

FRANCESCA SILVIA ROTA
CITIES AS COMPLEX SYSTEMS. A PLANNING PERSPECTIVE

I am really thankful to Centro Einaudi, Fondazione CRT, and the Departments of Economics of the University of Turin, Cognetti De Martiis and ESOMAS, for giving the opportunity to this speech.

Several years had passed since the first edition of the award was established in 2012 to honour the memory of my father, Giorgio Rota, who was Professor of Political Economy at the University of Turin and a leading Economist at the Centro Einaudi.

It has been a long path to get to this 11th Edition of the Giorgio Rota Conference. Up to nowadays, 33 young emerging scholars from prestigious Universities and research institutes in Italy (Torino, Milano, Firenze, Roma, L'Aquila, Cagliari), Spain (Madrid, Barcellona), Portugal (Lisbona), United Kingdom (York, Bristol, Manchester), France (Paris, Toulouse, Clermont-Ferrand), Belgium (Ghent), Germany (Bonn, Friedrichshafen) and Austria (Linz) have already been awarded (see Table 1) and their contributions are all published in the “Quaderni of the Giorgio Rota Award” series, available for posterity.

To give a flavour of this relevant scientific production on different aspects of the contemporary economy, Table 1 shows the list of the papers awarded in the different editions of the award.

**TABLE 1 • EDITIONS, THEMES, AND WINNERS OF THE FIRST
11 EDITIONS OF THE GIORGIO ROTA AWARD**

<i>Ed.</i>	<i>Theme</i>	<i>Awarded Papers</i>
11 th	Urban Economies as Complex Systems	Léa Bou Sleiman, <i>Displacing Congestion: Evidence from Paris</i> Ilaria Malisan, <i>The effect of being a European Capital of Culture: Evidence from Matera</i> (co-author Luca Favero) Giacomo Rosso, <i>Local Economy Housing Prices and Neighborhood Change</i>
10 th	Labor, Value, Robots	Filippo Passerini, <i>Monopsony in Labor Markets: Empirical Evidence from Italian Firm</i> Ana Sofia Pessoa, <i>Earnings Dynamics in Germany</i> Eleonora Priori, <i>Simulating a basic income to cope with the technological transition: an agent-based model</i>
9 th	Main Economic Tendencies in the Contemporary World Economy	Martina Aronica, Caterina Sciortino & Pietro Pizzuto, <i>Covid-19 and tourism: what can we learn from the past?</i> Pietro Bompresni & Filippo Passerini, <i>Directionality of spillovers in Europe: Evidence from the EU sovereign debt Crisis</i> Luca Sandrini, <i>Direct and indirect effects of competition on private incentives to R&D and licensing</i>



