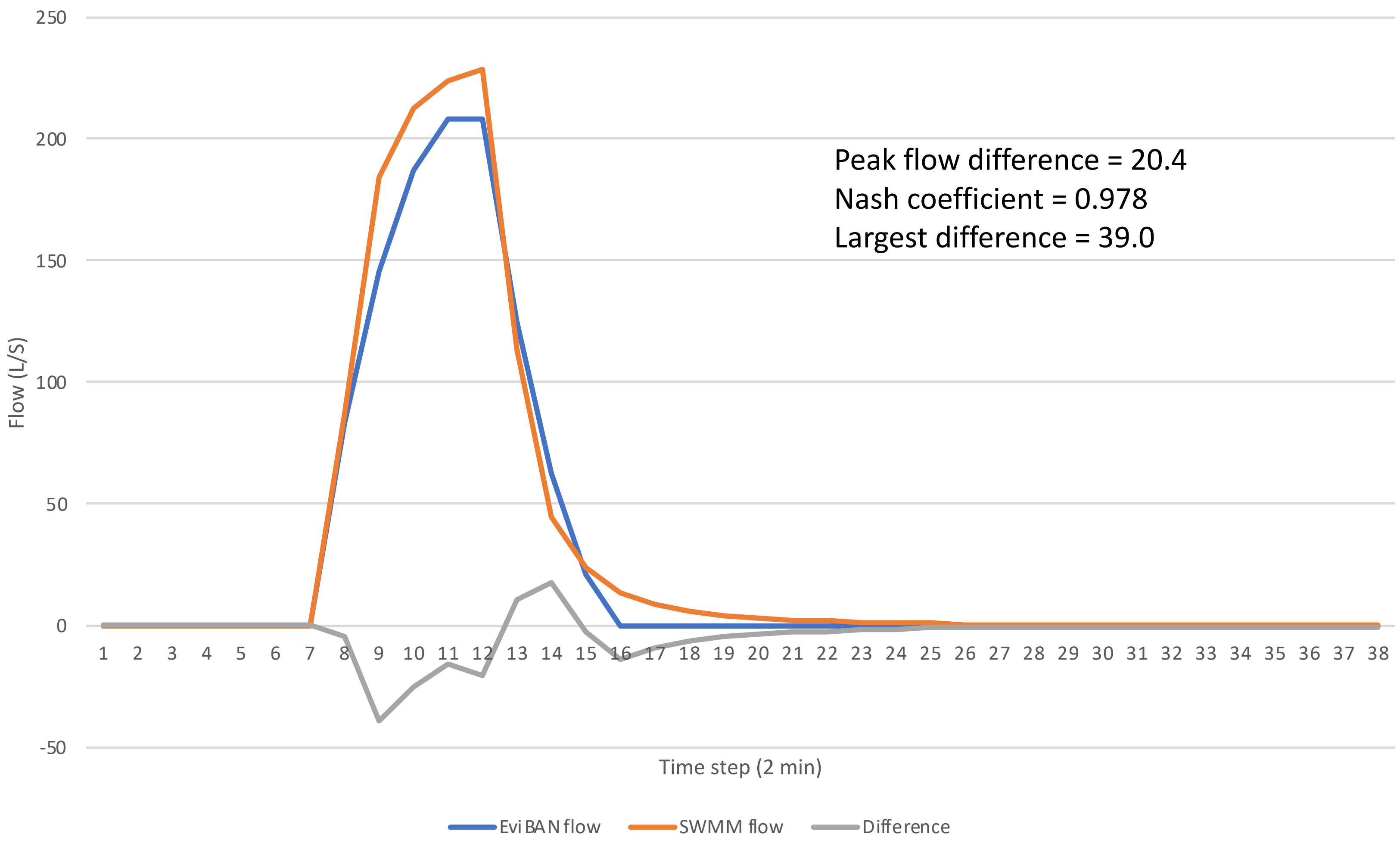
Option 4

Node	NO NBS	Rain Garden (€21)	Green Roof (€20)	Swale (€18)	Permeable Paver (€22)
1	65 %	0 %	35 %	0 %	0 %
2	95 %	0 %	5 %	0 %	0 %
3	99 %	0 %	1 %	0 %	0 %
4	100 %	0 %	0 %	0 %	0 %
5	47 %	14 %	40 %	0 %	0 %
6	67 %	0 %	33 %	0 %	0 %
7	78 %	0 %	5 %	17 %	0 %

