Kuva Juha Alaluukas,
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Taustakartta:
Maanmittauslaitos

General pluvial flood map of Finland

Aspects into Multidimensional Nature-Based Stormwater Treatment October 2, 2024, SAMK, Pori

Mikko Sane, Development Engineer,
Finnish Environment Institute (Syke), Finland

Suomen ympäristökeskus
Finlands miljöcentral
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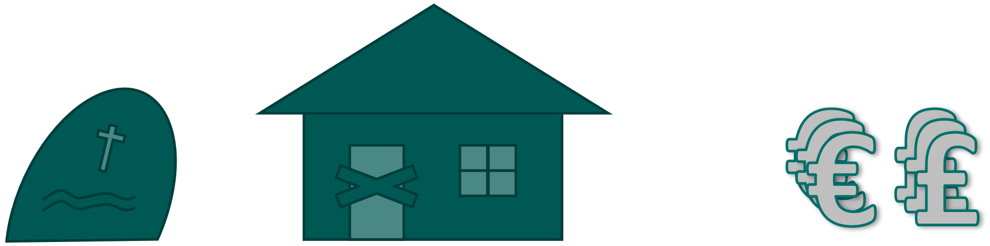
EU Floods Directive

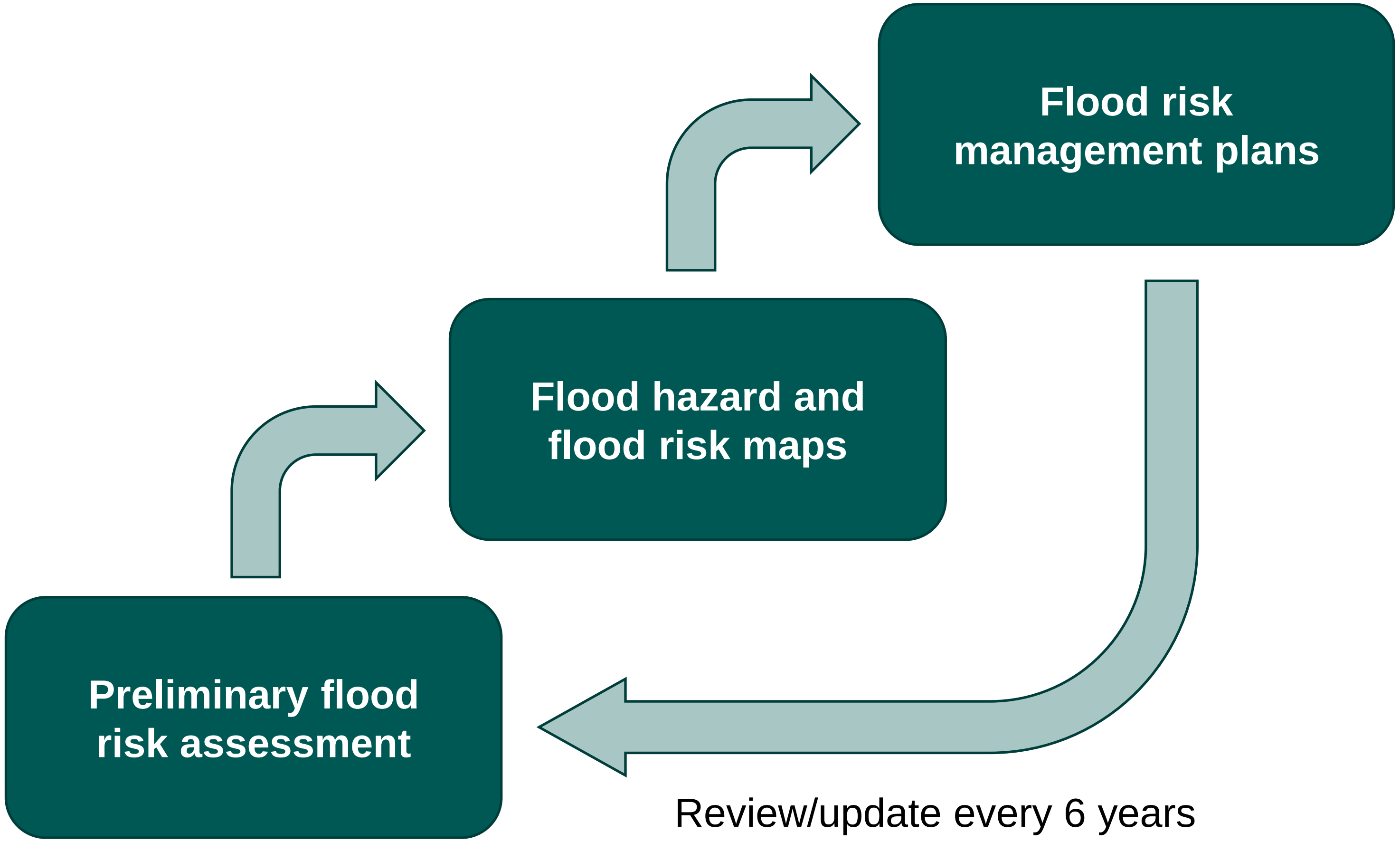
- Over 200 major damaging floods in Europe 1998-2009
  ➔ **2007 EU Floods Directive**
- The aim is to **reduce** and **manage** the risks that floods pose to human health, the environment, cultural heritage and economic activity
- The directive is implemented into **national legislation** in Finland (620/2010, 659/2010)
- All types of floods – rivers, lakes, urban areas, coastal flooding...



1126
deaths

displacement of about
half a million people

at least €52 billion in
insured economic losses



Review/update every 6 years

Identification areas of potential significant flood risk

Finnish Environment Institute's (Syke) role in the field of the flood risk management

- Manages the **Watershed Simulation and Forecasting System**
  - Real-time hydrological maps and **forecasts** and flood **warnings** covering the whole country (https://waterinfo.fi)
- Maintains an **overview of the national flood situation** (Flood centre)
- Coordinates **flood risk management planning nationally**
- Provides **expert services**
  - For example, user support for regional centres
- Develops and maintains many **flood information systems and GI-databases**
- **Reporting** the information required by the Floods directive to the EU-commission
  - Implementation in the regional centres and municipalities
- Flood **research**
  - Different kinds of R&D-projects

Some other responsibilities:

Municipalities:
- Flood risk management of the *pluvial floods* (caused by the storm water)
- Land use planning

Regional environment authorities (ELY Centers):
- Flood risk management of the *other flood types*

