Urban Decision Infrastructure: A Systemic Model for Transforming Urban Data into Decision-Making Capacity in Italian Local Governments

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***Abstract*— Italian cities have invested substantially in digital infrastructure: the smart city solutions market exceeded one billion euros in 2024, growing by 5% year-on-year (Politecnico di Milano Smart City Observatory). Yet between 60% and 73% of data collected by organisations is never used for analysis, and only eight out of 108 Italian provincial capitals reach the 'full digital' threshold (ICity Rank 2024, FPA). This paper introduces the Urban Decision Infrastructure (UDI) model as a systemic framework for analysing and designing urban data infrastructure—not as an assemblage of technological platforms, but as a cognitive architecture oriented towards public decision-making. The UDI articulates five sequential and interdependent layers: Observation, Integration, Intelligence, Decision, and Action. The paper analyses three cases at different scales (Ghent, Trento, Alta Sabina Municipal Union) and proposes three advances relative to the smart city literature: the urban cognitive infrastructure construct, a framework for algorithmic governance in public AI systems, and a scale-differentiated articulation of the UDI model. Findings suggest that urban maturity in data governance is determined not by endowment metrics but by the coherence and quality of the decisional chain.**

Index Terms— urban decision infrastructure, data governance, smart city, public decision-making, AI governance, invisible infrastructures, inter-municipal cooperation, data sovereignty

I. INTRODUCTION

A paradox characterises the current state of urban data governance in Italy. Cities have invested heavily in smart city infrastructure—sensors, IoT platforms, open data portals, connectivity networks—yet the gap between data collected and decisions improved remains structurally wide. According to the Politecnico di Milano Smart City Observatory, the Italian smart city solutions market exceeded €1 billion in 2024. Against this investment, between 60% and 73% of organisational data is never used for analysis [1], and only eight of Italy's 108 provincial capitals qualify as 'full digital' in the ICity Rank 2024 produced by FPA [2].

This paper argues that the problem is not technological but architectural. Italian cities have invested primarily in the first layer of a data system—collection—while neglecting the four subsequent layers that transform collected data into decision-making value. They have, in the terms developed in this paper, built eyes without a nervous system.

Our contribution is the Urban Decision Infrastructure (UDI), a five-layer systemic model that reconceptualises urban data infrastructure as a cognitive architecture oriented towards public decision-making rather than as a collection of technological components. We analyse three cases representing different scales and resource contexts, and derive three theoretical advances relative to the existing smart city literature.

II. LITERATURE REVIEW

A. Smart City Data Platforms

The dominant paradigm in smart city research has conceptualised urban data infrastructure in terms of platform architectures [3], [4]: layered technical systems for data ingestion, storage, processing and exposure. This literature has generated valuable insights into interoperability, API design and data quality management, but has tended to treat decision-making as an output that follows naturally from data availability.

A growing body of critical scholarship challenges this assumption [5], [6]. Green [7] observes that technological capability and decision-making capacity are analytically distinct and frequently misaligned in practice: cities can be rich in data and poor in decisions. This misalignment is the empirical starting point of the present paper.

B. Data-Driven Governance

Research on data-driven governance [8], [9] has highlighted the organisational and institutional conditions under which data inputs are translated into policy outputs. Key findings include the central role of data stewardship roles [10], the importance of cross-departmental data integration [11], and the need for formal governance structures that assign ownership, quality responsibility and access rights [12]. The UDI model synthesises and operationalises these findings within an urban context.

C. AI in Public Administration

The integration of artificial intelligence into public decision-making processes has generated a substantial literature on algorithmic governance [13], [14]. The European AI Act (2024) [15] introduces binding obligations for public sector AI systems classified as high-risk, requiring transparency registers, human oversight mechanisms, and contestation rights. The UDI model incorporates AI governance as a structural component of the Intelligence layer rather than as an add-on.

