Toward an agentic understanding of the urban metabolism: a landscape theory perspective

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Abstract

An understanding of human and non-human agency is essential to fully capture the nature and configurations of resource circulations and "metabolic" dynamics in cities. Since their inception, urban political ecology and more-than-human ontologies have raised fundamental questions about these entangled agencies, which resonated widely in urban studies and, to some degree, in urban metabolism research. This essay argues that landscape theory provides a rich, yet less explored, reservoir of concepts and methods to investigate the role of agentic capacities in metabolic dynamics and the society-nature relations they reflect. Two landscape approaches describing the landscape as a locus of distributed agency are discussed to illustrate novel modes of agentic inquiry in metabolic studies. Finally, using water ecologies as examples, I ask to what extent a sociology of distribution of resources and agencies can become a new "matter of concern" for urban metabolism research and foster dialectical conceptions of the metabolic paradigm.

Keywords

Urban political ecology; non-human actors; urban assemblages; water infrastructure; urban nature

Introduction

Growing evidence demonstrates that a deep understanding of the relations that communities establish with natural resources is essential to identify novel pathways toward more sustainable development of human activities. For the last decades, these relations of interdependence and the material and political space that both shape and are shaped by them have been the focus of social metabolism research (Haberl et al., 2019). As one of the main traditions in this field, urban metabolism (pioneered by Abel Wolman in the 1960s) has gained new traction with the becoming mainstream of the "limits-to-growth" discourse across engineering, natural, and social sciences. For more than fifty years, urban metabolism has been concerned with the crafting of holistic frameworks to apprehend the relations of different kinds and nature through which urban communities ensure their biophysical and socioeconomic functioning over time (Perrotti, 2019). Resource accounting methods such as material flow analysis and dynamic stock modeling can provide an accurate description of the relations between societies and natural resources and lay the foundations for a quantitative understanding of the production-consumption dynamics that underpin a city's (or society's) metabolism (Perrotti & Iuorio, 2019). These dynamics are inwoven in a material and political spacetime that is inflected by different types and modes of agency deployed by a host of heterogeneous actants (Hausknost et al., 2016) and that obviously extends well beyond the physical boundaries of the city as traditionally understood (see, e.g., the "methodological cityism" discussion, Angelo & Wachsmuth, 2015). Hence, it is by bringing a greater focus on agency that the complexity and distinctive configurations of metabolic dynamics can be fully captured, apprehended, and, eventually, modeled.

In this essay, I argue that recent approaches in landscape theory and practice can help advance urban metabolism research toward a deeper understanding of the entangled agentic modes and capacities on which metabolic dynamics rest. For several decades now,

landscape approaches have strived for disentangling questions of agency in the study of urban landscapes; through this, they can prompt new ways of knowing and investigating agency in metabolic studies and, ultimately, foster alternative conceptions of the "metabolic" paradigm per se. I will illustrate my argument in three steps. First, drawing on urban political ecology perspectives and more-than-human ontologies, I will argue to what extent an agentic understanding carries implications for urban metabolism research and its descriptions of production-consumption dynamics in metabolic assemblages. Second, I will discuss insights from two landscape approaches that describe the landscape as a locus of distributed agency and illustrate novel modes of inquiry into the manifold agencies producing the urban landscape and its metabolic foundations. Finally, learning from landscape theory and using water ecologies as an example, I will address the question of whether and to what extent a sociology of distribution of resources and agencies can become a new focal area (or "matter of concern") in urban metabolism research and favor the uptake of more dialectical conceptions of the urban metabolism.