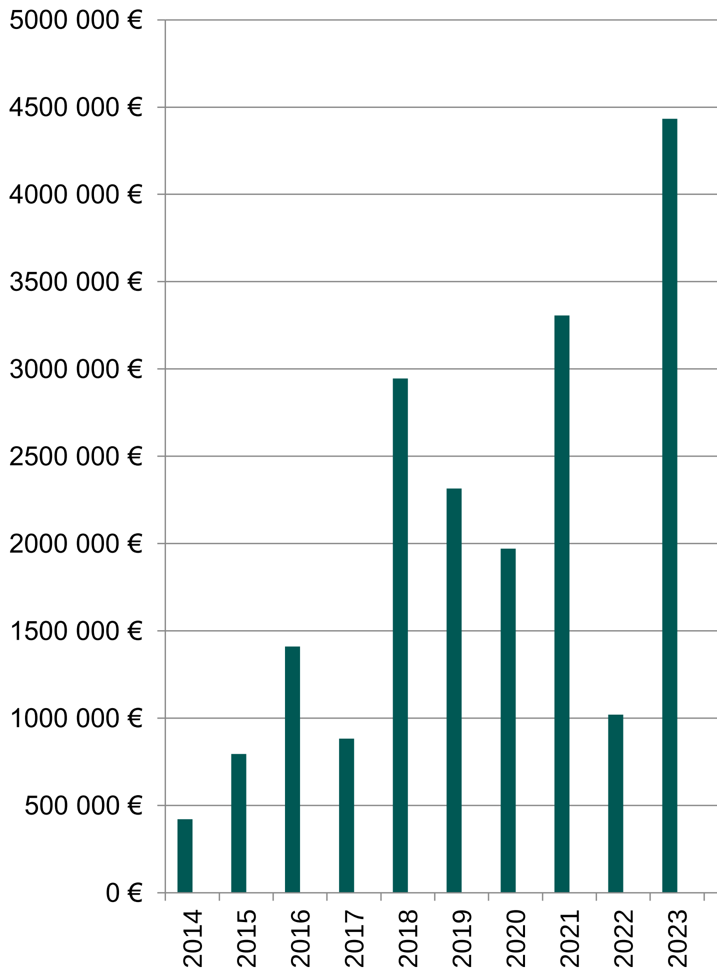
Rescue services
- Take leadership in the case of dangerous flood
- Protecting e.g., vulnerable buildings

Pluvial flood risks are increasing

- As a result of climate change, **average rainfall will increase** about 10 % by the end of the century
  - In summer, the **heaviest rainfall can intensify** by 10…25%, but according to the latest studies, up to 30...70%(1,2,3
  - **Winter stormwater flooding** is increasing due to milder and rainier winters
- Cities are becoming **denser**
  - The amount of **impervious surfaces** is growing
  - The capacity of the current **stormwater network** is insufficient
  - There is **no space** for stormwater to flow, retain, and infiltrate (lack of space on and below the ground surface)
- **Vulnerability** is increasing as construction becomes more technical

Flood damages compensated by insurance companies

https://vesi.fi/tulvaindikaattorit



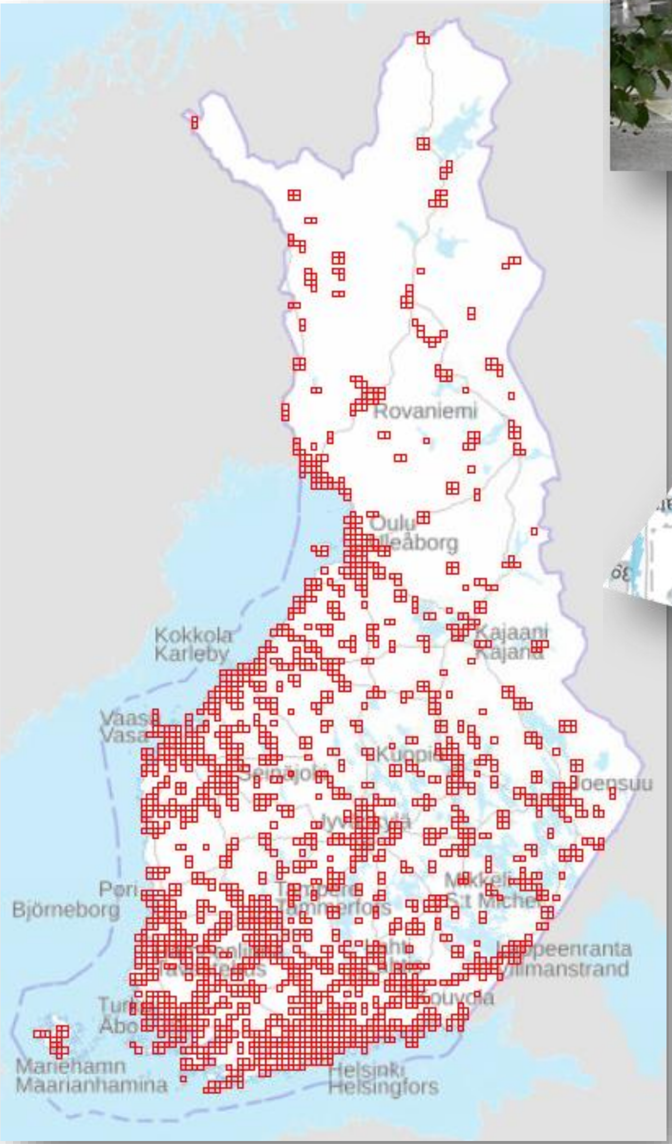
1 Toivonen, Erika ym. (2021). Ilmastonmuutos vaikuttaa hulevesien mitoitukseen Suomessa ja muissa Pohjoismaissa. Vesitalous-lehti 2/2021. https://vesitalous.fi/wpcontent/uploads/2021/03/Vesitalous_0221_lowres-1.pdf

2 Dyrrdal, Anita et al. (2023). Changes in design precipitation over the Nordic-Baltic region as given by convectionpermitting climate simulations. Weather and Climate Extremes. 42. https://doi.org/10.1016/j.wace.2023.100604

3 Utriainen, Laura (2023). Sadannan ja tuulen nopeuden muutokset Suomessa − konvektion salliva alueellinen ilmastomallinnus. Pro gradu, diplomityö. Aalto-yliopisto. https://aaltodoc.aalto.fi/handle/123456789/120943

General pluvial flood map supports climate change adaptation

- **Municipalities are responsible** for the management of pluvial flood risks (Flood Risk Management Act)
  - Preliminary flood risk assessment to be reviewed by the end of 2024
- **ELY Centers and Syke** support municipalities
  - Syke published a general pluvial flood map in March 2024
  - Covers all urban areas in Finland
- Available as **open data**
  - https://vesi.fi/hulevesitulvat
  - Map service, viewing, and download interfaces



