UNIVERSITÀ DEGLI STUDI FIRENZE

DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

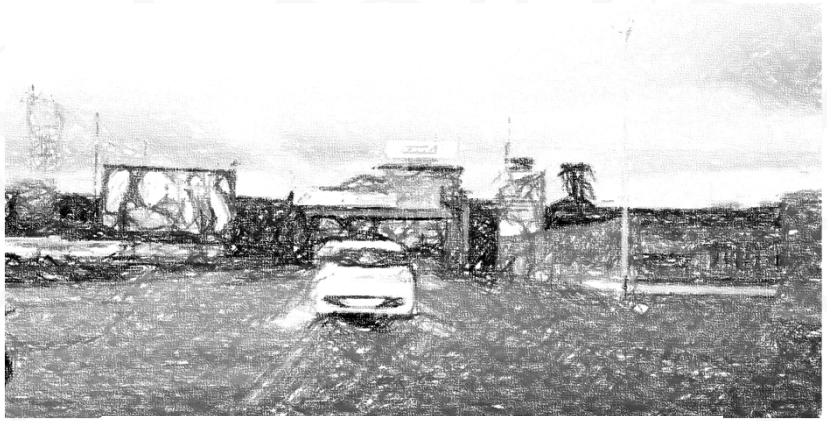
Planning Nature Based-Solutions through geographic information tools to manage flood risk on Florence city environment

Pacetti T., Cioli S., Castelli G., Pampaloni M., Bresci E., **Caporali E.**

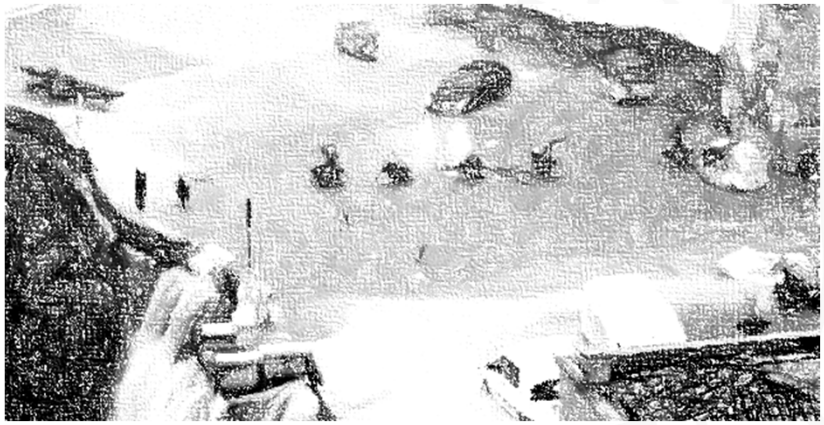
2nd December 2020

Pluvial flood risk in city environment

Livorno, 10th September 2017



Florence, 2nd December 2019

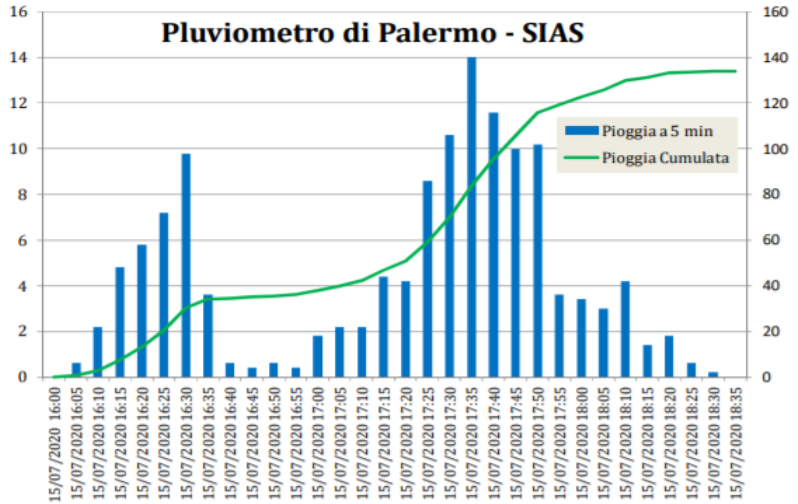


Matera, 12nd November 2019

Pluvial floods are flooding events in urban areas in which water flows on surface and overflow from the sewer system network or minor urban channels often buried.