8 th	Digital Transformation: Analysis of Economic Impact and Potential	Leonardo Madio, <i>User-generated Content, Strategic Moderation, and Advertising</i> Antonio Aloisi, <i>Hierarchies without firms? Vertical disintegration, personal outsourcing and the nature of the platform.</i> Moreno Frau, <i>Digital Transformation behaviors in the agri-food context: an exploratory analysis</i>
7 th	Rural Economies, Evolutionary Dynamics and New Paradigms	Federico Fantechi, <i>Spatial dynamics of community disaster resilience in rural areas. Evidence from Central Italy after the 1997 earthquake;</i> Georgios Manalis, <i>Land rights and risk-sharing in rural West Africa;</i> Stefano Menegat, <i>Montreal: Alternative Food Networks: Growing Niches or Paradigm Shift? Exploring the Case of U.S. Farmers' Markets Through a System Dynamics Approach</i>
6 th	The Economics of Health and Medical Care	Gabriel A. Facchini Palma, <i>Low Staffing in the Maternity Ward: Keep Calm and Call the Surgeon</i> Valentina Tonei, <i>Mother's health after childbirth: does delivery method matter?</i> Gianni Ghetti, <i>Model for the Estimation of Societal Costs for Pertussis in Italy</i>
5 th	Economic Consequences of Inequality	Bonk Alica Ida, <i>Capital account liberalization and inequality. The role of skill levels and financial depth</i> Kurmangaliyeva Madina, <i>Criminal Justice and Wealth Inequality. How much freedom can money buy in Russia?</i> Martínez-Toledano Clara, Dept. of Economics (Paris France) - <i>Housing Bubbles, Offshore Assets and Wealth Inequality in Spain (1984-2013)</i>
4 th	The Economics of Migration	Ainhoa Aparicio Fenoll e Zoë Kuehn, <i>Education Policies and Migration across European Countries</i> Simone Bertoli e Ilse Ruyssen, <i>Networks and migrants' intended destination</i> Xingna Zhang, <i>Analysis of interprovincial migration and its streams in China from 2000 to 2010 with extended and enhanced gravity models.</i>
3 rd	The Economics of Illegal Activities and Corruption	Riccardo Novaro, <i>Money laundering in the real estate sector: evidence from the Italian market at a provincial level</i> Lucia Rizzica, Marco Tonello, <i>Exposure to media and corruption perceptions</i> Angela De Martiis, <i>Shadow Economy, poverty and institutional quality</i>
2 nd	Creative Entrepreneurship and New Media	Fania Valeria Michelucci, <i>New media, financial resources and funding opportunities for creative entrepreneurs</i> Alessandro Gandini, <i>Social media e lavoro autonomo. Precarietà, lavoro gratuito, innovazione</i> Giovanna Santanera, <i>Afro-modernità in polvere: esperienze</i>
1 st	Contemporary Economics and the Ethical Imperative	Massimiliano Artoni, Matteo Del Popolo, Marco Guerci, <i>HRM Practices, Ethical Work Climate and Sustainability Perception. An Employee Perspective</i> Sarah Marie Hall, <i>Disjointed discourses of Ethical Consumption: Juxtaposing Consumer and Company Narratives</i> Patrizio Ponti, Federico Tabellini, <i>Sviluppo umano e sostenibilità ambientale: in cerca di una strada verso l'integrazione</i>

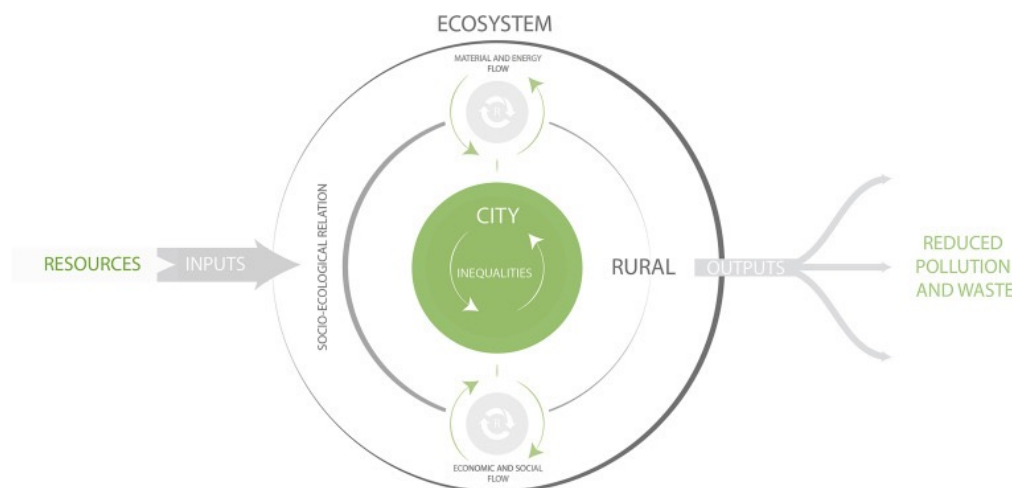


For the current edition, the aim was to reflect on urban economies as *complex systems*.

Pushed by continued systemic crises and the advent of the industry 4.0 technologies (data analytics, internet of things, cloud computing, additive manufacturing, cyber security, big data, advanced robotics, augmented reality, wearable technology, machine learning, and artificial intelligence), cities are evolving towards hyper-complex multi-layered webs of functions, that pose new challenges and ask for novel paradigms. To say with the philosopher Edgar Morin, we observe a “change of change” that determines a “new complexity of the complexity”.