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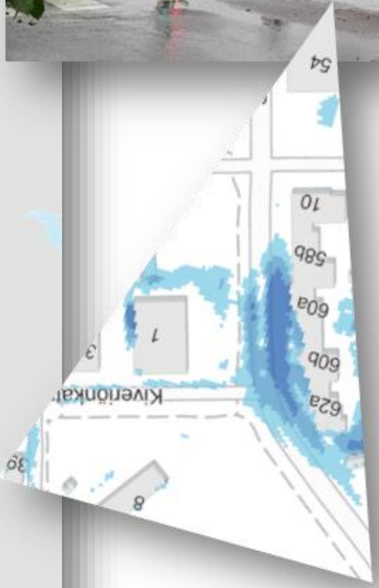

Taustakartta: Maanmittauslaitos

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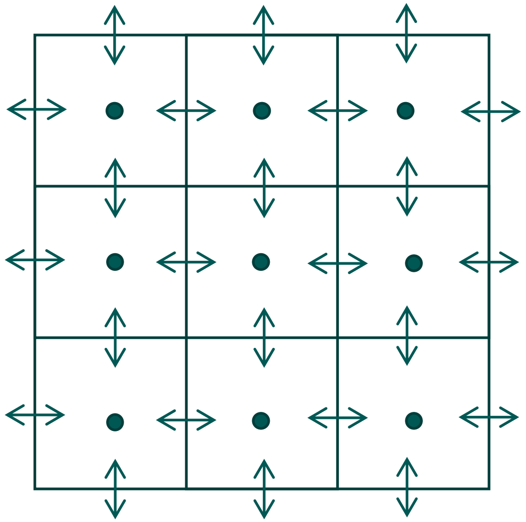
Potential pluvial flood hazard areas on the map

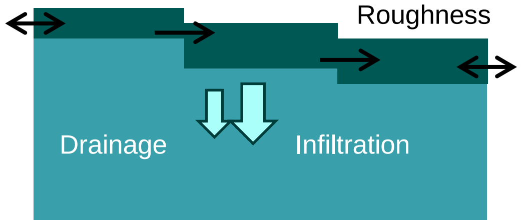
- The map presents the **potential** pluvial flood hazard areas (“hot spots”) in urban areas
- Two heavy rain scenarios
  - The same time-dependent rain intensity for the entire calculation area
  - 1/100a precipitation **52 mm/h**[4] and **80 mm/h** in the first hour, simulation time 2 h (the impact of **climate change** has been taken into account()
  - The maximum water depth in each cell during the simulation is presented on the map
- Taking **uncertainties** into account is key
  - Errors e.g. if the culvert is not taken into account in the elevation model

Kannelmäki, Helsinki 18.8.2021. Photo Anneli Sane

4 Rosqvist, Kajsa & Sillanpää, Nora (2024). Tietopohjaa sadeskenaarioiden ja tulvamallien tarkastelusta varautumistason asettamiseksi Helsingille. Vesitalous-lehti 4/2024. https://vesitalous.fi/2024/09/vesitalous-4-2024-kaupunkivesien-hallinta-on-ilmestynyt/

How the pluvial flood maps have been produced? (1/2)





- A hydrodynamic **2D surface flow model** developed at Syke[5], utilizing powerful GPU computing
- Input data includes several kinds of **nationwide open spatial data**, such as:
  - KM2 Digital Elevation Model (DEM) (2 m resolution)
    - Based on **laser scanning**, height accuracy typically around 10 cm (with a 95% probability better than 30 cm)
    - Culverts and pipes are not taken into account
  - Flow correction data for the KM2 DEM
    - The DEM is modified at e. g. culvert locations, resulting in a **hydrologically corrected elevation model**

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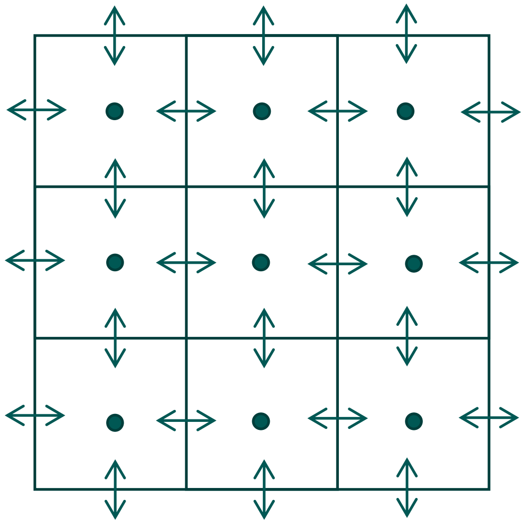
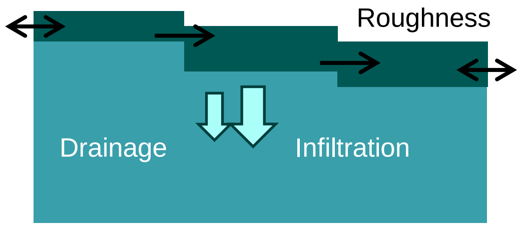
5 Bates, P.D., Horritt, M.S., Fewtrell, T.J., 2010. A simple inertial formulation of the shallow water equations for efficient two-dimensional flood inundation modelling. J. Hydrol. 387, 33–45. https://doi.org/10.1016/j.jhydrol.2010.03.027

How the pluvial flood maps have been produced? (2/2)

