



# The urban political ecology of antimicrobial resistance: A critical lens on integrative governance

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## ABSTRACT

The objective of this paper is to integrate Urban Political Ecology (UPE) as a theory for identifying under-exposed urban dimensions of Antimicrobial Resistance (AMR). A UPE lens allows us to conceptualize urbanization as a ubiquitous socio-ecological process and an interpretive frame that could inform AMR governance strategies across related contexts by: a) situating AMR risks in relation to urbanization processes shaping social and political co-determinants of such systemic threats as climate change; b) aligning UPE scholarship with One Health (OH) approaches that address AMR to reveal the under-exposed link of AMR to environmental threats and broader structural dimensions that influence these threats; and c) identifying shared AMR and environmental governance pathways that inform the rationale for more equitable governance arrangements. We delineate a context in which the speed and scale of human activity in the larger context of urbanization, driven by global market integration strategies, impacts human-animal-environmental health threats such as AMR. We demonstrate how UPE scholarship can be leveraged to offer theoretical depth to approaches considering the interdependencies of AMR and climate change threats. We then propose a strategic approach focused on identifying shared governance pathways and intersectoral accountability frameworks to address upstream structural drivers of AM-Environmental threats. The co-benefits of a UPE-informed framework to human-animal-environmental health that leverages enabling policy environments to foster a more collaborative, equitable and sustainable approach to address systemic global health threats are clarified. Just as the concept of “health in all policies” emphasized taking health implications into account in all public policy development, the integration of UPE in AMR governance arrangements would emphasize the need to take other sectors into account through an intersectoral whole-of-government approach that fosters shared AMR - climate change governance pathways.

## 1. Introduction

Complex interdependencies among natural disasters (Leaning and Guha-Sapir, 2013), conflicts (Garry and Checchi, 2020) and structural inequities (Schrecker, 2020) have become more evident in recent years (Walker et al., 2009). These interdependencies exacerbate global health inequities as – under their cascading impacts – governments and national health systems are often unable to adapt to and address sustained levels of fragility, instability and insecurity (Center for Health Security, 2019; Global health disruptors [Internet], 2018). The compounding effects of these systemic and intertwined global health threats also induce forced migration (McMichael, 2015), pandemic diseases (Klain, 2018; Rocklöv and Dubrow, 2020), and antimicrobial resistance

(Rodríguez-Verdugo et al., 2020; Nadimpalli et al., 2021; Fayad et al., 2023). Interconnected at the global scale by accelerating patterns of human activity (Keys et al., 2019) - of which urbanization (Brenner and Keil, 2014) can be considered one of its most pervasive forms and processes (Connolly et al., 2020; Keil, 2018; Keil et al., 2016; Lancione and McFarlane, 2021; UN-Habitat, 2020; United Nations, 2016) - these global health threats impact human-animal-environmental health systems (One Health High-Level Expert Panel (OHHLEP), 2022), putting new populations and the systems in which these threats manifest at increased systemic risk (Keys et al., 2019; UNDP, 2020; Gostin, 2022).

The objective of this manuscript is to propose the integration of Urban Political Ecology (UPE) as a theoretical framework for assessing under-exposed urban dimensions of Antimicrobial Resistance (AMR)

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within governance strategies. First, by aligning UPE scholarship with One Health (OH), we bridge two epistemic domains, offering theoretical depth that clarifies the sociopolitical ecologies of AMR and its interdependence with other OH threats (Broom and Doron, 2022). Second, drawing on UPE as a multifaceted approach and a guide to practical politics of sustainability and human-nature relationships, we mobilize UPE to inform governance strategies addressing the upstream structural drivers of AMR and interconnected environmental threats.

