SUMO CONFERENCE 2026 — Celebrating 25 years of SUMO

Center for Automotive Research and Sustainable Mobility — Cars@PoliTO

Politecnico di Torino — Department of Environment, Land and Infrastructure Engineering — DIATI

Integrating Macroscopic and Microscopic Road Traffic Simulations for Impact Assessment of Flood-Related Disruptions

Amirehsan Charlang Bakhtyari[1,*], Francesco Deflorio[1], Matteo Ferraro[1], Michele Amaddii[2], Fabio Castelli[2], Chiara Arrighi[2]

1 DIATI, CARS@Polito, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy

2 Department of Civil and Environmental Engineering, Università degli Studi di Firenze, Via di S. Marta 3, Florence, 50139, Italy

**corresponding author: amirehsan.charlang@polito.it*

Introduction and Background:

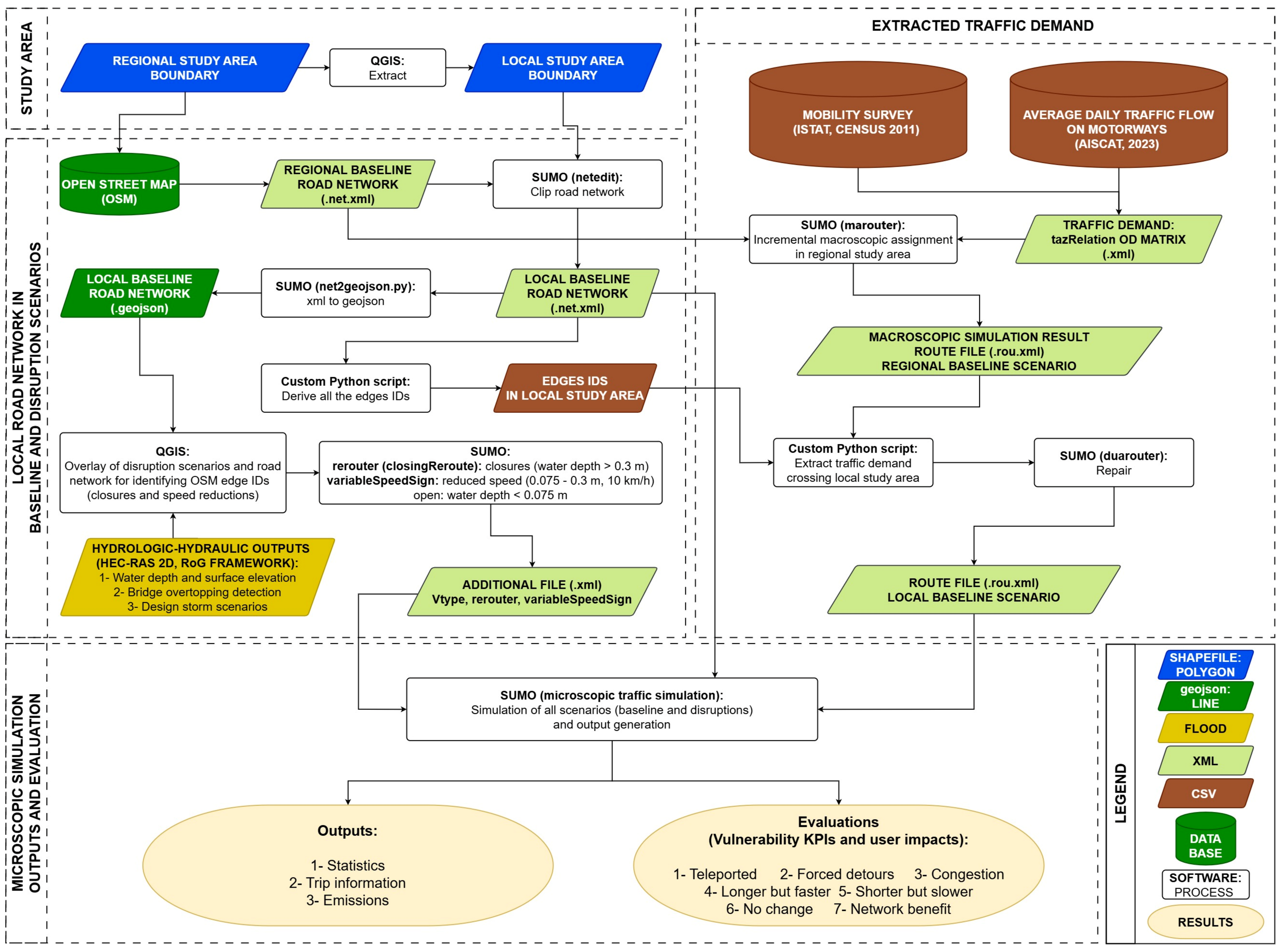
Flooding events pose a significant threat to road transportation infrastructure, particularly bridges**,** which function as connectors between regional and local road networks. Previous work applied **a GIS-based screening** methodology at a large catchment scale to detect bridges prone to overtopping **[1]** and combined it with **macroscopic traffic simulations** to assess the **regional mobility impacts of bridge closures.** By integrating large-scale bridge overtopping potential screening, iterative macroscopic traffic assignment performed using the **marouter** tool in **SUMO,** and vulnerability indicators, critical bridges were identified within the flood-prone Magra River basin in northwestern Tuscany, Italy **[2]**.

