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Special Session S.15 **| Rethinking public space and planning strategies in urban and post-suburban areas for regenerating livable environments**

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Smart Urban Management Through Georeferenced Digital Models: Towards a Common Urban Intelligence Framework

(Extended Abstract)

1. Introduction

European cities are increasingly confronted with complex and interdependent urban challenges: fragmented public spaces, socio-spatial inequalities, environmental stress, demographic transformation, and declining trust in planning institutions. At the same time, policy frameworks such as the New European Bauhaus (NEB) call for urban environments that are sustainable, inclusive and beautiful. Bridging these ambitions with operational planning tools remains a structural difficulty for municipalities.

A critical gap persists between available urban data and its strategic use. Cities collect vast amounts of cadastral, infrastructural, demographic and environmental information, yet these datasets often remain fragmented, non-interoperable and analytically underexploited (Kitchin, 2014). Without an integrated digital model, planning decisions risk remaining reactive, sectoral and insufficiently evidence-based.

This paper develops a methodological perspective on how a georeferenced Common Digital Model (CDM) can function as the backbone of a smart urban management framework. The objective is to articulate and illustrate a structured approach to integrating heterogeneous geospatial datasets at neighbourhood scale in order to enable territorially differentiated urban analysis. The contribution lies in systematising data harmonisation, layered modelling and comparative diagnostics within a coherent analytical framework suitable for regional science applications. Building upon traditions of planning support systems and spatial decision-support infrastructures (Geertman & Stillwell, 2009), the contribution outlines how such a system can be conceptually structured and operationalised to support neighbourhood-scale regeneration and comparative urban analysis.

The central argument is that smart urban management should not begin with technology alone, but with a coherent epistemological architecture linking spatial morphology, social dynamics, environmental performance and participatory input within a harmonised geospatial intelligence system.

2. Conceptual Framework: From Data Accumulation to Urban Intelligence

Urban space is not merely a physical substrate but a relational system composed of built form, mobility networks, socio-demographic distributions, ecological processes and cultural practices. Spatial configuration itself influences movement patterns and patterns of co-presence, revealing structural links between morphology and social outcomes (Hillier, 2007). Yet planning systems frequently treat these dimensions in isolation, producing fragmented interventions disconnected from lived urban realities.

A Common Digital Model should therefore be structured around three foundational principles:

1. **Multi-scalar integration** – connecting parcel-level information to neighbourhood patterns and city-wide structures.
2. **Interoperability and harmonisation** – ensuring that heterogeneous datasets can be standardised and made comparable across administrative contexts, consistent with interoperable data stewardship principles (Wilkinson et al., 2016).
3. **Operationalisation of normative values** – translating sustainability, inclusion and spatial quality into measurable and spatially explicit indicators.

The objective is not simply to map the city, but to render visible the relationships between spatial configuration and social performance. A digital model becomes meaningful when it functions as an analytical and governance instrument rather than a static repository.

3. Methodological Architecture for a Common Digital Model

The framework is illustrated through an exploratory spatial comparison between contrasting neighbourhood typologies using openly available geospatial datasets (e.g., OpenStreetMap street networks and land-use data, green space layers and publicly accessible population grids). The demonstration relies on a limited set of indicators—network centrality, land-use mix, green space per capita and average distance to public space—to operationalise the layered model and assess structural differentiation.

3.1 Data Identification and Harmonisation

The first methodological step consists of systematically identifying and categorising available data sources. A robust digital urban model should incorporate, at minimum:

- Cadastre parcels and building footprints
- Land use and functional classifications
- Transport and mobility networks
- Public and quasi-public spaces
- Green infrastructure and environmental indicators
- Socio-demographic distributions
- Economic activity nodes
- Administrative and planning boundaries

Crucially, harmonisation must be prioritised. Differences in classification systems, coordinate reference systems and attribute fields should be resolved through a predefined standardisation protocol. Adoption of metadata structures aligned with FAIR principles supports long-term usability and interoperability (Wilkinson et al., 2016).