We begin by introducing a theoretical framework to assess the urban political ecologies of AMR, and advance a notion of planetary and extended urbanization processes and forms, to delineate a context in which the speed and scale of human activity driven by global market integration impacts human-animal-environmental health threats such as AMR. We trace the interconnection of AMR to other threats through urbanization and accelerated transformation processes, which are obscured by notions of urbanization that disregard the detrimental impact of these transformations on structural determinants influencing human-animal-ecosystem health (Ali et al., 2023; Kaika and Swyngedouw, 2014). We then propose UPE as an alternative lens to explore the impact of urbanization for AMR. A UPE lens is premised on more equitable and just societal relations with nature, that situates the impact of these accelerated transformations into sociopolitical ecologies, which is imperative when exploring threats impacting human and non-human dimensions. A UPE lens allows us to mobilize the urban dimension as a ubiquitous spatial scale and interpretive frame to inform approaches addressing interdependent global health threats such as AMR and climate change. We adapt theoretical frameworks from Brenner and Ghosh (2022), Ali et al. (2023), and Treffers et al. (2021) to explore similar connections between urbanization and political ecologies of disease to illustrate how UPEs of AMR clarify the influence of structural dimensions on sociopolitical ecologies as drivers of AMR and related threats.

We first highlight the need for a critical urban lens to advance OH approaches addressing AMR. As AMR is a natural mechanism accelerated by antimicrobial use and anthropogenic activities affecting microbial organisms, it is deeply interconnected with anthropogenic pressures on planetary health systems, the fabric of our society, current modes of care, production and consumption, and to pathways exacerbating other global health threats such as climate change. We then discuss how efforts to address AMR are contingent on an assessment of urbanization processes that enable the commodification of health determinants and the privatization of commons resources management, referred to as the structural dimensions of AMR, that connect the OH approach to UPE theory.

We then engage UPE scholarship to demonstrate the way in which it offers a theoretical foundation that aligns with and underpins the United Nations Environmental Program approach and guidance for addressing the interdependence between AMR and climate change (United Nations Environment and Programme, 2023). Two tenets of UPE scholarship are introduced to structure the way in which UPE can inform AMR governance strategies: *rescaling socioecological governance arrangements* and *redressing human-animal-environmental relations*.

We propose that *rescaling socioecological governance arrangements* through a UPE lens informs strategies that seek to address AMR externalities. We also posit that *rescaling* via whole-of-government and whole-of-society approaches (Tzaninis et al., 2021; Ortenzi et al., 2022) would enable One Health shared governance to advance action on climate change while "... addressing the collective need for clean water, energy and air, safe and nutritious food ..." as the joint Tripartite and UNEP statement advises (FAO and WHO, 2021).

A UPE lens also informs OH approaches to AMR concerned with *redressing human-animal-environmental relations* by considering the health inequities and environmental injustices accelerating AMR, that go beyond current approaches premised on the logic of biomedical security, surveillance, and behavioral change. Insights into human-animal-environmental relations also consider how different

urbanization processes influence the health and environmental dimensions shaping AMR risks, and how urbanization forms linked to these processes have been regarded AMR hotspots (Larsson and Flach, 2022). Such insights offer new entry points to explore how extended urbanization processes intensify AMR risks. The theoretical insights then inform a strategic approach focused on identifying shared AM-Environmental governance pathways to address these related threats. We examine environmental stewardship literature to suggest the adoption of shared governance pathways and intersectoral accountability frameworks that simultaneously address AMR threats, their structural dimensions and interdependencies with other threats. The co-benefits of shared governance pathways and intersectoral accountability frameworks to human-animal-environmental health are highlighted as a UPE-informed framework relying on enabling policy environments to foster a more collaborative, equitable and sustainable approach to address systemic global health threats.

An urban dimension thus informs OH approaches designed to address the global health threat of AMR by *adjusting its drivers*. Although an in-depth and systematic engagement with UPE literature is beyond the scope of this paper, we engage key works to generate synergies across disciplines, reveal and address gaps in the literature by juxtaposing articles summarizing main contributions of UPE scholarship (Brenner and Ghosh, 2022; Tzaninis et al., 2021) with those focused on the theory and practice of AMR governance.

