Civic Digital Twin

How Bologna uses data, AI and participation to shape urban decisions

Stefania Paolazzi · Comune di Bologna

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What happens if…?

One decision.

Many effects.

Some of them invisible.

Cities are not machines

	Industrial-style twin	Civic twin
The city is…	a system to regulate and optimise	an ecosystem in constant evolution
Citizens are…	passive users	co-authors of policy impacts
It models…	physical assets and flows	behaviours and social dynamics too
It speaks to…	experts	non-experts as well, through co-design

Why we chose a research partnership

A civic digital twin can't be bought off the shelf. So we invested in a research consortium to fill that gap, together.

Comune di Bologna

Fondazione Bruno Kessler **University of Bologna** **CINECA** **Fondazione IU Rusconi Ghigi**

ICSC – National Research Centre in HPC, Big Data and Quantum Computing

Other collaborations: CRIF · ARUP · University of Virginia · Local public services companies

Two layers, one twin

Geometric & physical

3D buildings, infrastructure and urban green from LiDAR, satellite imagery and orthophotos

Building energy models, climate and environmental indicators

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Civic

Individual and collective behaviours

Attitudes toward change, and how they shape transformation

Data from civic engagement and public consultation

Next: an interactive 3D city model combined with the civic twin for joint simulation

Data, AI and participation

Data

Data governance: clear rules on access, use and responsibility

From open data to a data ecosystem: purpose-bound sharing with public, private and research actors

Models & AI

Simulation and machine learning to build "as-is" and "what-if" scenarios

Traceability, quality and fairness checks built in

Participation

Co-design with city departments, stakeholders and citizens

Results designed to be understood by non-experts

Foundation One open-source, cloud-native **Data & AI platform**: data, models and AI all run on open infrastructure

One twin, many policies

Mobility

Assess the direct and indirect impacts of sustainable mobility policies before adopting them

Heatwaves

Understand who is exposed and test mitigation and adaptation measures

Historic centre

Co-design actions for liveability with citizens, balancing heritage, public space and climate resilience

Other potential domains

- Urban green
- Energy in buildings
- [domain]
- [domain]

Mobility: testing a policy before it exists

1. Input Data
- Road network & sensors
- Origin–destination matrices
- Commuting surveys
- Social fragility indices

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2. Baseline (As-is)
- Current Traffic flows
- Baseline Emissions
- Social Fragilities

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3. Policy Levers
- Rules: active hours, exemptions
- Behaviour: elasticity & rigidity
- Effort required for fragile groups

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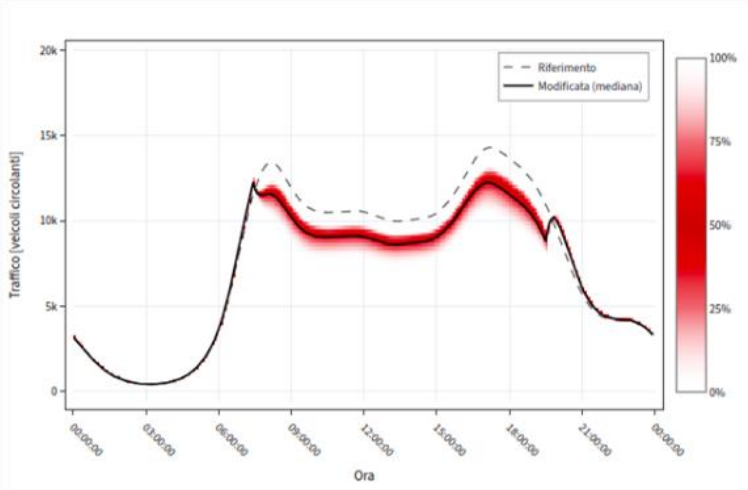
4. What-if Scenario
- Simulated Traffic shifts
- Projected Emissions impact
- Social Fragility re-evaluation

Mobility: testing a policy before it exists

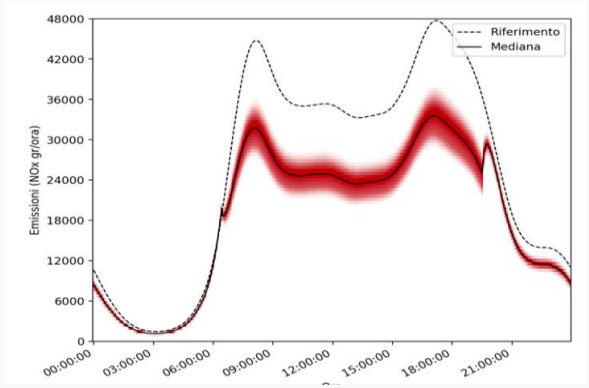
Policy Parameters



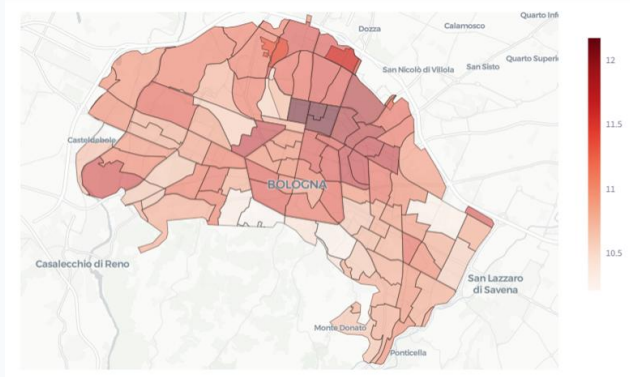
Traffic Profile & Behavioural Rigidity



Output A: Environmental Impact (Emissions)



Output B: Social vulnerability analysis



Who pays the price of a new policy?

