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Urban ecosystems: Intersecting philosophical and biological perspectives in city analysis

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Abstract

How to address urban systems as biological entities has become a hot topic, especially since modern problems - such as climate change and urbanization - have emerged. A scientific approach to comprehending modern urban problems and the development of new technological possibilities to solve urban ecology-related problems can only be achieved, first and foremost, by blending the perception of urban systems with a biological framework. For this, it is necessary to understand and reconstruct the axioms of the organization of the human populations that create city systems. The main research question of this paper is whether urban systems can be studied from a biological perspective, and if so, to discuss the basic premise arguments for such a biological perspective, and the potential for these arguments to take concrete form for the study of the city system in a biological way. In this context, in this article, we have aimed to construct an abstract treatment of urban systems as biological phenomena. It is hoped that this work will open up new perspectives in the academic literature, which may help in the translation of abstract philosophical concepts into a biological understanding of urban systems.

Keywords

City, Phenomenon, Ecosystem, Survive, Paradigm

Introduction: Paradigms of Ecological Assessment of Cities

> *"Man is by nature a social animal; an individual who is unsocial naturally and not accidentally is either beneath our notice or more than human. Society is something that precedes the individual. Anyone who either cannot lead the common life or is so self-sufficient as not to need to and, therefore, does not partake of society is either a beast or a god."*
> *— Aristotle, Politics*

A lot can be written about cities. The history of cities, their architecture, the complex human relationships, wars, generations lived in cities... Cities are the places where many of the things that are engraved in our minds about human beings materialize. Small or large, they are places that bring people together, where exchanges of materials occur and human life are concretized, where boundaries become clear, and where the things we define as abstract come to the fore in a tangible form. In the modern sense, we come into contact with many elements of cities in our daily lives. We accept cities as concrete artifacts of human beings and treat them as such. However, cities are not just the interrelationships of people; on the contrary, human beings, like everything else, are included in the network of relations of the ecosystem with their bodies and actions; they are affected by the relations they are involved in and affect the relations they are in. This big picture of the interrelations of the phenomenon, which includes cities, is fundamentally a picture of *life*. Although interpreting cities from a biological perspective is not a fiction we often encounter in our daily lives, cities -like other biological structures- are part of the web of dynamic biological relations. Moreover, abstract changes in the way cities are conceived are essential if we are to deal realistically with the problems we face in the modern world since our abstract assumptions generate our lives in cities.

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The main research question of this paper is whether urban systems can be studied from a biological perspective, and if so, to discuss the basic premise arguments for such a biological perspective, and the potential for these arguments to take concrete form for the study of the city system in a biological way. It is hoped that this work will open up new perspectives in the academic literature, which may help in the translation of abstract philosophical concepts into a biological understanding of urban systems. In this context, in this article, we have aimed to construct an abstract treatment of urban systems as biological phenomena.

Modern cities face many challenges, one of which is, for example, climate change. Climate change is an ecological transformation that has an impact on urban systems (McCarthy, Best, and Betts 2010). The climate change we are currently experiencing is one of the countless climate changes in the history of the world, but it is the only one we know of that is directly linked to modern urbanization (Karl and Trenberth 2003; Satterthwaite 2009). Climate change and modern urbanization are transforming many vitality interactions in the biosphere and creating the ground for countless new relationships through changing ecosystem dynamics (Smith, Knapp, and Collins 2009). Like climate change, many problems such as migration problems, microbial problems, food problems, and energy problems, are emerging as a reality in modern cities (Baldwin 2017; Cohen and Garrett 2010; Pareto and Pareto 2008; Tiedje et al. 2022). How people are involved in ecosystem dynamics and how this involvement affects other bio-eco-related dynamics is closely connected to all these emerging issues (Alberti 2010; Alberti et al. 2003). At this point, a need for a holistic assessment of cities within the ecosystem becomes apparent.

The exact biological counterpart of humans and human artifacts in the biosphere is a multi-dimensional problem. Many disciplines need to be utilized to at least discuss and comment on this problem (Alberti et al. 2003; Pickett 2012). How do humans, as biological populations, relate to other living populations? Where exactly does the human being stand in the ecosystem, given that its ability to intervene in nature as a whole - both in non-human natural elements and in human nature itself - has reached these huge multi-dimensions? These questions call for a theoretically interdisciplinary system of thinking because every issue related to this problem is related to how human beings are *defined*.

Since humans are a species capable of producing multifaceted artifacts, it is necessary to consider human activities such as economic activities, social relations, politics, etc., and interpret human actions as a whole when including humans in a bioecological model (Grimm et al. 2008). Therefore, to understand ecological mechanisms occurring in urban areas - or other systems dominated by the human species - there is a need for overarching theoretical foundations that can explain the various human actional extents under a biological framework. These theoretical foundations, in turn, need to relate all fundamental human-related elements, especially the economic and social aspects of human beings, to biological-physical systems (Pickett et al. 1997). As different ecological relationships in different parts of the city are examined, the methods of studying ecological relationships and the paradigms used to interpret the exchange system of life that is currently functioning will also change. Naturally, there are paradigms for understanding ecological relationships in urban systems, with variations depending on the purpose of the study, and these paradigms interpret ecological relationships by considering cities from various perspectives(Pickett et al. 2016).