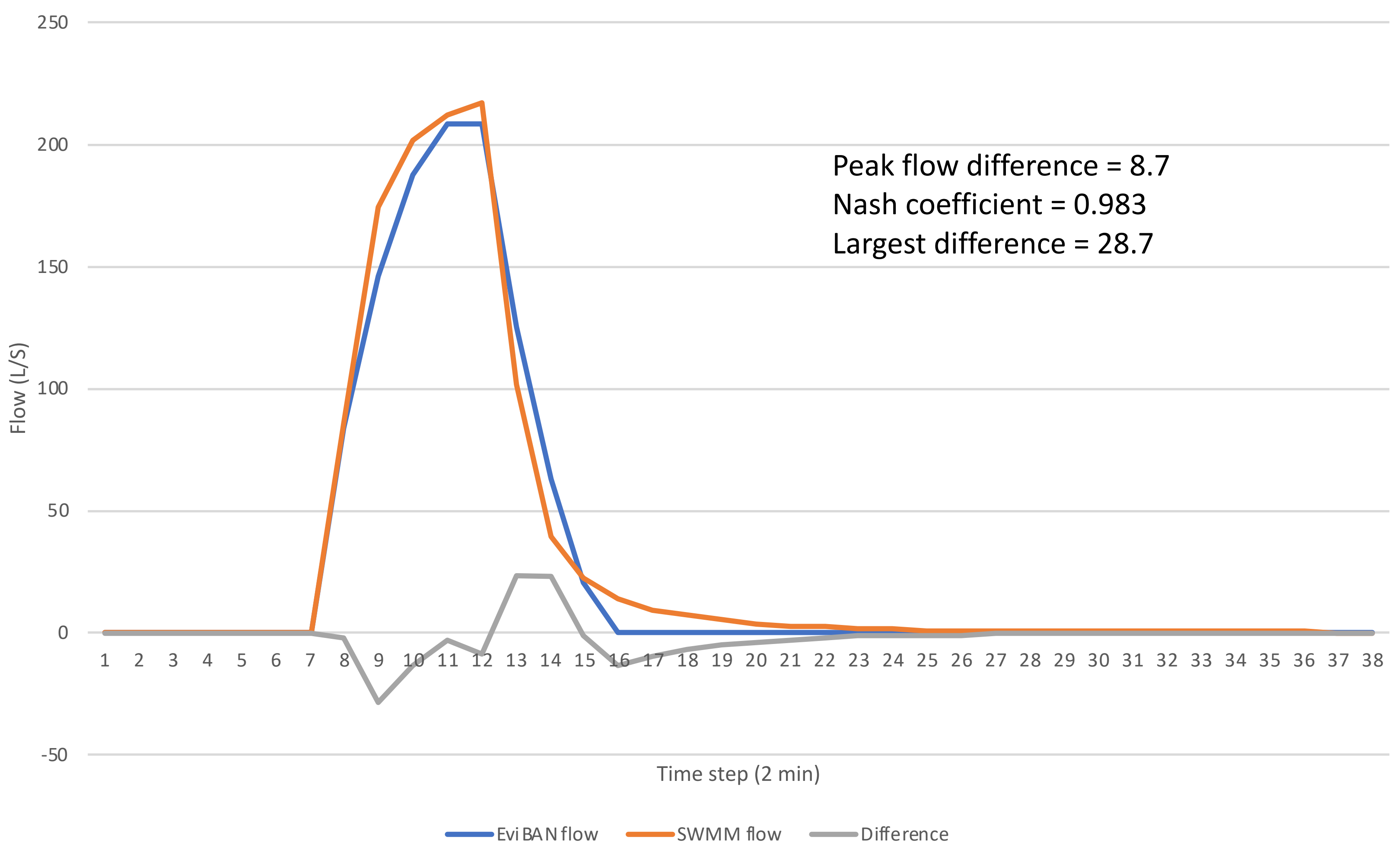
Validation of optimized scenario 1



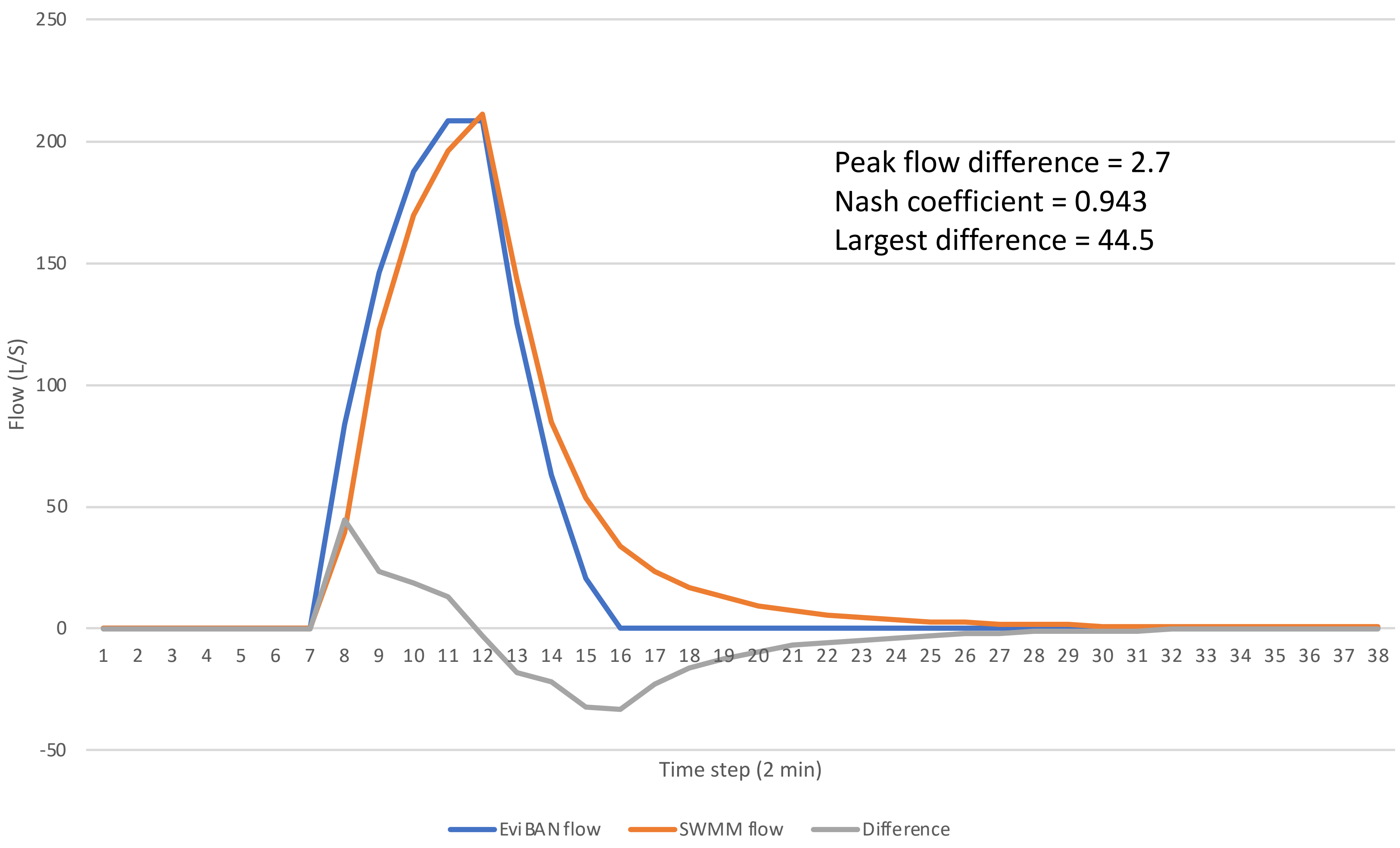
Validation of optimized scenario 2



Validation of optimized scenario 3



Validation of optimized scenario 4



Findings

Findings from results

- Model prioritizes meeting peak flow target while minimizing costs.
  - Cost
  - Retention
  - Detention
- Tool is validated as it produces realistic flow calculations, but room for improvement.
- More realistic limit areas for NBS are needed.
- Parameters only pertain to a specific storm event.