In such a context, scholars from different scientific disciplines argue that theories and methods drawn from *complexity science* are more and more *urgent* to steer the development of cities (Bertuglia and Vaio 2019). Especially after experiencing the covid-19 pandemic, we observe increased general attention to the *liveability* of the urban systems and more frequent use of the metaphor of *urban metabolism* to describe cities as mutually interwoven self-organizing phenomena, evolving like *living systems* (Caldarelli *et al.* 2023).

FIGURE 1 • URBAN METABOLISM CONCEPT. SOURCE: LUCERTINI & MUSCO, 2020: 140



Source: Lucertini and Musco 2020, 140

However, applying to cities the biological analogy also presents some threats.

Firstly, it is sufficient to look back at the history of urban science to realise that the analogy of cities-living organisms arose long ago. To quote Bally and Marshall (2009), “ever since urbanists began to map and describe the city, the language of the human body has been widely used to describe urban form and to suggest ways in which cities might be planned”. Examples also are in the works of Leonardo da Vinci, Ebenezer Howard (1898), and Le Corbusier, who considered towns biological phenomena (Le Corbusier 1933; 1947).

Secondly, likening cities to organisms doesn’t allow urbanists to cope with the paradox that urban economies are systems *open* in some proprieties yet *closed* in others (Licata 2013) and the fact that cities do not follow a life-cycle developmental programme of birth, growth, maturity, decline, and death.



Thirdly, despite its popularity, the biological analogy has almost often remained implicit in the urban studies and unexploited in its practical consequences: barely anything more than a figure of speech without any direct application (Bally and Marshall 2009).

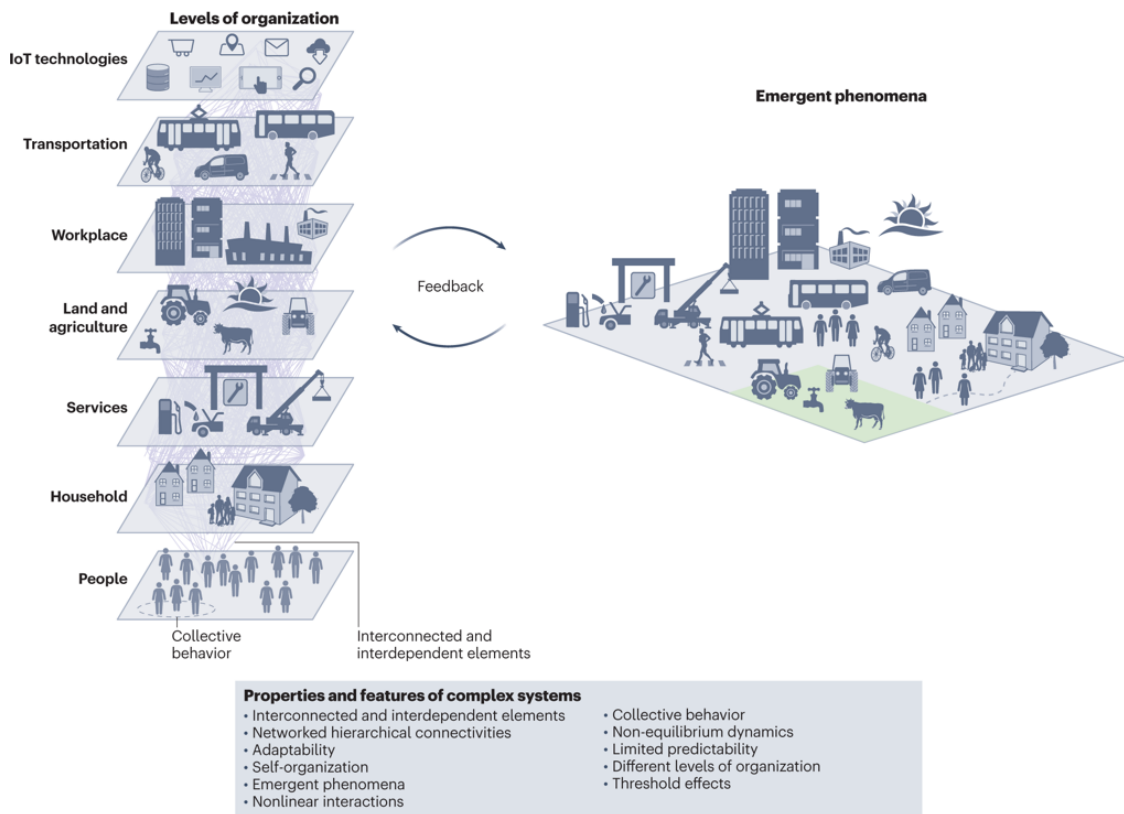
To overcome these limits and give operability to the biological metaphor, complexity science can make a significant contribution.