To give examples of the use of these paradigms, we can look at the different ways of addressing the ecological relations of the city at different levels (Pickett et al. 2016). *Ecology in the city* paradigm focuses on the ecological relations between plants, animals, microbes and so on within the city. This paradigm particularly focuses on areas within the city where the activity of the human species is less visible than the activity of other living things: parks, gardens, etc.In the matter of interpreting the city, we may want to direct ecological relations toward a fiction in which humans are involved. At this point, *the ecology of the city* paradigm is used to include human impact in the ecological dynamics of the city (Grimm et al. 2000): In this approach, the so-called human elements - economics, politics, culture, etc. - are included in the system of ecological relations and the city as a whole is treated as an ecological system. The justification for this is the assumption that human beings are basically biological organisms, and therefore the actions of the human organism, whose body is biological, will also be biological/ecological: Economy, politics, culture, urbanization, traffic, and technology are all part of the system of biological relations, and the city as a whole can be interpreted from an ecological point of view, including the actions of humans. *The ecology for the city* paradigm is used to place the city in a larger context than its own, to study how urban systems are situated within the biosphere and how they relate to external non-urbanized systems (Rozzi and Palmer 2013). In this way, the eco-biological aspect of cities within a larger system can be envisioned with a consideration of human-related factors: The acceleration of the melting of glaciers due to the impact of climate change accelerated by the industrial revolution on the biosphere, the increase in water levels due to the accelerated temperature increase will affect cities, even human migration due to climate/climate change, factories affecting the water and air structure and this transformation affecting agricultural systems.

Of course, as in any scientific discipline, paradigms provide an intellectual and axiomatic basis for doing work, in other words, for producing scientific knowledge, but in practice, it is possible to have blunt, soft work in which each paradigm is intertwined - more precisely, it is usually not possible to produce knowledge with a single paradigm in actual scientific work. Because in reality, every ecological/biological relationship in which humans are involved - or not - is part of another totality. Therefore, as mentioned at the outset, an integrated approach is also required to study human relations of the city from an eco-biological perspective (Grimm et al. 2008; Ramalho and Hobbs 2012).

At this point, we should not lose sight of the fact that the phenomenon being studied and understood - that is, the search for methods of evaluating urban systems within the biosphere as a human ecosystem - involves a new world of meaning for us (McDonnell and MacGregor-Fors 2016). Although the study of these areas has the advantages of technology and the conveniences of the modern world, such as the development of data systems, the variety of algorithms to analyze data, and the combination of different data sources, how to evaluate the available data is a problem of methodology and axiomatic approach. For this reason, scientific studies in this field undeniably need a set of meanings that will help to evaluate the existing data accurately and at the same time make meaningful predictions for the future, and thus address cities holistically. However, for such an endeavor - that is, for predicting the consequences of climate change and modern urbanization that we will experience over time and for constructing a holistic world of meaning to evaluate the data - we need to engage to understand the nature and evolutionary infrastructure of human population organization from the very beginning.

Axiomatic Foundations in Human Organization

Each of our interpretations of how urban systems will be affected in a changing and transforming world is fundamentally related to the organization of people as populations/masses. Ultimately, the fundamental force that creates cities is the organized action of people, hence human organization (Grimm et al. 2008; Portugali 2016). We can divide the basic motivations for human organization into various categories, social reasons - such as culture - political or economic reasons, geographical reasons... However, when we try to think more broadly, it is possible to see that underneath each of the motivations for organization, we can see more overarching unifying elements that have evolutionary underpinnings and are related to our animal behavior(Bejan 2020). Accordingly, the fundamental element that enables humans to organize en masse on a population basis is axiomatic, that is, abstract value judgments based on presuppositions, in other words, presuppositions (Kwantes and Karam n.d.; Wang 1996). Because basically, there are genetic and phenotypic transmissions that are evolutionarily transmitted and serve the survival and fitness parameters of the human population (Campbell and Tishkoff 2010; Chen, Krinsky, and Long 2013; Zhang and Long 2014), even if we do not categorize them with the help of language. The question of how these pre-assumptions are transmitted, whether they exist intuitively, etc., is of course a matter of curiosity, but the aim of this study is not to question this situation, but to build something on the assumption that there is such an organizational infrastructure. In other words, it is necessary for the construct put forward in this paper to recognize that the action processes of human populations are fundamentally shaped by their inherent assumptions and beliefs. Therefore, understanding the fundamental axioms that bring people together will enable us to understand the ecosystem structures in which people are organized en masse. If we can unravel these fundamental paradigms, we can unravel the foundations of the structures that people build in ecosystems.

