Artificial Intelligence and New Urban planning: Interpretative Paradigms and Impacts on Urban and Territorial Systems

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Abstract. Given the current widespread development of Artificial Intelligence (AI), it is now necessary, in all fields of human activity, to study in depth the characteristics, reasoning processes, and actual potential of different Large Language Models (LLM) in order to determine and verify their effective support for humans. Relying uncritically on digital agents can lead to incorrect decisions or outcomes that harm the community. The uncritical "admiration" of the "plausible" answers provided by artificial reasoners may generate new, altered, and potentially dangerous relational dynamics, as observed in the growing use of affective chatbots. In this period of change, scholars from every research field, including experts on urban phenomena, are called to promptly undertake three activities: to understand and formalize the impacts of AI on urban and territorial systems by redefining the systemic interpretive paradigm and evaluating potential transformations of the subsystem components; to prefigure a new governance process for urban and territorial transformations, considering the appropriate and verified adoption of AI in the individual phases and in the prefiguration of planning scenarios for anthropogenic settlements; to promptly analyze the "weights" and the energy-ethical, and socio-environmental implications of the new data-processing megastructures (data centers) indispensable for the development of LLMs. Along these three lines of reflection, comparisons and debates among urban planners should be organized, in light of the transformations already underway in many territories worldwide. The paper offers reflections on these three topics that contribute to defining a new dimension in the management of urban and territorial transformations, in which the human agent appropriately adopts, drives, and validates the support that new digital agents and artificial reasoners can provide to the discipline.

Keywords: Artificial Intelligence · New Urban Planning · Data Centers

1 AI and the Management of Territorial Transformations

Territorial governance in Italy is currently at a critical juncture, urgently requiring updated methods and procedures to handle urban and regional shifts. The Italian conventional urban planning, which relies on rigid, long-term prescriptive documents introduced by a regulatory provision that is often outdated, is no longer adequate. It simply

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O. Gervasi et al. (Eds.): ICCSA 2026 Workshops, LNCS 16765, pp. 549–559, 2027.
https://doi.org/10.1007/978-3-032-30536-7_35

cannot keep pace with the rapid socioeconomic, climatic, demographic, and geopolitical changes defining our current era. A territory is no longer just a spatial blank slate where planners assign functional land uses and try to guess at unpredictable future developments.

Rather, it is a complex, dynamic system that needs careful steering toward sustainable development, remaining mindful of available resources. Cities which serve as the testing grounds for humanity's future are dealing with simultaneous and often compounding forces that would have been unimaginable just a few years ago. Armed conflicts, climate-induced disasters, migration waves, rapid population ageing, and the restructuring of urban economies are driving these new dynamics. In Italy, these shifts carry a particular weight. Against this backdrop, AI acts as a massive catalyst for change.

The rise of AI is not merely a technological upgrade; it marks a fundamental ontological shift. Italian researchers and planners must quickly understand this change and figure out the best ways to adapt to it. Recent literature on AI's role in territorial governance (Fusero, 2024; Fistola and La Rocca, 2025) emphasises the need to deliberately weave AI into urban planning. However, this means we must rigorously test the actual benefits these artificial reasoning systems can offer in practice.

Used correctly, these digital agents can play a decisive, active role in forecasting. They have the potential to contribute across all stages of the planning process, helping to navigate environmental complexity while opening up new avenues for democratic involvement in urban decision-making.

Academic discussions point to the need for a fresh methodological framework (Zingariello & Fistola, 2025). Instead of passively accepting AI outputs, planners should use the technology to build dynamic scenarios that fully acknowledge systemic complexity (Batty, 2018). Today, we have access to massive, multi-layered datasets describing human settlements. The challenge lies in extracting real meaning from this data, which is absolutely essential for prying open the algorithmic "black box" and ensuring both transparency and accountability.

2 Three Tasks for Urban Planners

Innovation Technology (IT) has always represented a driver for the development of human settlements (Batty, 2018).

The history of human evolution can be easily segmented by considering the technical and technological advancements that have progressively allowed us to experience increasingly complex activities.