Ways to further develop the EviBAN tool

- Include different retention rates for pervious and impervious coverage.
- Develop a methodology to determine limit area parameters of NBS for each node.
- Explore the possibility of adding water quality parameters into the tool.
- Explore the detention parameter a bit more to have better understanding of it. influence

Questions & comments

General data

General data:	
Discount rate ()	0.07
Time units economic modelling (years)	20
Runoff limit in sink node ()	25000
Time units water modelling ()	37
Selected rainfall profile ()	6
Show in- vs. outflow at node	7
Run as simulation (uses fixed NBS shares)	0
Limits on installed measure area in nodes	1

Measures

		Costs		Retention	Detention (time step)		total time = 74 min, 1 time step = 10 min			
Measure	mID	CAPEX	OPEX	Losses	1	2	3	4	5	6
No measure (base)	0	0	0	0.28	0.4	0.3	0.2	0.1	0	0
Rain garden	1	501	0.1	0.92	0.4	0.2	0.2	0.1	0.1	0
Green roof	2	564	0.07	0.83	0.4	0.2	0.2	0.1	0.1	0
Swales	3	371	0.06	0.46	0.4	0.2	0.2	0.1	0.1	0
Permeable pavements	4	252	0.04	0.92	0.4	0.2	0.2	0.1	0.1	0

Nodes

Nodes		Measures feasible mID (yes>0, no=0)								
nID	Area (m2)	All NBS	1+3	1+4	3+4	0	1	2	3	4
0	0	0	0	0	0	0	0	0	0	0
1	2275	2275	1187.8	1489.6	1489.6	2275	1187.8	785.4	1187.8	936
2	846	800.5	526.7	800.5	800.5	846	526.7	45.5	526.7	273.8
3	1692.3	1442.5	1332.3	1442.5	1442.5	1692.3	1332.3	17.1	1332.3	1071.7
4	602.2	602.2	0	0	0	602.2	0	602.2	0	0
5	2608.2	1393.8	860.3	1393.8	1393.8	2608.2	860.3	1037.8	860.3	675
6	3441.9	1988.6	1316	1988.6	1988.6	3441.9	1316	1141.5	1316	817.2
7	2437.1	1080.9	414.9	1043.4	1043.4	2437.1	414.9	1080.9	414.9	628.5

Network

Network			
From node	To node	Share	Time of concentration (time unit)
1	0	1	1
2	0	1	1
3	0	1	1
4	0	1	1
5	0	1	1
6	0	1	1
7	0	1	1