In my view, of course, we have sufficient grounds to unify every organismal action on evolutionary grounds, but still, the idea that axiomatic thought has natural origins -and they are natural as well- is not new. At this point, we would like to give some aspects of this way of thinking from Santayana and Aristotle to provide examples of how we can intellectually connect abstract concepts with elements of life. For instance, with Santayana's method, it was possible to interpret the world entirely biologically while still having a deep appreciation for poetry, art, imagination, and religion (Cronan 2004). Santayana emphasizes that everything that is classified as abstract or concrete in human life has a common ground when he says, "The origin of beliefs and ideas, as of all events, is natural." (Saatkamp and Coleman 2020). He also argued "Belief in substance, I have seen, is inevitable" (Santayana 1923) based on this shared unifying principle and creates nodes that will bring unity to all existence, including the individual human and his thoughts, existence, and self (Cronan 2004). In fact, relating abstract concepts to the elements of life goes back even further than Santayana. Another example can be found in Aristotle. According to a biological perspective, Aristotle's ideas in De Anima appear to be a sound study of life. The dimensions of the soul are also the dimensions of life, he says, using the word "soul" to equalize the meaning of the word "live". Two things are required for a living biological entity to have a soul or to be considered to be alive: motion and perception. The soul is the first capability (entelekheia) of a natural existence; if there is life, then there must also be a soul. He says: “The soul is the principle of living beings.” (Aristotle 1994) He therefore strictly investigates life in his inquiries, perceptions, assessments, and classifications of the concept of soul, which is directly related to the life. Moreover, based on this basic assumpitons, he draw a natural picture of cities which because of the connection of cities to human life (Ambler 1985).

At this point, we can argue that the human predisposition to axiomatic thinking is biological. When evaluating human beings, we need to remember that individual and social processes of human beings are also included in evolutionary processes and that modern homo sapiens emerged on the scene in a historical process. The individual human being lives as a biological organism, both in terms of the human body and human place in the social organization (Bourke 2011). Therefore, we can conclude that structures such as city systems, which are the direct embodiment of human actions, are biological products of the human population. Therefore, to say that human beings are biologically distinct from other living beings living as populations would be a presupposition that has no realistic grounds for considering human beings within the biosphere. However, a presupposition that cities, which are built by humans coming together as biological organisms, should be considered in their context within the biosphere, like other living populations, has the potential to provide a realistic, biological, and scientific presupposition for studies on urban systems. It is based on this assumption that the axioms that sustain the biological existence of humans, pave the way for their actions, and provide the basis for them to come together and display social behaviors at the population level should also be evaluated from a biological framework. Just as the structures that are the products of human concrete actions - cities - are biological, the axioms that bring people together, provide a reference point for them to think, and enable them to build cities through their actions, which are the products of their thoughts, can also be considered within a biological framework. Therefore, since the determination of the axiomatic grounds of human behavior and the reference points based on this presupposition is involved in the biological actions of humans, city building behavior of the human population is also involved on biology.

The proposed axiomatic framework provides a foundational methodology for analyzing urban systems by redefining them as biological entities embedded within the broader ecosystem. By establishing fundamental axioms that govern human organization and interaction, this framework allows for a holistic evaluation of urban dynamics, integrating social, economic, and ecological factors within the same ontological plane. This approach overcomes the limitations of conventional urban studies, which often treat city components in isolation, by considering cities as complex adaptive systems where human actions, infrastructure, and environmental processes interact continuously. The axiomatic principles facilitate a unified understanding of urban phenomena, enabling researchers to analyze patterns of urban development, resilience, and sustainability in relation to broader ecological and evolutionary processes. By incorporating concepts such as feedback loops, interdependence, and systemic interactions, this framework can guide the development of predictive models for urban transformation, aiding in policy-making, urban planning, and environmental management. Ultimately, it offers a paradigm shift that aligns urban analysis with biological and ecological sciences, fostering a more integrated and adaptive approach to addressing modern urban challenges.

Using The Phenomenon as a Unifying Unit to Assess Urban Systems

For urban systems to be considered in their own right and unity with the biosphere, it is necessary to identify the phenomena that each system has within itself and to decide on the order and unity of their interrelationships. But this may not be possible despite advances in technology. Because no matter how large the data sets get, if dimensionality is not reduced and a meaningful picture is not built, the data will not be enough to understand the city system as a whole. This dimensionality problem arises not only when trying to understand the totality of cities, but also when trying to get information about any element of a city, for instance, sub-elements of cities such as waste water management, urban transport systems or vehicle design for smart cities also involve multi-dimensionality problems (Aina et al. 2012; Bahabry et al. 2019; Hajduk and Litavniece 2019). Because it seems to me that the first and most fundamental thing that is necessary to evaluate city systems, to take a stand against the uncertainties that lie ahead, is to identify the principles of a system of thinking that can deal with all phenomena topologically on the same plane. To do this, we must first define the nature of the phenomenon to use in our context, which is the urban systems, and do so in an axiomatic setting. Presuppositions are needed to construct a method in which both human actions and those of other elements of the biosphere can be considered on the same plane, and in which the problem of multi-dimensionality can be reduced.