In some cases, technological innovation has produced true "entropic watersheds," exponential advancements in a very short amount of time: from the Egyptian seed drill to the Internet network.

In general, it can be stated that technology represents a complexity generator in social systems that also fuels the progress of human settlements

Recently, the ability to use technologies capable of ensuring relationships and communication flows in the city was vital, as in the case of the global Covid-19 epidemic (Fistola & Borri, 2020), which transformed urban and metropolitan aggregates into ghost

towns due to the lockdown extended to all inhabitants, but nevertheless allowed almost all human activities to be carried out

Today, digital network infrastructures represent the true nervous and lymphatic system of the city, which bases a large part of its economy on the production, processing, and exchange of data.

The birth of the smart city, although initially driven by large digital multinationals, is strictly connected to the exchange of data in urban contexts and the birth of the Internet of Things (IoT).

Only a few years ago, we witnessed the latest anthropic watershed, which will characterize the entire global economic structure of the near future. The acceleration induced by the spread, in November 2023, of the first Artificial Intelligence Large Language Model produced a disruption in all areas of human activity and, consequently, also on human action and interaction in the city. Thanks to the use of artificial intelligence, the organization of work, economic processes, social relations, and more are progressively transforming.

Scholars of urban phenomena, urban planners, and city administrators have always had to chase technological change, as in the case of the smart city, elaborating ex-post methods and procedures for IT adoption (Fistola & Ronsivalle, 2017).

The capillary spread of AI and the sudden diffusion of this innovation shorten adaptation times, requiring a total change in perspective and the elaboration of new dimensions of action. Modern urban planners are therefore called to a complex commitment that primarily involves the in-depth study of new LLMs and their operational processes.

The acquisition of solid and dynamic knowledge of the new technology must allow for the appropriate adoption and inclusion of AI in the methods and governance processes of territorial transformations, including those determined by AI itself (Fistola & Zingariello, 2025). In summary, considering the reflection this study intends to propose, it can be stated that urban planners must commit to three main tasks:

- Identify, choose, and/or reconsider the interpretative paradigms of urban transformation that consider the characteristics and potential of AI.
- Understand how to effectively adopt and integrate AI in the processes of prefiguring and governing urban development.
- Evaluate the new functional weights generated by physical infrastructures, and in particular the substantial use of (ecosystemic) resources necessary for training and maintaining LLMs across various urban components.

This last topic, which deserves specific and more extensive reflection, informs a task that urban planners must take on today, which is attributable to the appropriate territorial location of data centers (DCs). This commitment is of significant importance, also considering the enormous funding supporting the development, updating, and spread of new LLMs all over the world.

3 Task 1: The Systemic Approach. A New Dimension of an Old Way to Construe the City

The need to understand the new dynamics of urban systems, determined by the significant phenomena characterizing their current historical phase, has led to a new formulation of "systems thinking" (Fistola and Pennino, 2026). Today's city can be likened to a dynamic and complex system for which it is necessary to develop a control methodology to appropriately guide its evolution.

Being a complex system, it must necessarily involve continuous evolution and transformation, which places it among chaotic systems (Packard, 1998). In other words, the city can be interpreted as a dynamically complex system that evolves in space and time, requiring the preparation of appropriate governance procedures for transformation and development that are attentive to sustainability and compatibility with available resources. This definition stems from many years of study in the social sciences and complex systems (Miller & Page, 2007). By adopting a systemic approach, it becomes possible to model the components of the urban system and their active relationships, outlining a multidimensional organizational framework for urban planning. The need to adopt new paradigms for interpreting urban processes derives, as emphasized, from the observation of the substantial failure of the models adopted so far for the organization, management, and planning of human settlements.

As has happened in many fields of science, particularly in physics with quantum mechanics, considering the possibility of a different operating principle for phenomena, going beyond canonical laws, can open new dimensions in urban research. Briefly, it can be stated that cities can be seen as complex systems of interactions between people, infrastructure, economy, and environment. These systems exhibit non-linear dynamics and multiple, sometimes overlapping, emergent behaviors that make it difficult to predict their evolution over time, which is the main activity of urban and territorial planning.