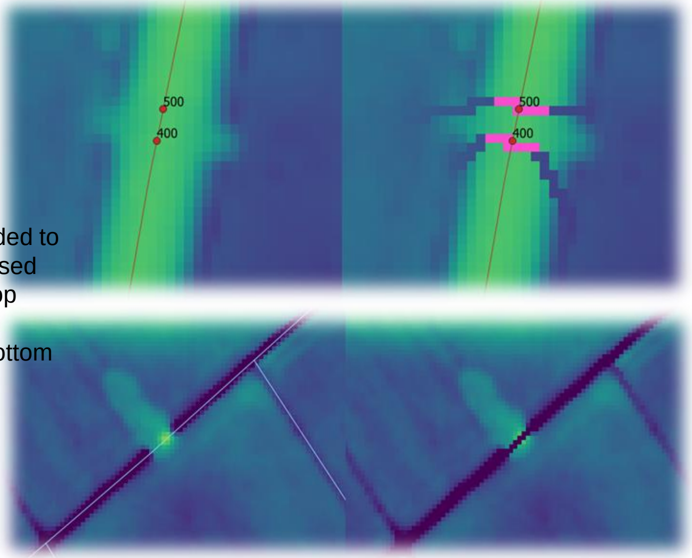




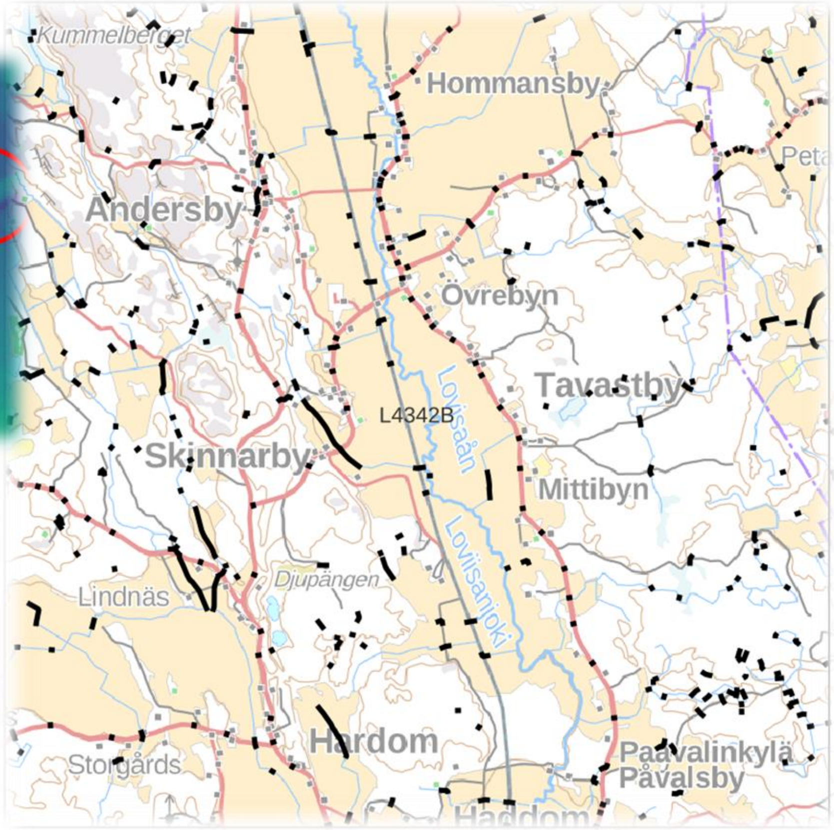
- Land cover 2 m 2022 data
  - Used to define **impervious areas** (no infiltration) and to determine **roughness coefficients** (flow resistance, Manning's n values)
- Superficial deposits data (soil property)
  - Utilized to calculate infiltration using the **Green and Ampt method**
- Corine 2018 Land cover data
  - Used to define urban areas for underground **drainage with the constant value 10 mm/h**

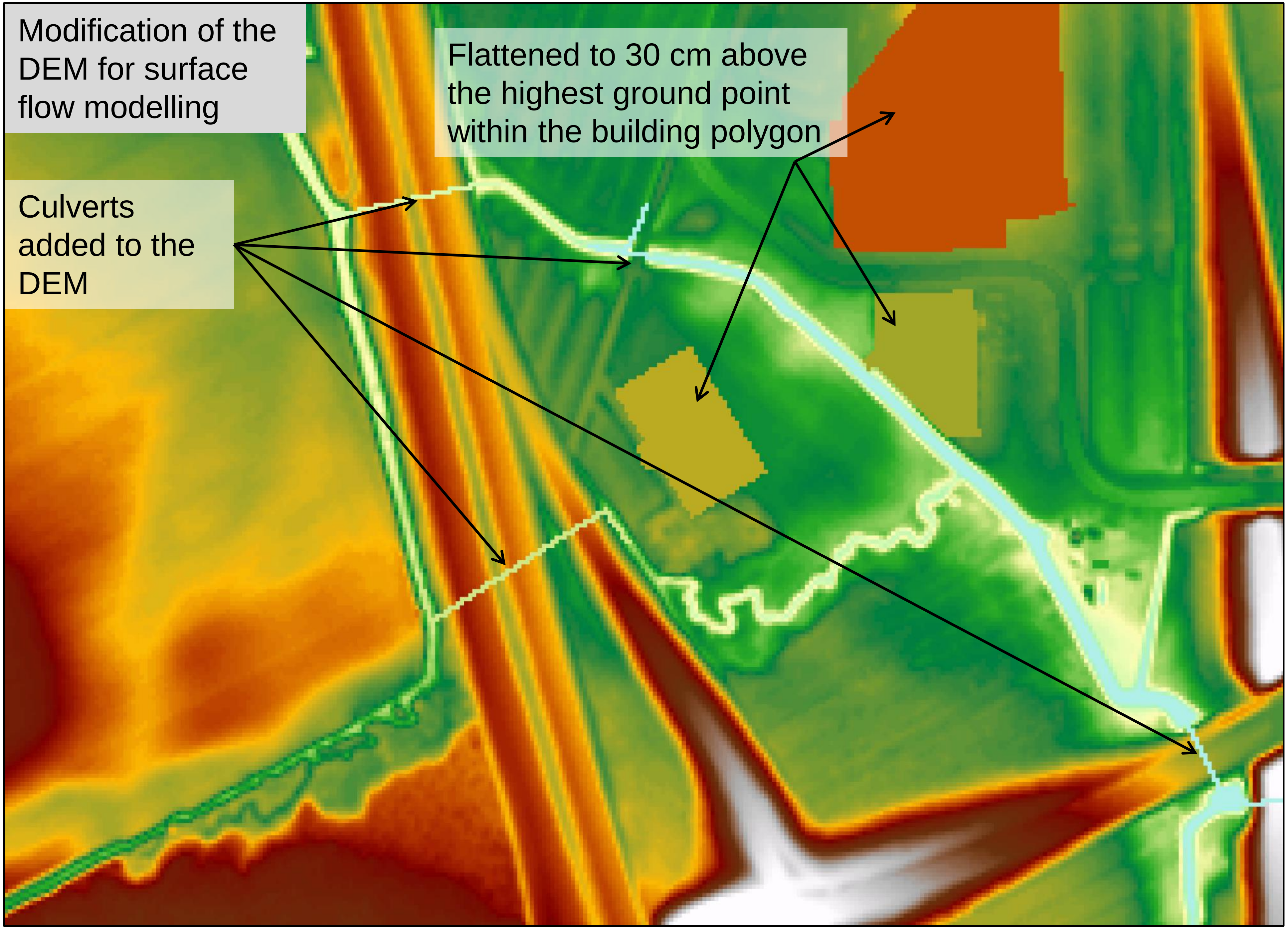
New nationwide flow correction data

- The original KM2 DEM elevation values have been lowered at **intersections of streams&ditches and traffic network**, as well as at **known culvert and pipe locations**
- The result is a flow correction data **compatible with the KM2 Digital Elevation Model**, allowing for **more accurate flow path and catchment area modeling**
- Nationwide source data utilized, such as:
  - Topographic database (National Land Survey of Finland)
  - Digiroad network and Culvert register (Finnish Transport Infrastructure Agency)
- Additionally, some municipalities and cities have digitized missing culverts/pipes
- The **diameter** of an added culvert is based on the Culvert register, if available, and is taken into account in the modeling
- Buildings have also been added to the DEM