We argue that in order for city systems to be considered as a whole, the nature of the phenomenon must first be defined for this purpose. We tried to construct some axiomatic approaches to describe the nature of phenomena. These principles should be taken as the basis for describing *the conditions* - including the context of the phenomenon and reference points to determine the exact location of the events-, *the process* and its steps, and *the possible outcomes* such as some possible aftermath or possible creation of a successfully living city in harsh and uncertain conditions:

1. There are/can be domains/situations where all phenomena share the same ontological *(to become, make reality)* context.
2. Engaging in activity is the ontologically common context of phenomena.
3. Phenomena reveal/create their mutual subjective effects according to the common context between them, and they are capable of continuing the process.
4. The effect of each phenomenon on the other is subjective/relative according to the context between them.
5. The processes of mutual influence of phenomena are continuous.
6. In the process of mutual influence, the subjective qualities and quantities of phenomena are determined/defined according to the context and purpose.
7. Therefore, phenomena have the authority to act. As a result of its activity, each phenomenon experiences the reaction generated by the other phenomenon(s).
8. The totality of phenomena is relative.
9. The totalities of phenomena are interdependent with each other.
10. The totality of phenomena and their actions can only be complete concerning one or more contexts and one or more reference points. In other words, the totality of phenomena and their actions cannot be defined as autonomous by itself.
11. Unless there is an effect, a phenomenon comes into existence out of nothing or disappears from existence by itself.
12. Therefore, phenomena are in *a state*.
13. The results of the activity of phenomena always constitute a quality(s) that can be measured and experienced by the phenomenon(s) in itself and across the other phenomenon(s).

The principles described above may seem too abstract to apply to city systems. But in reality, human beings are biological creatures that form animal organizations, and they live in cities in a way by concretizing many abstract constructs in their minds to maintain survival and fitness (Figure 1). We suggest that, if we can somehow build from the ground up the way each phenomenon is handled, our approach to ecosystem dynamics and city systems will change. We am convinced that such an approach can solve many complex problems before they start. Consequently, if we could try to understand city ecosystems including all components such as the economical activities of humans or biodiversity of the urban systems, we would not have to unify the distinctions we made via this preassumptions. Although we cannot say that these distinctions are unnecessary, in terms of the problems that modern cities face, we would argue that making these distinctions at the outset prevents us from finding more complete solutions. So we suggest that it is the distinctions made at the outset that is at the heart of the unpredictability of complex problems such as climate change, urbanization, energy systems, etc. For instance, the effort to match data from the social sciences with the ecological nature of cities, despite the abundance of data available, is hampered by the singular treatment of each phenomenon, which prevents us from understanding predictions and human actions in the context of the ecosystem as a whole. Instead, if we can consider each phenomenon – such as phenomena that will be caused by environmental factors, or the dynamics of the ecosystem itself, its biodiversity, etc. - within the framework of the principles it is mentioned above, we can form more realistic and holistic insights about the ecosytems of cities. In other words, even understanding urban systems as ecosystems depends to a certain extent on data and technological elements, the ability of these data and technological elements to make sense of city systems within the ecosystem is limited only by their ability to provide data and make tools, but it is the way of thinking that can make a contribution to making sense.

To better grasp these abstract principles, it may needed to translate them into more concrete examples and real-world applications. One way to do this is by relating them to observable phenomena in urban systems, ecosystems, or social interactions:

1. Shared Ontological Contexts: We can think of cities as spaces where various elements—humans, infrastructure, nature—coexist and influence each other under a unified framework, such as urban planning or environmental regulation.
2. Engagement in Activity: The interaction between different urban components, such as transportation, economy, and social behavior, illustrates how activity sustains urban life.
3. 3.Mutual Subjective Effects: Traffic congestion in one area may influence business productivity, while economic growth can impact migration patterns, showing how phenomena create effects within shared contexts.
4. Subjective Influence Based on Context: The impact of urban policies varies depending on socio-economic conditions, much like how the same law may lead to different outcomes in different neighborhoods.
5. Continuous Processes of Influence: The climate impact of industrialization, migration due to economic opportunities, or changing land use policies illustrate the ongoing interplay of different urban phenomena.
6. Context-Dependent Qualities of Influence: A city's public transportation system might be efficient in one context (low population density) but inadequate in another (high population density), showing how effectiveness is shaped by circumstances.
7. Phenomena as Active Agents: Human-driven urbanization transforms landscapes, just as ecosystem changes (e.g., deforestation) reshape biodiversity and living conditions.
8. Relativity of Totality: The "completeness" of a city or an ecosystem depends on what is being measured—economic success, environmental health, or social cohesion—illustrating that no totality is absolute.
9. Interdependence of Totalities: A city's economy is linked to its education system, healthcare, and environment, demonstrating how different systems rely on each other.
10. Context-Dependent Wholeness: A city is only fully understood when analyzed in relation to its historical, economic, and ecological conditions, just as a biological system is shaped by external factors.
11. Necessity of Influence for Existence: No urban phenomenon arises without cause—population growth, infrastructure expansion, or cultural shifts all stem from underlying influences.
12. The State of Phenomena: Cities exist in fluctuating states of growth, decline, renewal, or crisis, much like living organisms transition through developmental stages.
13. Measurable Outcomes of Phenomena: The success of urban policies, environmental interventions, or technological advancements can be quantified through metrics like air quality, GDP, or biodiversity indexes.