Agency and the urban metabolism narrative

The concepts of "urban metabolism" and "agency" (of both humans and nature) have been mobilized in urban political ecology since its inception (Zimmer, 2010) as a way of framing the relations societies establish with nature and the circulations of resources as political and socioecological processes (Gandy, 2004; Swyngedouw, 2006). In these conceptual frameworks, the flourishing of new forms of "agency, materiality, or imagination" in cities has been proposed as a means to open novel socioecological and technological pathways alternative to those traced through the "functionalist imperative of capitalist urbanization" (Gandy, 2018). Post-structuralist and more-than-human ontologies have further intricated the "metabolic" narrative by raising fundamental questions of agency for urban metabolism research: *who/what* has the capacity to affect

resource access and distribution in an urban assemblage, under what conditions (*where/when*), and through which modus operandi (*how/to what extent*) (Bennett, 2010; Latour, 2005). Further momentum came from the uptake of Actor-Network-Theory (ANT) (Law & Hassard, 1999) in urban studies and the increased attention received by agentic readings of urban assemblages over the last decade (Brenner, Madden, & Wachsmuth, 2011; Farías, 2011; Färber, 2019; McFarlane, 2011). Agency represents the common ground between the three central principles in ANT: *radical relationality*, *generalized symmetry*, and *association* (Farías, 2010). Following the first principle, *all* entities have agency (as crystallized in ANT's key descriptive term, "actant") and the assemblages that populate our world emerge from the *relations* that heterogeneous actants establish under specific spacetime conditions. This suggests that agency is not only enacted through individuality or human intentionality but relies on a panoply of contingent, local interactions that humans establish with other non-human and material actants (Dwiartama & Rosin, 2014), ranging from animals, ecosystems, natural phenomena and climate, to infrastructures, commodities, technology, and even microbes, bacteria, viruses, and diseases (Latour, 2005). Following from the above, material objects also have agency, and agency is distributed *symmetrically* amongst human and non-human actants. Finally, rather than existing as things with their intrinsic properties, "the social", "the natural", and "the urban" come together (or are "assembled") through *associations* between actants that are not social, natural, or urban by themselves. In turn, social and urban assemblages enable new types and modes of agency, which leads to an understanding of agency as an emergent capacity of assemblages.

As these perspectives suggest, an understanding of agency carries profound implications for the way the urban metabolism is investigated and can be instrumental to challenge the binary production-consumption approaches that lie at the core of most

metabolic studies and their modes of inquiry. When understood as a capacity that emerges from symmetrical relations, agency can affect scientific descriptions of the metabolic relations between humans and other non-human and material actants in urban assemblages. For example, human actants would only acquire a "consumer" identity once understood as hybrids or "quasi-objects" (Latour, 1993) in a network composed of a variety of actants including (among others): the resource being consumed (e.g. drinking water) and the (micro)organisms living in it (e.g. waterborne bacteria), the ecosystem providing the resource (the river or aquifer from which the water has been abstracted), the utility provider or retailer (the local water supply company in case of tap water or the grocery store for bottled water), the waste management system (the wastewater treatment plant and the managing governmental or private company), the ecosystem in which, once treated to a sufficient quality standard, the waste is rejected (the river into which the outfall flow is discharged), and the local microclimate conditions as affected by the circulation of the resource (the water cycle altered by the water abstraction/rejection process). In other words, when considered from an agentic perspective, such as that endorsed by ANT, the act and practice of consuming can be regarded as a consumer's hybrid identity-chain, i.e., a chain composed of any (human and non-human) actant that modifies the consuming state of affairs or course of action by "making a difference" that produces "observable traces" (Latour, 2005, p. 71, 53). Therefore, an agentic understanding can equip the urban metabolism analyst with tools to radically reconfigure metabolic production-consumption chains as objects of study. These can be investigated as networks where agency is distributed across all nodes and stages of the very process of producing and consuming and across all entities that hold responsibility for them rather than as cascading systems in which marketed values are progressively increased and non- or under-marketed values disregarded (e.g. various environmental externalities and, in