Pluvial flood risk in city environment

Palermo, 15th July 2020



ISPRA, 2020

Main **characteristics of the events**:

- Short (<3 h) and heavy (>30 mm/h) rainfall.
- High flow peaks
- Small urban catchment areas
- High flow coefficients

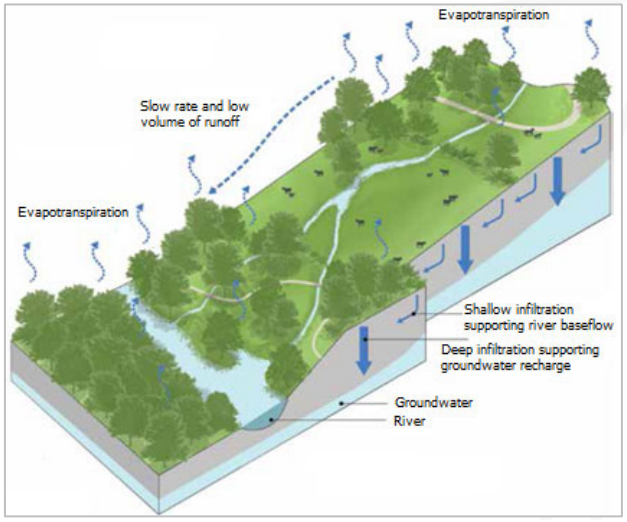
Pluvial flood risk in city environment

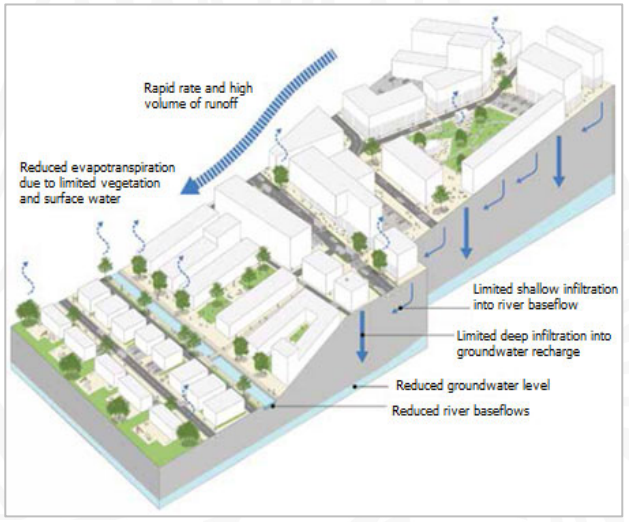
Main causes of pluvial flood:

- **LAND USE CHANGE**

Water cycle is guaranteed through **evaporation**, **precipitation**, **infiltration**, **groundwater recharge**, **absorption** and **transpiration** of the plants.

Urbanization alters hydrological processes by **reducing surface permeability** ad **increasing surface runoff.**

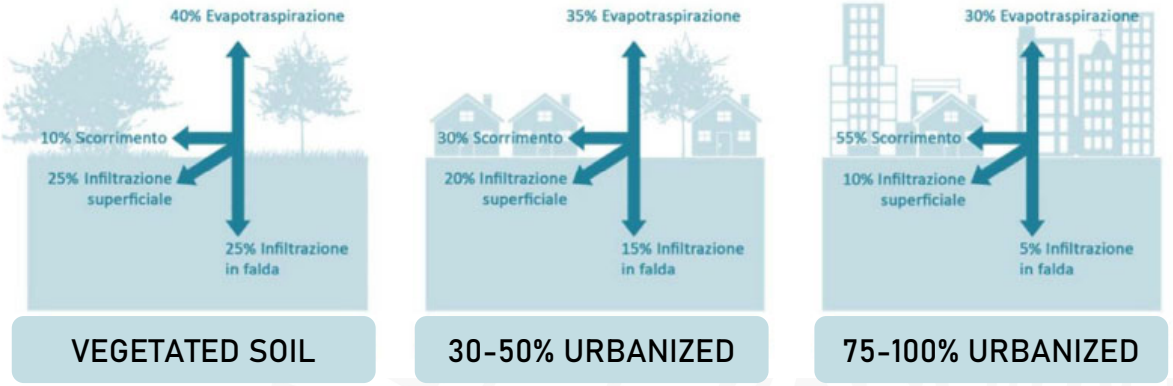




Woods Ballard et al. 2015. The SuDS Manual

Pluvial flood risk in city environment

Main causes of pluvial flood:



Manuale di drenaggio urbano - Gibelli G., 2015,

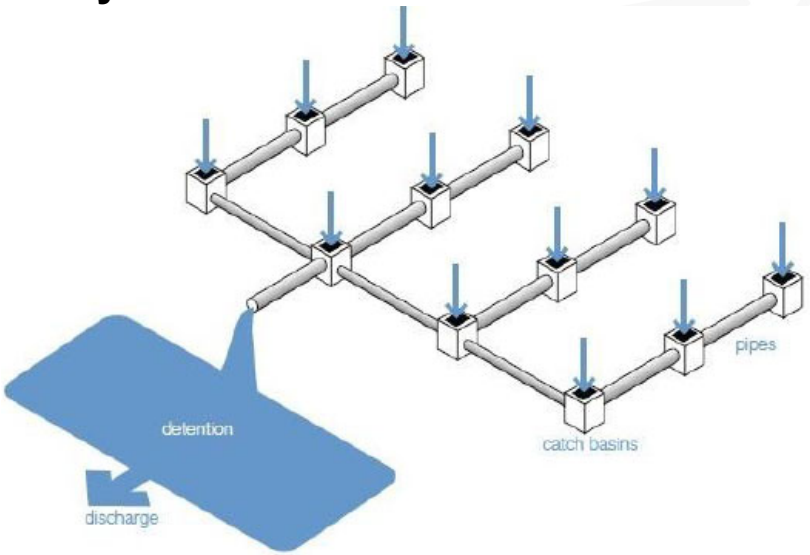
- **SEWER SYSTEM NOT SUITABLE FOR TODAY'S LOAD**
- **CLIMATE CHANGE**

Is an "**ONLY GREY**" engineering approach, to rainwater treatment and disposal, still sustainable?