How the data and technological elements can be used is first and foremost a problem of methodology. Even if existing methods are successful to a certain extent, there is at least the phenomenon that existing methods are incomplete in that they are based on singular points when incorporating urban systems into ecosystem elements. But we argue that the main reason why existing methods cannot evaluate cities as a whole is in the assumptions that underpin the action. The incompleteness of existing methods, at least in terms of incorporating urban systems into ecosystem elements, is based on the fact that they act from singular points. But because there is an initial ontological distinction between these individual elements, on the paradigmatic side, there is a lack of insight into how the interaction of these elements will play out in the ecosystem. For instance, defining a linkage between an economic factor, such as the GINI index which describes the inequality by measuring the gap between rich and poor in a county (Frank A. Farris 2010), and a biodiversity factor in cities - such as the social behavior of cockroaches - in terms of their relationship on ontologically common ground, would provide a comprehensive network to understanding the relations in the cities. If we can construct this phenomenon by which we can judge the cohesion of these relationships, and if we can concretize the action-response between them, our network analyses will be transformed by this new paradigm and it will provide us with more realistic information about the future of cities. With current approaches and paradigms to evaluate urban systems, even if there would studies of the relationship between economic factors and cockroaches, such studies were data-providing studies. In other words, by studying each relationship individually, information can be gathered about complex structures such as city systems, but the sum of these information is an incomplete collection of data that will not tell us the place of city systems in the ecosystem (Figure 1.A.). This creates a multidimensionality problem because these problems are based on the assumption that the data are in different dimensions. But, if we accept that these data have the same ontological basis for biological treatment, then the social elements of cockroaches and the economic elements of humans would have the same topological projection in terms of ecosystem dynamics (Figure 1.B.). Of course, data and technological tools are needed to materialize such a presupposition, but this is not fundamentally a technological process, rather a process of changing the ground for axiomatic thinking. Therefore, a new set of pre-assumptions is needed to reconsider and redefine each of the ecosystem elements and assign new relationships and build on the insights that will result from their change and transformation. We argue that this effort is essential if complex structures such as city systems are to have a meaningful place in the ecosystem.