The city can therefore be studied, interpreted, and probably completely assimilated into a complex system, not because of its foundational condition, but as a biotope of complex systems, a habitat of connected structures, and a settlement space for dynamic relational organizations. Adopting the systemic approach alongside complexity theory to govern urban development in a sustainable manner and compatible with available resources represents one of the most interesting possibilities currently offered to scholars of human settlement sciences. As Tullio Tinti points out: "Complexity theory is the multidisciplinary study of complex adaptive systems and the emergent phenomena associated with them" (Tinti, 2011).

Complex systems are chaotic and generally dissipative systems, in the sense that they use and dissipate energy. In this regard, I. Prigogine's reflection on the relationship between city and countryside appears illuminating. In his text entitled *The Laws of Chaos*, he writes: "The simplest example of a dissipative structure that can be evoked by analogy is the city. A city is different from the countryside that surrounds it; the roots of this individualization reside in the relationships it maintains with the adjacent countryside, if these were suppressed, the city would disappear" (Prigogine, 2008). Considering the city as a dynamically complex system (Papa et al., 2021), it is possible to identify a certain number of components and interacting subsystems (Fig. 1). The adoption of this paradigm leads to the ability to evaluate: on the one hand, the impacts that AI

produces on the subsystems and to understand ex-ante how it causes their transformation; on the other, how AI can contribute to formalizing the interactions that are generated between the different subsystems and their components, succeeding in defining urban transformation scenarios more adherent to the future urban structure.

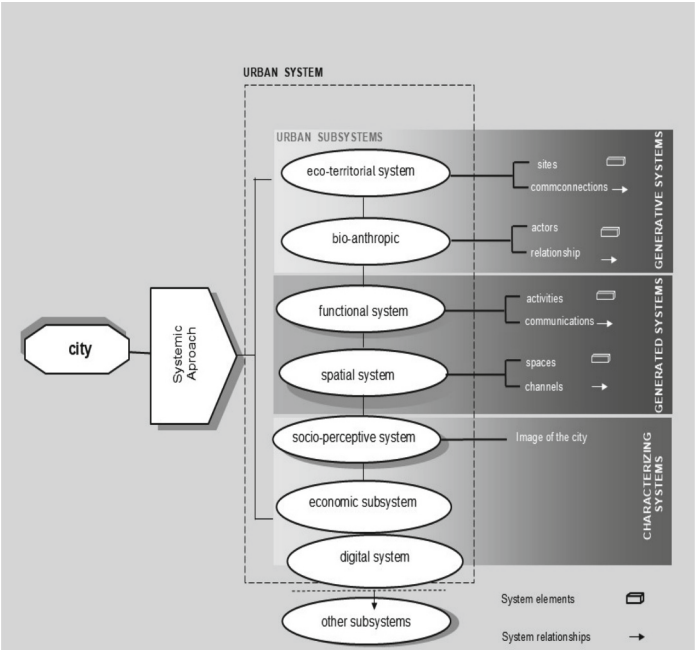

Fig. 1. The city interpreted as a system composed of subsystems

4 Task 2: AI in the Managing Cycle of Territorial Transformations

The need to govern the sustainable development of the urban system over time and space leads to adopting a cyclical process derived from systems control, used in cybernetics. This process can be divided into three fundamental phases, with a final feedback step represented by monitoring the system's evolution: knowledge, decision, and action.

In the knowledge phase, AI and Machine Learning systems revolutionize the acquisition and analysis of spatial and socio-economic data. Automated analysis allows for the rapid production of urban economy reports and the decoding of functions established within the territory. Through the processing of demographic big data and the use of advanced pattern recognition models applied to satellite imagery and point clouds, the automatic recognition of buildings, trees, and infrastructure is now possible. This is accompanied by crucial predictive analyses, such as estimating urban growth, simulating climate impacts, and forecasting socio-demographic dynamics.