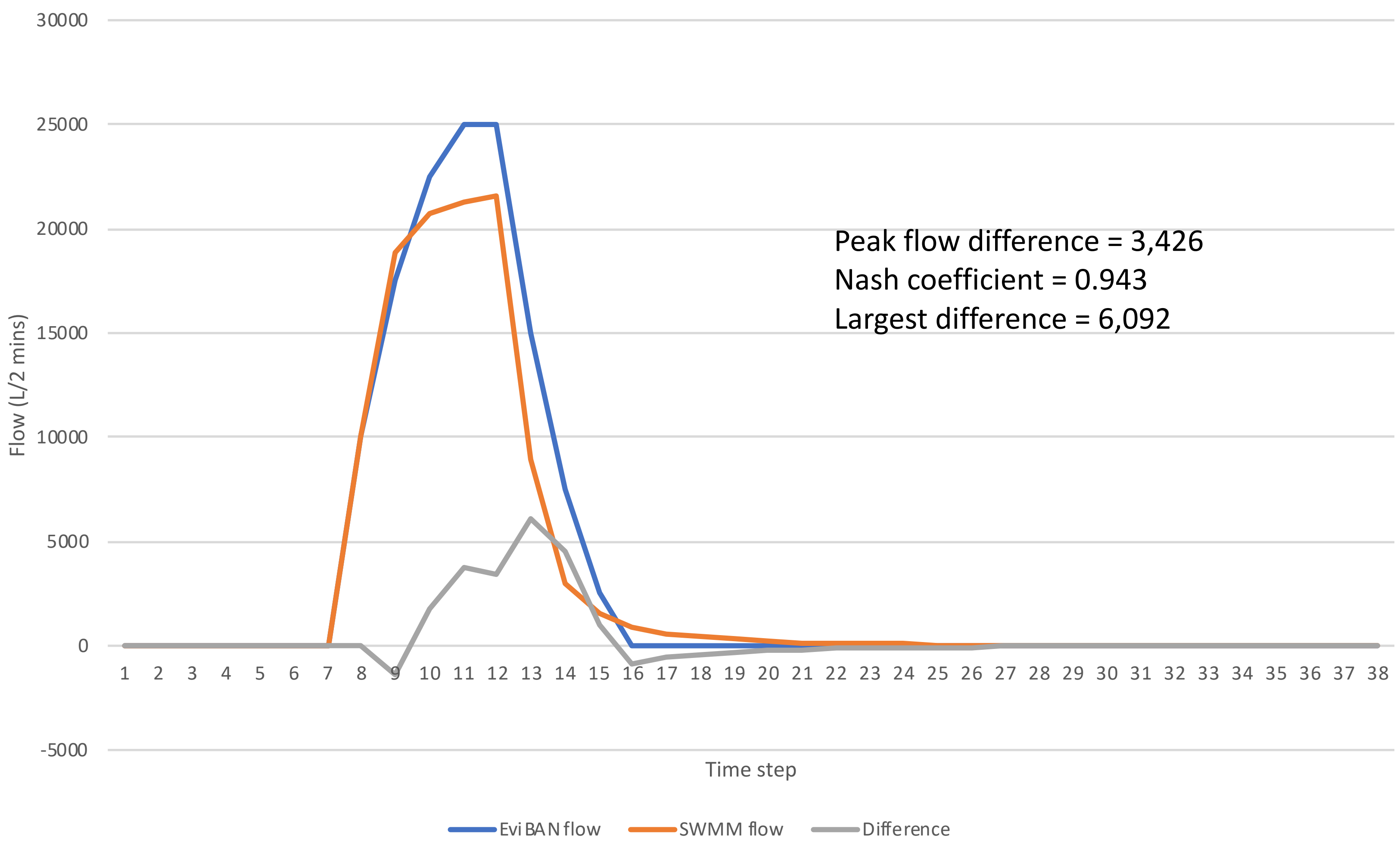
Design rainfall

Scenario	Rainfall (time step) (liter/m2)									
	1	2	3	4	5	6	7	8	9	10
1-year	0	0	0	0	0	0.86	0.86	0.86	0.86	0.86
2-year	0	0	0	0	0	1.3	1.3	1.3	1.3	1.3
5-year	0	0	0	0	0	1.9	1.9	1.9	1.9	1.9
10-year	0	0	0	0	0	2.34	2.34	2.34	2.34	2.34
25-year	0	0	0	0	0	2.94	2.94	2.94	2.94	2.94
50-year	0	0	0	0	0	3.38	3.38	3.38	3.38	3.38

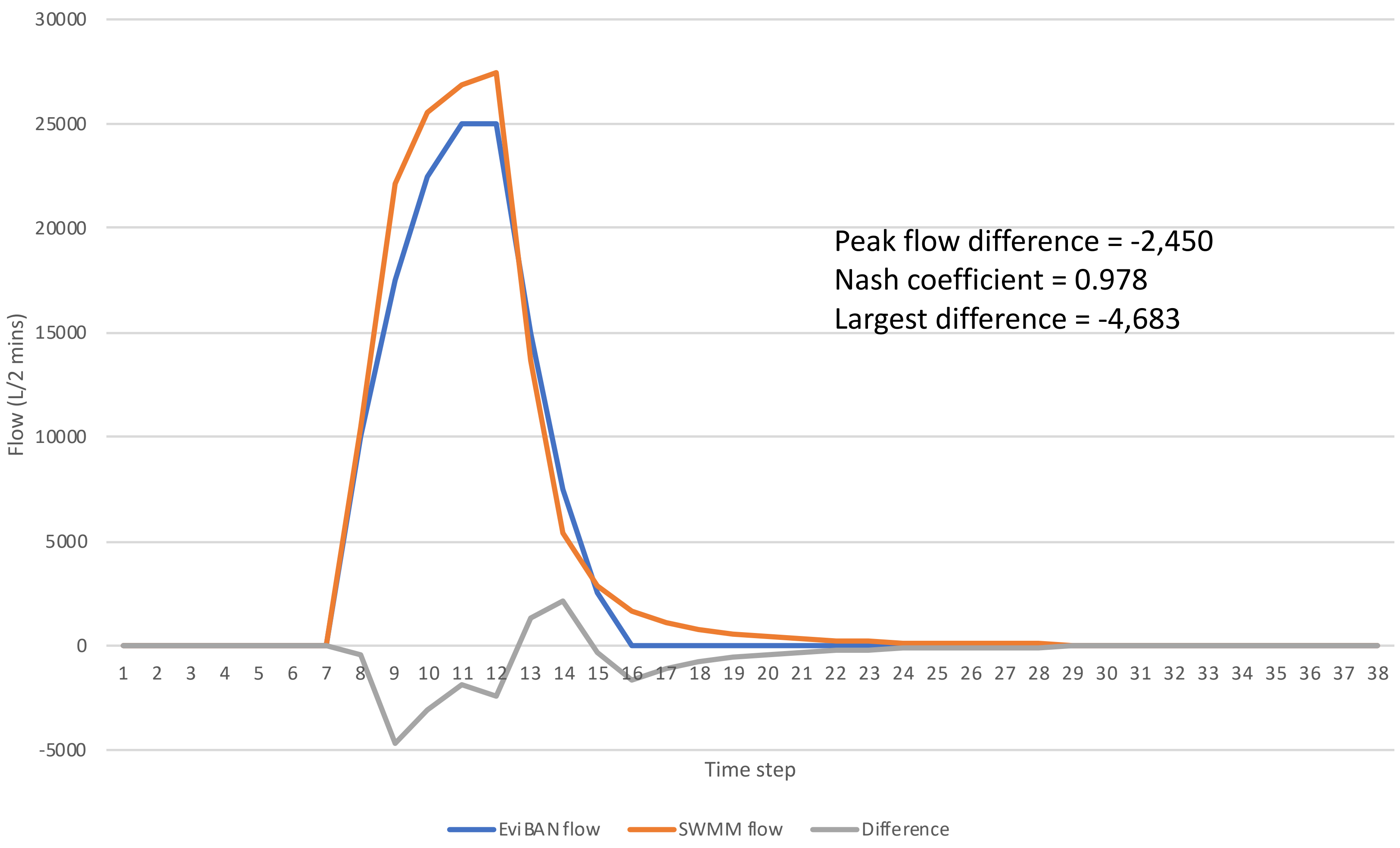
Fixed shares

Nodes	Measures mID (shares <= 1, sum =1)					
nID	0	1	2	3	4	5
0	0	0	0	0	0	0
1	1	0	0	0	0	0
2	1	0	0	0	0	0
3	1	0	0	0	0	0
4	1	0	0	0	0	0
5	1	0	0	0	0	0
6	1	0	0	0	0	0
7	1	0	0	0	0	0