some cases, labor). This way of investigating the urban metabolism can provide an increased focus on the particularities and contingencies of localities as an expression of the specific relationalities that enable humans to perform agency, including their dependence upon the non-human components of metabolic assemblages. For example, such components can include entities like resource scarcity and infrastructure failures which have the capacity to influence production-consumption assemblages and, consequently, the entire configuration of the urban metabolism (Bennet, 2010). On this basis, an agentic understanding of the urban metabolism does not only enable the analyst to nail down the "cosmopolitical" nature (Latour, 2004a; Stengers, 2005) of production-consumption assemblages. It can also provide a "sociology of distribution" (Callon & Latour, 1981) of both resources and agencies, where distribution is understood as a concrete phenomenon assembled in heterogeneous networks rather than as an abstract structure. As I will discuss in the following sections, it is precisely this sociology of distribution of resources and agencies that landscape approaches have to offer to urban metabolism research as one main "matter of concern" for its scientific descriptions alongside its usual "matters of fact" (the results of material flow and stock accounts) (Latour, 2004b).

Distributed agency in landscape theory

There exists a host of theoretical discourses on the concept of "landscape" and the making of the urban landscape which can point to new modes of inquiry into agency in urban metabolism research. I will discuss two landscape theories in particular: the *landscape-infrastructure nexus* outlined by landscape urbanism theorists and practitioners (Bélanger, 2009, 2017; Corner, 2006; Waldheim, 2016), and German philosopher Ute Guzzoni's (1990) *landschaftliches Denken* (from the German "*Landschaft*", "landscape", and "*denken*", "to think"). Both theories understand the landscape as a locus of

symmetrically distributed agency. They can help discern the manifold individual agentic capacities (and their entanglements) in a landscape and facilitate their understanding as drivers of urban metabolism dynamics.

The landscape-infrastructure nexus

Since their inception in the 1990s, landscape urbanism approaches have opened the path to some of the most radical conceptualizations of landscape and infrastructure in design theory and practice (Perrotti, 2014). Their proponents (including landscape architects and urban designers as well as landscape and urban theory scholars) have pushed the boundaries of the two concepts to their limits and challenged their meaning and relevance as independent entities. Infrastructures are seen and designed as artificial ecologies and landscapes as social-ecological infrastructures providing the metabolic foundations for urban life (Waldheim, 2016). Infrastructures are conceptualized as "instigators" or "catalysts" of ecological, social, and economic growth which can be "orchestrated" by the designer and, thereby, function as a model for the urban landscape in its entirety (Allen, 1999; Corner, 2006). Conversely, through self-maintaining landscape operations that are essential to the metabolism of cities and regions, urban landscapes can become infrastructures for the provision of critical resources (water, food, energy, and land) (Bélanger, 2009; Perrotti, 2015). On this basis, instead of discrete entities in the urban fabric, landscape urbanism operations have increasingly targeted the horizontal "mat" of ecological processes and socioeconomic dynamics occurring in cities as a "landscape-infrastructure nexus" that functions as a matrix for the urban metabolism (Bélanger, 2017; Corner, 2006). Similar to urban assemblages in ANT (Farías, 2010), this nexus has been conceptualized as a geography of associations among overlapping networks of human and material actants; their combined, symmetrical agencies translate into ecological processes and socioeconomic dynamics that operate across the regional and local scale.

In this sense, the landscape-infrastructure nexus provides a locus of synthesis between agencies and their effects on the city as well as the core operational focus of urban design. Although not all landscape urbanism operations have explicitly engaged with the politics underpinning metabolic dynamics in cities, they have arguably contributed to a broader understanding of the role of material (landscape-infrastructure) components and their agency in the production of urban space especially thanks to their relatively high visibility in educational programs and the industry in Anglo-American contexts (Waldheim, 2016).