## 2. Unsettling traditional urban conceptions towards more productive urbanization approaches in global health

Globalized urbanization (Schrecker, 2020; Brenner and Keil, 2014), in conjunction with rapid technological change (OECD, 2020; Fukuyama, 2020; International Science Council, 2020) has accelerated the transformation of social, health, political, economic and environmental dimensions and relationships (Klain, 2018; Fukuyama, 2020; McMichael, 2013; Augé, 1995; Labonté, 2016; van de Pas, 2017; Ostrom, 2009). At structural levels, these transformations lead to an acceleration in the time needed to produce and sell commodities to generate quicker accumulation of profits for firms and investors, and to restructure or privatize previously public institutions and public goods, including provisions for healthcare and education. In turn, these transformations result in processes which intensify the exploitation of human beings and nature for purposes of extraction and profit, leading to the dispossession of communities of their basic and local means of subsistence and livelihood, with land often at the centre of concerns (Gill and Benatar, 2016; Hardt and Negri, 2003). Driven by the pervasive financialization of economic relationships in all sectors (Lancione and McFarlane, 2021; Sassen, 2017, 2018), many of these transformations are obscured by the mobilization of generic notions of urbanization commonly cited as an inherent dimension of human development (Brenner, 2016; Ramirez-Rubio et al., 2019).

These same accelerating patterns that transform societies and open new frontiers of production and consumption possibilities also appear to widen local and structural health inequities (Connolly et al., 2020; Keil et al., 2016; Syvitski et al., 2020). Much like the transition to industrial societies where large scale manufacturing created instability and restructured the previous agrarian order through various forms of commodification (Coburn, 2010; Hermann, 2021), recent patterns of accelerated human activity also create instability, replace the social and economic foundation of pre-existing systems, accelerate the negative impacts of the Anthropocene (Venter et al., 2016), and restructure the distribution of resources globally (Schrecker, 2020; Syvitski et al., 2020; Labonté et al., 2011). The current restructuring facilitates new forms of commodification of health determinants such as housing, food security and education (Bambra et al., 2005), and facilitates the privatization of commons resource management such as water, land and natural resources (Bakker, 2010). It is against this backdrop that One Health approaches aim to address the collective need for clean water, energy and

air, taking action on climate change to promote human-animal-ecosystem health and well-being (One Health High-Level Expert Panel, 2022; Wallace et al., 2015).

The commodification and privatization of structural dimensions sustaining planetary health are thus accelerated by shifts in the scale of human activity advanced by traditional urbanization approaches promoting visions of smart cities in the global south (Boateng et al., 2022), or a combination of technological innovation, economic development and world-class leadership in “super-cluster” initiatives in the global north (Government of Canada, 2017). Considered an essential step in state economic development, these approaches postulate that successful high-income societies depend on efficient economies with urban connectivity and infrastructure, that enable networks of communication and productivity, that in turn accelerate consumption patterns (Augé, 1995; Collier, 2007). The scale of these shifts has been measured in terms of economic growth and the developmental imperative to move economies from low to high productivity (Collier, 2007). Traditional urbanization approaches thus enable the acceleration and increase the scale of human activity by rescaling the nature of economic relations (Jessop, 2005). In doing so, they also rescale societal relations and shape human behaviors according to global market integration strategies, which has been shown to exacerbate inequalities and systemic threats to global health (Keil et al., 2016).

Current notions of urbanization may therefore mask the detrimental impact of these accelerated transformations on health determinants and commons resources (Ali et al., 2023; Kaika and Swyngedouw, 2014), calling for approaches that can problematize their influence on structural dimensions and global health threats (Duarte et al., 2019).

An urban political ecology lens (UPE) can develop new ways of understanding global health threats such as AMR in these complex and interdependent systems. UPE conceives human and more-than-human relations with nature as non-linear and mutually constitutive processes of urbanization (Connolly et al., 2020; Tzaninis et al., 2021), as these contend with climate change and environmental degradation in a predominantly urbanized world. UPE provides the conceptual tools to examine how societal relations with nature shape the conditions and produce the vulnerabilities that enable the acceleration of AMR (Keil, 2020; Broom et al., 2022). Through a UPE lens we can situate these accelerated transformations within more productive sociopolitical ecologies that are premised on equitable and just societal relations with nature (Tzaninis et al., 2021).