Culverts added to the DEM based on points (top image) and polylines (bottom image)





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More detailed nationwide land cover data

Corine Land cover 2018

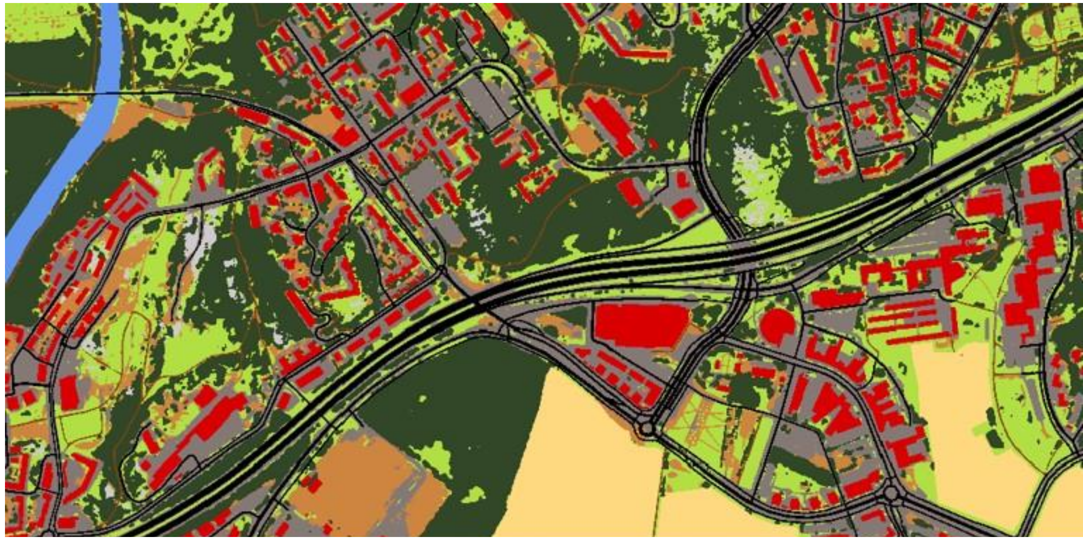
Pixel size 20 m

⬇

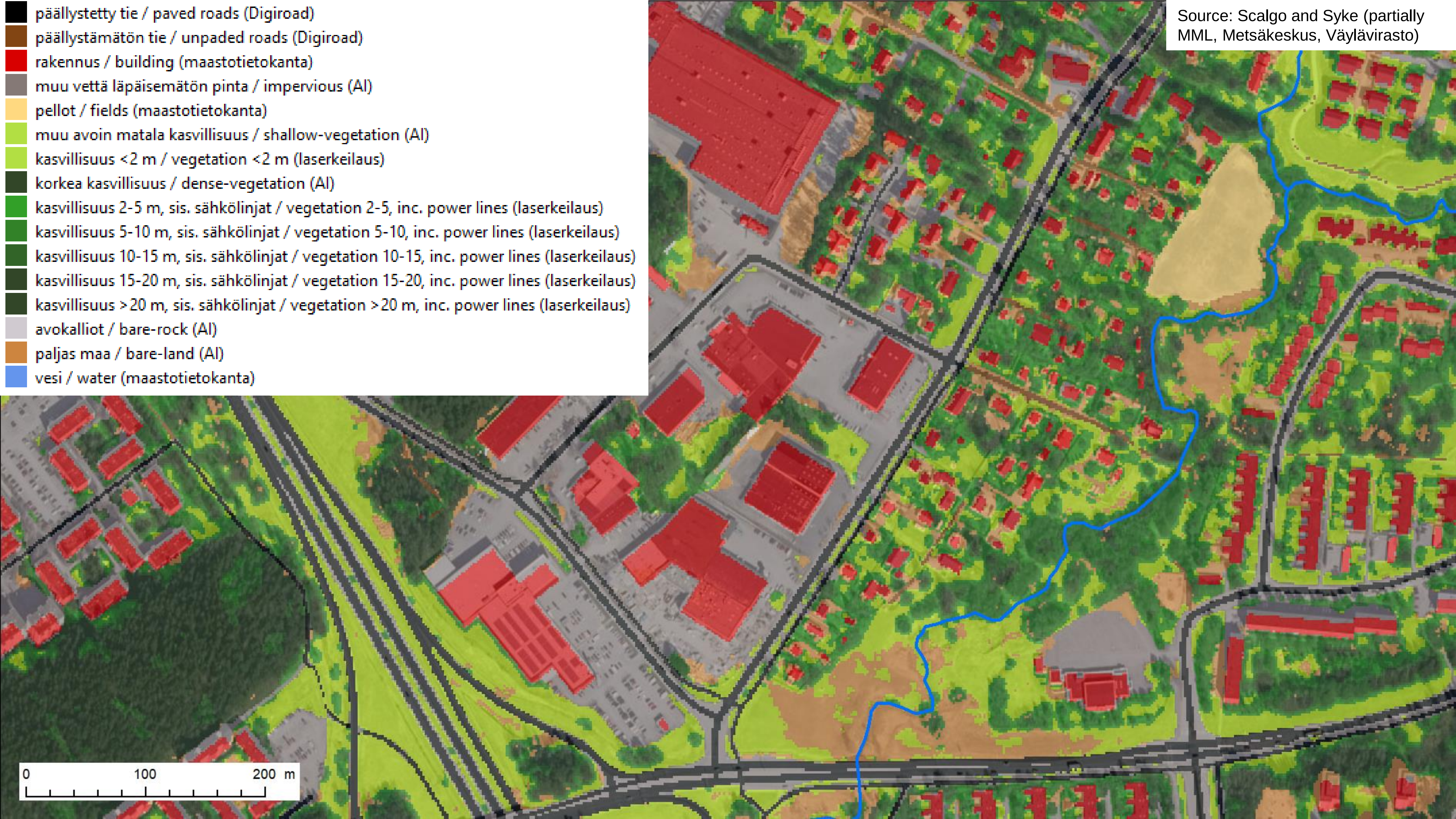
2 m

Land cover 2 m 2022

- Interpreted from National Land Survey aerial imagery using **artificial intelligence**
- Includes information on **imperviousness** and **pervious** surfaces, vegetation, and bare land
- Applications:
  - Describing infiltration and roughness coefficients in surface flow modeling
  - Identifying **built** / **paved** areas and **green structures**
  - **Monitoring changes**
  - Provided as open data
    - Metadata, viewing service and download



Top image: original Land cover 2 m data. Bottom image: the data further processed to classify vegetation heights based on the canopy height model based on lasers scanning from the Finnish Forestry Center.