For instance, it helps planners to identify the role the different actors play at the different levels in the urban system: firms, entrepreneurs, managers, scholars, policymakers, and inhabitants. Figure 2 represents an example of how the city is conceived as a combination of different interacting layers, which gives rise to emergent properties such as clusters of communities and traffic patterns.

Also, it allows scientists to read the dynamics of the city and its interactions from an evolutionary perspective of short- and long-term.

Finally, it explains emerging complex proprieties of the urban economy such as: multi-level interactions and networks, self-organized dynamics, tipping points, and cascading effects.

FIGURE 2 • SCHEMATIC ILLUSTRATION OF A CITY AS A COMPLEX SYSTEM GENERATING EMERGENT PHENOMENA.



Source: Caldarelli et al. 2023, 377

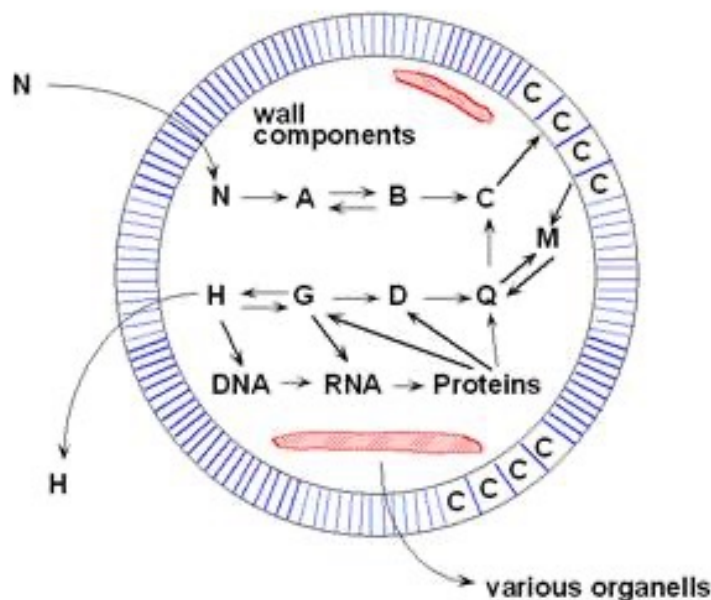


Considering specifically the perspective of urban planning, the recent developments in digital modelling, multi-agent simulation, digital twins of cities, and artificial intelligence are indeed making critical steps ahead in turning operative the analogy of the city as a living system.

The autopoiesis concept elaborated in the 70s by the biologists Humberto Maturana and Francisco Varela, in particular, is at the centre of a new consideration by urban scientists that assumes the form of a *new (planning) autopoietic paradigm*.

Autopoiesis is the property of cells to continuously regenerate and modify their inner processes to react to external influences, preserving structural integrity and the capacity of reproducing (see Figure 3). In the 90s, geographers, as well as planners, urbanists, and political scientists, started using this concept to describe some of the complex dynamics of cities (Dunsire 1996). Similarly to the functioning of the cell as an autopoietic machine (Maturana and Varela 1980), the city too continuously regenerates and modifies its inner mechanisms and processes to preserve from the external influences its structural integrity and the capacity of developing.

FIGURE 3 • THE FUNCTIONING OF A CELL



Source: Lusi 2006

Since the 90s, the autopoiesis concept has thus been diffusely used to describe the city as a self-organising, self-regenerating system, whose constituting parts interact with each other and the external environment via a continuous flux of goods and energy. It has also been used to acknowledge that cities, like other complex social systems, behave as unitary and autonomous collective actors (Dematteis 1994) that have an identity, an agency and a will of their own (Kostof 1992).