Pluvial flood risk in city environment

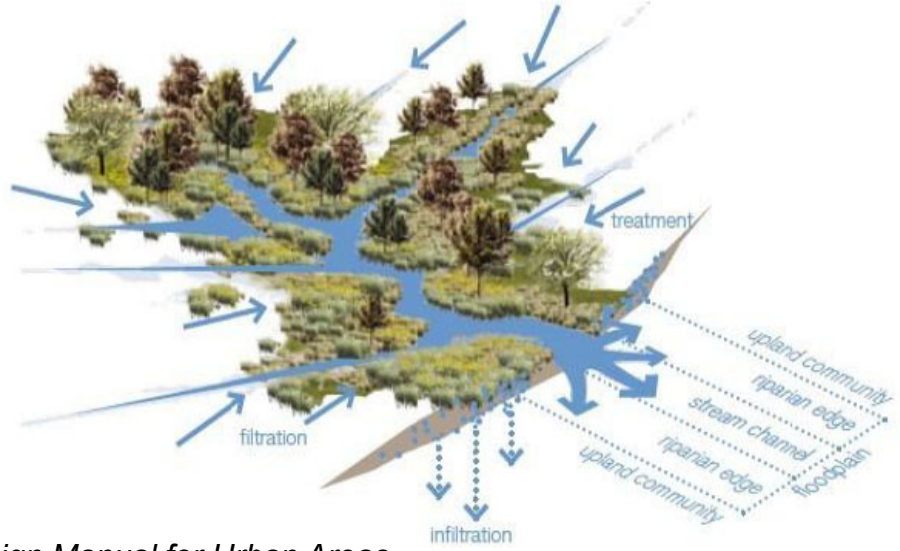
HARD/GRAY ENGINEERING

- Collection of surface runoff in mixed or separate sewer systems.
- Discharge to receiving water bodies (rivers, lakes, seas).
- Without observe the principles of **hydraulic invariance**.



SOFT/GREEN ENGINEERING

- Integrated solutions (**Nature Based Solutions - NBS**) for urban water management with benefits in terms of:
  - **Water quality**
  - **Use of public areas**
  - **Increased biodiversity**



Huber, J., 2010. Low Impact Development: a Design Manual for Urban Areas

Soft engineering with NBS

NBS in urban environments have different names, the most common are:

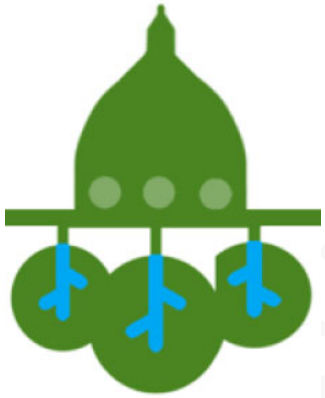
- **SuDS** – Sustainable Drainage System
- **WSUS** – Water Sensitive Urban Design
- **LID** – Low Impact Development
- **BMP** – Best Management Practices

Sustainable management of urban rainwater with reduction of loads on the sewer system and an overall hydrological rebalance

Use of vegetation, specific soil types, filter materials, storage areas.

Woods Ballard et al. 2015. The SuDS Manual

The FLORENCE project



FLO od risk and water
RE sources management with
N ature based solutions on
C ity
E nvironment

Identification of the most suitable areas for the installation of NBS within the Municipality of Florence with the primary target of pluvial flood risk mitigation

The FLORENCE project: research phases

CONTEXT AND RESOURCES **EVALUATION**

- Identification of urban areas prone to **hydraulic criticalities** and **problems in water resources management**.
- Mapping **Ecosystem Services** priority areas (main functioning and co-benefits) and constrains.
- Preliminary evaluation of **suitable NBS**.

CHOICE AND **DESIGN** OF NATURE BASED SOLUTIONS

- **Hydrological and hydraulic simulations** at different temporal and spatial scales.
- **Modeling the response of the system** before and after the NBS installation.

ASSESSMENT OF BENEFITS AND CO-BENEFITS

- What are the hydraulic and hydrological **improvements**?
- What are the social, environmental and economics **benefits**?
- What are the **co-benefits** due to multi-functionality?

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- ***Context and resources evaluation***

  Identification of urban areas prone to hydraulic criticalities and problems on water resources management.