Urban water ecologies provide a paradigmatic case to illustrate the entanglement of different types and modes of agency in the landscape-infrastructure nexus. Studies from the scale of sub-catchments down to urban water commons show that water ecologies are irreducible structural elements of urban systems supporting the manifold environmental, economic, and cultural dimensions of urbanization (Perrotti, Hyde, & Otero Peña, 2020). Watersheds represent an ever-growing focus of landscape urbanism operations that aim at creating opportunities for greater economies and "ecologies" of scale in urban regions. In post-industrial regions in North-America, for example, the ecology and economy of the watershed have been the repository of strategies for economic and urban regeneration, land use redistribution, and site redevelopment (Bélanger, 2009). In these cases, water ecologies have materialized the codependency of the economy and the environment and provided among the most compelling expressions of the landscape-infrastructure nexus (Bélanger, 2010). From an agentic point of view, water ecologies rest on multiple entanglements between human and other biophysical actants (hydrology, geology, climate) that deploy distinct types and modes of agency and coalesce into a range of diverse metabolic assemblages (see, e.g., the examples discussed in McFarlane, 2011). On this basis, the study of water ecologies as physical manifestations of the landscape-infrastructure nexus can offer urban metabolism research

an increased focus on the manifold agencies that precondition the coming together of metabolic assemblages.

Landschaftliches Denken

Ute Guzzoni's (1990) essay *Landschaften* can be described as an *avant la lettre* ANT-based inquiry into the landscape. By answering the question "in what ways are landscapes 'landscapes'?", the essay provides an insightful investigation of the landscape as a locus of distributed agency (or as a landscape-assemblage). At the core of Guzzoni's *landschaftliches Denken* lies a description of the landscape as a "concrete constellation", i.e. a manifold contemporaneity of spatial and temporal relations between things. Through the use of the metaphor, the landscape is identified with the manifold interwoven relations existing in it, which express interdependence rather than simple cohabitation among individuals. It is by means of the relations established among all the individuals comprised within its space and time, that the landscape is one and precisely this landscape. In other words, the landscape constellation unfolds from the combined actions of every single element that composes it.

Guzzoni's work is relevant to our journey into an agentic understanding of the urban metabolism for at least three reasons.

First, through the metaphor of the concrete constellation, the philosopher brings into focus radical relationalities and associations as core dynamics in the constitution of a landscape-assemblage. Indeed, Guzzoni's constellation of relations is a "concrete universal" (partially building on the Hegelian understanding of the term, Hegel, 1951), i.e. a "universal" that self-produces itself from the *jeu d'ensemble* of the individuals, with no ontological prominence over them; this "universal" is hence unique each time, neither sharply delimited in space nor stable for eternity.

> It [the constellation] is not firmly delimited in the sense that this hill may belong to this landscape, and that one to another. The landscape of woods shades off into the landscape of the river and, together, they form the landscape of this valley. (Guzzoni, 1990, p. 30, own translation)

This mutability of relations that makes a landscape 'a landscape' within a given space and in a specific time resonates with what DeLanda (2006), in his assemblage theory, describes as the "relations of exteriority" that underpin the very changing nature of each assemblage.

> These relations imply, first of all, that a component part of an assemblage may be detached from it and plugged into a different assemblage in which its interactions are different. (DeLanda, 2006, p.10)

In this sense, Guzzoni's *landschaftliches Denken* transcends the landscape-infrastructure approach since it goes one step further. Guzzoni not only acknowledges that different individual actants have distinct types and modes of agency. She also argues that the agentic capacities that ultimately determine the coming together of a landscape-assemblage rely on a panoply of contingent, local interactions. Consequently, being a landscape is not an intrinsic characteristic of that assemblage but, rather, an emergent property resulting from a specific combination of agencies.

Second, Guzzoni reminds us that space and time also play a central role in determining how actants can coalesce into a range of possible metabolic assemblages. For Guzzoni a landscape identifies all the things that have their time, space, and determinedness in that landscape (i.e., that belong spatially and temporally to that landscape). Like actants with their agency, space and time also characterize the way assemblages operate as wholes through interactions. Spacetime congeals into actants' relations of exteriority or mutability of relations and, through these, generates a frame of reference in which the conditions for assembling are determined.

