Nature-Based Solutions for flooding risk mitigation in an urban area: The case study of Catania (Sicily, Italy)

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Interreg Italia-Malta gifluid

Fondo Europeo di Sviluppo Regionale
European Regional Development Fund

Green Infrastructures to mitigate flood risks in Urban and sub-urban areas and to improve the quality of rainwater discharges - GIFLUID

The project aims to develop and promote practical tools which integrate the planning and design of **Green Urban Infrastructures** (GUIs) in critical urban areas of Malta and Sicily in order to mitigate floods effects, to increase the infiltration of rainwater also improving its quality.

Green Roofs

Porous Pavements

Rain Gardens

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Preface

Frequently, traditional drainage networks, known as "***GRAY INFRASTRUCTURE***," demonstrate their inadequacy in managing stormwater, and it would be necessary to adapt them to new flow rates and runoff volumes.

The main causes of the significant ***increase in flow rates and runoff volumes*** in urban and suburban areas are due to:

•The increase in rainfall intensity, primarily due to climate change phenomena.

•The increase in ***soil sealing*** caused by urbanization and large infrastructures.

In the last 20 years, the extent of urbanized areas in Europe has increased by an average of 20% - (ISPRA, 2020).

"STREAMS as ROADS"


Lavinaio Stream (Aci Catena)


Forcile Stream (Catania)

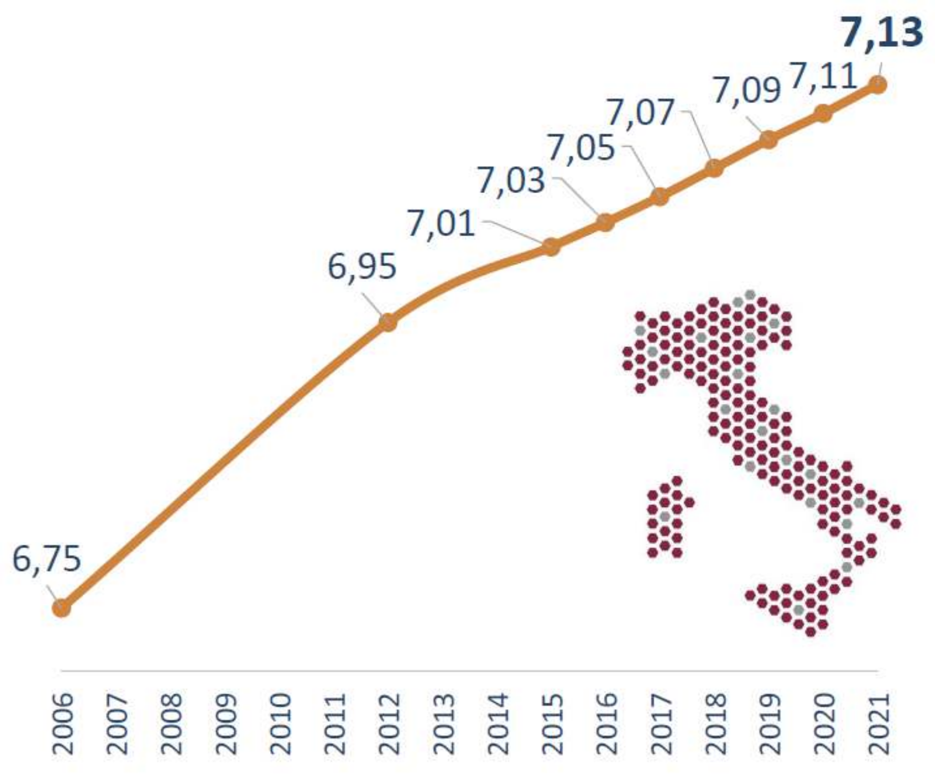
"ROADS as RIVERS"


Catania – 25 Oct 2021

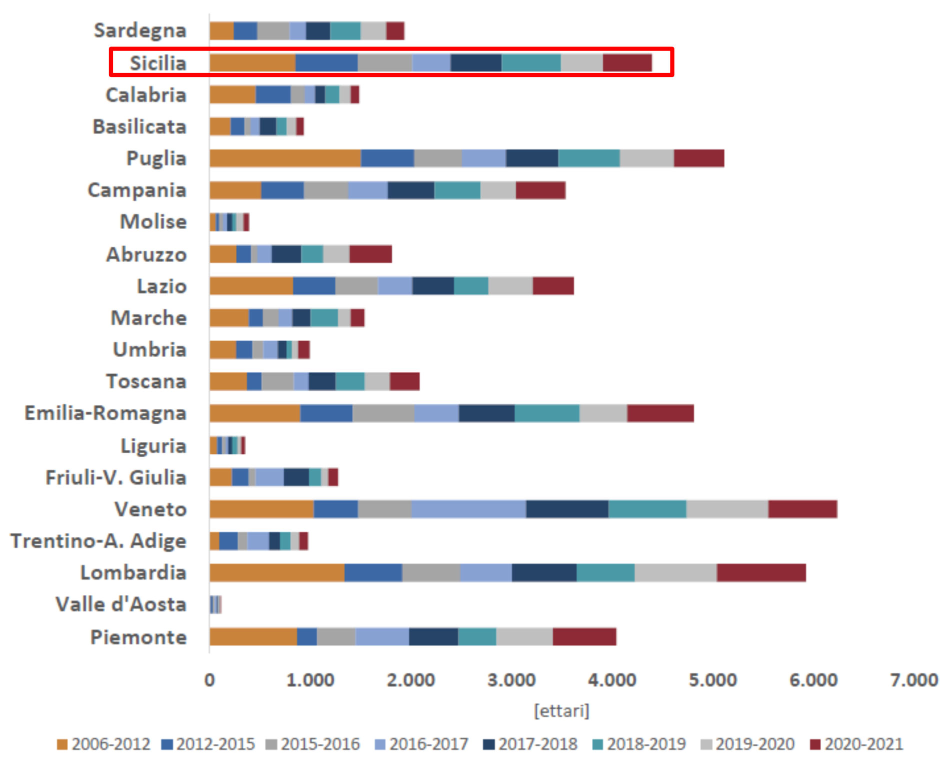

Catania – 26 Oct 2021

Land use consumption in Italy (2006-2021)

Percentage of the total annual land use consumption at ***National*** level



Total annual land use consumption at ***Regional*** level



Total annual land use consumption (**2021**):
69.1 km² → **19** hectares per day
2 square meters per second

ISPRA (Italian Institute for Environmental Protection and Research)

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Flood events in Sicily

NEED FOR A CHANGE OF CURRENT WATER MANAGEMENT MODELS TO CONTROL FLOODING AREAS THROUGH THE CONCEPT OF "SPONGE CITY" OR "PERMEABLE CITY"

