Geosciences supporting urban flood mitigation

K. Nuottimäki, J. Jarva & P. Schmidt-Thomé

GTK
gtk.fi

Contents

- Background
- Mapping methodology for urban floods
- Results
- Urban flood risk mitigation
- Summary

GTK
gtk.fi

Background

- Urban flood modeling has become more topical during 21st century
  - Heavy flooding events: Pori 2007, Malmö 2007 + 2014, Copenhagen 2011
  - Damages to infrastructure and buildings
  - Pori / Malmö 20-25 M€ - Copenhagen 745 M€ damages during one rain event
  - Rain events with 1/10a - 1/100a return periods
- Main factors for urban flooding
  - increased precipitation around Baltic Sea along climate change
  - outdated drainage systems in old cities
  - expansion of urban areas and soil sealing in areas with permeable soil

Background

- Urban floods have adverse effects of groundwater and surface waters
  - Groundwater contamination by bacteria
  - Nutrients, fertilizers from fields and parks
  - Heavy metals and other harmful substances (PAHs, oils, PCB)
- Significance to the Baltic Sea
  - Low quality of coastal waters
  - Overflow in wastewater treatment facilities
  - Eutrophication of surface waters
    - Oxygen depletion
    - Poisonous algae blooms

Background

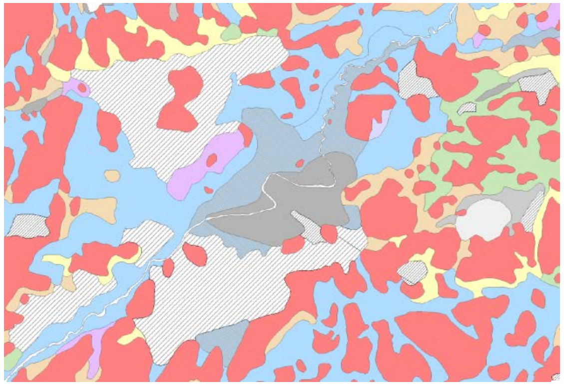
- Project CliPLivE – Climate-Proof Living Environment aimed to recognize geological and environmental risks on the coast of the Gulf of Finland
- Funded by South-East Finland – Russia ENPI CBC 2007 – 2013
- Partners
  - Geological Survey of Finland GTK
  - Regional Council of Kymenlaakso
  - Regional Council of Uusimaa
  - Helsinki Region Environmental Services Authority HSY
  - State Geological Unitary Company SC Mineral
  - A.P. Karpinsky Russian Geological Research Institute VSEGEI
  - Committee for Nature Use, Environmental Protection and Ecological Safety of the city of St. Petersburg
- Urban floods were one of the hazards project CliPLivE studied

Mapping methodology for urban floods

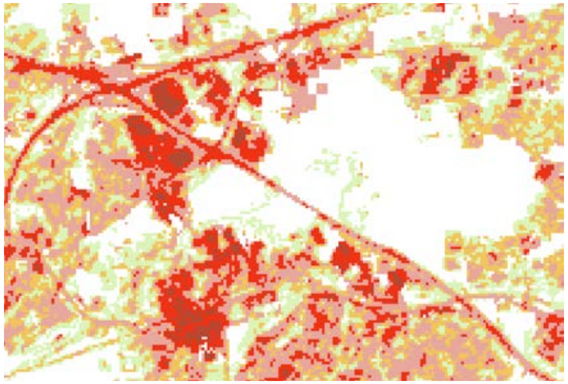
- Combines data in raster format:
  - Quaternary deposit map – GTK 1 : 20 000 or 1 : 50 000
  - Soil sealing map – EEA 2009 (asphalted areas, roofs…)
  - Soil surface slope – National Land Survey of Finland LiDAR
- Data processed in ArcGIS
- Two first datasets were reclassified; low hydraulic conductivity or area with high percentage of soil sealing gets a higher value
- Surface slope either heightens or lowers an area's sensibility to urban flooding
  - On plain areas flood potential is high; on steep slopes very low
- Qualitative assessment