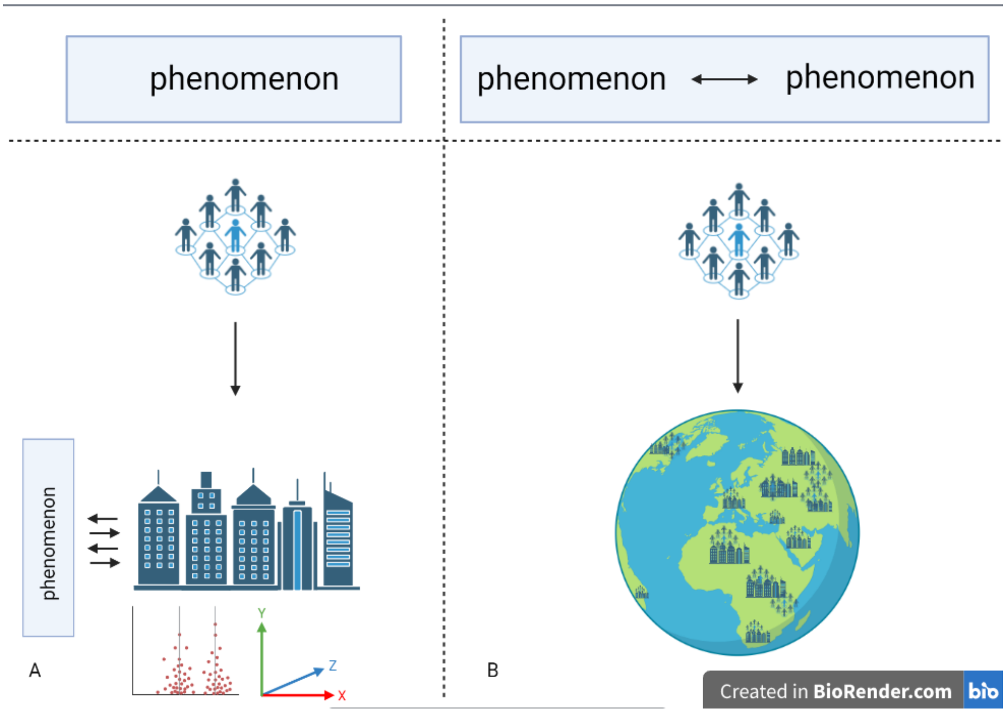

Figure 1. A scheme to represent outputs of the thinking systems of humans in cities.
(A): When each phenomenon such as entities or events in the city systems is considered as a single unit, we are reaching the current approaches and methods to evaluate the cities; the connections are separate and we cannot witness how the data we get from cities is fully integrated into the ecosystem, we can consider only single interactions and try to make a fiction based on these interactions. However, these constructions lead us to interpret the place of cities in the ecosystem as incomplete, so we cannot predict the fate of city systems. Moreover, the arising problems such as the multi-dimensionality of the accumulated data make it difficult to make a comprehensive analysis of the cities. (B): My suggestion is that if we can fundamentally change the principles of the way of thinking by which we interpret city systems and interpret events in line with this principle, we are likely to draw a more comprehensive picture of the cities in the ecosystem. In other words, we need to have a holistic approach to interpreting city systems within the ecosystem to predict the future of city systems. The way to do this is to reinterpret the way each phenomenon is handled, and this reinterpretation must start at the axiomatic level of thought.

Examples For Integrating Multidimensional Datasets for Holistic Urban System Analysis

The proposed axiomatic framework for urban system analysis can be supported by diverse datasets spanning ecological, socio-economic, infrastructural, and technological domains, such as: Ecological and environmental data, such as climate patterns, air and water quality indices, biodiversity assessments, and urban green space distribution, help analyze the interaction between urban areas and natural ecosystems; demographic and social data, including population density, migration patterns, socio-economic stratification, and public health indicators, provide insights into human organization and behavior within cities; economic and infrastructure data, such as urban metabolism indicators, energy consumption, waste production, and transportation networks, facilitate the study of how cities function as dynamic systems; additionally, behavioral and mobility data, obtained from GPS tracking, public transit usage, and commuting trends, offer a deeper understanding of human movement and interaction in urban environments; lastly, historical and evolutionary data on urban development and land-use changes allow for the examination of long-term urban transformations. By integrating these datasets within the axiomatic framework, researchers can develop more comprehensive and predictive models that analyze cities as interconnected biological and ecological systems, fostering sustainable and adaptive urban planning.

By integrating ecological, socio-economic, infrastructural, and technological data, researchers can assess how well the framework captures the dynamic interactions within urban environments. A case study approach can be used, selecting a city with diverse urban challenges—such as climate change adaptation, resource distribution, or socio-economic disparities—to observe how the axiomatic principles apply in practice. Using historical and real-time data, predictive models can be built to test whether the framework provides new insights into urban resilience, sustainability, and systemic interactions. Additionally, comparisons with existing urban analysis paradigms can help validate the framework's ability to offer a more holistic understanding of city systems. Ultimately, testing the approach in a real-world urban setting would determine its applicability and refine its theoretical foundations, ensuring that it can be effectively utilized for urban planning and policy-making.

Conclusion

In short, addressing urban systems is a necessity in the changing conditions of the modern world(Kennedy, Cuddihy, and Engel-Yan 2007; Sassen and Dotan 2011). The fact that we have come so far with the accumulated data and paradigms for understanding urban systems does not change the fact that our interpretations are still incomplete to infer the real presence of cities in the ecosystem. What is firstly needed to understand city systems within ecosystems, and to envision the future of cities, is a set of principles from which all available data and events can be viewed in the same framework, and from which we can develop a holistic and dynamic understanding. In this paper, we have tried to propose a set of principles that have been developed for this need. we am not suggesting that these principles are absolutely true or that they should be used when taking action. However, we believe it is essential to act by establishing a set of principles to understand cities with remained ecosystem. Moreover, we suggest that this set of principles should consider all the elements of the ecosystem on the same ontological plane and thus define the relationship between them from a holistic perspective. Moreover, we believe that the technology and data sets available will be sufficient for the application of these - or other principles that have been developed for this purpose - to analyze the data and draw conclusions and to infer the future of cities. What is essential, however, is to start a process of reinterpretation of how we think about cities, and to work towards the concretization of the abstract principles that emerge from this process. Conducting a new ecosystem analysis with these or similar principles is the next step in this regard.

While the idea of analyzing cities from a biological perspective is intellectually compelling, its real-world applications must be clearly defined to ensure practical relevance for urban planners, ecologists, and policymakers. The proposed axiomatic framework can serve as a foundation for integrating diverse urban elements—such as human behavior, ecological dynamics, and infrastructural networks—within a unified system. Urban planners can use this framework to model city resilience by analyzing how socio-economic activities interact with environmental constraints, aiding in sustainable development strategies. Ecologists can apply it to assess urban biodiversity and ecosystem services, offering insights into how cities can be designed to function as self-sustaining ecological units. Policymakers can utilize this approach to make data-driven decisions by understanding the systemic interconnections between economic policies, public health, and environmental regulations. In practical urban planning decisions, the axiomatic framework can guide adaptive city design, ensuring that urban expansion aligns with ecological balance and long-term sustainability. By demonstrating case studies and real-world implementations, the applicability of this framework can be further refined, making it a valuable tool for addressing modern urban challenges in a scientifically grounded and holistic manner.