Palermo, 5-6 October 2013

Siracusa, 22 October 2021

Licata, 19 November 2016

Catania, 26 October 2021

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Study area localization

Garibaldi-Nesima watershed (8.75 km^2)

Catania municipality | 37° 30' 45.786" N
Misterbianco municipality | 15° 2' 21.731" E

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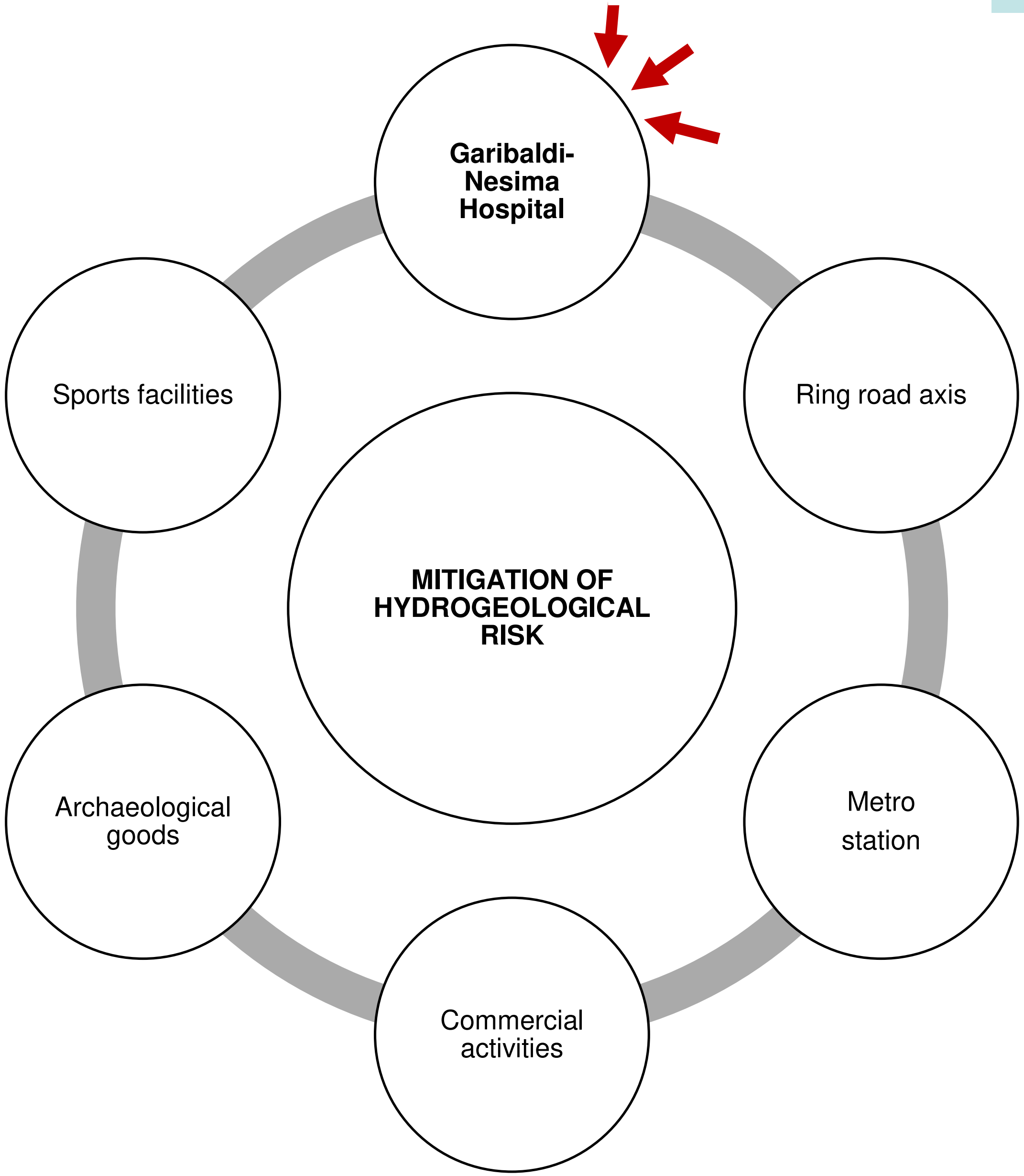
Problem statement



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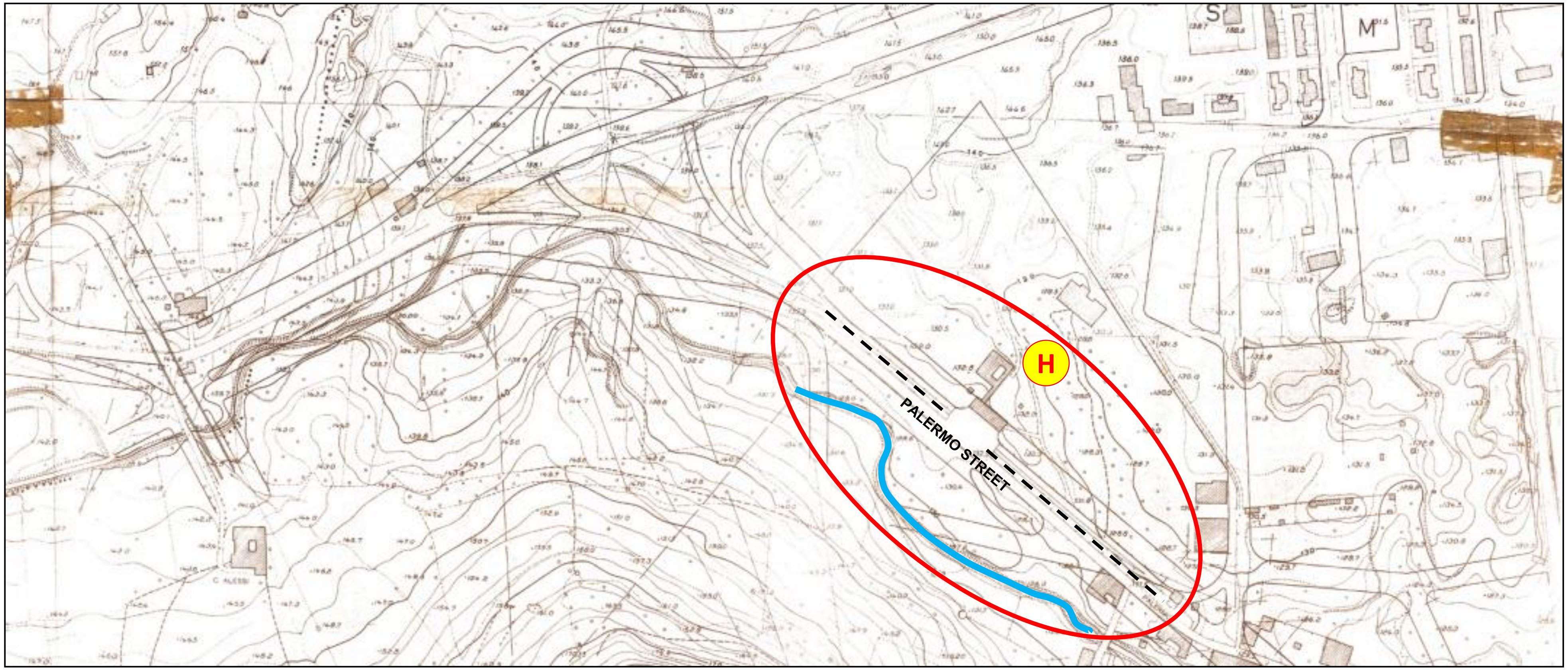
Preliminar study: regional hystorical map 1970s