[1] [2]

Methodology (Zoom-In Approach):

- Based on the regional vulnerability assessment, **a dual-scale modeling framework** is implemented to capture localized traffic impacts and user effects.
- A **subset of the regional network** is extracted as the local study area, including critical sub-basins, key municipalities, and motorway segments. The corresponding microscopic road network is derived from OpenStreetMap and refined for simulation.
- Traffic demand is generated by **extracting trips from macroscopic assignment results (SUMO-marouter).** A custom Python script filters routes crossing the local study area and converts them into **vehicle route definitions** at edge level, suitable for microscopic simulation.
- Flood disruption scenarios use **HEC-RAS 2D Rain-on-Grid (RoG)** outputs, based on design storms with varying return periods (RP) and durations (h), identifying:
  - ✓ Bridge and road edge closures
  - ✓ Speed reductions based on water depth thresholds (mean water depth, D)

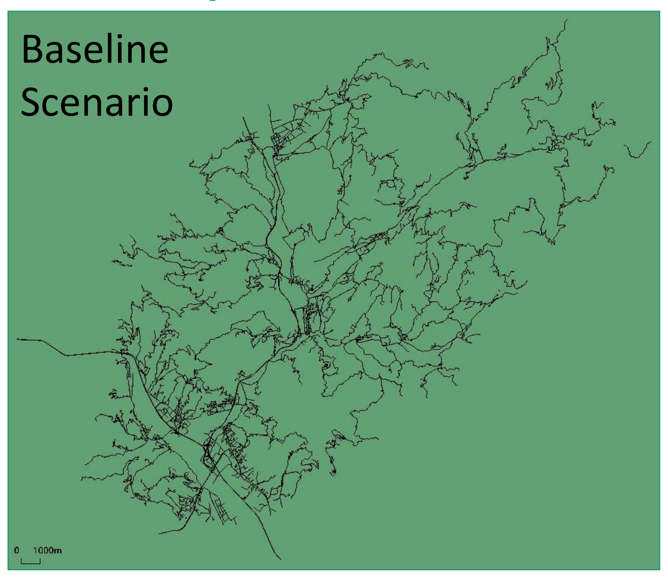
  These scenarios are implemented in SUMO using **rerouter and variable speed sign** elements.
- Finally, **microscopic simulations** are performed for baseline and disruption scenarios to evaluate:
  - ✓ Rerouting behavior
  - ✓ Congestion patterns
  - ✓ Local network performance impacts