Spatial Multi-Criteria Evaluation

ILWIS

Selection of five indicators

SLOPE

IMPERVIOUSNESS

HYDROLOGIC SOIL GROUPS

DENSITY OF THE SEWER SYSTEM

SOCIAL VULNERABILITY INDEX

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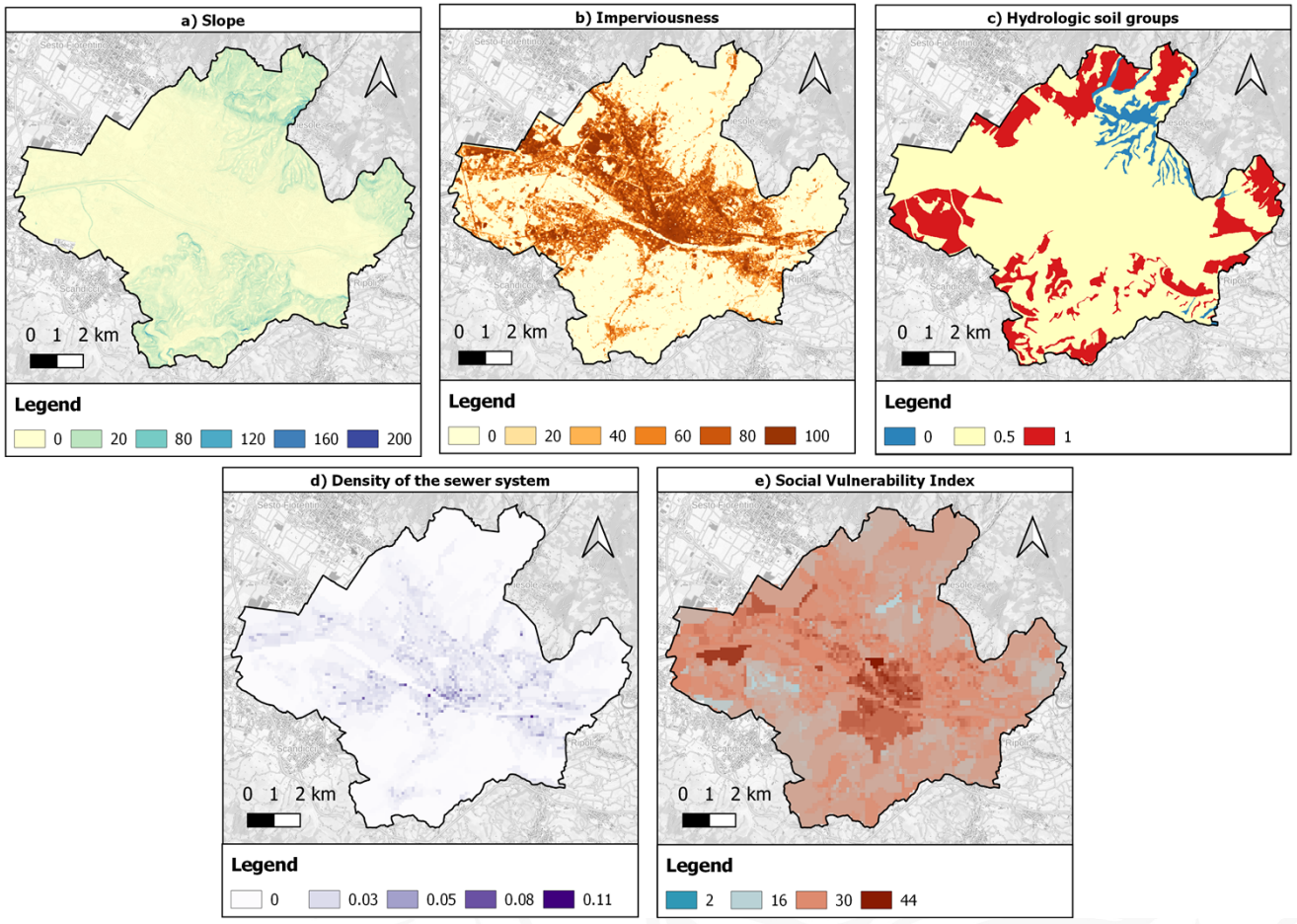
- ***Context and resources evaluation***



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- ***Context and resources evaluation***