Elements of particular interest:

1. Ditch guard (– – –) facing the old Geriatric Hospital.
2. Land elevations between Acquicella stream (▬▬) and Palermo street are about -2 m above road elevation.



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Preliminar study: diachronic analysis


Google Earth – 2013


Google Earth – 2016

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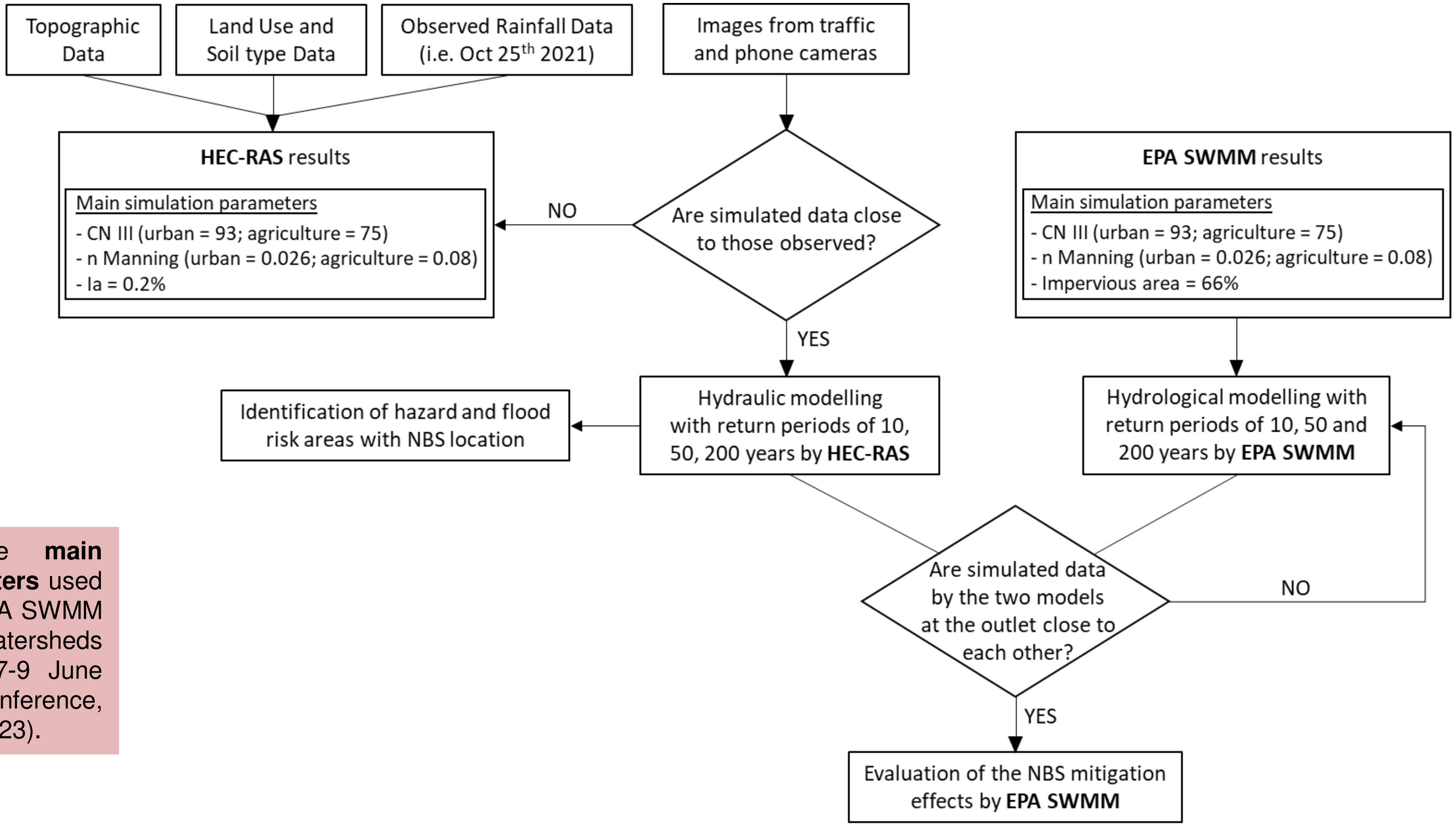
Methodology – hydraulic and hydrological modelling



Validation of the **main simulation parameters** used in Hec-RAS and EPA SWMM models in other watersheds (WIC Conference 7-9 June 2023, WETPOL Conference, 10-14 September 2023).