By mobilizing a UPE lens to explore mechanisms underlying the intensification of microbial traffic and the production of infectious diseases, Brenner and Ghosh (2022) propose a theoretical framework to situate political ecologies of infectious disease within planetary urbanization processes operating at a global scale. They succinctly describe planetary urbanization processes as an “intensification of city-building processes ... and the remaking of territories and political ecologies beyond metropolitan centers, whether in zones of high-intensity agro-industrial and extractive capitalism, or in more remote hinterlands, forests, and oceans that are being more directly subsumed into global circuits of capital ...”

We also adapted the approach of Ali et al. (2023) and Treffers et al. (2021) to consider AMR as not only determined by biophysical processes, but also constructed out of a particular set of social and spatial relations that are mediated through the landscape, including extended urbanization forms. As research on governance of AMR strategies is concerned with the influence of similar global governance and market forces, and hierarchies of economies from the Global North (Keil, 2018; Kirchhelle et al., 2020; Hinchliffe, 2021; Overton et al., 2021; Willis and Chandler, 2019; Hinchliffe et al., 2018; Broom and Doron, 2020), our framework exploring UPEs of AMR conceives similar global forces and hierarchies as urbanization processes that influence the local production of AMR. Specifically, UPEs of AMR would consider the impact of planetary and extended urbanization processes on health determinants and commons resources, as these structural determinants influence local socioeconomic demand and sociopolitical ecologies producing

vulnerabilities accelerating AMR (Wallace et al., 2015). While UPE-informed research on AMR responses that consider the impact of urbanization processes, structural determinants, or global governance and economic forces are largely nonexistent, research identifying AMR hotspots subject to socioeconomic demands and sociopolitical ecologies include: marine, freshwater and terrestrial ecosystems, wastewater treatment infrastructures, agricultural sites, aquaculture operations, hospitals, and urban settlements (Larsson and Flach, 2022; Kim and Cha, 2021; Nadimpalli et al., 2020; Almakki et al., 2019; Chandler and Nayiga, 2022; Orzech and Nichter, 2008).

In a world increasingly interconnected by urbanization processes and forms that profoundly rescale human-nature relations and the subsequent unequal global distribution of resources (Schrecker, 2020; Hensher et al., 2020), addressing emerging and interdependent global health threats under these conditions demands an analytic framework that falls outside traditional global health governance (Gostin, 2022; McMichael, 2013; Frenk and Moon, 2013; Lee et al., 2011; Foreign Affairs Magazine, 2020; Bardosh et al., 2020). AMR, pandemics, biodiversity loss and climate change are examples of threats which require effective mobilization of shared governance approaches that consider the interdependencies at multiple scales, topographies and through constellations of agencies (Gandy, 2023). Although these threats pose similar risks to human-animal-planetary health, institutional responses jointly addressing them have only recently been proposed (FAO et al., 2022), but not yet fully implemented (United Nations Environment and Programme, 2023; United Nations Environment Programme, 2022; Global Leaders Group on Antimicrobial Resistance (GLG), 2021; G7, 2022; Minister of Health Mandate Letter [Internet]). The UN Quadripartite, a group of UN agencies collaborating to address global health threats such as AMR, publishes guidance documents supporting the integration of environmental dimensions alongside human and animal health measures addressing AMR and its interdependencies. The UN Environment Program (UNEP) recommends the integration of environmental considerations into National Action Plans on AMR, and AMR into environmental-related plans such as national chemical pollution, waste management programmes, biodiversity and climate change planning (United Nations Environment and Programme, 2023). Exploration of UPEs of AMR can thus offer theoretical depth to inform shared governance approaches, by informing AMR responses that consider local and structural determinants and similar interdependent threats addressed in broader commitments to climate change (for example), potentially enhancing shared governance approaches jointly addressing AMR and related threats (Mora et al., 2022).