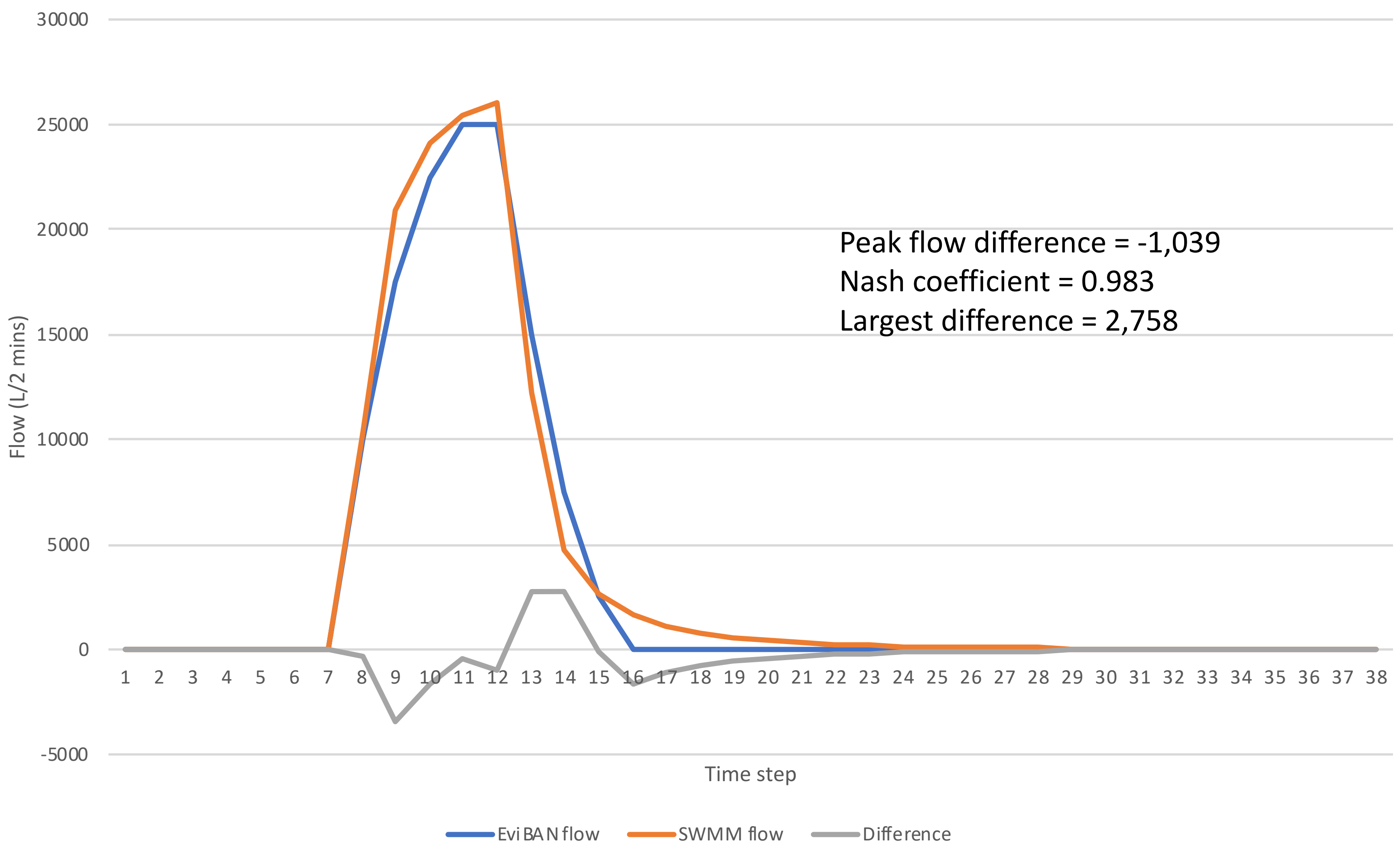
Validation of optimized scenario 1



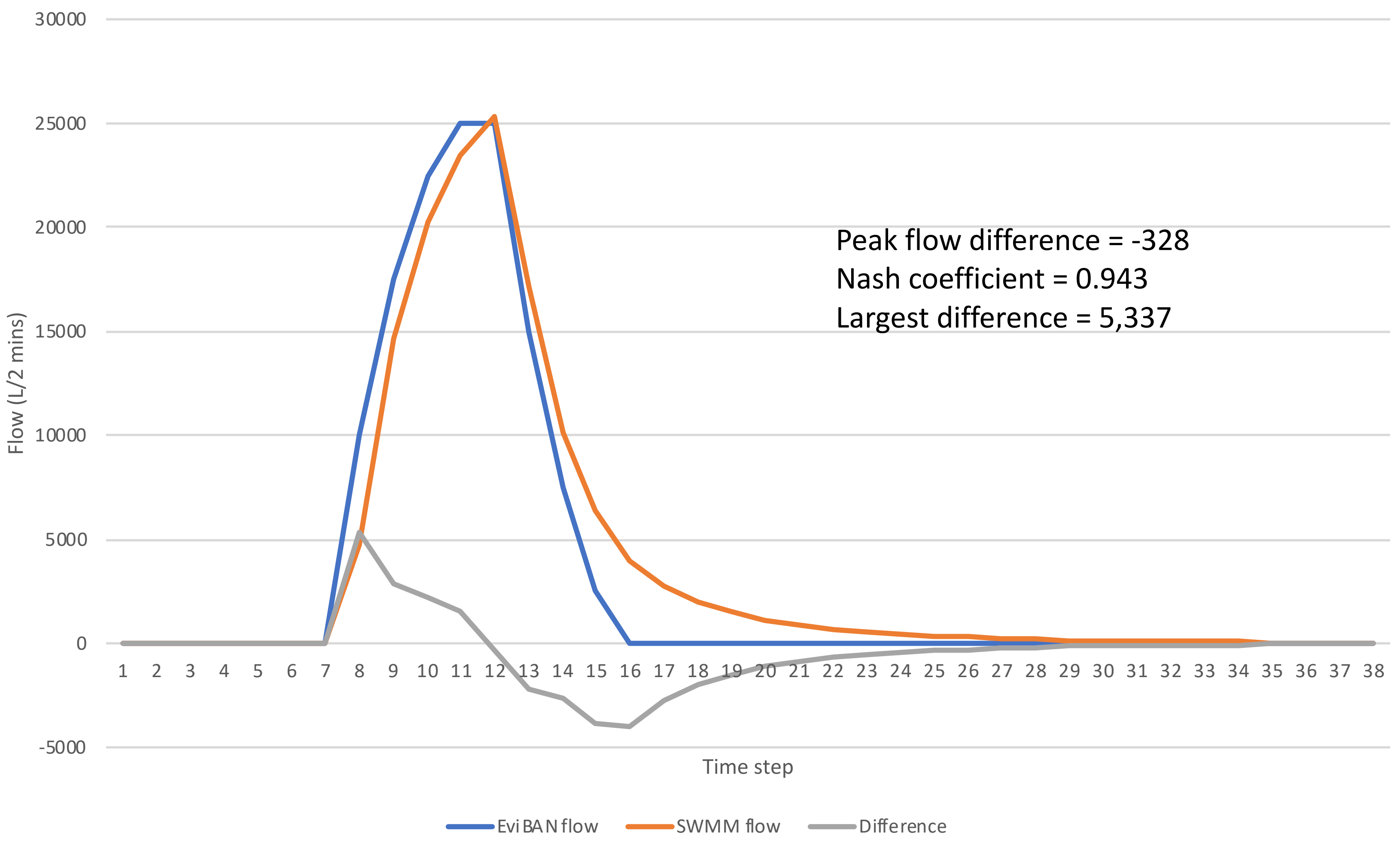
Validation of optimized scenario 2



Validation of optimized scenario 3



Validation of optimized scenario 4



EviBAN

—

Modelling of stormwater management measures in Finland