NBS = Nature-Based Solutions

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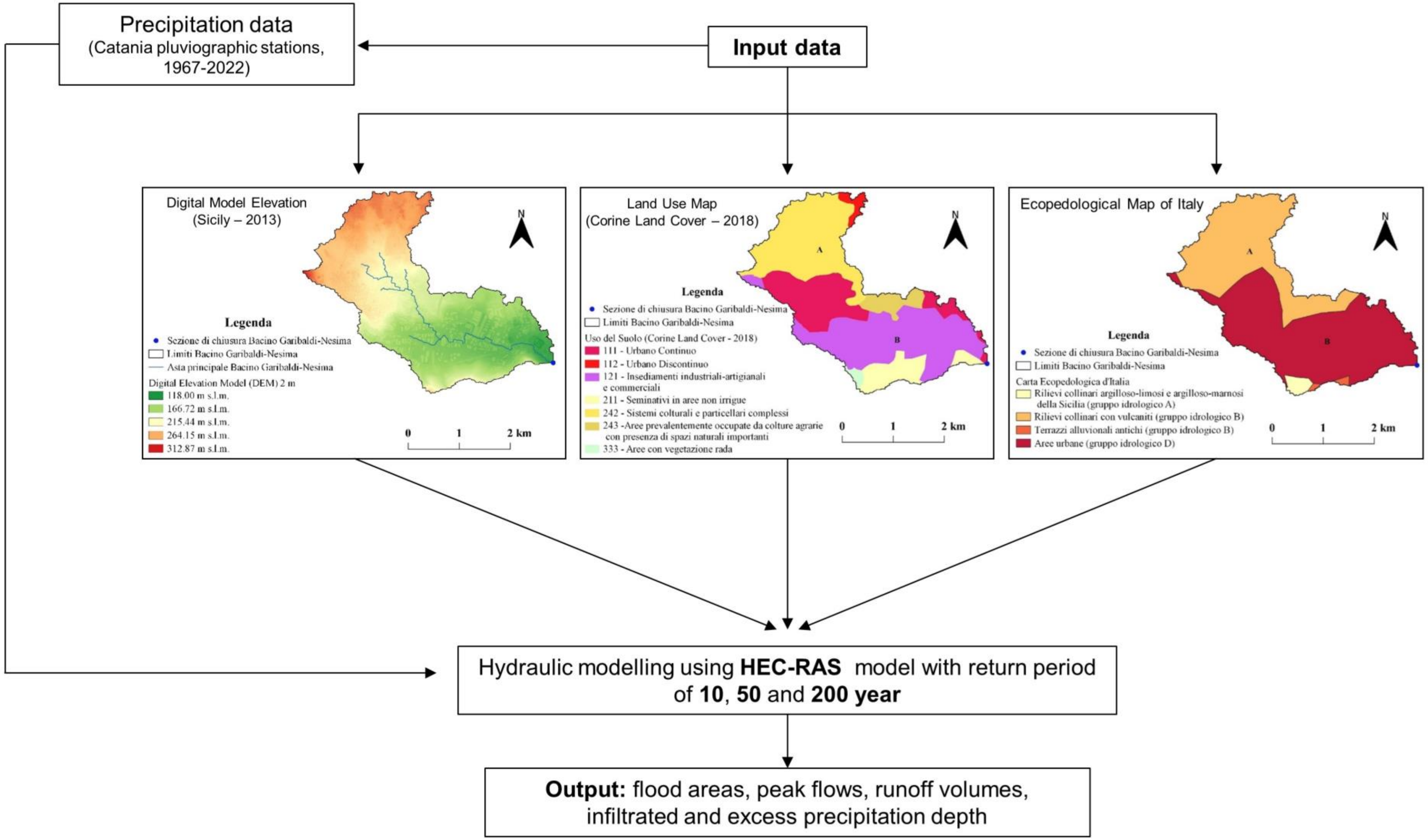
Hydraulic modelling – Hec RAS

Garibaldi-Nesima watershed (8.75 km²)



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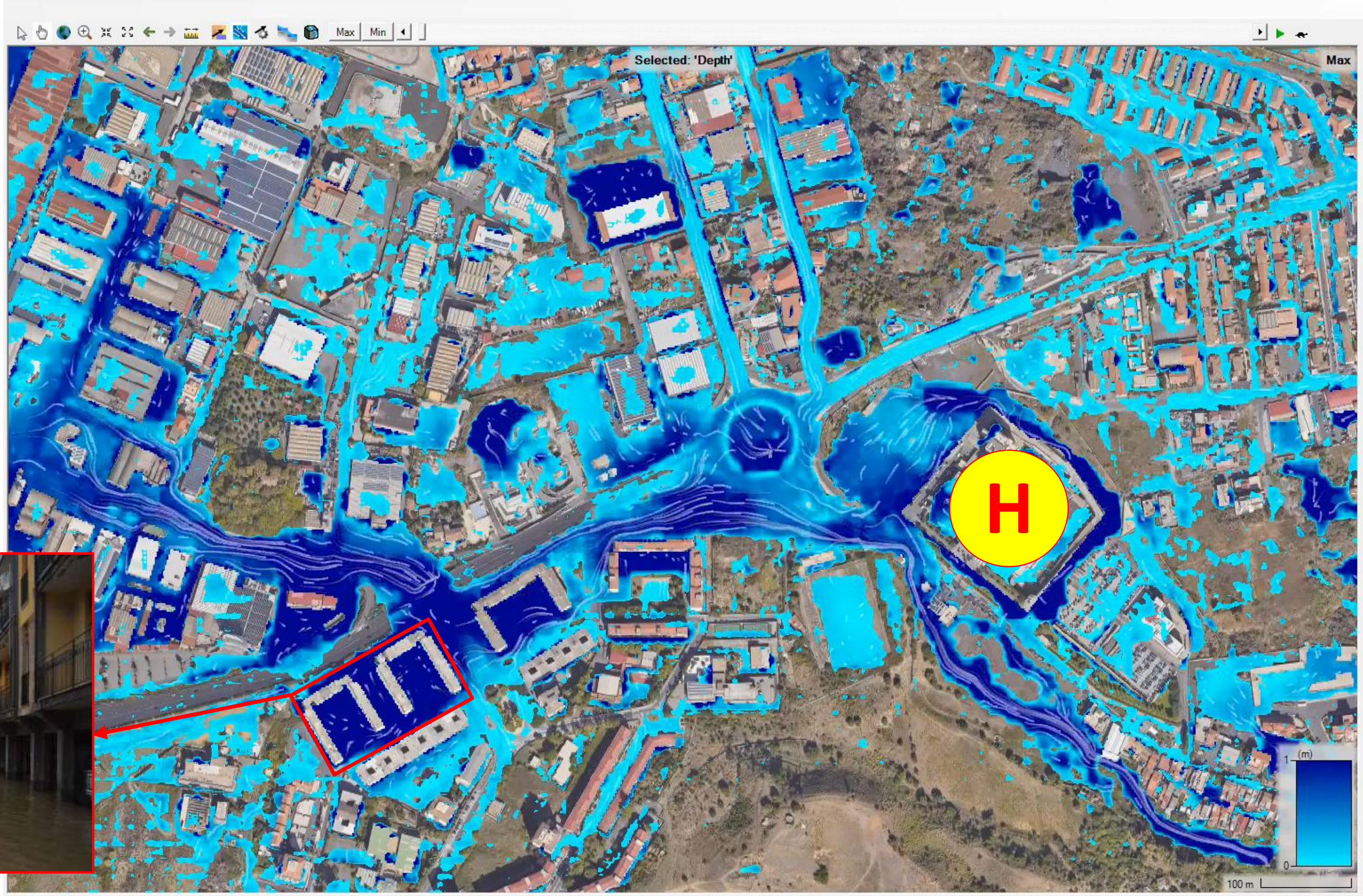
Hydraulic modelling – Hec RAS

Garibaldi-Nesima watershed (8.75 km^2)

Hydraulic simulation – 200 year return period



The largest contribution in terms of runoff comes from Carlo Marx, Montepalma and Lineri streets