### 3. Towards a critical urban dimension of AMR and One Health

Increasing evidence shows that AMR can be intensified by other existential threats such as pandemics, climate change, and biodiversity degradation (Cavicchioli et al., 2019; Ansari et al., 2021; Gruetzmacher et al., 2021). A recent review revealed significant research gaps linking AMR and Climate Change (CC), synthesizing evidence of shared processes exacerbating both threats (Magnano San Lio et al., 2023). Examples linking AMR and CC look at the effect of the climate crisis impacting concentrations of heavy metals or biocide in soil and water, which are also associated with increased bacterial growth rates and horizontal transfer of resistant genes. Rising temperatures, flooding and the resulting heightened population densities and population displacement also lead to increased waterborne infections and added pressure on healthcare and water, sanitation and hygiene (WASH) systems, increasing risk of infection by antibiotic-resistant pathogens (see Table 1 for a summary of the relationship between CC and AMR).

Despite knowledge gaps underlying causal relationships relating AMR and CC to anthropogenic activities and other interconnected health threats, policymakers already seek to adopt approaches and measures addressing the interdependencies of AMR (United Nations Environment Programme, 2022; Global Leaders Group on Antimicrobial Resistance



**Table 1**  
Impact of climate change on microbial lifecycles.

Microorganisms	Role of Climate Change	Disease
Campylobacter spp. and Salmonella spp.	Rising temperatures in water system contributes to better survival of these microorganisms [31,58,59,82]	Waterborne and foodborne diseases
Vibrio cholerae	Rising temperatures led to natural disasters, determining better conditions for the microorganism survival [59,116]	Waterborne diseases (Cholera)
Candida auris	Gained thermotolerance and salinity tolerance on the wetland ecosystem [31,76,77]	Fungal infection (Candidiasis)
Plasmodium falciparum	Rising temperatures and humidity contributes to increased transmissibility [56,78,80]	Vector-borne disease (Malaria)
Zika, Chikungunya and Dengue viruses, Trypanosoma cruzi	Warmer temperatures led to rising spread of vectors, even in winter months [83]	Vector-borne diseases (Zika, Chikungunya, Dengue and Chagas diseases)
Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli, and Staphylococcus aureus	Warm-season changes in temperature contributes to their optimal growth conditions at 32–36 °C [101]	Gram negative infections (especially in healthcare settings)
SARS-CoV-2	Increased aridity and prolonged droughts led to bats migration and increased viral transmission [32,33]	COVID-19 disease

Source: San Magnano San Lio et al., 2023 (Magnano San Lio et al., 2023)

(GLG, 2021; G7, 2022; Federal Ministry of Economic Cooperation and Development, 2021).

The One Health approach has been increasingly adopted in academia, by the public sector and international organizations seeking to address similar global health challenges. In 2022 members of the Quadripartite (FAO, WHO, WOA and UNEP) released a joint statement supporting a more transdisciplinary and holistic operational definition of One Health (FAO and WHO, 2021), as:

“an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.”

Contributions to AMR research are key to understanding the structural and socioeconomic dimensions of AMR and its implications for OH responses, including research considering antimicrobials as a common good that characterizes AMR as a “tragedy of the commons” (Giubilini, 2019; Hoffman and Behdinan, 2016; Rogers Van Katwyk et al., 2020), highlighting the importance of global collective action to address antimicrobial use (AMU). This perspective aligns with OH definitions emphasizing action to address collective needs and human-animal-ecosystem health, and a UPE lens that problematizes the structural dimensions of human-animal-ecosystem health and their influence on AMR risks. Increasing evidence also links AMR to poor governance, deficient urban infrastructure, and the current dynamics of modern society (Nadimpalli et al., 2020, 2021; Collignon et al., 2018;

Hendriksen et al., 2019; Holmes et al., 2016; Maugeri et al., 2023). In an urban context of social and health inequality, Chandler emphasizes higher AMR risks in urban informal settlements, and how antibiotics are a quick fix to protect against economic, political and social marginalisation. Situating AMR risks within broader political economy and structural factors influencing pathogen exposure and the embodiment of urban informality, Chandler points to the lack of AMR studies bringing urban planning into conversation with public health policy (Chandler and Nayiga, 2022).