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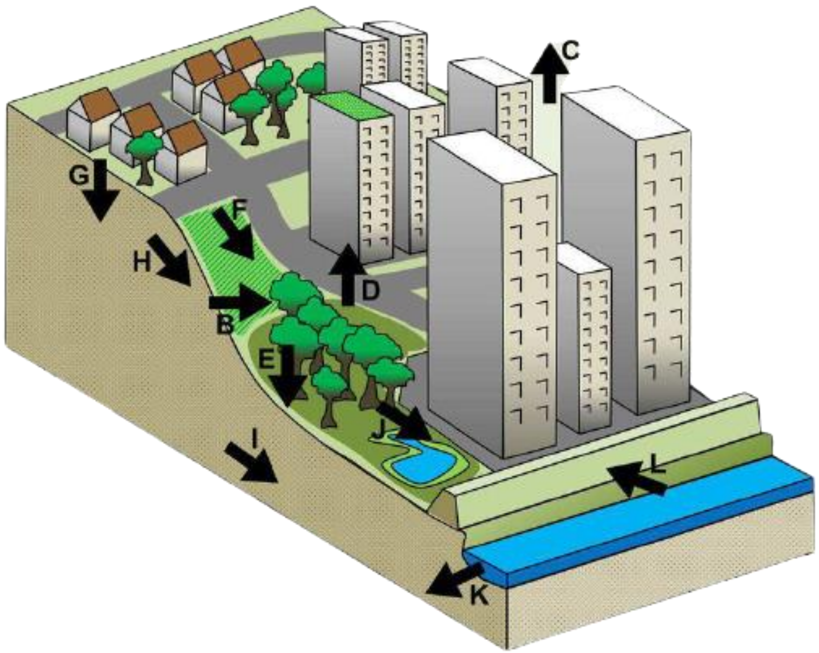
Aalto-universitetet
Aalto University

Ottar Tamm
17.08.2021

Research questions



- What will happen to urban water balance in the future?
- How and to what extent can LID techniques positively alter the urban water balance in the future?