päällystetty tie / paved roads (Digiroad)
päällystämätön tie / unpaded roads (Digiroad)
rakennus / building (maastotietokanta)
muu vettä läpäisemätön pinta / impervious (AI)
pellot / fields (maastotietokanta)
muu avoin matala kasvillisuus / shallow-vegetation (AI)
kasvillisuus <2 m / vegetation <2 m (laserkeilaus)
korkea kasvillisuus / dense-vegetation (AI)
kasvillisuus 2-5 m, sis. sähkölinjat / vegetation 2-5, inc. power lines (laserkeilaus)
kasvillisuus 5-10 m, sis. sähkölinjat / vegetation 5-10, inc. power lines (laserkeilaus)
kasvillisuus 10-15 m, sis. sähkölinjat / vegetation 10-15, inc. power lines (laserkeilaus)
kasvillisuus 15-20 m, sis. sähkölinjat / vegetation 15-20, inc. power lines (laserkeilaus)
kasvillisuus >20 m, sis. sähkölinjat / vegetation >20 m, inc. power lines (laserkeilaus)
avokalliot / bare-rock (AI)
paljas maa / bare-land (AI)
vesi / water (maastotietokanta)
Source: Scalgo and Syke (partially MML, Metsäkeskus, Väylävirasto)
0
100
200 m

Multiple uses for the pluvial flood map

- Preliminary pluvial flood risk assessments
- Stormwater surveys, e.g., related city plans
- Small surface water body assessments
- Rescue service planning
- Maintenance, e.g., prioritization of culvert and drain clearing

- **The map can be used to identify areas for more detailed surveys**
  - A trigger for pluvial flood risk management
  - Uncertainties should be taken into account

Mikkeli 3.9.2024
Photo: Pihla Oivanen,
general pluvial flood map:
Syke (vesi.fi/tulvakartat), background map MML

Photo: Mikko Sane

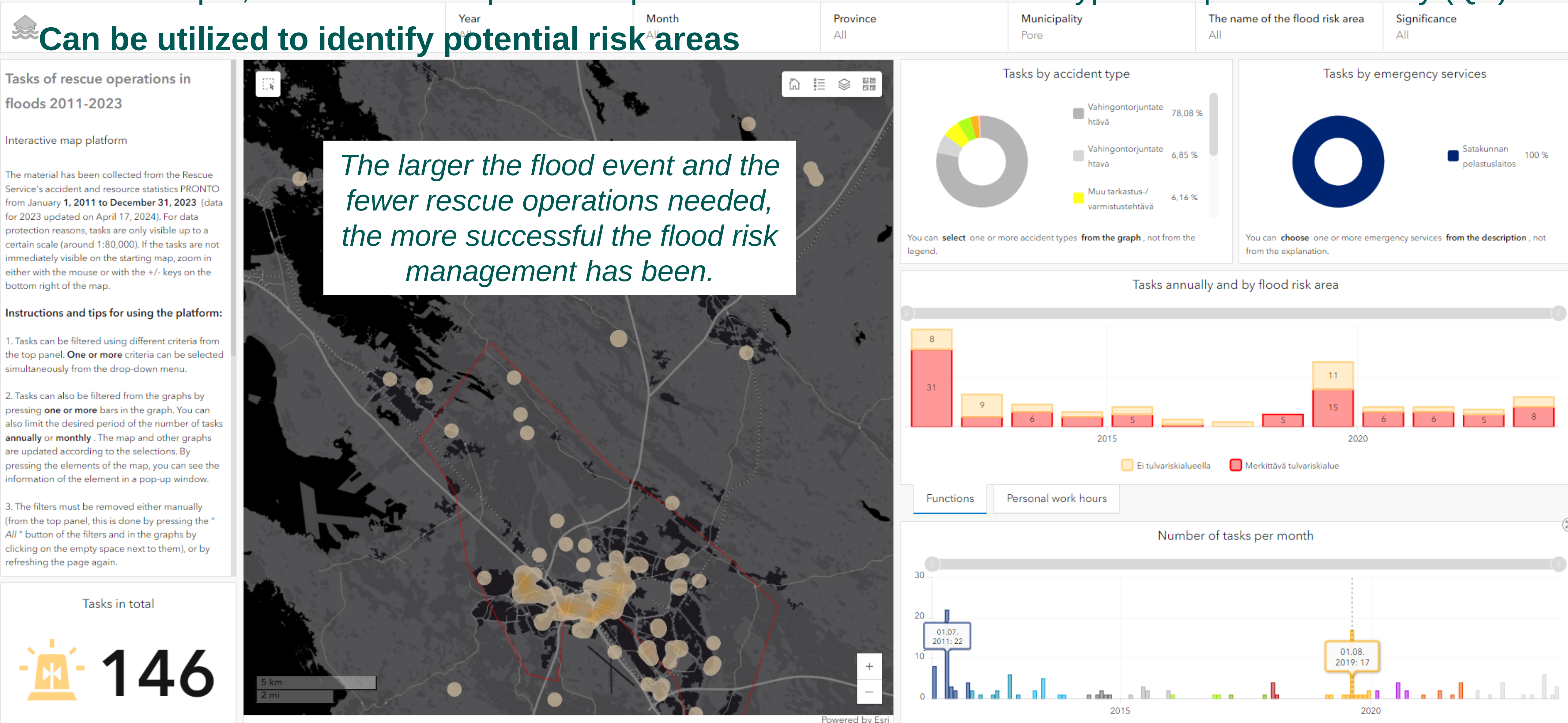
Flood-related rescue operations from 2011 to 2023

Interactive visualization (https://vesi.fi/tulvaindikaattorit) – Example of Pori (translated by Google)

For example, the number of operations per month – Includes all flood types – Updated annually (Q2)