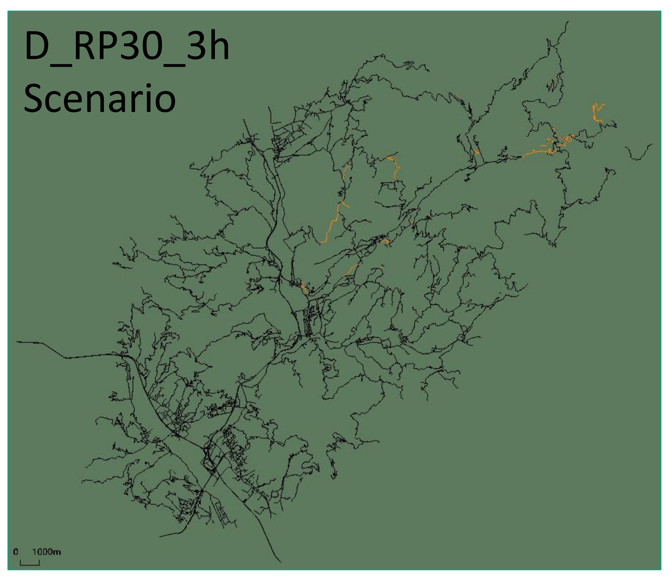


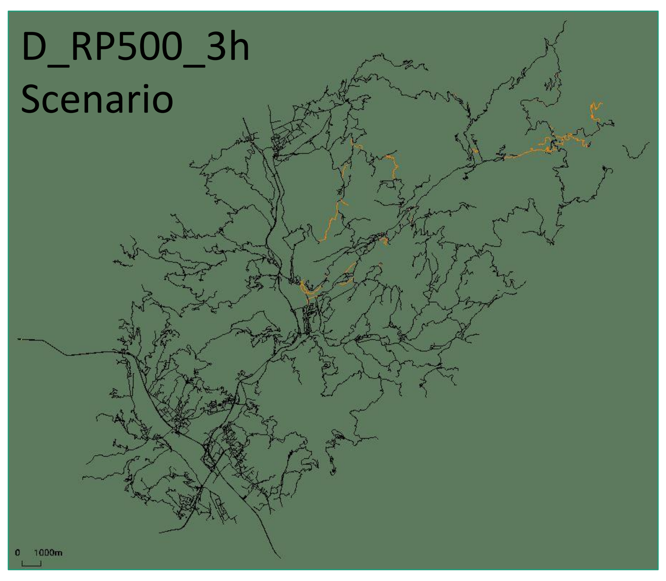
Case Study and Results (User Impacts and Emissions):

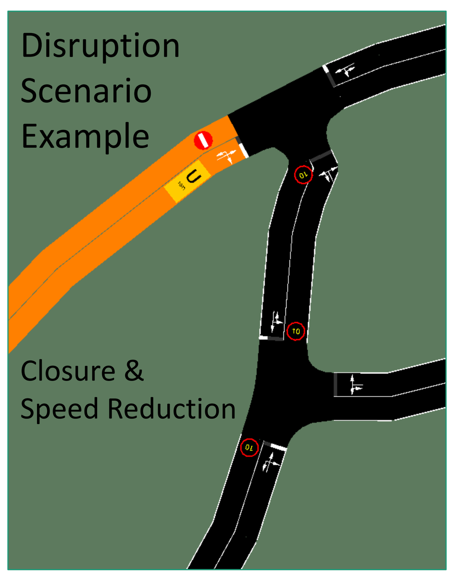
scenario	baseline	D_RP30_3h	D_RP500_3h
loaded	10963	10963	10963
inserted	10963	10937	10868
inserted (%)	100	99.8	99.1
not inserted	0	26	95
not inserted (%)	0	0.2	0.9
teleported	1	789	826
teleported (%)	0	7.2	7.5
Forced detours	0	300	610
Forced detours (%)	0	2.7	5.6
Congestion	0	1464	787
Congestion (%)	0	13.4	7.2
Longer but faster	0	29	19
Longer but faster (%)	0	0.3	0.2
Shorter but slower	0	4	3
Shorter but slower (%)	0	0.0	0.0
No change	0	6857	6913
No change (%)	0	62.5	63.1
Network benefit	0	1493	1709
Network benefit (%)	0	13.6	15.6