Third, Guzzoni suggests that landscapes come into existence through and by means of a (mental, verbal, or visual) storytelling that, first, recovers the individuals' actions unfolding in their spacetime and, then, recomposes them in a concrete constellation of relations. However, since landscapes are neither defined nor definable in a single way, they can only be enacted when a storytelling is stripped off its "ontological objectivity" and "origin-hungry" character and becomes a "dwelling in the world" and "among worldly things" (own translation). Hence, Guzzoni's *landschaftliches Denken* is a storytelling that belongs to the constellation of individuals being thought and narrated. The unfolding of her landscape story exemplifies that a narration of agentic capacities is essential to discern the different levels of agency co-existing in an assemblage and to apprehend each actant's ability to perform agency. In other words, Guzzoni's storytelling conveys shades of modes and meanings of agency, while enabling the inquirer to engage actively and deeply with agency and its expressions, in the same way, she would argue, that one walks in a landscape not simply to move through it but to *encounter* and *experience* it.

Distributed agency as a *matter of concern* for urban metabolism research

What can we learn from these landscape theory perspectives in our journey into an agentic understanding of the urban metabolism? Our discussion suggests that an understanding of distributed agencies as conveyed through the landscape-infrastructure nexus and Guzzoni's *landschaftliches Denken* can bring into focus relationalities and associations and, through this, provide alternative pathways into the different types and modes of agency that enact metabolic assemblages into being. As already argued for the study of adaptive capacities and resilience conditions in social-ecological systems using ANT (Dwiartama & Rosin, 2014), relationalities and associations can be influenced by many factors such as "the vibrancy of the non-humans" (e.g., diseases or other types of shocks,

crops, climate, technology, and the markets) and the extent to which heterogeneous networks of actants are maintained. By unveiling individuals' actions and capacities to act in specific local contexts, landscape approaches can stage the diversity of human experience and a multiplicity of standpoints and wills as opposed to all-encompassing perspectives and binary production-consumption approaches. From a landscape-infrastructure perspective, an agentic understanding of water ecologies can shed light on the interplay between socioeconomic and ecological dynamics occurring in cities and the manifold agencies associated with them; through this, it can broaden the scope of urban metabolism research via a novel synthesis between geographies of associations and sociologies of distribution (of agencies and resources). As shown in Guzzoni's work, an agentic narration can recover the specific associations and interrelations of local agencies and their contingencies that make a landscape become an assemblage; landscape-assemblages are "concrete constellations" resulting from constantly-changing interactions among actants and the fluctuating spacetime circumstances than enable them. Both approaches can be read as a hint for urban metabolism research to engage with the recollection of the manifold agencies that configure consumption-production dynamics in cities and their systematization and interpretation in the study of material flows and stocks. A similar approach has been embraced in urban studies using intra-urban comparison to, for example, theorize infrastructural politics in Mumbai, Delhi, and Cape Town (McFarlane, Silver, & Truelove, 2017). Here, the revealing of plurality within cities is proposed as a way into a more fluid understanding of the diverse practices that shape communities' relations to urban infrastructure as opposed to all-encompassing, overarching narratives of "singular economic systems and divisions between public and privately provisioned services" (McFarlane et al., 2017, p. 1412-1413).

The case of water ecologies is, here again, helpful to illustrate how relationalities and associations are different in each urban metabolic assemblage and to what extent the integration of landscape-driven ways of accounting for agency can broaden the scope of urban metabolism research. Water networks have a dual significance when it comes to understanding the urban metabolism in agentic terms (Gandy, 2004). On the one hand, they are the locus of urban policy decisions and practical arrangements related to stormwater drainage and collection, wastewater treatment, and communities' access to drinking water, which can follow market-driven models of utility privatization, hybrid public-private partnerships for resource management, or, in some cases, grassroots modes of urban governance. On the other hand, water networks provide an analytical lens through which to observe the social and political complexity of the urban space and its materiality, as well as the coming together of different kinds of metabolic assemblages over time through context-specific socioecological and technological entanglements. This is particularly compelling when considering the diversity of water supply systems alimenting many fast-growing cities in the Global South that did not experience the "modern infrastructure ideal" (Graham & Marvin, 2001) and the emergence of the "bacteriological city" (Gandy, 2004) dominating the 19th century hygienist turn and subsequent urban development orientations in Western countries. A similar dualism is evident in environmental history scholarship in which the relevance of urban waterways for the urban metabolism is presented through a two-fold lens: as a natural resource in their own right, whose appropriation and "domination" has empowered different forms of societies or particular social groups in various ways, and as avenues to extend the spatial range of economic and social interactions in cities and the agentic modes and capacities underpinning them (Lübken, 2020).