Similar contributions focusing on forms of urbanization similarly adopt a more holistic approach, calling for more equitable and environmentally just urban infrastructure to address urban health threats. A Lancet Commission on water, sanitation, and hygiene (WASH) suggests that improved WASH systems in low and middle income countries (and high income countries, vis a vis persistent colonial legacies) are a pathway to social and environmental justice efforts to address CC and AMR (Amebelu et al., 2021). How, then, can a UPE lens inform public and global health policy, given its potential to problematize AMR in relation to its structural drivers and local socioeconomic determinants of these policies?

Urbanization has long been established as playing a key role in health equity, environmental justice (Walker et al., 2009; Connolly et al., 2020; Nadimpalli et al., 2020; Almakki et al., 2019; Patel and Burke, 2009; Wu et al., 2017; Ahmed et al., 2019; Allender et al., 2011; Friel et al., 2011; Guidry et al., 2018; Holifield, 2015) and AMR (Nadimpalli et al., 2020, 2021). In this sense, cities have historically been considered breeding grounds of infectious disease. One reason is that increased migration to urban areas has not always been met with the commensurate scale of infrastructure and public health measures needed to sustain the health and living conditions of their inhabitants (Bollyky, 2019). Strikingly, in lower income states where most urban development and densification currently occurs, evidence suggests a decline in deaths from certain infectious diseases in cities, but not due to better quality of life or decline in disease incidence. The decline has instead been attributed to increased antibiotic use, which has been shown to contribute to the acceleration of AMR (Nadimpalli et al., 2020, 2021; Willis and Chandler, 2019). This exemplifies the complex role of urbanization as both an enabler and barrier to health threats (Connolly et al., 2020; Ali et al., 2023; Ahmed et al., 2019), calling for more nuanced urban lenses to help us expose and understand the dynamics of threats like AMR.

Global health literature typically includes notions of societies with pre-conceived institutional and international organizational lenses, without considering the role and impact of socio-ecological interactions as UPE emphasizes. By engaging with urbanization as a socioecological transformation deeply connected to the natural “One Health” world outside pre-conceived geographies of cities or states, and by assessing the ways human and more-than-human relationalities help shape environments that do not necessarily operate within these pre-conceived boundaries, UPE scholars analyse under-exposed relations beneath and beyond societal angles normally entrenched within institutional scales and relations, as they focus on unsettling traditional notions of an urbanizing world. Thus, UPE theorizes a politicized urbanization of nature writ large – a process that is global in scope, but also locally situated and manifested through various forms and processes of urbanization (Keil, 2018; Tzaninis et al., 2021) - as they relate to CC and biodiversity degradation.

Following the call to integrate the political economy and structural causes underlying collapsing health ecologies in OH (Wallace et al., 2015), while accounting for historical agency and the political parameters of human intentionality in nature-society relations (Kaika et al., 2022), the next section engages UPE scholarship to suggest how a UPE lens can inform OH approaches to AMR. Rather than draw on a particular strand of UPE, we build on UPE’s foundational propositions to explore how the main contributions of UPE scholars can inform the rationale for strategies addressing the environmental dimension of AMR

and its interdependencies, as well as nature-society relationalities shaping AMR risks.

**4. Mobilizing UPE scholarship to explore the sociopolitical ecologies of AMR and its interdependencies**

As a critical social theory of urban environmental change, UPE has generated insights that help us understand the new realities and risks of the Anthropocene (Keys et al., 2019; Jon, 2021). UPE scholars Kaika, Swyngedouw, Heynen and others (Kaika and Swyngedouw, 2014; Kaika et al., 2022; Swyngedouw, 1996; Heynen et al., 2006) pioneered and inspired further debates on how and why relationships between cities and environments are engendered by exploitative urbanization processes that – under conditions of accelerating environmental degradation – demand more sustainable socio-ecological relations.

For example, when Brenner considered early notions of an urbanizing world as “efforts to decipher the accelerated industrialization of capital in XIX Century Euro-America” (Brenner, 2016), he noted the focus on local and global scales of human activity also served as a framework to justify the multitude of urban interventions that reproduce an exclusionary global history of environmental degradation, dispossession and uneven capitalist development (Brenner, 2016). Drawing on his perspective reinforces the argument that a depoliticized notion of urbanization may conceal and thus reproduce the impact of these exclusionary forces on structural dimensions identified previously, posing risks to Global Health.