GTK
gtk.fi

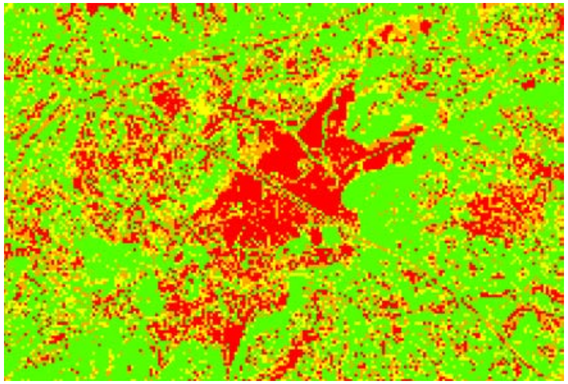
Mapping methodology for urban floods



Soil type

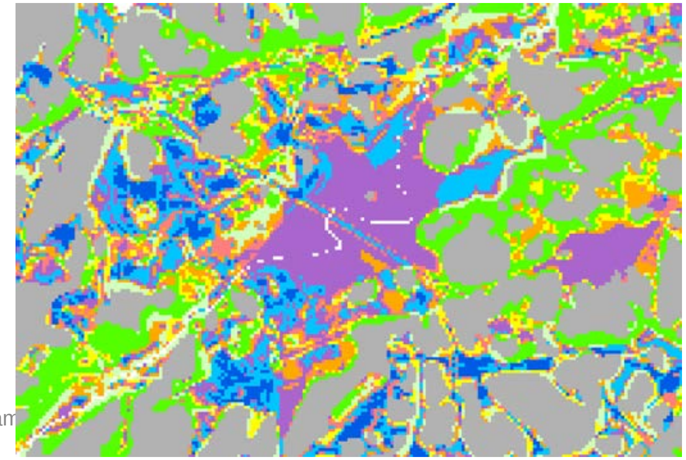


Soil sealing %



Slope

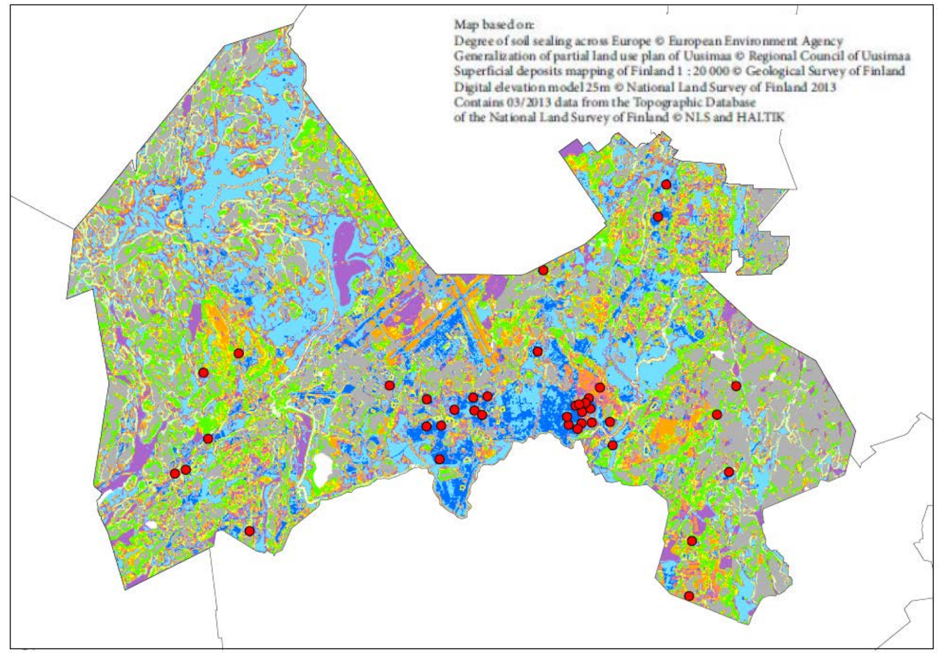
Urban flood potential



This project is co-funded by the European Union, the Russian Federation and the Republic of Finland

Mapping methodology for urban floods

- Results were verified by comparing the map with urban flood sites defined by the city of Vantaa, 39 points
- The distribution of three contributing factors (soil type, soil sealing, slope) were compared to the characteristics of flood site locations
- Flood potential classes 0 (lowest) – 7 (highest)
- 3 highest classes determined 75 % of the identified flood sites



Urban flood potential map of Vantaa; identified urban flood sites (red points).