As a conceptual effort, this work serves as an experimental convergence point, attempting to bridge abstract philosophical reasoning with empirical urban studies. As mentioned in this text, much of the work that has been done to address urban systems from a biological perspective has relied primarily on the construction of paradigms that are essential for a holistic assessment of these systems. In this context, to be able to deal with the human aspects of urban systems without separating them from other non-human biological elements, while preserving the integrity of urban systems, it is necessary, in our opinion, to first discuss the axioms with which biological phenomena should be approached. To this end, in this text, we have attempted to lay down principles for how biological systems, including city systems, should be approached by defining thirteen conditions. In this way, we have emphasized the potential for biologising the collective actions of human populations within urban systems, rather than individual interactions (Figure 1). Of course, the application of the hypotheses suggested by this study in more concrete research - and hence their falsification or confirmation - will require much more extensive work in this area and much more research into how philosophical arguments and biological phenomena can be jointly fused.

References

Aina, M. P., B. Djihouessi, E. W. Vissin, N. M. Kpondjo, V. Gbèdo, and K. C. D. Sohounhloué. 2012. “Characterization of the Domestic Wastewaters and Dimensionality of a Pilot Treatment Station by Lagooning at Abomey Calavi City- Benin.” *ISCA Journal of Engineering Sciences* 1:45–50.

Alberti, Marina. 2010. “Maintaining Ecological Integrity and Sustaining Ecosystem Function in Urban Areas.” *Current Opinion in Environmental Sustainability* 2(3):178–84. doi: 10.1016/j.cosust.2010.07.002.

Alberti, Marina, John M. Marzluff, Eric Shulenberger, Gordon Bradley, Clare Ryan, and Craig Zumbrunnen. 2003. “Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystem.” *BioScience* 53(12):1169–79.

Ambler, Wayne H. 1985. “Aristotle’s Understanding of the Naturalness of the City.” *The Review of Politics* 47(2):163–85. doi: 10.1017/S0034670500036688.

Aristotle. 1994. *Aristotle’s “De Anima.”* edited by E. J. Brill. Leiden .

Bahabry, Ahmed, Hakim Ghazzai, Gregg Vesonder, and Yehia Massoud. 2019. “Space-Time Low Complexity Algorithms for Scheduling a Fleet of UAVs in Smart Cities Using Dimensionality Reduction Approaches.” Pp. 1–8 in *2019 IEEE International Systems Conference (SysCon)*. IEEE.

Baldwin, Andrew. 2017. “Climate Change, Migration, and the Crisis of Humanism.” *WIREs Climate Change* 8(3). doi: 10.1002/wcc.460.

Bejan, Adrian. 2020. “Human Evolution Is Biological & Technological Evolution.” *Biosystems* 195:104156. doi: 10.1016/j.biosystems.2020.104156.

Bourke, Andrew F. G. 2011. “Social Group Formation.” Pp. 95–128 in *Principles of Social Evolution*. Oxford University Press.

Campbell, Michael C., and Sarah A. Tishkoff. 2010. “The Evolution of Human Genetic and Phenotypic Variation in Africa.” *Current Biology* 20(4):R166–73. doi: 10.1016/j.cub.2009.11.050.

Chen, Sidi, Benjamin H. Krinsky, and Manyuan Long. 2013. “New Genes as Drivers of Phenotypic Evolution.” *Nature Reviews Genetics* 14(9):645–60. doi: 10.1038/nrg3521.

Cohen, Marc J., and James L. Garrett. 2010. “The Food Price Crisis and Urban Food (in)Security.” *Environment and Urbanization* 22(2):467–82. doi: 10.1177/0956247810380375.

Cronan, Todd. 2004. “Biological Poetry: Santayana’s Aesthetics.” *Qui Parle* 15(1):115–45. doi: 10.1215/quiparle.15.1.115.

Frank A. Farris. 2010. “The Gini Index and Measures of Inequality.” *The American Mathematical Monthly* 117(10):851. doi: 10.4169/000298910x523344.

Grimm, Nancy B., Stanley H. Faeth, Nancy E. Golubiewski, Charles L. Redman, Jianguo Wu, Xuemei Bai, and John M. Briggs. 2008. “Global Change and the Ecology of Cities.” *Science* 319(5864):756–60. doi: 10.1126/science.1150195.

Grimm, Nancy B., J. Grove Grove, Steward T. A. Pickett, and Charles L. Redman. 2000. “Integrated Approaches to Long-Term Studies of Urban Ecological Systems: Urban Ecological Systems Present Multiple Challenges to Ecologists—Pervasive Human Impact and Extreme Heterogeneity of Cities, and the Need to Integrate Social and Ecological Approaches, Concepts, and Theory.” *BioScience* 50(7):571–84.