We look for **indirect discrimination** and **mobility gaps** linked to gender, age, abilities, economic condition, language.

Fragility indexes

Economic, demographic and social fragility, zone by zone, today

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Effort functions

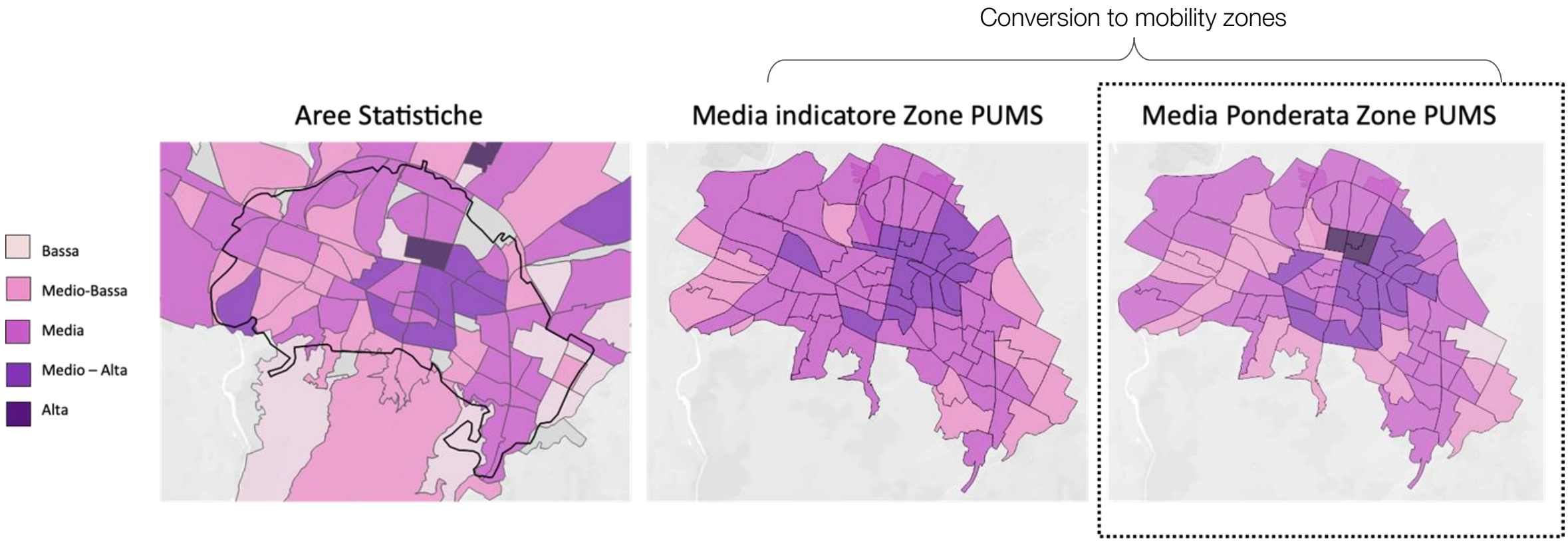
Extra cost and time the policy imposes on each fragile group

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Updated indexes

Fragility in the what-if scenario, by zone and by group

How you aggregate decides who you see



Key issue: Fairness in data and algorithms

Participation is how we build the twin

11

co-design workshops in 10 months for the mobility use case

Sept 2024 – June 2025

1. Collect needs, choose the research questions
2. Map the systems and subsystems involved
3. Select data and indicators
4. Co-design the model, build a prototype
5. Test, validate, refine

Four lessons from our digital twin for the age of AI

How do we invest without being locked in?

Open infrastructure that other cities can reuse.

How do we get partners to share data?

Clear rules first. Trust comes before data.

How do we make sure no one is left behind?

Measure the effects of every policy on the most fragile.

How do we make decisions people believe in?

Build the twin with citizens, not just for them.

What we're working on now

Civic twin	New tools and a public interface for mobility, heatwaves and the historic centre
Models integration	Interactive 3D city combined with the civic twin
Fairness and inclusion	Equity indicators for vulnerable groups in every use case
AI ethics and reliability	A sandbox for AI Act compliance
External engagement	Civic participation, data crowdsourcing, co-design of the public interface

Every city has its own challenges, but the questions are the same.

Let's answer them together.

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