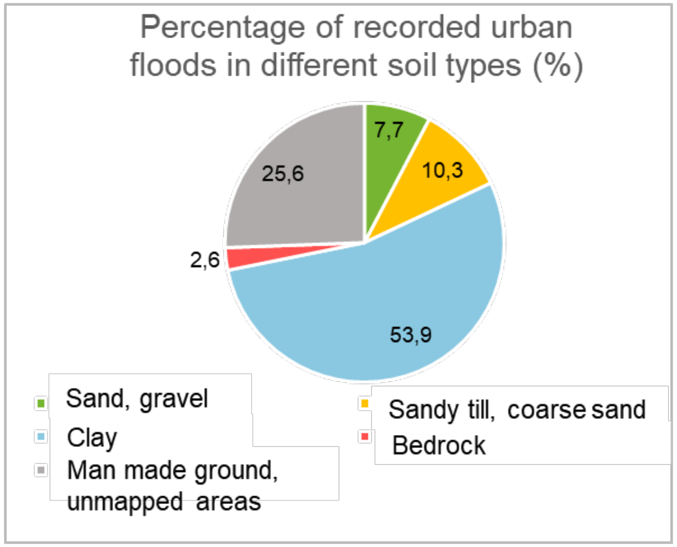
GTK
gtk.fi

This project is co-funded by the European Union, the Russian Federation and the Republic of Finland

Results – The effect of soil type

Soil permeability / other character	Soil type	Number of urban floods	Percentage of urban floods	Distribution of soil permeability class in the city of Vantaa
			%	%
Very good	Sand, gravel	3	7.7	5.0
Good	Sandy till, coarse fine sand	4	10.3	17.0
Good	Man-made ground / geologically unmapped areas	10	25.6	9.4
Retaining	Fine sand, silt, fine-grained till	0	0	2.4
Retaining, organic	Peat, gyttja	0	0	4.5
Very retaining	Clay	21	53.9	43.1
Bedrock area	Bedrock outcrops and bedrock areas covered with less than 1 m thick soil layer	1	2.6	18.7

Source: Nuottimäki, K., Jarva, J. 2015.



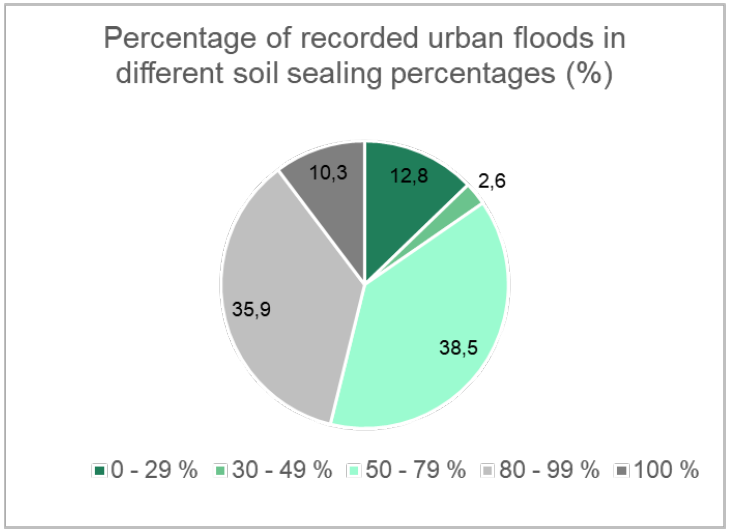
Source: Nuottimäki, K., Jarva, J. & Schmidt-Thomé, P. 2016.

GTK
gtk.fi

Results – The effect of soil sealing

Soil sealing percentage	Number of urban floods	Distribution of the recorded flood locations in different soil sealing percentages in the city of Vantaa	Distribution of soil sealing class in the city of Vantaa
		%	%
0 – 29 %	5	12.8	68.3
30 – 49 %	1	2.6	10.2
50 – 79 %	15	38.5	13.0
80 – 99 %	14	35.9	6.9
100 %	4	10.3	1.7

Source: Nuottimäki, K., Jarva, J. 2015.