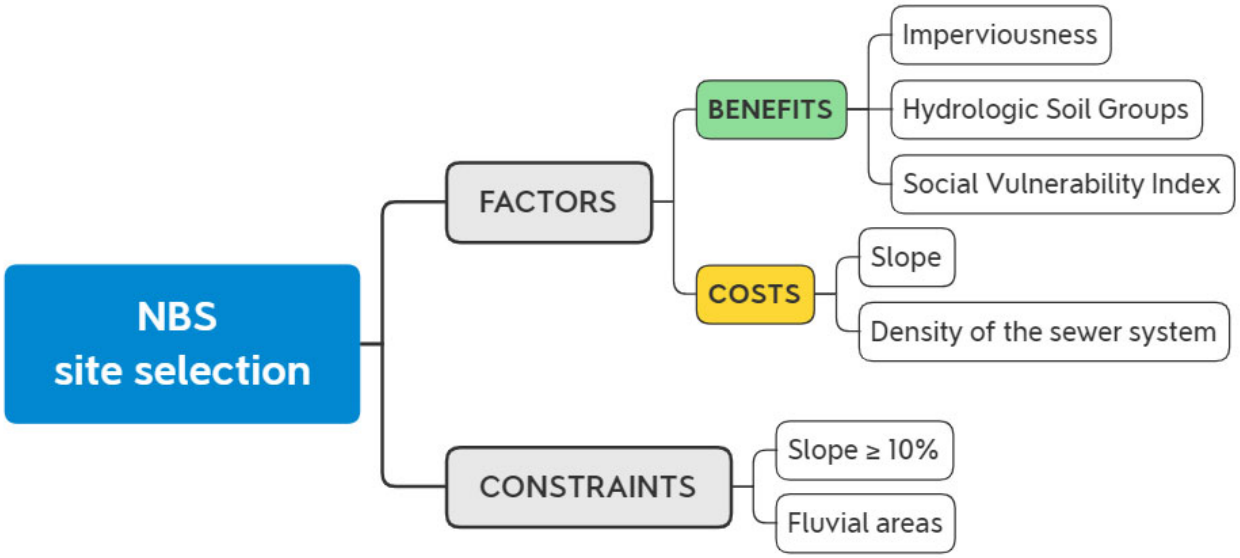
  Classification in factors and constraints, according to the SMCE module within the ILWIS software.

CONSTRAINTS

Criterion that determines which areas should be considered as absolutely NOT suitable for NBS.

FACTORS

Criterion that contributes to a certain degree to the output (suitability)



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- ***Context and resources evaluation***

  Determining the **weight** of each indicator using the **Analytic Hierarchy Process** method and literature data.

	I	S	H	D	SO
I	1	1/3	3	5	3
S	3	1	5	3	5
H	1/3	1/5	1	1	3
D	1/5	1/3	1	1	1
SO	1/3	1/5	1/3	1	1

AHP Matrix – CR = 0.069 < 1

Weight

- **I**mperviousness – 0.267
- **S**lope – 0.460
- **H**ydrologic soil group – 0.112
- **D**ensity of the sewer system – 0.090
- **SO**cial vulnerability index – 0.071

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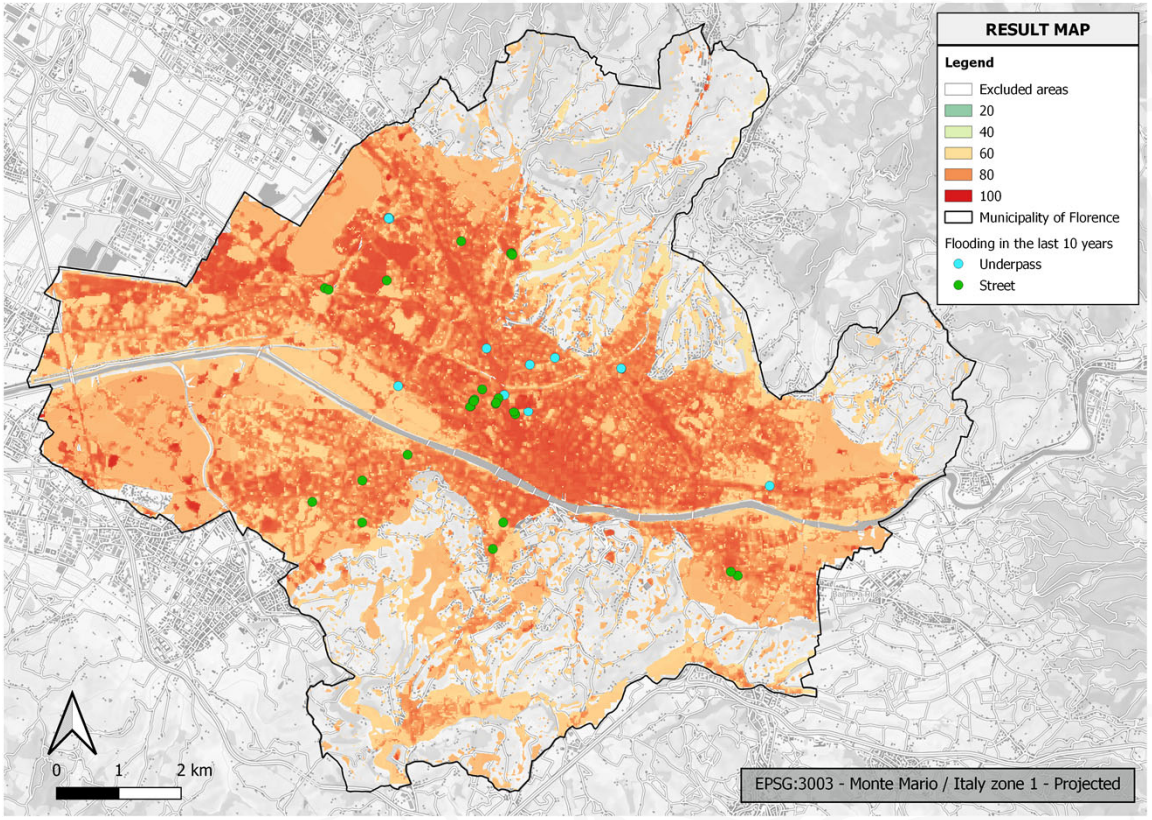
- ***Context and resources evaluation***

The resulting map identifies the potentially floodable areas. The higher the value, the greater the exposure of this area to floods.