Can be utilized to identify potential risk areas

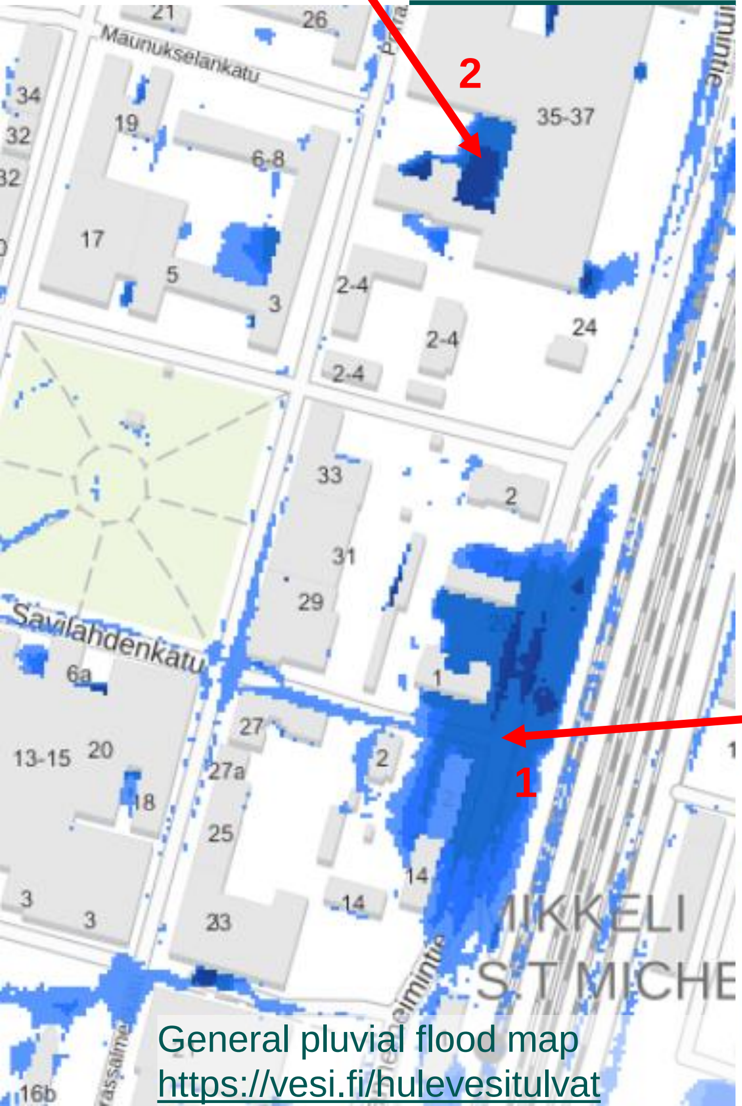
The larger the flood event and the fewer rescue operations needed, the more successful the flood risk management has been.



The hospital floor flooded, and people paddled through the streets on SUP boards – a heavy rainstorm caused chaos in Mikkeli

Mikkelin keskussairaalan alakerrokset tulvivat myrskyn seurauksena pahanpäiväisesti. Myös kaupungin kiinteistöissä on vaurioita.

YLE 4.9.2024



General pluvial flood map
https://vesi.fi/hulevesitulvat

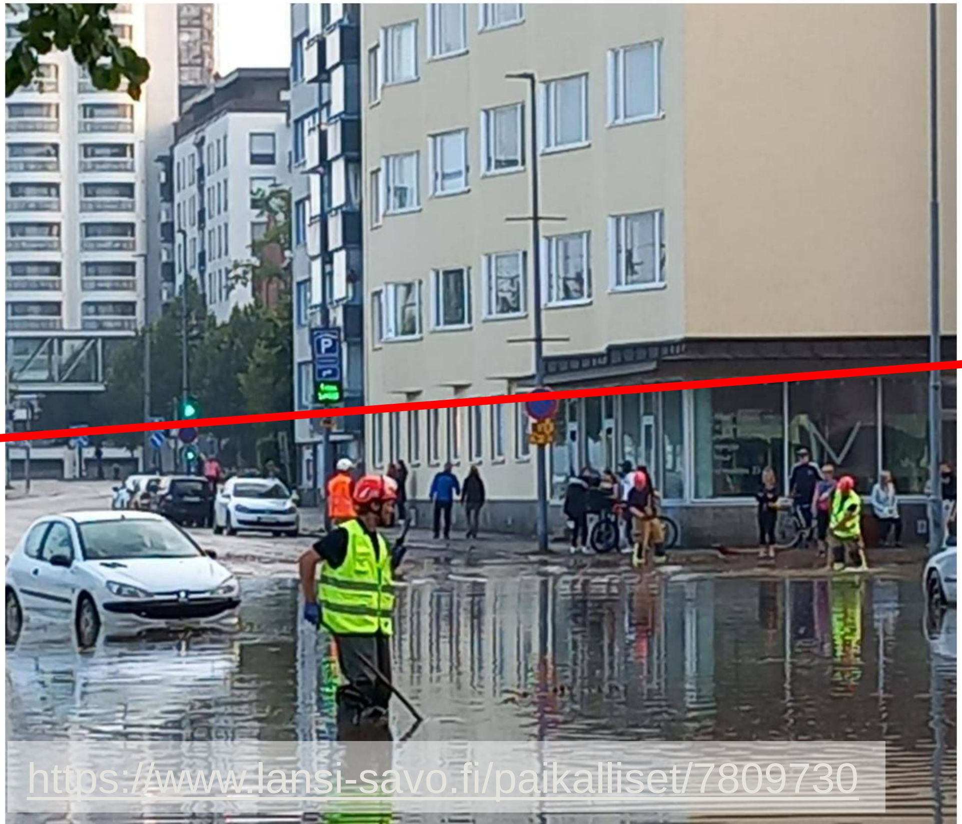
Stormwater issues are known, and the city is trying to resolve them

Länsi-Savo 4.9 ja 5.9.2024

Putkiverkostoa ei ole mitoitettu lähelläkään tiistain sademääriä. Hulevesimaksua kerätään juuri koetun kaltaisten tilanteiden hoitamiseen.

Kirsti Vuorela

Ilmatieteen laitos arvioi Mikkelin keskustan sademäärän olleen rankimmillaan jopa 45 milliä tunnissa – Hulevesiongelmat ovat kaupungin tiedossa, ja niitä pyritään ratkomaan



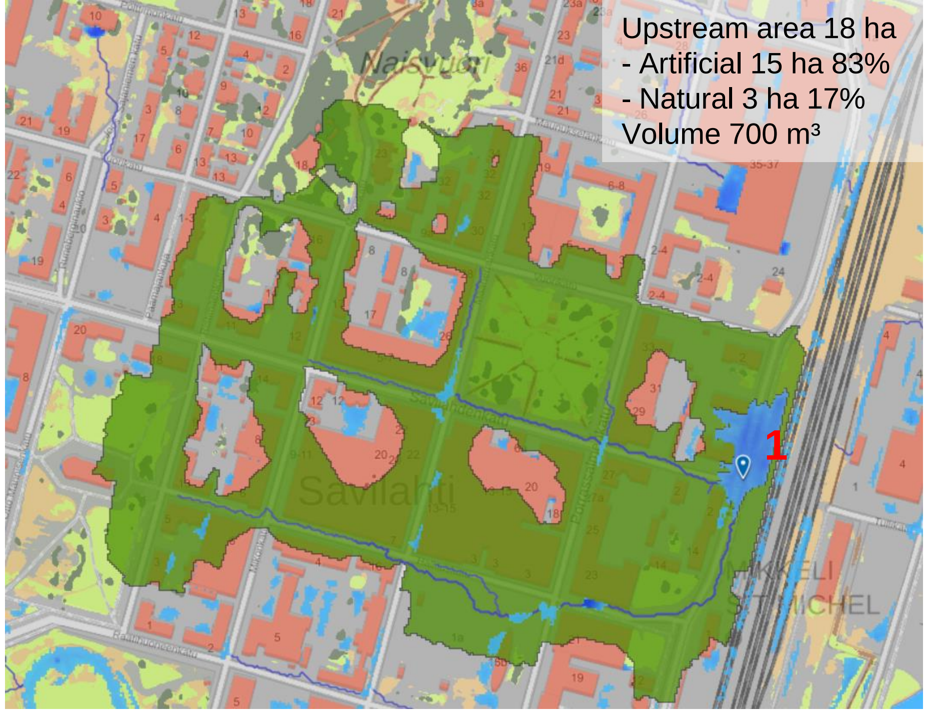
https://www.lansi-savo.fi/paikalliset/7809730