Several propositions developed by Brenner and others align with critical theories of urban change relevant to global health research and practice (Brenner and Ghosh, 2022; Brenner, 2016, 2021; Brenner and Katsikis, 2020; Brenner and Schmid, 2015). In addition, UPE scholars explicitly connect urban expansion/concentration and environmental degradation in the face of climate crisis, emerging pandemic and AMR threats (Connolly et al., 2020; Tzaninis et al., 2021; Hinchliffe, 2021; Hinchliffe et al., 2018; Wolf, 2016). As a multifaceted, interdisciplinary project, UPE scholarship allows a variety of access points to the multiple interactive relations of urbanization and nature (Kaika et al., 2022).

In mobilizing UPE scholarship to inform approaches to address AMR, we draw on Tzaninis and colleagues’ (Tzaninis et al., 2021) work that identifies five contributions of UPE scholarship to urbanization research and aligns with epistemological propositions and calls made by Kaika, Swyngedouw, and others for radical urban socio-ecological imaginaries in two distinct but related ways (Kaika and Swyngedouw, 2014). Specifically, they first respond to calls for new ways of mapping ecologies of urbanization (Leaning and Guha-Sapir, 2013) by *redressing societal relations with nature*, which can inform approaches addressing the anthropogenic pressures affecting AMR. Second, the summary of their five contributions align with calls to reorganize non-city geographies or urbanization (Garry and Checchi, 2020) by informing the *rescaling of socio-ecological governance arrangements*. This rescaling can inform the design of governance arrangements addressing the commodification of health determinants and the privatization of commons resources management, which impact human-animal-environmental health systems. We summarize these five contributions into four categories that

illustrate their potential to inform OH approaches to AMR (Box 1).

*4.1. Problematizing or redressing societal relations with nature at the interface of human-animal-environmental health systems*

*Rethinking human and more-than human relations*

Tzaninis and colleagues’ emphasis on human and more-than-human relations shaping urbanization processes and forms considers human relationships with soil, water, air and even bacteria; they propose an alternative approach to urbanization that promotes non-hierarchical and non-exploitative socio-ecological spatial configurations with nature (Tzaninis et al., 2021). Similarly, Wolf uses the term “biocultural events” to describe the study of epidemics as the analytical blending of biological dynamics, environmental effects and social practice (Wolf, 2016). Articulating an analysis of these human and more-than human relations in environments that accelerate AMR can guide a critical analysis of evidence and surveillance systems that monitor “biocultural events” accelerating AMR (Hinchliffe, 2021; Overton et al., 2021; Zhuang et al., 2021; Pahlman et al., 2022), as they relate to the effects of CC and environmental degradation. Recent approaches to AMR primarily focused on a biomedical security logic of surveillance and behavioural change are not effective, as they disregard the impact of social determinants and neglect the effects of environmental degradation and CC on AMR risks (Broom and Doron, 2020; United Nations Environment Programme, 2022; Global Leaders Group on Antimicrobial Resistance (GLG), 2021). Moreover, recent research suggests that AMR responses based on similar logics tend to reproduce northern-dominated biosecurity and biomedical innovation framings (Overton et al., 2021), triumphalist global health security approaches premised on technical and market integration efforts (Hinchliffe, 2021), whose lack of clarity conceals ethical considerations and value systems informing the conceptualization and design of OH-AMR governance responses (Pahlman et al., 2022). Drawing on UPE scholars’ work could re-scale and recast the governance lens to explicitly address this axiological gap and consider the root causes underlying AMU and AMR acceleration, to address upstream socioeconomic factors and structural drivers of AMR in water and sanitation programs, AMU and AMR awareness raising activities (Joshi et al., 2018; Nair et al., 2021, 2023), and harmonization of OH surveillance systems that can reveal disparities in the distribution of environmental and health risks and benefits (Nabadda et al., 2021; Nambiar, 2020). Similar to the design of early warning systems where multiple biomedical and social dimensions are jointly analysed, governance responses concerned with productive engagements would leverage AMU and AMR surveillance dimensions alongside behaviour change information, and measures addressing health inequities and environmental injustices accelerating AMR, related to CC and biodiversity degradation (Cole et al., 2022). A renewed focus on supranational and state governance mechanisms that foster enabling policy environments and the progressive realization of AM stewardship would be imperative.