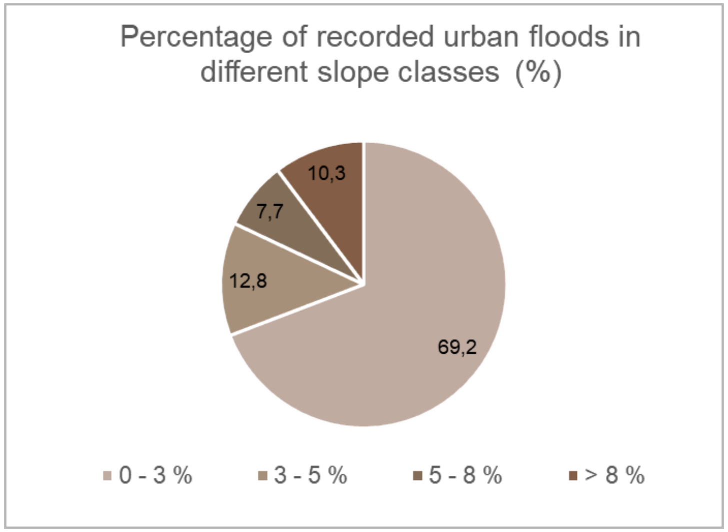


Source: Nuottimäki, K., Jarva, J. & Schmidt-Thomé, P. 2016.

Results – The effect of soil surface slope

Slope class	Number of urban floods	Distribution of the recorded flood locations in different slope classes in the city of Vantaa	Distribution of slope class in the city of Vantaa
		%	%
0 – 3 %	27	69.2	39.5
3 – 5 %	5	12.8	16.1
5 – 8 %	3	7.7	17.0
> 8 %	4	10.3	27.3

Source: Nuottimäki, K., Jarva, J. 2015.



Source: Nuottimäki, K., Jarva, J. & Schmidt-Thomé, P. 2016.

Limitations of the methodology

- Keeping all datasets up to date
  - Fast land use development and construction affect the soil sealing distribution
- Level of detail
  - City plan scale benefits from more detailed datasets
  - Quaternary deposits: 2- 6 ha feature size
  - Soil sealing 20 m x 20 m grid
  - LiDAR quite good: 2 m x 2 m grid
- ”Double features” → bridge + tunnel = flood safe or flood prone
- Underground structures → are not taken into account
- Sealing quality: partially permeable structures?