At the same time, however, the use of the autopoiesis metaphor often remained superficial. Although it undoubtedly had a pivotal role in the justification of the first experiences of participatory urban planning¹, it is in the light of the recent contemporary challenges of pandemics, climate change, soil consumption, and urban sprawl that we see the attempt of working exhaustively through the theoretical and operational consequence of the biomorphic metaphor for cities and city planning. And the way this attempt is carried out mainly involves the theories and tools of complexity science.

The features of this emerging autopoietic and complex approach to the conceptualisation of cities can be synthesised as follows:

- the city is conceived of as a collection of interdependent coevolving parts without implying there is a fixed relationship or an optimal mature form;
- the city is the result of an open-ended nonlinear co-evolution with the environment and the policy-making, which is unpredictable in the long term (Bally and Marshall 2009).

From a theoretical point of view, it helps re-interpreting existing experiences of policy making, governance and participatory urban planning (Chettiparamb 2020).

From an operational point of view, it helps reframing – via the Industry 4.0 technologies and a variety of modelling styles and types that have recently emerged – digital models of cities in an increasingly detailed and realistic way, so that they can be used in many practical purposes (Caldarelli *et al.* 2023).

Nevertheless, its application to urban theory and planning also suffers from some weaknesses that Caldarelli *et al.* (2023) ascribes mainly to the scarce availability of: data, computational power for large-scale computer simulations, interpretation of results, and determination of tipping points, as well as problem-solving routines and the fixing of systemic instabilities. Also, the fact that urban actors and stakeholders “interact through emergent phenomena such as social norms, individual emotions and personal history [that generate] a highly nonlinear co-evolution in response to environmental changes and governance inputs or related forms of decision-making” (Caldarelli *et al.* 2023, 379) turns the autopoietic approach hard to implement in a real-life urban context.

A solution can arrive from the *urban bioregion* concept elaborated² by the planner and territorial scientist Alberto Magnaghi (Magnaghi 2018; 2020a; Fanfani 2018).

According to Magnaghi (2018), an urban bioregion is a territorial local system constituted by:

- a multitude of settlements organised in a non-hierarchical network of cities that are mutually interconnected with their external rural environment in a specific, synergic, and multifunctional way (see the peri-urban region concept);

¹ Modern community planning developed in the late 19th and early 20th centuries when city governments and urban planners started creating centralized, comprehensive community plans.

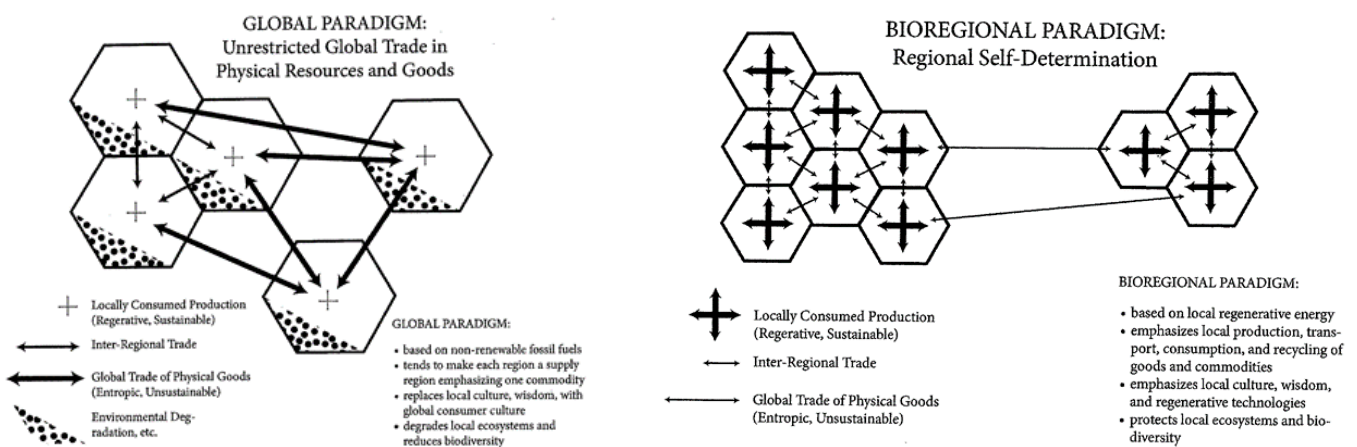
² Originally, the idea of an urban biology asking for a bioregional approach emerged in the North America in the 1940s-50s (Bally and Marshall 2009).