MINNA JUDÉN

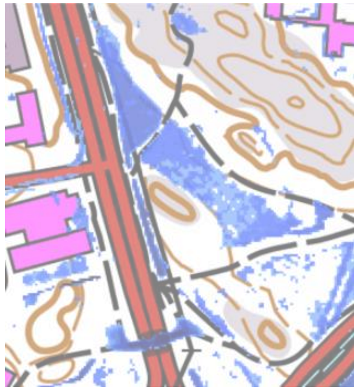
Savilahdenkadun ja Mannerheimintien risteyksessä vettä oli paljon.

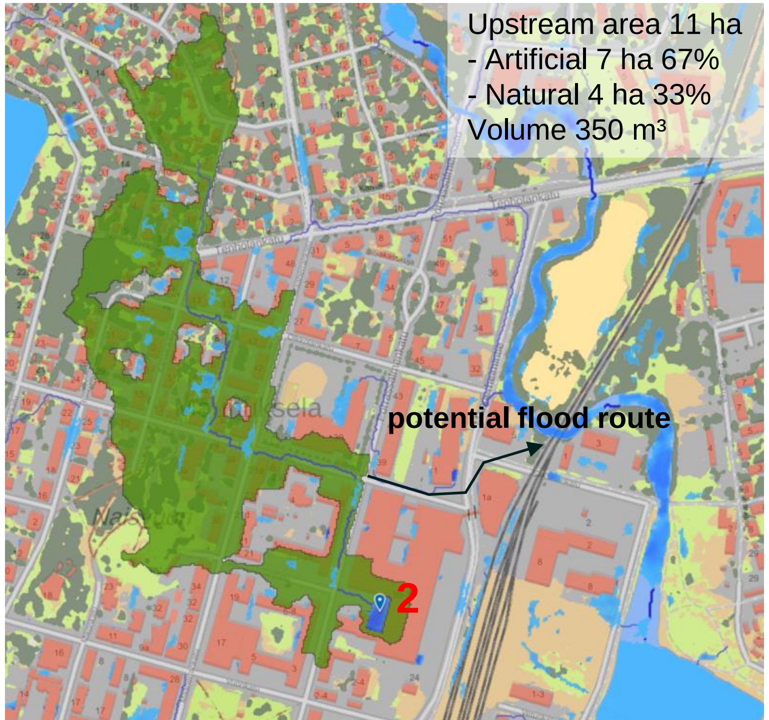
Pay Attention to Stormwater!

- **Areas prone to stormwater**
  - Avoid building or densifying
  - Implement stormwater management solutions in the **catchment area**, such as:
    - Nature-based solutions, basins, swales, flood routes, as well as tools like the blue-green factor and stormwater retention requirements…
- Preparing for heavy rainfall events requires **extensive, diverse measures**
  - Stormwater drainage systems cannot manage rare heavy rainfall
  - The focus should be on **delaying stormwater**, which provides multiple benefits, for example, in urban wetlands:
    - Managing the quantity and quality of stormwater
    - Increasing biodiversity
    - Providing recreational and well-being benefits



Catchment areas of the affected hot spots from the previous slide and examples of stormwater-prone areas





Scalgo Live (left) and General pluvial flood map (top)
Syke, background map MML

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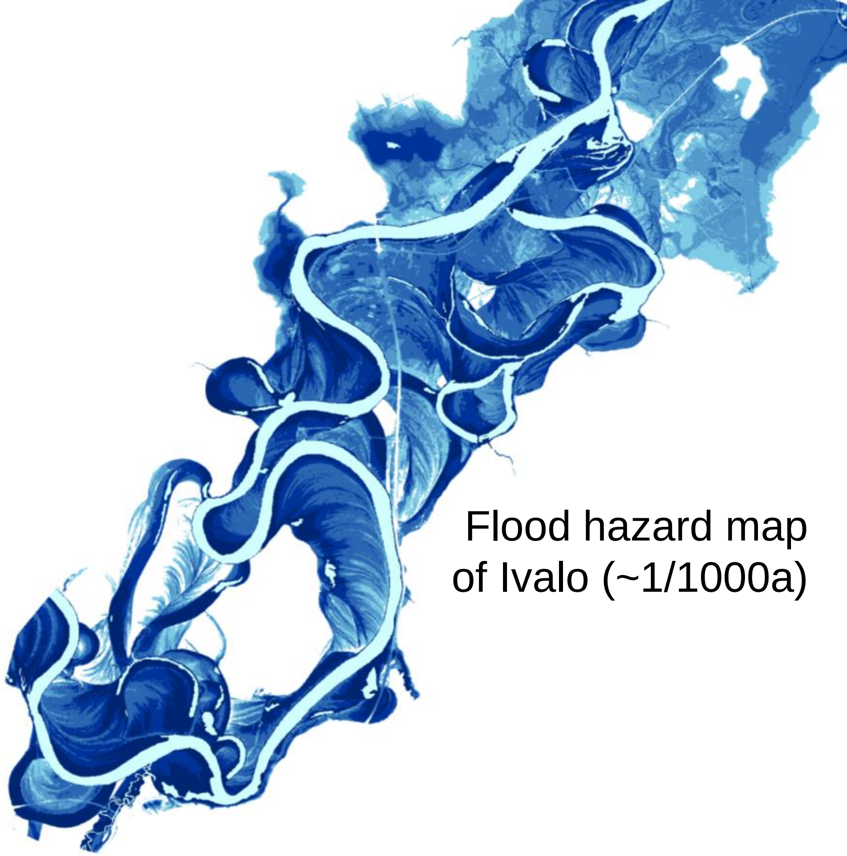
Nappaa hiilestä kiinni

MAANKÄYTTÖSEKTORIN ILMASTORATKAISUT



Flood hazard map of Ivalo (~1/1000a)

Thank you!

hulevesitulvat@syke.fi

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https://vesi.fi/hulevesitulvat

https://vesi.fi/tulvakartat