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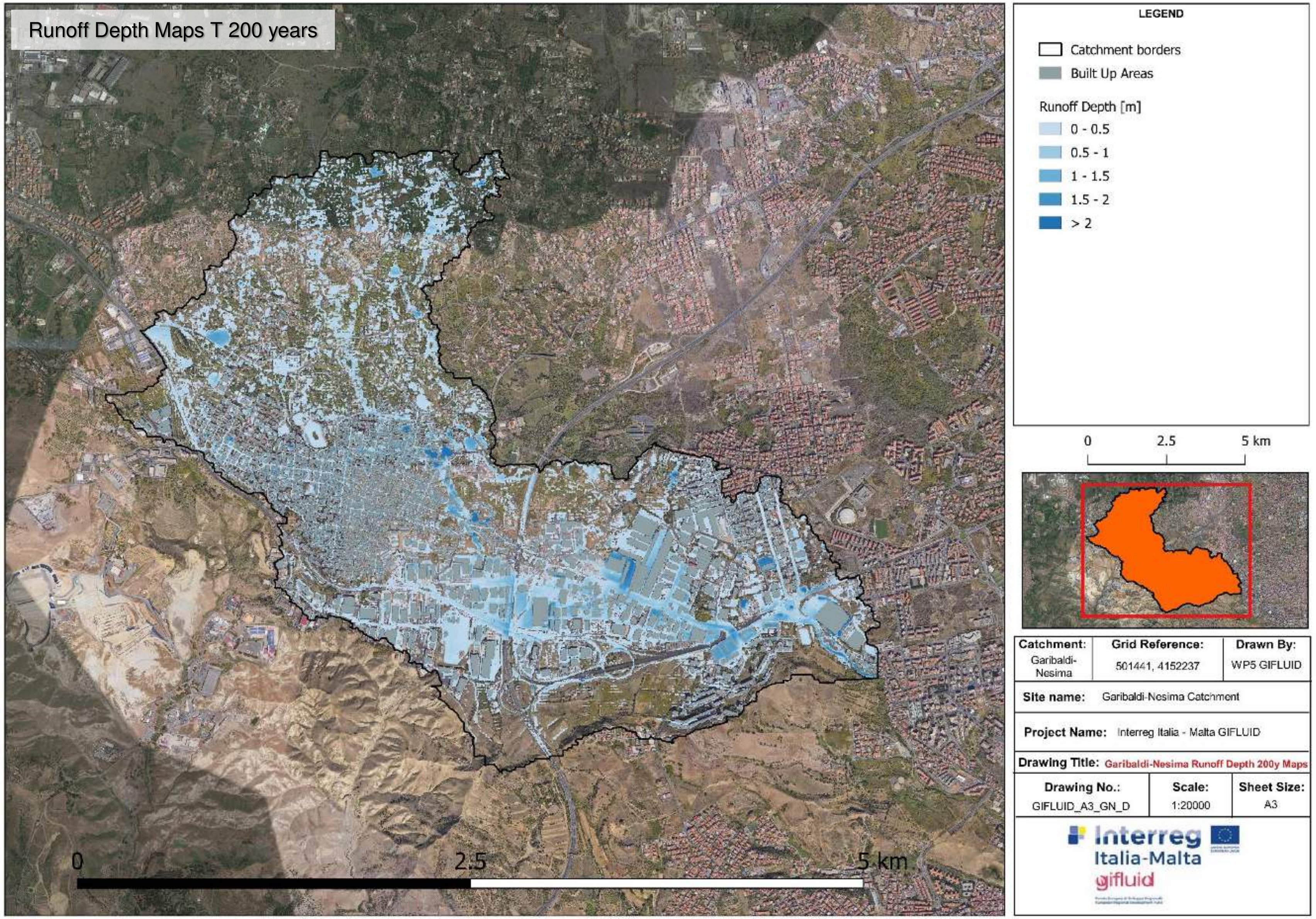
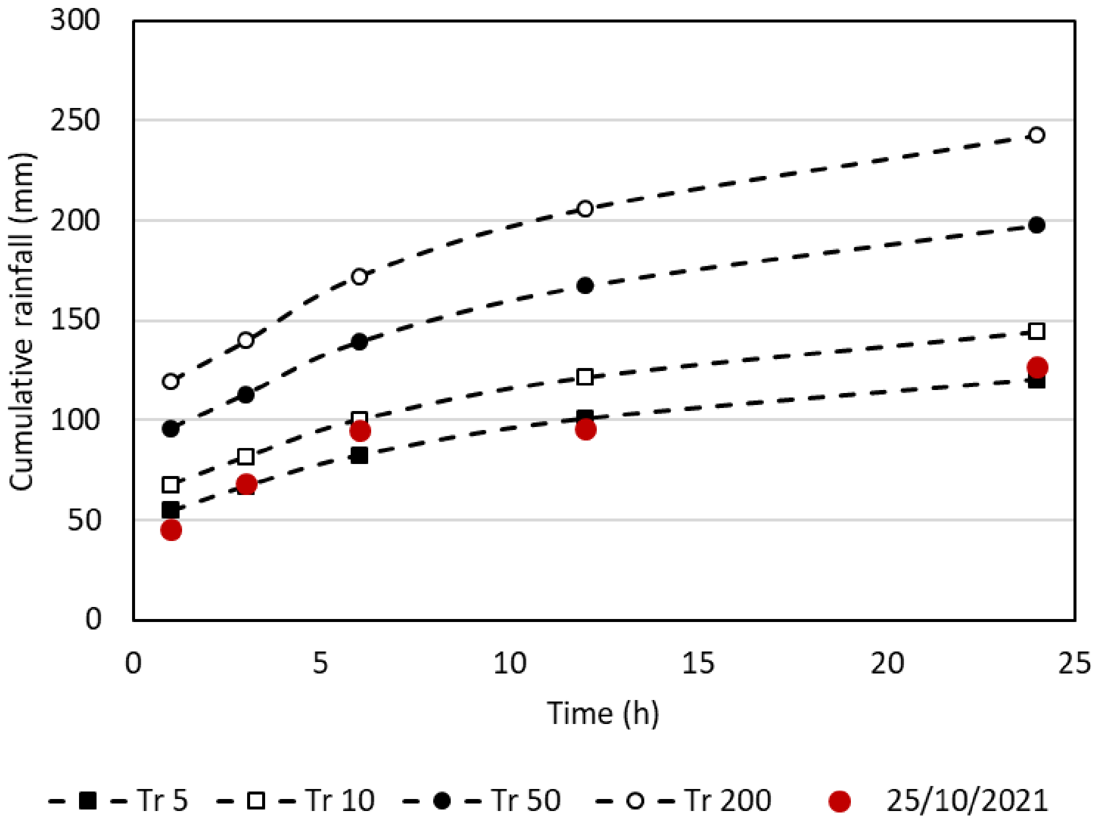


How is Hec-RAS model tested?