Hajduk, Sławomira, and Lienite Litavniece. 2019. “Dimensionality of an Urban Transport System Based on ISO 37120 Indicators for the Case of Selected European Cities.” *Engineering Management in Production and Services* 11(4):80–91. doi: 10.2478/emj-2019-0035.

Karl, Thomas R., and Kevin E. Trenberth. 2003. "Modern Global Climate Change." *Science* 302(5651):1719–23. doi: 10.1126/science.1090228.

Kennedy, Christopher, John Cuddihy, and Joshua Engel-Yan. 2007. "The Changing Metabolism of Cities." *Journal of Industrial Ecology* 11(2):43–59. doi: 10.1162/jie.2007.1107.

Kwantes, Catherine T., and Charlotte M. Karam. n.d. "Social Axioms and Organizational Behavior." Pp. 31–50 in *Psychological Aspects of Social Axioms*. New York, NY: Springer New York.

McCarthy, Mark P., Martin J. Best, and Richard A. Betts. 2010. "Climate Change in Cities Due to Global Warming and Urban Effects." *Geophysical Research Letters* 37(9):n/a-n/a. doi: 10.1029/2010GL042845.

McDonnell, Mark J., and Ian MacGregor-Fors. 2016. "The Ecological Future of Cities." *Science* 352(6288):936–38. doi: 10.1126/science.aaf3630.

Pareto, V. E., and Marcos Pompeu Pareto. 2008. "The Urban Component of the Energy Crisis." *SSRN Electronic Journal*. doi: 10.2139/ssrn.1221622.

Pickett, Steward. 2012. "Ecology of the City: A Perspective from Science." Pp. 162–71 in *Urban Design Ecologies*. John Wiley & Sons, Ltd.

Pickett, Steward T. A., William R. Burch Jr., Shawn E. Dalton, Timothy W. Foresman, J. Morgan Grove, and Rowan Rowntree. 1997. "A Conceptual Framework for the Study of Human Ecosystems in Urban Areas." *Urban Ecosystems* 185–99.

Pickett, Steward T. A., Mary L. Cadenasso, Daniel L. Childers, Mark J. Mcdonnell, and Weiqi Zhou. 2016. "Evolution and Future of Urban Ecological Science: Ecology in, of, and for the City." *Ecosystem Health and Sustainability* 2(7). doi: 10.1002/ehs2.1229.

Portugali, Juval. 2016. "What Makes Cities Complex?" Pp. 3–19 in.

Ramalho, Cristina E., and Richard J. Hobbs. 2012. "Time for a Change: Dynamic Urban Ecology." *Trends in Ecology & Evolution* 27(3):179–88. doi: 10.1016/j.tree.2011.10.008.

Rozzi, Ricardo, and Clare Alexandra Palmer. 2013. *Linking Ecology and Ethics for a Changing World: Values, Philosophy, and Action*. edited by R. Rozzi, J. B. Callicott, C. Palmer, and S. T. A. Pickett. Springer.

Saatkamp, Herman, and Martin Coleman. 2020. "George Santayana." *The Stanford Encyclopedia of Philosophy (Fall 2020 Edition)*.

Santayana, George. 1923. *Scepticism and Animal Faith*. Dover Publications.

Sassen, Saskia, and Natan Dotan. 2011. "Delegating, Not Returning, to the Biosphere: How to Use the Multi-Scalar and Ecological Properties of Cities." *Global Environmental Change* 21(3):823–34. doi: 10.1016/j.gloenvcha.2011.03.018.

Satterthwaite, David. 2009. "The Implications of Population Growth and Urbanization for Climate Change." *Environment and Urbanization* 21(2):545–67. doi: 10.1177/0956247809344361.

Smith, Melinda D., Alan K. Knapp, and Scott L. Collins. 2009. "A Framework for Assessing Ecosystem Dynamics in Response to Chronic Resource Alterations Induced by Global Change." *Ecology* 90(12):3279–89. doi: 10.1890/08-1815.1.

Tiedje, James M., Mary Ann Bruns, Arturo Casadevall, Craig S. Criddle, Emiley Eloe-Fadrosh, David M. Karl, Nguyen K. Nguyen, and Jizhong Zhou. 2022. "Microbes and Climate Change: A Research Prospectus for the Future." *MBio* 13(3). doi: 10.1128/mbio.00800-22.

Wang, X. T. 1996. "Domain-Specific Rationality in Human Choices: Violations of Utility Axioms and Social Contexts." *Cognition* 60(1):31–63. doi: 10.1016/0010-0277(95)00700-8.

Zhang, Yong E., and Manyuan Long. 2014. "New Genes Contribute to Genetic and Phenotypic Novelties in Human Evolution." *Current Opinion in Genetics & Development* 29:90–96. doi: 10.1016/j.gde.2014.08.013.

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