3.2 Layered Geospatial Architecture

All datasets should be georeferenced within a unified GIS environment and organised into structured layers. Such layered architectures reflect established approaches in planning support systems (Geertman & Stillwell, 2009). A recommended configuration includes:

- **Morphological Layer** – parcels, buildings, density and typologies
- **Mobility Layer** – street hierarchy and connectivity indices
- **Common Space Layer** – classification of accessible public and semi-public spaces
- **Socio-Demographic Layer** – geocoded population indicators
- **Environmental Layer** – green infrastructure and exposure metrics
- **Participatory Layer** – geotagged citizen inputs, drawing on traditions of volunteered geographic information (Goodchild, 2007)

This layered structure enables both intra-urban and cross-neighbourhood comparison.

3.3 Embedded Spatial Analytics

A Common Digital Model should move beyond representation and incorporate spatial analytics capable of revealing structural urban dynamics. Relevant analytical components include:

- Network centrality metrics (Porta, Crucitti, & Latora, 2006)
- Spatial syntax indicators capturing configurational properties (Hillier, 2007)
- Proximity and service-area analysis
- Land-use mix indices
- Accessibility scoring
- Green space per capita measures

Such indicators allow identification of spatial disparities and latent potentials. Analytical transparency is essential to ensure that decision-support systems enhance, rather than obscure, public accountability (Geertman & Stillwell, 2009).

3.4 Comparative and Diagnostic Capacity

An effective digital model should allow structured comparison between neighbourhood typologies, including urban and suburban contexts as well as territories embedded in different regional structures. Comparative diagnostics can reveal systematic differences in density, connectivity, environmental exposure, distribution of common spaces and accessibility patterns across metropolitan cores, peri-urban belts and more peripheral areas.

Such territorial comparison makes it possible to identify spatial asymmetries and regionally differentiated development trajectories. This comparative capacity strengthens the analytical basis for regeneration strategies and reduces the risk of uniform policy prescriptions across structurally distinct territories.

4. From Digital Model to Smart Urban Governance

The transformation of a geospatial database into a smart urban governance framework requires additional components beyond data integration. A Common Digital Model becomes operational when it supports participatory processes, scenario exploration and institutional learning, thereby linking spatial analysis to territorially grounded decision-making.

4.1 Participatory Integration

Digital platforms should allow residents to contribute geotagged observations, perceptions and proposals, integrating experiential knowledge into spatial analysis (Goodchild, 2007). Such integration strengthens the evidential base of planning by combining technical indicators with situated knowledge. When properly structured, this approach supports meaningful participation and helps avoid purely symbolic engagement (Arnstein, 1969).

Beyond data collection, participatory integration should be designed as a continuous feedback loop: citizen inputs inform spatial diagnostics, and analytical outputs are communicated back to communities in accessible formats. This reciprocity enhances democratic legitimacy and supports shared ownership of regeneration processes.

4.2 Scenario Simulation and Adaptive Planning

Scenario modelling enables testing of potential interventions—such as redistribution of green infrastructure, pedestrianisation strategies, reallocation of curbside space or activation of underused indoor public spaces—prior to implementation. By simulating impacts on accessibility, connectivity, environmental exposure and potential social interaction density, planners can evaluate trade-offs transparently.

This approach aligns with planning support system methodologies that emphasise structured comparison of alternatives and evidence-based evaluation (Geertman & Stillwell, 2009). Importantly, scenario modelling also facilitates adaptive planning, allowing policies to evolve in response to monitored outcomes.

4.3 Decision-Support Interfaces and Institutional Integration

Analytical outputs should be translated into accessible decision-support dashboards presenting key indicators, spatial disparities and scenario outcomes. These interfaces must be interpretable not only by technical experts but also by policymakers and non-specialist stakeholders.

Clarity and transparency are necessary to prevent technocratic opacity and to maintain alignment between digital innovation and democratic governance (Kitchin, 2014). Institutional integration is equally critical: the digital model should support interdepartmental coordination, linking planning, mobility, environmental and social services within a shared analytical environment.

5. Scientific and Policy Implications

A carefully structured Common Digital Model can contribute simultaneously to scientific advancement and municipal capacity-building, particularly in contexts where territorial disparities and uneven regional development require differentiated analytical tools.

Scientific Implications

- Development of replicable geospatial harmonisation protocols applicable across diverse administrative contexts.
- Integration of morphological, socio-demographic and environmental layers at neighbourhood scale, enabling fine-grained comparative analysis.
- Advancement of transdisciplinary digital urban methodologies that bridge spatial analytics and social research.
- Strengthening of evidence-based approaches to evaluating spatial configuration and social performance (Hillier, 2007; Porta et al., 2006).