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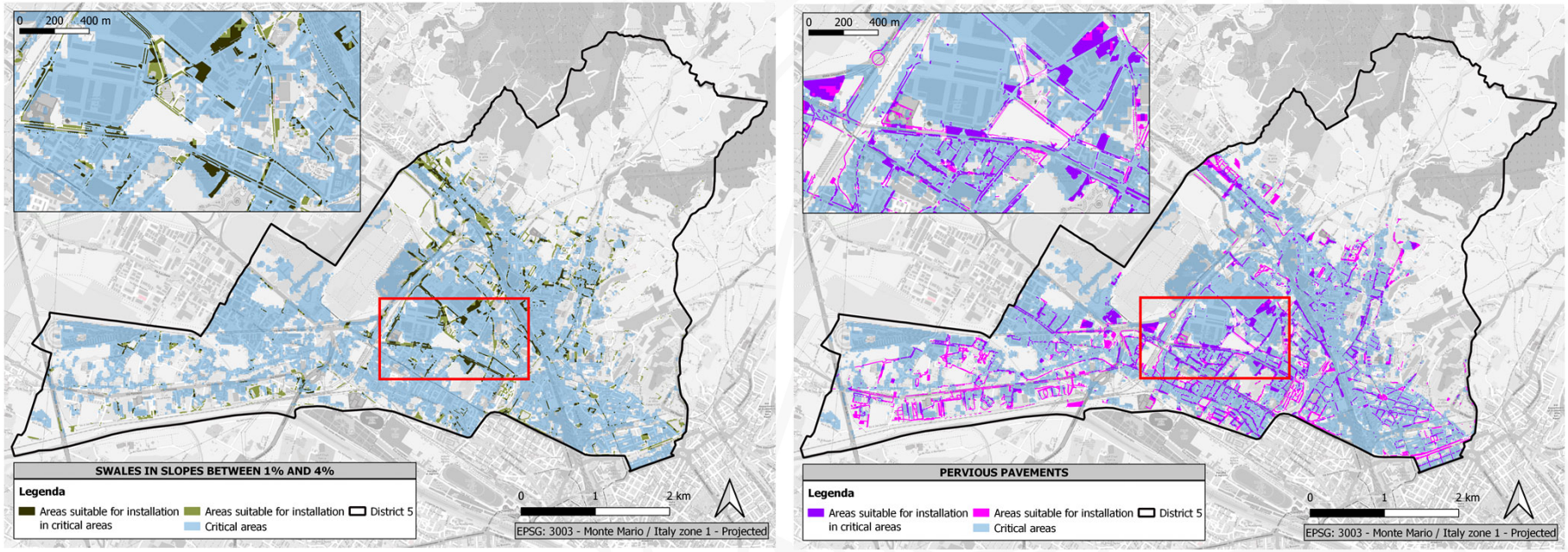
- ***Context and resources evaluation***

  Once the map was obtained, **urban constraints** were also considered for the correct implementation of NBS (e.g. public and private areas, urban development areas, areas to be reconverted).



Martina Tonola, 2020, Feasibility analysis of the implementation of Nature Based Solutions in the presence of urban constraints in the district n.5 of City of Florence. Master Degree Thesis in Environmental Engineering. Supervisors: Enrica Caporali, Tiziana Pileggi, Simona Cioli.