Hec-RAS is tested at flood event scale by using **images from traffic** and **phone cameras** of an extreme rainfall event occurred in Catania on the 25th October 2021.



Rainfall probability curves for different return periods of the Catania pluviographic stations with the placement of the event occurred on 25th October 2021 (data by the SIAS, 2021).

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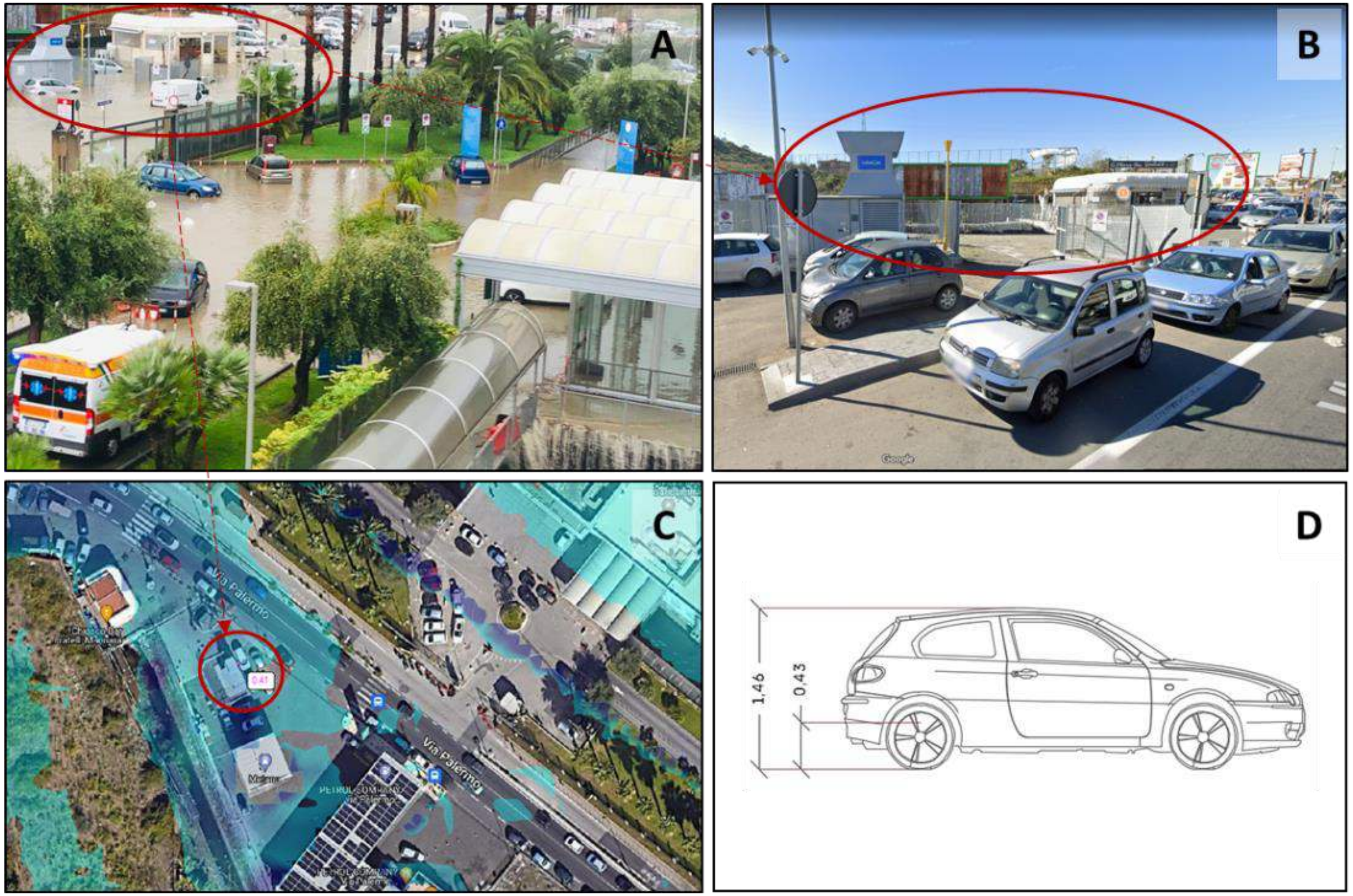
How is Hec-RAS model tested?

The observed runoff depths in correspondence of **some fixed points** (i.e. cars headlights, bumpers and wheels) are compared with those simulated with the hydraulic model for the same T of the rainfall event occurred in October.



The testing process showed **satisfactory results**. At the four randomly chosen test points, the observed and simulated runoff depth are very close to each other with a difference in the range of **0.01 m - 0.10 m**.

A) Observed runoff depths by using an image of the event occurred in October from Garibaldi-Nesima hospital security camera; B) Google Maps image; C) Simulated runoff depths by using HEC-RAS model; D) Fixed point, back bumper of an Alfa Romeo 147.