III. THE UDI MODEL

A. Model Architecture

The Urban Decision Infrastructure is defined as an integrated system of capabilities oriented towards decision-making, articulated across five sequential and interdependent layers. The key analytical proposition is that the value of the system does not reside in the quality of any single layer, but in the coherence of the complete chain. A city with advanced sensing capabilities and no data integration produces noise rather than information; a city with sophisticated predictive models and no structured decision process produces recommendations that never reach decision-makers.

B. Layer 1: Observation

The Observation layer encompasses all mechanisms through which the city produces a digital representation of its physical state: distributed sensor networks, IoT infrastructure, open data feeds from national and regional sources, utility telemetry, anonymised mobility data from telecommunications operators, and citizen-generated data. The critical design question at this layer is not 'how many sensors?' but 'which decisions need to be supported, and what data do they require?'

C. Layers 2–5

The Integration layer transforms collection into system by connecting data silos through documented APIs, formal data catalogs, and governance policies that assign responsibility for data quality, update cadence and access rights. The Intelligence layer applies analytical and modelling capabilities—from business intelligence to AI—to transform integrated data into insights. The Decision layer ensures that insights reach decision-makers in the right form at the right time, through integrated dashboards, cross-departmental KPIs, and scenario simulation tools. The Action layer closes the feedback loop: decisions translate into verifiable operational interventions whose effects feed back into the Observation layer.

IV. CASE ANALYSIS

A. Ghent: Organisational Data Sovereignty

Ghent (Belgium) established District09 in 2021 as an autonomous municipal company with an explicit mandate for digital partnership rather than IT procurement. The conceptual innovation—wisje stad (wise city) rather than smart city—signals the deliberate choice to subordinate technology to governance. District09's PROBE project publishes council deliberations as Linked Open Data; the SCORE initiative shared data management solutions with eight other European cities. The Ghent case illustrates that the most impactful choices for UDI Layers 2 and 4 are organisational rather than technological.

B. Trento: Structured Research Partnership

The Municipality of Trento has participated since 2015 in Horizon Europe projects in partnership with Fondazione Bruno Kessler (FBK) and the University of Trento. Projects including QROWD, STARDUST and C2S2 have progressively built UDI Layer 3 capability. Critically, the case also illustrates the governance risks of AI deployment: in 2024, the Italian Data Protection Authority (Garante) sanctioned the municipality €50,000 for projects conducted without adequate impact assessment, despite FBK's technical involvement. Competence does not substitute for formal algorithmic governance.

C. Alta Sabina: Inter-Municipal Cooperation

The IN.Alta Sabina project (2024) demonstrates that UDI construction is feasible even for very small municipalities. Ten communities in the province of Rieti, with a combined population of 7,500 and a depopulation rate 14 times the national average, built a shared civic platform integrating territorial, environmental and community data. A Community Pact established before any technology deployment. The case establishes inter-municipal cooperation as the only viable UDI architecture below a critical resource threshold.

V. THEORETICAL CONTRIBUTIONS

The paper proposes three advances relative to existing literature. First, the concept of urban cognitive infrastructure as distinct from digital infrastructure: not the volume of data collected, but the capacity to transform decisions into collective learning and learning into governance of urban complexity.

Second, a framework for algorithmic governance in public AI systems: public register, formal approval process, contestation mechanism, periodic audit cycle. These four conditions are interdependent; the absence of any one weakens the others. This framework is consistent with but more operationally specified than AI Act requirements.

Third, scale differentiation of the UDI model. Metropolitan cities, medium-sized cities and small municipalities do not share the same feasible path through the five layers. The paper specifies minimum viable UDI configurations for each scale category, with inter-municipal cooperation as the structural solution for sub-threshold entities.

VI. CONCLUSIONS

The UDI model reframes the urban data challenge as one of decisional architecture rather than technological endowment. Evaluation metrics for smart city data initiatives should shift from endowment indicators (datasets published, sensors installed) to capability indicators (data integration quality, existence of formal data governance, presence of cross-departmental KPIs, functioning feedback loops between action and observation).

Future research should develop longitudinal measurement instruments for UDI maturity and investigate the governance mechanisms through which inter-municipal UDI cooperation can be sustained beyond individual project cycles.

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