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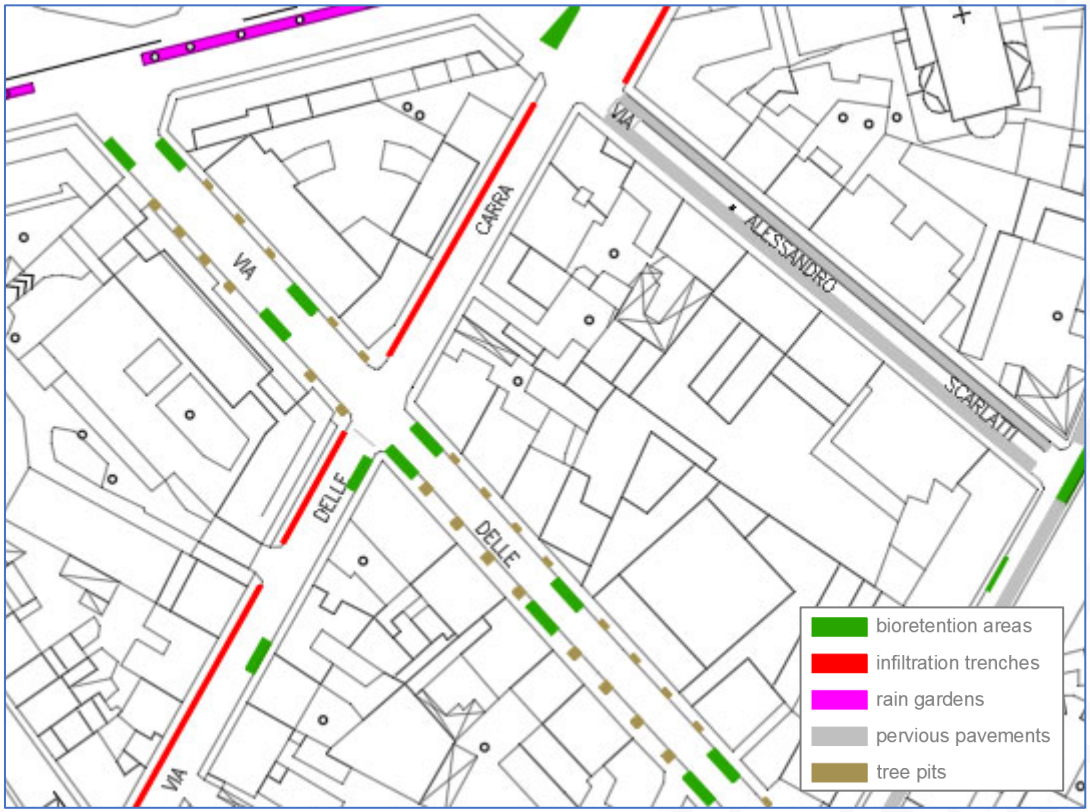
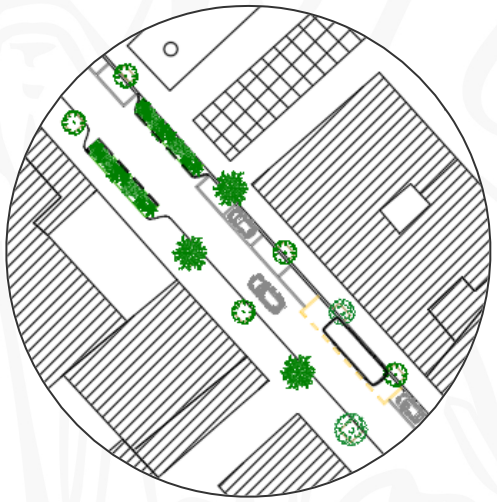
- Choice and design of NBS and assessment of benefits and co-benefits



Damiano Giannelli, 2020, Design of NBS for hydraulic risk mitigation from "pluvial floods" in the municipality of Florence. Master thesis in Civil Engineering. Supervisor: Enrica Caporali, Matteo Isola, Simona Cioli.



Bioretention areas
and permeable pavements

EPA – SWMM model

The FLORENCE project

- Choice and design of NBS and assessment of benefits and co-benefits

Scenario 0 – no intervention

Scenario 1 – NBS in road areas

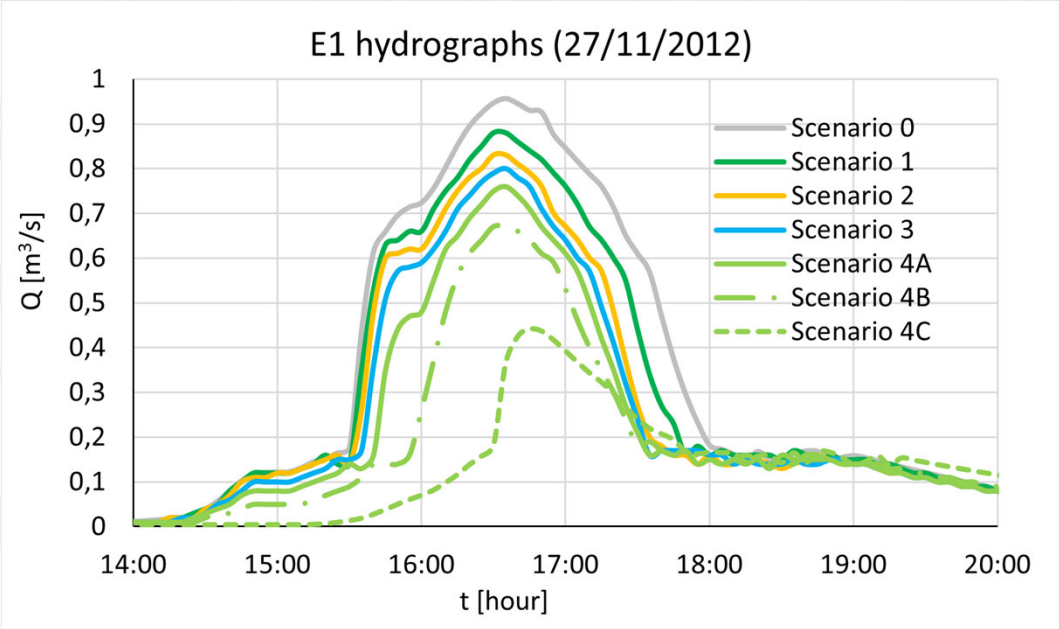
Scenario 2 – Model 1 + permeable parking