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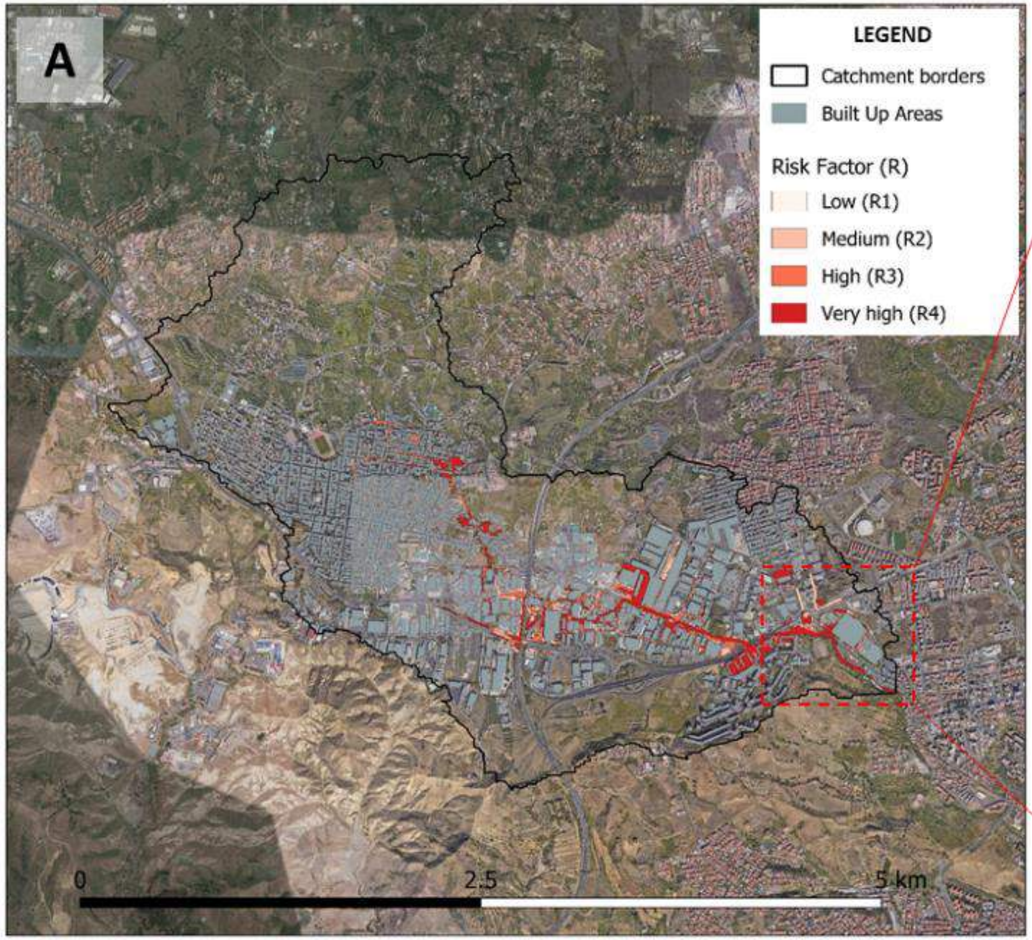
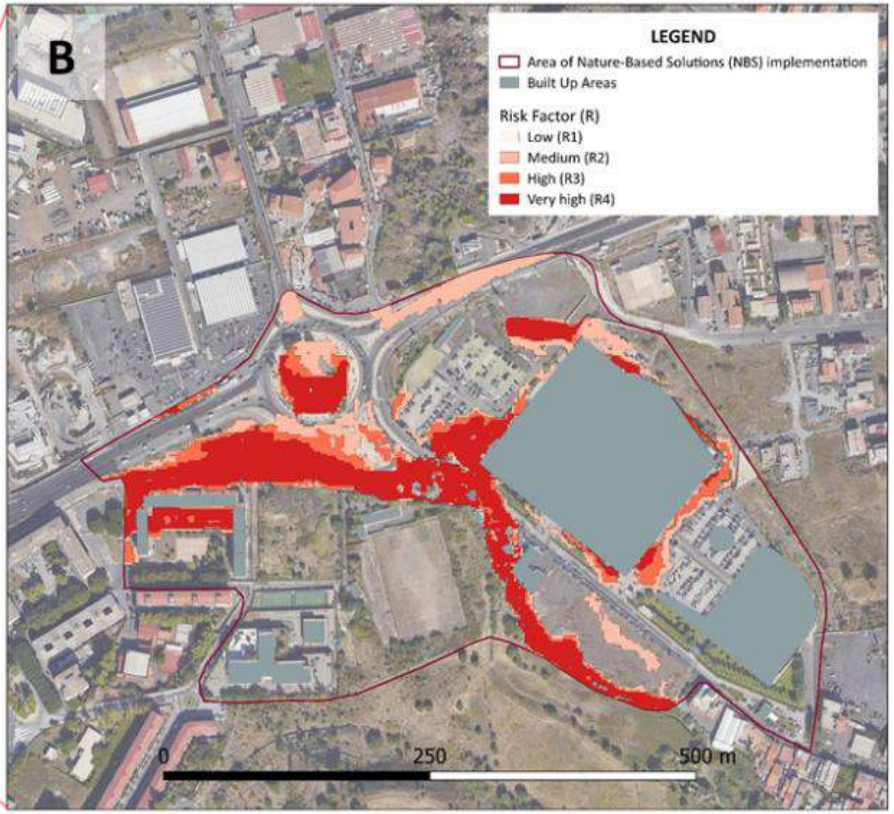
Flood risk map for Garibaldi-Nesima watershed





A) Flood risk map for Garibaldi-Nesima catchment; B) Risk areas in the area of Nature-Based Solutions (NBS) implementation.

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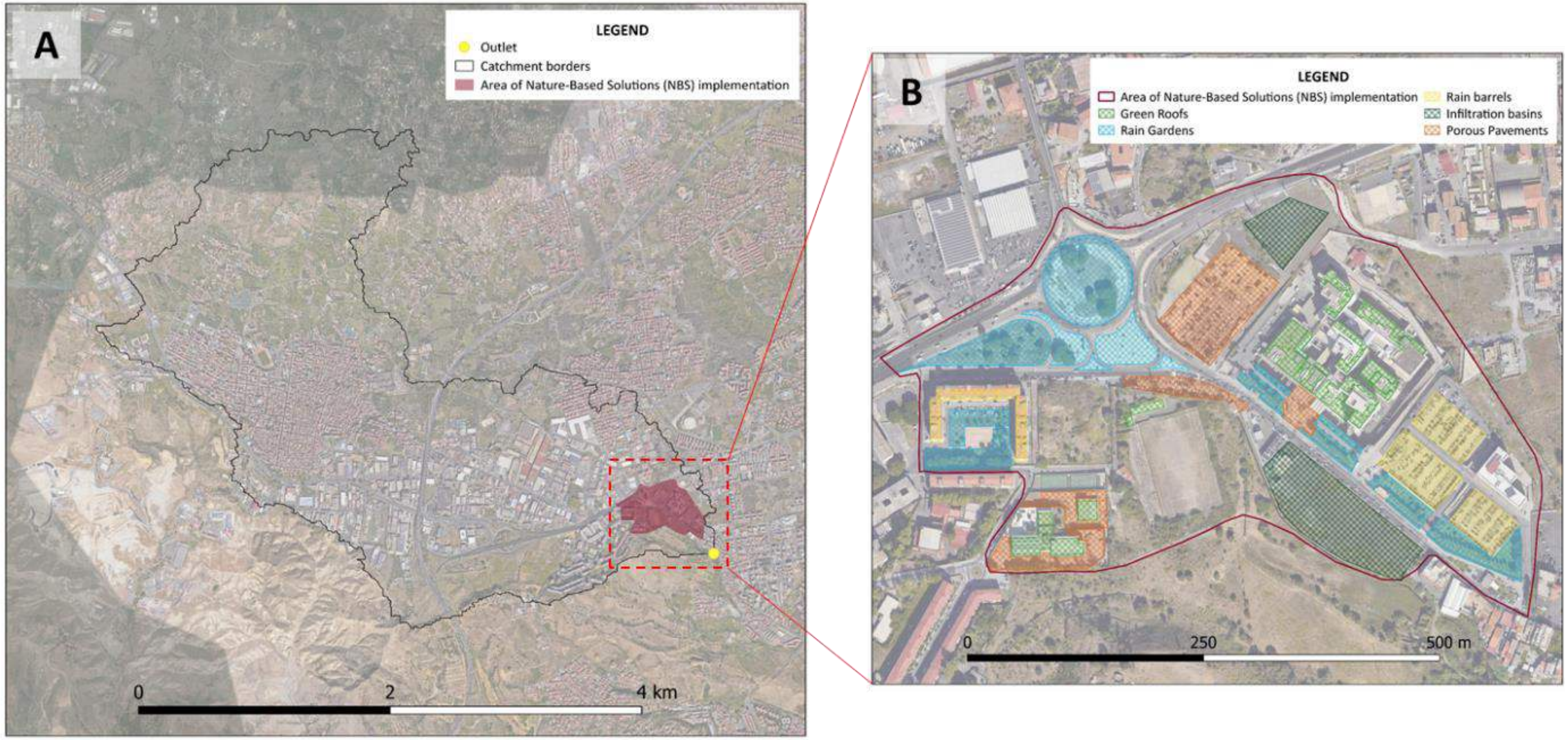
NBS implementation for Flood Risk Mitigation