- a collection of rural and urban systems embedded in webs of residential, service, and production relationships;
- a diversified system of hydro-geomorphological and natural systems that coevolve with the urban and agroforestry systems;
- a place characterised by specific quality and lifestyle, identity, heritage, long-lasting ecosystem balance and the capability to self-reproduce.

The urban bioregion is a self-governed territorial system whose aim is its own sustainability and the well-being of the inhabitants. To fulfil this aim, the urban bioregion activates local productive systems based on the valorisation of the local capital of common environmental, territorial, social, and cultural goods and the promotion of environmental policies for the closing of the cycles of water, waste, food and energy (Magnaghi 2018).

In the bioregion, each city or cluster of small-medium sized cities coexists with its hinterland in an ecological, productive and social equilibrium that reduces congestion, environmental crises and pollution. In the urban bioregion, the endogenous factors influenced by the external environment are influenced also by their “remote scenario”, i.e. by their history and their evolution in time (Bertuglia and Vaio 2019).

FIGURE 4 • RELATIONAL MODELS BETWEEN REGIONS IN LOCAL DEVELOPMENT PROCESSES, ACCORDINGLY WITH BOTH GLOBAL (LEFT) AND BIOREGIONAL (RIGHT) PARADIGMS



Source: Thayer 2013 (quoted in Fanfani 2018, 63)

Magnaghi brings to synthesis the complex system theory and the autopoietic approach to re-frame urban policy-making, governance, and participatory approaches. Consistent with a territorial approach, the urban bioregion assumes the features of a complex living system where the living organisms (humans, plants, animals) co-evolve with their external environment and reproduce in a dynamic autopoietic way (Fanfani and Ruiz 2020, 38).



The strengths of this new planning paradigm are (Caldarelli *et al.* 2023, 379):

- it enhances knowledge (co-)creation, exchange and management at all levels of the government, civil society, the private sector and other relevant stakeholders;
- it increases the capacity to develop and progressively implement urban policies, offering participatory capacity-building processes;
- it provides networking platforms where all the actors of all levels can engage in the development process;
- it considers the endogenous factors influenced by external inputs as well as by their history and evolution.

Also, Magnaghi's urban bioregion provides urban planners and policymakers with:

- a tool to coordinate existing economic plans and strategies such as local communities, energy communities, local productive systems, food systems, green communities
- a tool to experience new solutions of self-efficiency, decarbonisation, and sustainable mobility, production and consumption.

In Magnaghi's view, the solution to the crisis of the contemporary urban model requires the planning of a highly interwoven network of urban villages and local communities (that are also energy communities and green communities) experiencing new solutions of self-efficiency, decarbonisation, sustainable mobility, responsible production, and consumption.