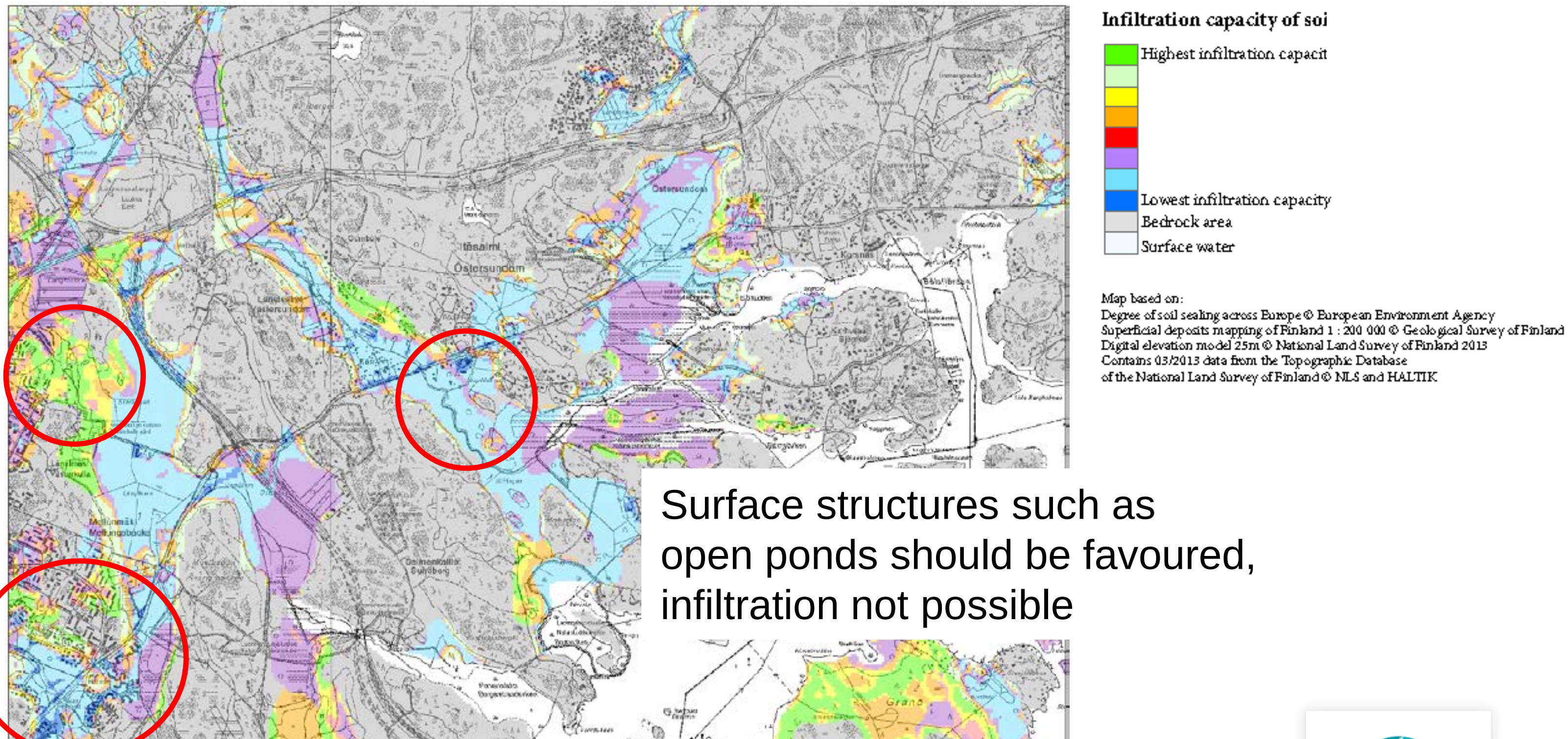
GTK
gtk.fi

Urban flood risk mitigation

- The method developed in CliPLivE –project helps to assess suitable method for mitigating and managing local or regional urban flooding

Infiltration possible → Sealing not recommended

Comprehensive solution for the area



Surface structures such as open ponds should be favoured, infiltration not possible

Map based on:
Degree of soil sealing across Europe © European Environment Agency
Generalization of partial land use plan of Uusimaa © Regional Council of Uusimaa
Superficial deposits mapping of Finland 1 : 20 000 © Geological Survey of Finland
Digital elevation model 25m © National Land Survey of Finland 2013
Contains 03/2013 data from the Topographic Database
of the National Land Survey of Finland © NLS and HALTIK

GTK
gtk.fi

This project is co-funded by the European Union, the Russian Federation and the Republic of Finland

Urban flood risk mitigation - summary

- It is possible to identify areas prone to urban floods with GIS
- Factors affecting the flooding are known
- The conditions that favour flooding are affected by land use practices
- We can affect these factors
  - Quality and quantity of soil sealing, preferring green areas
  - Considering soil surface slope in urban construction
  - Geology does not change, but can be taken into account
- The methodology provides support in identifying urban flood mitigation options even before the land is developed – locally and regionally
- Urban flood occurrences can be mitigated by good land use practices and by taking local and regional natural qualities into account
- Good land use practices help in mitigating adverse effects from urban floods to cities around the Baltic Sea and to its environment

Thank you!

More information on the subject:

kristiina.nuottimaki@gtk.fi

jaana.jarva@gtk.fi

CliPLivE –project:

www.infoeco.ru/cliplive

Article:

Nuottimäki, K., Jarva, J. 2015: A qualitative approach for identifying areas prone to urban floods with the support of LiDAR. GFF. 15p. 16.10.2015.

http://dx.doi.org/10.1080/11035897.2015.1055512