In the decision phase, generative and evaluative models support development strategies. AI enables the automatic definition of transformability maps by integrating complex

data regarding territorial constraints, as well as supporting scenario simulations through the use of Urban Digital Twins (UDT).

Finally, in the action phase, computational power is translated into implementation. AI facilitates comparative analysis to select the best development scenario in strict compliance with political-administrative guidelines, assisting the planner all the way to defining technical standards and automatically drafting urban regulations. This is an interesting aspect regarding assistance in drafting regulatory provisions, made possible by training large language models on local regulatory corpora. This leads to a faster definition of technical implementation rules and the automated generation of environmental impact assessment matrices as well.

The behavior to maintain with the digital agent plays a fundamental role in the widespread adoption of artificial reasoners in the territorial transformation governance process. Enthusiasm for the machine's prefigurative capabilities must be tempered by a solid methodological foundation, which must precede any operational implementation in professional practice. To briefly describe the interaction between the human agent and the digital agent, the Choice-Dialogue-Check (CDC) cycle was introduced within the broader Urban Territory Transition Model (UTTM). This cycle involves three phases containing a series of actions that the urban planner must implement in their "relationship" with the artificial reasoner.

Choice: in this initial phase, the urban planner must select, after having previously learned and studied the vast and constantly evolving landscape, the LLM most suited to the activity they are undertaking and the purpose they intend to achieve. Therefore, a near LLM (vertical model) must be identified, whose knowledge domain is specifically characterized by descriptive tokens and variables of urban planning activity (Fig. 2).

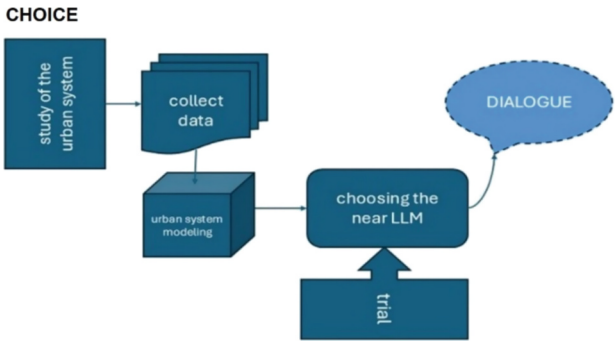

Fig. 2. The steps that make up the choice phase

Dialogue: this is the phase of dialectical interaction with the machine. This phase branches out into three sub-phases: profiling, prompt construction, and guiding the chain of reasoning. There is no space here to describe these sub-phases in detail, but suffice it to say that in the first, the reasoner is told the role it must assume in providing answers; in the second, questions are constructed by specifying what must and must not be provided; in the third, the machine's reasoning is progressively guided by considering the chains of thought developed and the answers progressively provided (Fig. 3).

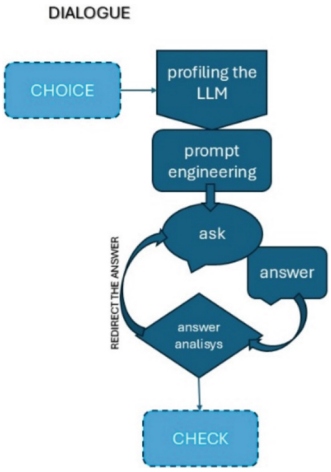

Fig. 3. The steps that make up the dialogue phase. The "Choice" and "Check" blocks represent the input and output of this phase

Check: this final phase informs the rigorous human validation of the provided answers, distinguishing the true from the plausible and identifying and declaring any hallucinations and biases they may contain (Fig. 4).