Scenario 3 – Model 1 + Model 2 + rainwater harvesting

Scenario 4A – Model 1 + Model 2 + Model 3 + green roof (20% of the total roof)

Scenario 4B – Model 1 + Model 2 + Model 3 + green roof (50% of the total roof)

Scenario 4C – Model 1 + Model 2 + Model 3 + green roof (100% of the total roof)



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Benefit: RUNOFF MITIGATION

The FLORENCE project

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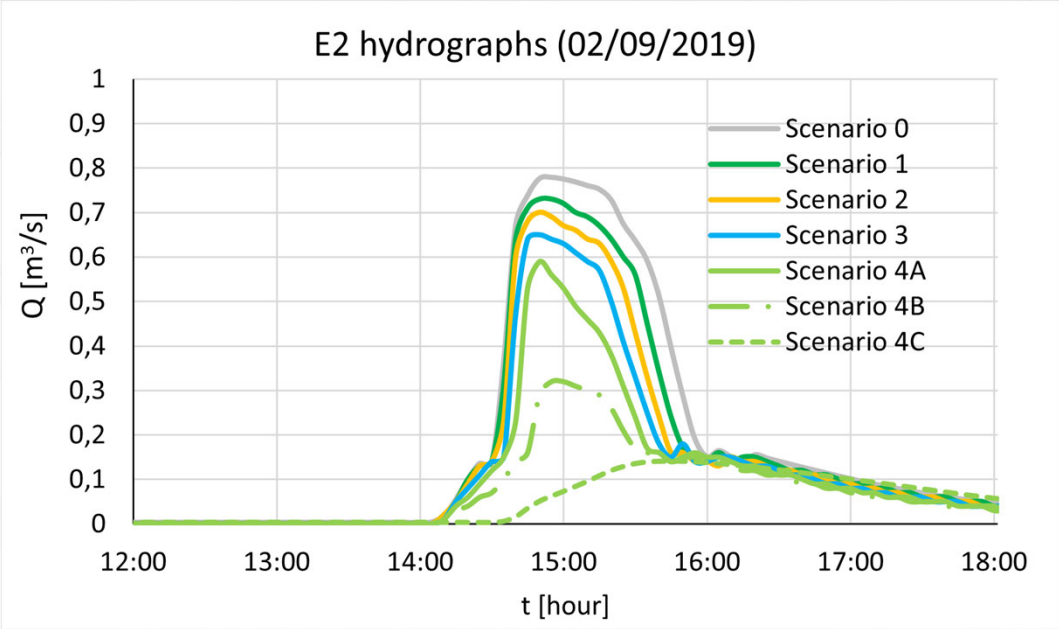

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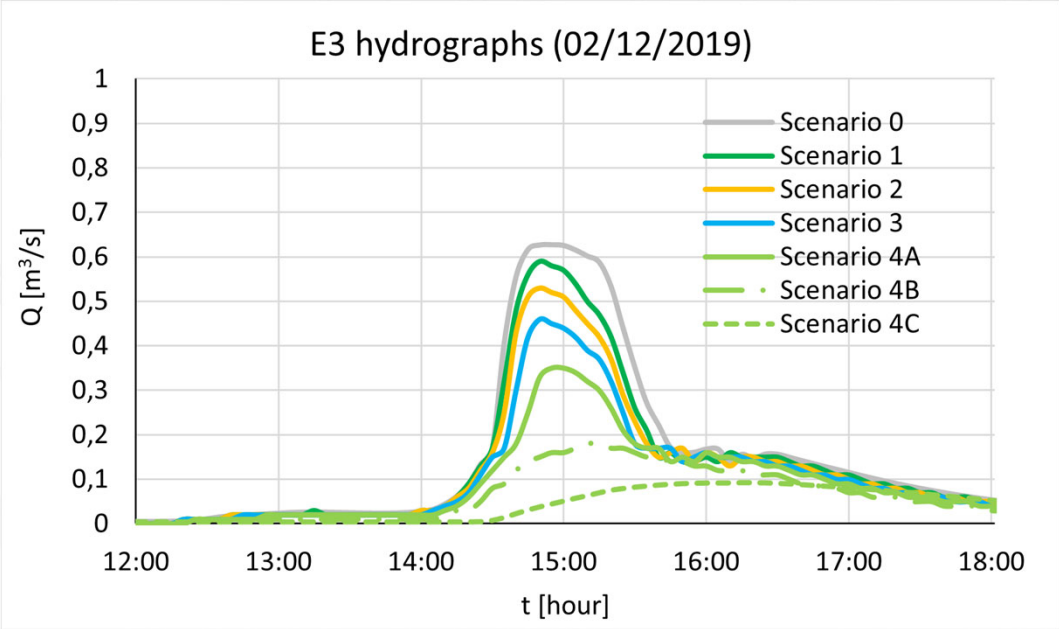

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THANK YOU FOR YOUR ATTENTION

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https://youtu.be/6iQx_D13Vc8