In recent years, several blue/green infrastructure design operations have aimed at addressing multiple socioecological concerns related to flood control, water supply, and epidemiological issues while generating inclusive public spaces for new urban encounters with nature. Examples include the publicly-accessible water retention and treatment complex *La Quebradora Hydraulic Park* in Mexico City, designed by Castro Reguera Mancera and Perló Cohen, which doubled the public space availability in the neighborhood while promoting a civic culture of water, and the *Bishan River Park* in Singapore by Ramboll Studio Dreiseitl, which aimed to transform a section of the Kallang River from a concrete drainage channel into a naturalized water flow and improve its capacity. Both projects involved an iterative process with multiple stakeholder feedback loops as a mechanism to inform the designers' comprehension of water circulations (at the local and regional level) and the flows of substances, human and non-human beings in and around the urban aquatic environments. In this process, an agentic understanding of local metabolic dynamics proved essential for the designers' inquiry into existing and future, desired metabolic systems. As both examples show, community engagement processes that are foundational to new water ecologies in cities can function as mining mechanisms for the recovery of localized individual agencies and the "environmental imaginaries" and "narratives" (Zimmer, 2010) underpinning the urban space. Through their recollection, such agencies can become vehicles for novel production-consumption dynamics to come into existence and, ultimately, an alternative urban metabolism as the locus of multiple socioecological, technological, and ideological entanglements potentially driven by other forces than just "the logic of capital" (Gandy, 2018).

Conclusion: a new urban metabolism?

A greater focus on agentic capacities as provided by landscape approaches offers novel insights into the mechanisms that drive the configuration of metabolic assemblages and

their transition into future spacetimes. In this sense, an agentic interpretation of metabolic assemblages can not only open to innovative modes of inquiry and novel scientific descriptions of production-consumption dynamics. It can also point to alternative pathways into more desirable metabolic assemblages and production-consumption dynamics in cities, which better express individual and collective aspirations and desires than *business-as-usual* models.

Drawing on a range of theoretical perspectives and local experiences, an agentic understanding of key metabolic components such as water networks can shed light on their role as actants participating not only in the sociotechnical configuration of metabolic assemblages but also in the production of urban space and urban culture. Landscape theory and practice provide a growing reservoir of concepts and methods to describe metabolic components such as water networks as essential constituents of an "urban hybridity", alongside other non-human and human actants. In this sense, landscape approaches can open the way to a novel synthesis of neo-Marxian and cyborg conceptualizations of metabolic circulations including "commodity chains, the particularities of local context and the fluidity of urban form" (Gandy, 2004, p. 374). In other words, they can build a stronger case for "relational" or "hybridized" conceptions of the urban metabolism grounded in urban political ecology perspectives (Swyngedouw, 2006) and ANT/more-than-human ontologies (Bennett, 2010; Latour, 2005), as complementary to "homeostatic" conceptions of cities as self-regulatory systems. Such efforts can help expand the urban metabolism agenda beyond anatomical or functional analogies and toward a critical apprehension of the intertwinements between social and biophysical dynamics that produce new forms of urban, "hybrid" nature. In the end, it is such dialectical conceptions of the urban metabolism that can better embrace the role of

human and non-human agency in the circulatory processes underpinning the transformation of nature into essential commodities (or *re-sources*) and their politics.

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