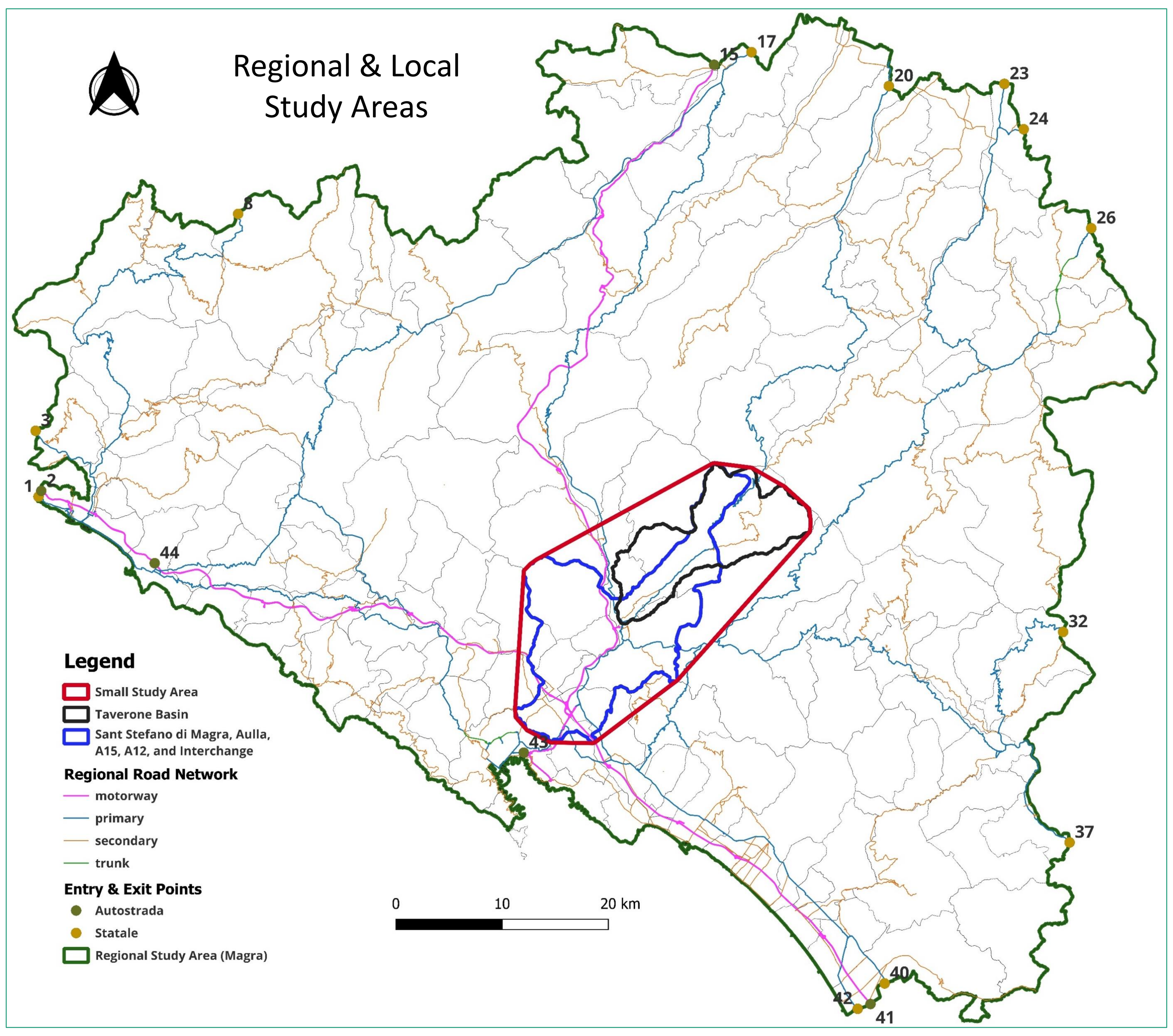
scenario	baseline	D_RP30_3h	D_RP500_3h
completed trips	10963	10937	10868
total distance (km)	268640.7	251908.6	255372.7
CO_2 (kg)	62101.5	73961.5	74226.9
CO_2 (g/km)	231.2	293.6	290.7
CO_2 (kg/trip)	5.7	6.8	6.8
NO_x (kg)	24.2	29.9	29.9
PM_x (kg)	1.4	1.7	1.7
CO (kg)	981.8	1921.1	1926.2
HC (kg)	6.0	10.5	10.6
fuel (L/100km)	7.4	9.4	9.3
fuel (L)	19807.4	23590.6	23675.3











Conclusion:

- The proposed **zoom-in dual-scale framework** links regional vulnerability assessment with detailed local traffic analysis by **integrating macroscopic and microscopic traffic simulations.**
- Results show that **edge closures and speed reductions due to flooding** generate significant localized impacts, including **loss of accessibility (teleported vehicles), congestion, rerouting, and increased travel times,** which are not fully captured at the macroscopic level.
- The **integration of macroscopic demand with microscopic simulation** enables a more realistic representation of user behavior under disruption scenarios. In addition, the analysis highlights increased emissions and localized environmental impacts associated with congestion and detours.
- Overall, the methodology provides **a practical and scalable approach** to support **targeted mitigation and adaptation strategies** for resilient transport networks.

FLOOD@ROAD — Flash-FLOOD risk at crossings between ROAD and river networks

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1- Amaddii, M., Castelli, F. & Arrighi, C. Assessing road-watercourse crossing overtopping potential using GIS and remote sensing: a large-scale screening approach. Nat Hazards 122, 108 (2026). https://doi.org/10.1007/s11069-025-07907-8

2- Prioritizing bridges at flood risk: a large-scale index based on overtopping and traffic impact / Amaddii, Michele; Deflorio, Francesco Paolo; Charlang Bakhtyari, Amirehsan; Castelli, Fabio; Arrighi, Chiara. - (2025), pp. 122-123. (Le Giornate dell'Idrologia 2025 della Società Idrologica Italiana: "Affrontare le sfide climatiche e territoriali: scenari, rischi e strategie di adattamento" Bari (Ita) 8-10 settembre 2025). https://hdl.handle.net/11583/3004202

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