Methods

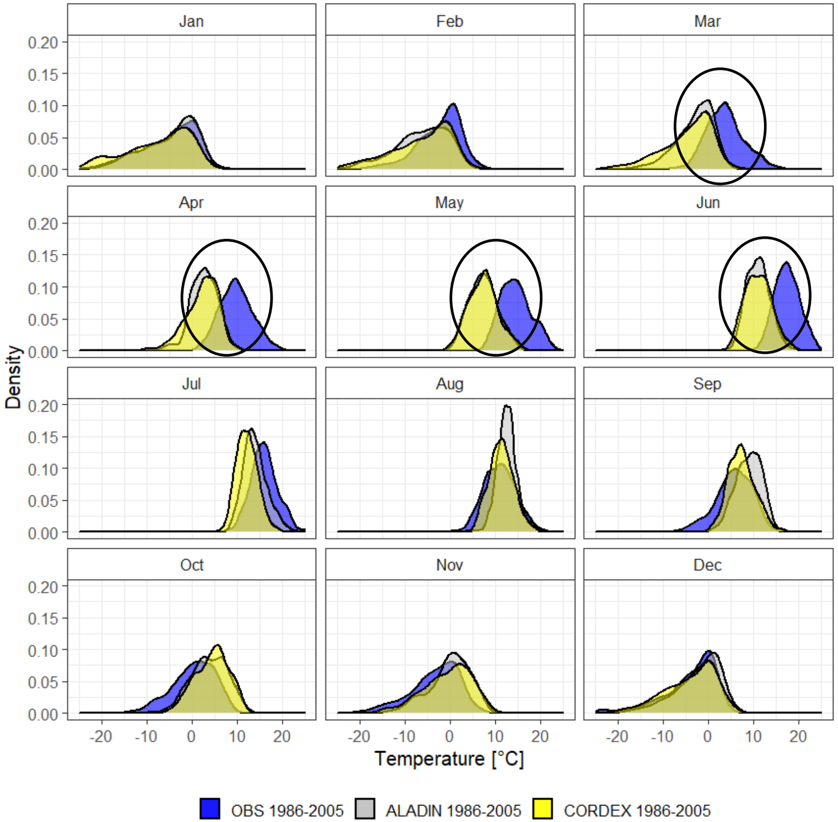
- **Tool: SWMM**

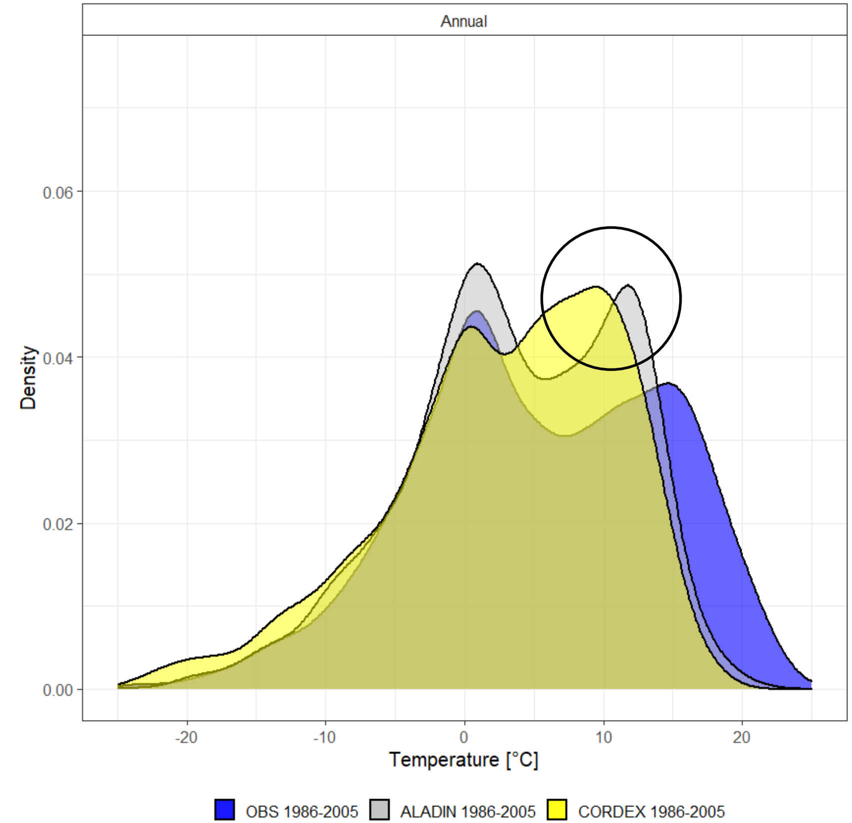
- **Regional climate model (RCM) outputs**

- **Are RCM outputs representative of the past?**

- **Future climate -> SWMM <- LID scenarios**

RAW RCMs temperature





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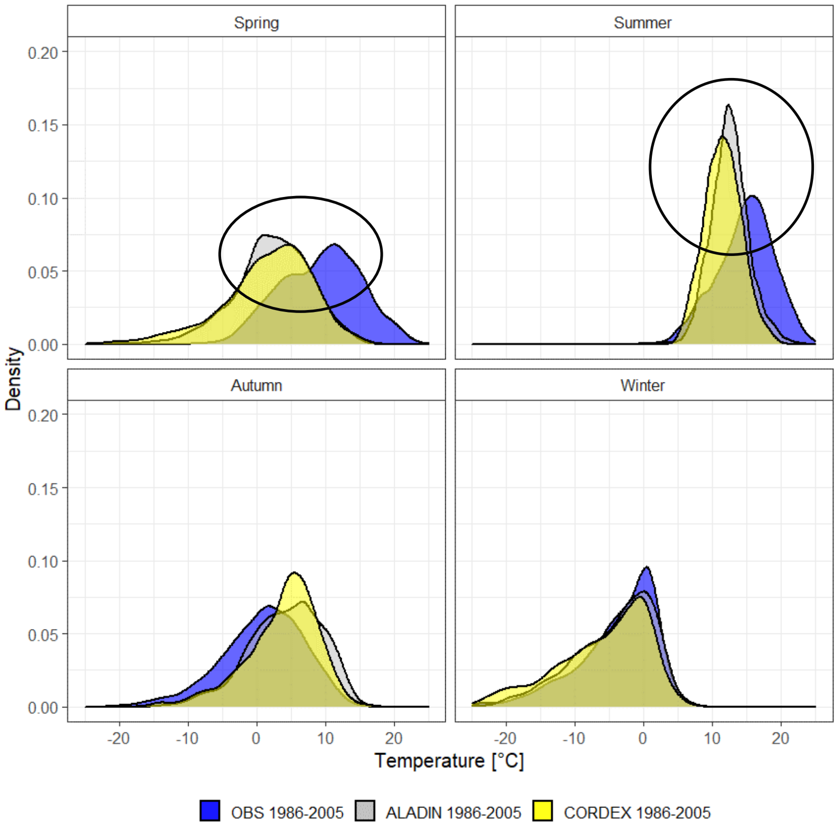
RAW RCMs temperature



- **Correction of this bias (BC) is required for temperature**
- **What about precipitation?**