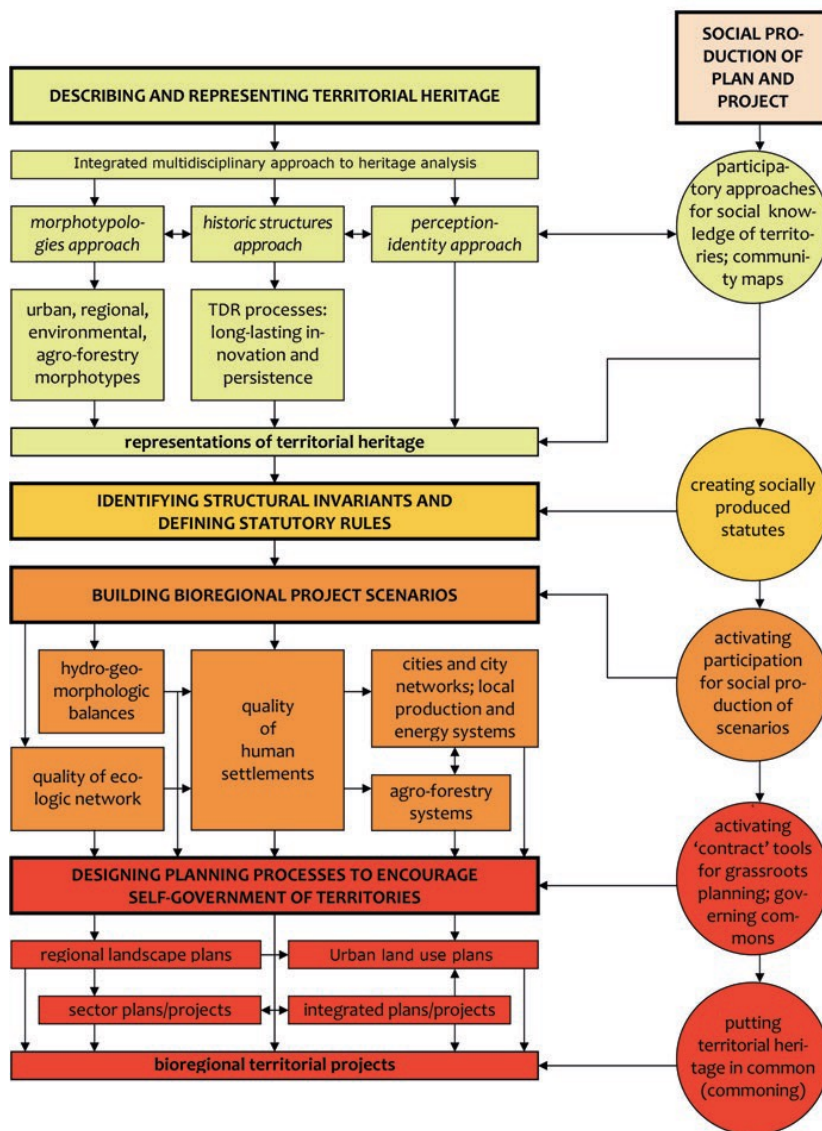
Another strength is the fact that the urban bioregion incorporates also the features of the external urban and non-urban systems as a missing desired value. This "neighbour microcosm" avoids the risk of "a world made of a sum of operatively closed autopoietic systems" that exchange a huge amount of goods, services, money, and information without effective communication and acceptance of their external environment (Dematteis 1996, 42). ??

The urban bioregion is thus an interpretative tool to critically re-conceptualise the current models of settlement, service and production in a new post-metropolitan perspective. Also, it helps to overcome the existing criticalities of the *metropolis* with practical decisions to:

- re-design the open spaces (agricultural, wooded, fluvial, natural) from a multifunctional perspective and in a framework of self-sustainability;
- complex re-design of the urban-centric networks;
- support urbanity and the urban self-government of the territorial structures and their relationships.

Although the literature on the subject is too young to make final statements, Figure 5 shows that the combination of the autopoiesis concept with the complex system approach appoints Magnaghi's urban bioregion to be a viable design process to combine urban policymaking, governance and participatory approaches, as well as to empower citizens and stakeholders.

**FIGURE 5 • DIAGRAM OF THE BIOREGIONAL DESIGN PROCESS
 DESIGN WITH TERRITORIES**



Source: Magnaghi 2020b, 43

In Italy, attempts to apply the urban bioregion are multiplying and involve, up to nowadays, the pivotal cases of Cagliari (Colavitti and Serra 2022), Firenze (Fanfani 2018; Fanfani and Duží 2019), Genova (Lombardini 2022), Torino (Ferlandino and Rota 2022), and Salerno (Panepinto 2022). The case of Torino, particularly, is emblematic of the opportunities linked to the urban bioregional approach. The city, in fact, has an urgent need for a new post-Fordist development paradigm to recover centrality in Europe and it hosts (in the so-called Corona

Verde; Figure 6) a large periurban concentration of productive green and rural spaces, which is ideal for testing the urban bioregional paradigm (Ferlaino and Rota 2020).

FIGURE 6 • LOGO AND AREA OF THE CORONA VERDE PROJECT



Source: <http://www.coronaverde.it>

In conclusion, we can say that the paradigm of the urban bioregion could unleash new promising paths of urban and territorial planning (Ferlaino and Rota 2022), especially in cities that are suffering from a long period of institutional immobility and closeness (as in the case of Torino). Particularly, this happens because it helps the reduction of soil consumption and urban sprawl, a new alliance with the natural environment, the reduction of metropolitan urban centrism, and the promotion of large-scale polycentrism, self-government, environmental connectivity, and accessibility.



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