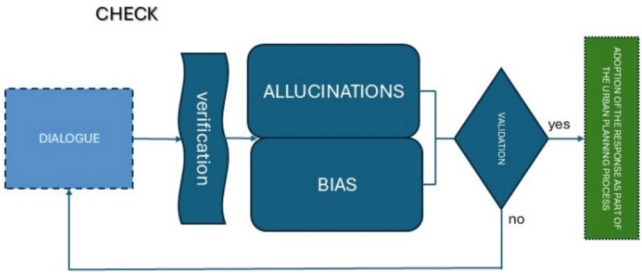

Fig. 4. The phase of checking the oriented responses provided by the artificial reasoning LLM. The green block represents the end of the cycle

It seems appropriate to point out that the use of AI can also effectively intervene in the final stages of the governance process for urban and territorial transformations, particularly in the phase of communication and support for understanding the plan. Already in the decision-participation phase, by operating in an ethically evaluable manner, it is possible to consider using chatbots to gather collective sentiment in order to formalize the emotional perceptions of citizens, transforming them into useful data to guide public decisions in a more inclusive way. However, this requires strengthening the public governance of urban algorithms, which must rest upon three pillars: the traceability of algorithmic decisions, continuous independent audits, and democratic public access to datasets and predictive models. Regarding communication, the creation of digital agents capable of conversing with the population to describe the forecasts of the governance

tool is an active field of research (Holland & Miller, 1991) and represents one of the activities developed with commitment by Italian researchers for many years now (Fig. 5).



Fig. 5. An initial experiment from 2010 on the creation of virtual agents
Source: Fistola, R. (2010). "Virtual Agents for Urban Planning Communication".

5 Task 3: AI Training Factories

The ethical and energy issue connected to the spread of AI represents perhaps the main problem of the new technology, which also produces significant impacts on the territory and the manifestation of new and justified forms of the NIMBY syndrome among populations. The energy demand and water consumption for the operation of Data Centers (DCs), the nerve centers of the new digital society, present worrying figures. In many countries around the world, enormous investments are driving the creation and establishment of these new territorial infrastructures, sometimes outside of any locational rules.

We are witnessing a rapid phenomenon of polarization of investments with a massive concentration of capital towards areas with ultra-resilient power grids. In 2026, it is estimated that data centers will absorb about 2% of global electricity (TTMS, 2026), creating tensions on local tariffs for citizens. In the United States, where there are approximately 4,000 DCs, the price is also borne by local communities, as they are potentially public infrastructures. In this way, the price of energy rises, the community pays for it, but the extra energy is used by AI companies. In a sense, the economic value produced

through the exploitation of the territory's material is transferred, in an immaterial way, through data, elsewhere. An indicative example is the current commitment of META in Louisiana, where it is building a $3 billion power plant for the needs of its DCs.

In Europe, different experiences can be found. In Ireland in 2023, DCs consumed more energy than all the homes in the nation (Coin, 2025). In Italy, referring to the research conducted by the Polytechnic University of Milan, there are currently about 200 data centers, almost all located in the northern part of the country. In the Milan metropolitan area alone, there are 33 active data centers, equal to 67% of the total 49 in Lombardy. These are infrastructures distributed across 32 municipalities in the Milanese metropolitan area. These infrastructures, present in the Milan area, alone represent about 68% of the installed capacity at the national level, equal to approximately 414 megawatts.

The location of a data center can no longer be dictated solely by land market logic or proximity to fiber optic backbones but must respond to criteria of "territorial symbiosis". The data center must become an energy donor (waste heat) for district heating or adjacent industrial processes, transforming a negative externality into a circular resource. The territorial location criteria for DCs must be codified within national urban planning regulations and adopted by regional legislation. It is not difficult, beyond specific technical and disciplinary matters, to indicate a series of actions that must inform the locational decision of new energy infrastructures:

Use abandoned industrial areas or defunctionalized sites that avoid land consumption and can potentially utilize already existing infrastructures and underground services. Consider territories with low mean annual temperatures to drastically reduce the need for active cooling and the consequent water consumption. Plan for synergistic district heating systems, favoring their location near urban or agricultural districts that can reuse the waste heat. Emerging examples in 2026 include data centers in Sweden that heat entire residential areas through thermal recovery.