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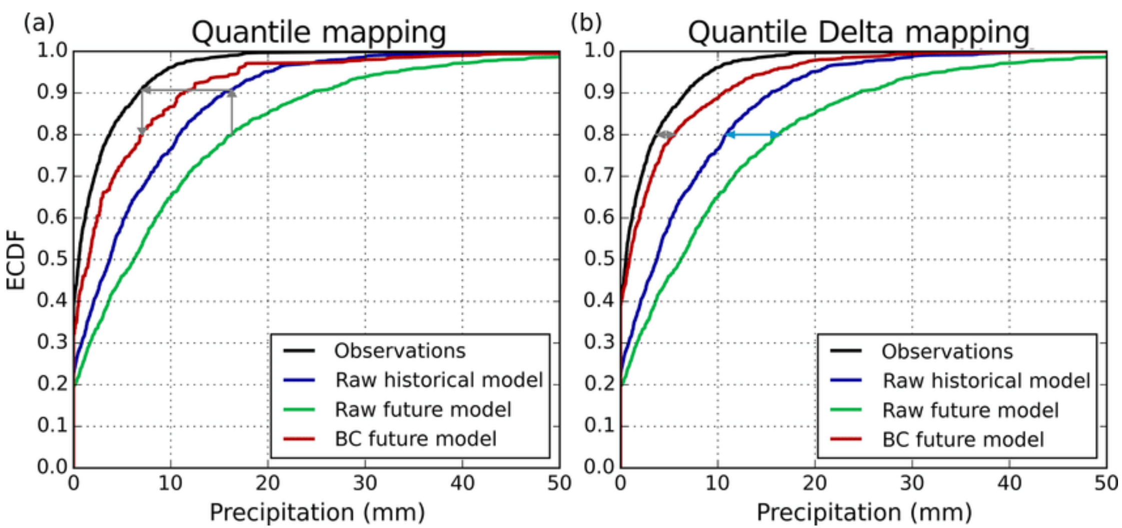
RAW precipitation extremes 24h

Daily extreme precipitation			
History (1986-2005)			
Observed	rawCordex	rawALADIN	rawAROME
65.5	41.4	57.6	66.6
54.2	37.2	42.1	45.3
53.5	36.5	41.4	44.4
44.9	35.7	38.5	40.1
44.8	35.1	37.5	40.0

BC

Method: Quantile Delta mapping

DOI:10.5194/hess-21-2649-2017



- **Detrending** the individual quantiles
- **It preserves the change signal in all quantiles.**

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BC

- BC daily precipitation

- BC daily average temperature

- Daily quantile corrections -> hourly data

BC precipitation extremes 24h

History	History (1986-2005)		
Observed	Cordex	ALADIN	AROME
65.5	41.4→Obs	57.6→Obs	66.6→Obs
54.2	37.2→Obs	42.1→Obs	45.3→Obs
53.5	12.8→Obs	41.4→Obs	44.4→Obs
44.9	12.6→Obs	38.5→Obs	40.1→Obs
44.8	12.5→Obs	37.5→Obs	40.0→Obs

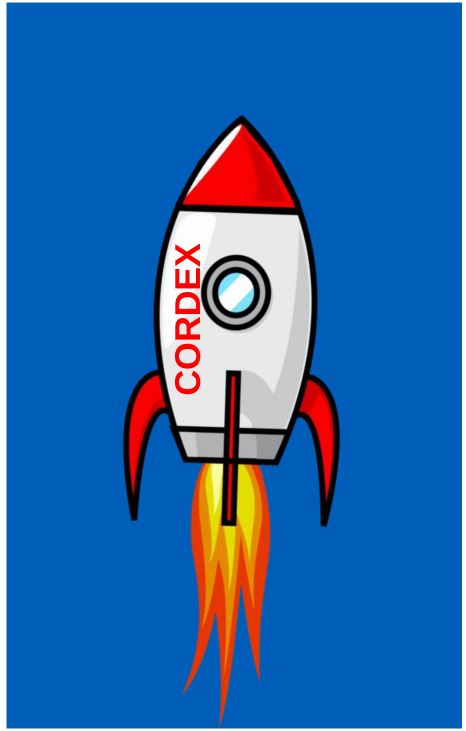
History

24h extreme values

BC precipitation extremes 24h

History	BC Farfuture (2081-2100)			
Observed	Cordex2.6	Cordex8.5	ALADIN	AROME
65.5	70.5→111.5	82.9→131.1	97.5	52.9
54.2	68.7→107.3	69.1→100.6	52.0	52.8
53.5	54.5→75.1	61.1→83.9	48.6	52.2
44.9	48.5→62.4	59.4→80.4	45.6	52.1
44.8	45.1→55.5	48.5→59.4	45.6	50.1

What about 1 hour precipitation extremes?



BC precipitation extremes 1h

History	History (1986-2005)		
2006-2015	Cordex	ALADIN	AROME
30.5	18.5→25.9	16.0→17.8	18.9→21.0
27.6	13.5→18.4	11.2→12.4	18.5→20.3
27.2	12.8→18.0	11.0→11.8	17.9→19.7
20.8	12.6→15.3	10.7→11.7	16.1→17.7
19.2	12.5→14.7	10.2→11.3	14.4→15.9

History

1h extreme values

BC precipitation extremes 1h

History	BC Farfuture (2081-2100)			
2006-2015	Cordex2.6	Cordex8.5	ALADIN	AROME
30.5	23.6	22.7	20.2	28.4
27.6	19.0	20.2	13.5	28.0
27.2	17.7	19.2	13.3	26.7
20.8	17.3	18.6	12.5	24.4
19.2	17.2	17.7	12.3	23.0

Farfuture

1h extreme values

SWMM

- Detailed "calibrated" SWMM urban model
- SWMM input – 1h future climate data
- Long-term continuous all-season modelling
- Changes in snow/evaporation/infiltration/runoff/precipitation

Study area - Vallikallio

SWMM

- Winter parametrization
- Measurements from earlier studies
- 2005-2006 – snow depth, outfall runoff,
- precipitation, temperature
- Winter “calibration”

LID

- **How can LID positively alter the future urban water balance?**

  1. Define LID scenario placement and coverage criteria

  2. Generate stochastic LID scenarios for future

EXPECTED RESULT

- **Urban water balance changes in the future**

- **Knowledge, how much LID can alter urban water cycle**

THANKS!

Tartu, Estonia

11.08.2021

Aalto-yliopisto
Aalto-universitetet
Aalto University

THANKS!

Any comments and/or questions?

CONSORTIUM

Private sector

SKANSKA
MESTERHUS
Multiconsult
Finans Norge
SKJÆVELAND GRUPPEN
NORGESHUS
Leca
isola

Public sector

Statens vegvesen
Norges vassdrags- og energidirektorat NVE
AVINOR
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