EPA SWMM model

The NBS mitigation effects (in terms of peak flow and runoff reductions) into the identified risk areas are evaluated at **sub-catchment scale** (0.20 km^2). Model simulations are performed by considering an area of 0.07 km^2 of NBS (in EPA SWMM model) that means 36.8% of the sub-catchment area.



A) Area of Nature-Based Solutions (NBS) implementation within the Garibaldi-Nesima watershed; B) Location of the different NBS typologies within the sub-catchment

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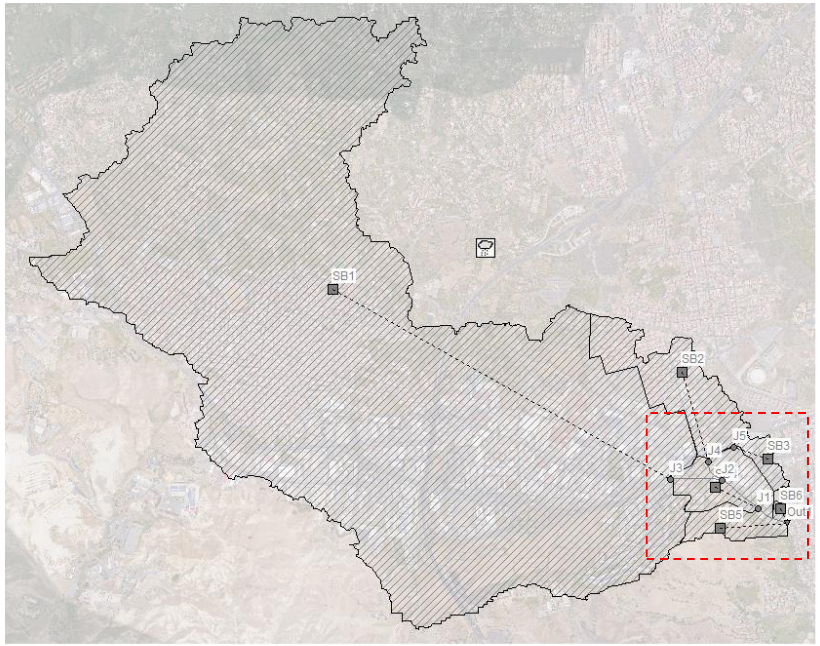
NBS implementation for Flood Risk Mitigation

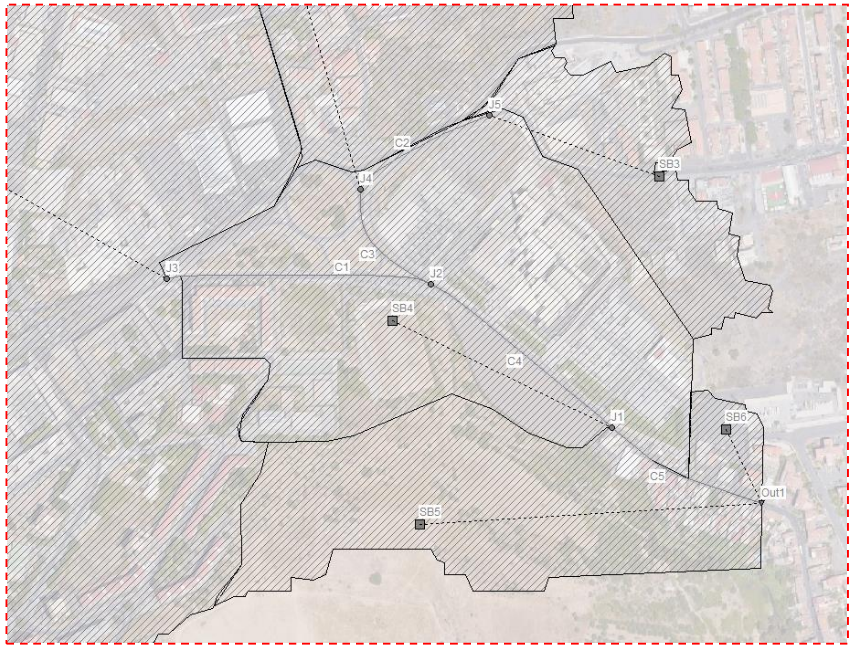
EPA SWMM model

RESULTS

Table A

	Peak flow at the outlet of the Garibaldi-Nesima watershed (m^3/s)		
	T 10 year	T 50 year	T 200 year
HEC-RAS Current Scenario	35.3	62.4	107.5
EPA SWMM Current Scenario	37.3	62.7	107.3
EPA SWMM with NBS	32.0	56.4	99.5





Conclusions

- The approach proposed to evaluate NBS mitigation effects in flood risk urban data scarce areas through the application of **Hec-RAS** and **EPA SWMM models**, based on images from traffic and phone cameras, is **promising**. The preliminary testing process of Hec-RAS model to simulate observed peak flows in different points in the areas and at the outlet of the Garibaldi-Nesima watershed showed **satisfactory results**.
- The model **EPA SWMM** is able to simulate the effects in terms of peak flow and runoff volume reduction due to the NBS implementation at sub-catchment scale.
- The proposed approach is **easy** to apply and has **high replication capacity** in urban hydrological data scarce areas.
- The results confirm that the integration of NBS with grey infrastructures in urban area could have hydrological and **hydraulic positive effects**, in terms of peak flow and runoff volume reduction.
- The proposed approach could be used as a **tool** to support decision makers, planners and stakeholders to investing in NBS as a green adaptation strategy against climate change in Mediterranean Regions.

Thank you for your attention!

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