Policy Implications

- Evidence-based prioritisation of regeneration areas through spatially explicit indicators.
- Measurable benchmarks for evaluating sustainability, accessibility and spatial inclusion.
- Enhanced transparency and accountability in decision-making processes.
- Support for long-term monitoring and adaptive governance cycles.

By embedding normative objectives—such as sustainability, inclusion and spatial quality—into measurable spatial indicators, planning discourse can shift from rhetorical ambition to operational accountability within data-informed governance structures.

6. Societal and Governance Dimensions

Integrated geospatial intelligence enhances democratic planning in several interrelated ways:

- Making spatial inequalities visible and measurable.
- Enabling informed public debate grounded in shared evidence.
- Supporting participatory co-design processes at neighbourhood scale.
- Reducing discretionary or arbitrary interventions by clarifying structural conditions.

Smart urban management should therefore be understood not merely as technological modernisation, but as governance innovation. A Common Digital Model can function as an instrument of institutional learning, supporting coordination across policy domains and reinforcing civic engagement.

7. Scalability and Replicability

For long-term impact, the proposed methodological architecture must be transferable across different territorial and administrative contexts. Scalability depends on:

- Modular data structures that allow incremental expansion.
- Open standards compliance and interoperable metadata.
- Flexible indicator frameworks adaptable to local policy priorities.
- Alignment with interoperable data stewardship principles (Wilkinson et al., 2016).

A Common Digital Model should therefore be conceived not as a fixed technical solution, but as a replicable framework capable of adaptation to cities of varying size, institutional capacity and data maturity.

8. Conclusion

Establishing a georeferenced Common Digital Model can provide a structured basis for more coherent smart urban management. The central challenge in smart urban management is not the absence of data, but the absence of structural integration (Kitchin, 2014). Cities already possess extensive datasets; what is required is a coherent methodological architecture capable of transforming dispersed information into actionable urban intelligence.

By linking morphology, mobility, environmental performance and participatory input within a unified geospatial framework, municipalities may move from reactive, sectoral interventions toward more proactive and evidence-informed governance supported by spatial decision-support infrastructures (Geertman & Stillwell, 2009).

In the context of contemporary European urban and regional transformation, such integrated digital approaches can support more resilient, inclusive and spatially coherent neighbourhood and territorial development. An exploratory comparison of contrasting neighbourhood typologies is expected to reveal differentiated structural profiles, where urban core areas may exhibit higher network integration and functional diversity but lower environmental provision per capita, while suburban territories may display greater green availability yet weaker configurational accessibility and lower land-use diversity. Such anticipated patterns illustrate how even minimal geospatial integration can make multidimensional territorial asymmetries analytically visible and support differentiated planning strategies without presupposing specific empirical outcomes.

To illustrate the analytical capacity of the proposed framework, an exploratory spatial comparison between contrasting neighbourhood typologies using open geospatial data can be undertaken, demonstrating how even minimal data integration reveals territorially differentiated patterns of accessibility, connectivity and environmental provision.

References

1. Arnstein, S. R. (1969). A ladder of citizen participation. Journal of the American Institute of Planners, 35(4), 216–224. https://doi.org/10.1080/01944366908977225

2. Geertman, S., & Stillwell, J. (Eds.). (2009). Planning support systems: Best practice and new methods. Springer. https://doi.org/10.1007/978-1-4020-8952-7

3. Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69(4), 211–221. https://doi.org/10.1007/s10708-007-9111-y

4. Hillier, B. (2007). Space is the machine: A configurational theory of architecture, e-edition. Space Syntax Ltd.

5. Kitchin, R. (2014). The real-time city? Big data and smart urbanism. GeoJournal, 79(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8

6. Porta, S., Crucitti, P., & Latora, V. (2006). The network analysis of urban streets: A primal approach. Environment and Planning B: Planning and Design, 33(5), 705–725. https://doi.org/10.1068/b32045

7. Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Mons, B., et al. (2016). The FAIR guiding principles for scientific data management and stewardship. Scientific Data, 3, 160018. https://doi.org/10.1038/sdata.2016.18