Utilize alternative energies by establishing and connecting the DC directly with wind and/or photovoltaic plants in order to lighten the energy demand from the public grid or even act as a storage battery to stabilize the grid during peak times. Locate DCs in areas where it is possible to use treated wastewater or zero-consumption closed circuits. Similarly to the location techniques for plants with high territorial vulnerability (Fistola & La Rocca, 2017), it is important to map the infrastructures that host sensitive population groups, such as schools or hospitals, and consider the acoustic impact and potential electrosmog. Furthermore, analyzing the local economy allows one to foresee induced employment and any potential synergies with energy communities.

A brief concluding note is necessary to point out two contiguous fields in which research is developing interesting projects. The first concerns the possibility of developing Open Source LLMs open to collective use. In this context, the European project Apertus should be noted; a European LLM developed in Switzerland and trained using the Alps supercomputer cooled by the lake's temperature, which is totally open source regarding the data used to train it and respects European AI regulations. It was created as a digital public infrastructure for researchers, businesses, and citizens, offering an ethical and transparent alternative to closed US or Chinese models.

Apertus is a large language model officially launched in September 2025 through the collaboration of the main Swiss scientific institutions: the EPFL, the ETH of Zurich,

and the Swiss National Supercomputing Centre (CSCS). The main features of this LLM are: Total Transparency: unlike many models defined as "open source" that release only the final weights, Apertus is a completely open model. The code, model weights, and training procedures are made public.

Size: the model has 70 billion parameters, a scale designed to balance high performance and manageability compared to giants like DeepSeek (about 700 billion). Multilingualism: it is designed to be natively multilingual, covering over 1,800 languages, with a focus on data sovereignty and European cultural inclusiveness. The other area in which intensive work is being done is energy saving. In fact, to save energy, it is also possible to act directly on the algorithms through neuromorphic computing, designing new computer architectures equipped with transistors that save energy by behaving like neurons and modifying themselves according to light, rather than electrical, stimuli they receive.

Moreover, so-called “in-memory computing”, without data transfer, saves a lot of energy. The possibility of using live neurons in computers, the so-called bio-chips, is the current frontier. The biological computer that uses neuronal processing for computing consumes much less energy.

6 Conclusions

AI is an achievement of technological advancement towards which we must not adopt an attitude of excessive concern, considering that the positive or negative use of technology is always a prerogative of human free will. It is essential that territorial governance maintains human supervision (Human-in-the-loop) to validate that the proposals generated by AI are consistent with the public good and not just with the optimization of a single parameter. In any case, it must be strongly reiterated that AI must be studied, ethically adopted, and taught to new generations, highlighting its potential and risks. In China, 200 billion dollars have been invested in AI. Thanks to this funding, in 2024 AI is being introduced and taught as early as middle school, and consequently, 12-13-year-old students are then able to program and design robots with AI.

The conscious adoption of new technologies can lead to envisioning a dynamic and integrated process for governing territorial transformations, warding off the risk of a dangerous automated urban planning, alongside the emergence of Urban Planning Service Companies, which are already spreading in Italian territories hosting small municipalities.

Today, it is necessary to consider the territorial impacts of the new power and survival infrastructures of AI on the territory and to pay the utmost attention to the ethical and energy implications of digital transition. These new places of production, for which mature formalizations of "territorial weight" do not exist, present massive energy consumption and significant physical impacts that the urban planning discipline must be able to govern. In conclusion, it is worth emphasizing and acknowledging that this paper focuses primarily on a theoretical reflection on the relationship between artificial intelligence and urban planning, without referring to empirical processes or real-world case studies. However, the paper aims to highlight the current lack, in this specific field, of a theoretical framework that could serve as an initial roadmap for urban planners. In other

words, it seems necessary to define a framework for reflection that can avoid (as has already happened in the case of the Smart City) chasing after and refuting definitions developed in contexts far removed from scientific research. Future research must, in any case, focus on the empirical validation of the proposed methodology, also with the aim of defining a new dimension of city and territorial governance. Between mind and algorithm (Zetti & Martino, 2025), the future of urban systems will depend on the ability to understand and consciously adopt AI not as an infallible oracle, but as a powerful tool for exploring the complexity of the contemporary city and prefiguring sustainable developments for the future structures of human settlement.

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