*UPE: situated and extended urbanizations*

UPE scholarship could also contribute by considering how urban

**Box 1**

indicates the foundational propositions of UPE (left side) and the corresponding summary of contributions to urban research (right side)

**4.1 Redressing societal relations with nature**

- Rethinking human and more-than human relationalities
- UPE: situated and extended urbanizations

**4.2 Rescaling of socio-ecological governance arrangements**

- Addressing the externalities of AMR
- UPE and planetary urbanization

environments have been locally shaped, politicized, and contested (Khan et al., 2020), and how they contribute to adverse health and environmental outcomes. UPE contributions build on Global South, Indigenous and abolitionist political ecologies, decolonizing theories and practices, and sites/products of relational connectivities such as Canadian pipeline politics (Tzaninis et al., 2021; Kipfer, 2018). They also call for a focus on how extended urbanization processes and forms shape societal relations with nature (Keil, 2018). In approaching the UPE of zoonotic diseases, for example, Gandy proposes a zoonotic framing of capitalist urbanization, or 'zoonotic urbanization,' to rescale risk analyses that consider diverse extractive frontiers, zoonotic transfer zones, and accelerator landscapes for new or emerging diseases (Gandy, 2023). Similar to the way Hinchliffe described how 'first world' biosecurity framings that ignore local conditions, market pressures and international competition may contribute to AMR in aquaculture in Bangladesh (Hinchliffe et al., 2018), considering these relations can inform the analysis of local and structural drivers of AMR and how they could be addressed in specific contexts.

Focusing on extended urbanization forms and processes can thus be a starting point to draw on UPE to reorganize and broaden human-centered approaches to geographic inequalities in health that rely on social constructions of health and place (Bambra et al., 2019). UPE could re-orient these approaches towards those that focus on "redressing societal relations with nature" to inform equitable and environmentally just strategies addressing AMR in human-animal-environmental health systems. A focus on relationalities in extended urbanization forms and processes requires recognizing their role in mediating, interconnecting and shaping urban realities that encompass such processes as suburbanization (Tzaninis et al., 2021) and combine economic growth with spatial extension. From a UPE perspective, examples of these include "informal settlements, gated communities, tower estates, kampungs, desakota, peri-urban villages, ... classical subdivisions of ground-related housing .... suburban employment zones, office cities and aeropolises, as well as recreational and infrastructural spaces" (Tzaninis et al., 2021), agri/aquacultural sites and operations, or the entire socio-spatial mesh of relationships that constitute the planetary urban fabric, from the inner city to the agro-industrial relationships and factory farming sites that span the globe (Brenner and Ghosh, 2022); many of which are regarded as AMR hotspots (Kim and Cha, 2021; Nadimpalli et al., 2020; Chandler and Nayiga, 2022; Brunton et al., 2019).

In approaching the ubiquity of extended urbanization as a global process at the same time composed by "disjunct fragments" that expand urban society, Keil notes that they reconfigure global peripheries in a world of complete urbanization, while being constantly "reassembled by human and more-than-human relationalities" (Keil, 2018). Rendering extended urbanization as a global scale process that incorporates human-nature relationalities reveals the often underexposed interdependences between ecologies and the urban as integral and mutually constitutive parts of extended urbanization processes.

The concentration of urban realities and the projection of peripheries, suburbs, vacation homes, satellite towns, and other forms and processes of extended urbanization are also influenced by hierarchies of global economies from the Global North (Keil, 2018).

As AMU became interwoven with the dynamics of modern societies and economies (Willis and Chandler, 2019; Hensher et al., 2020; Chandler, 2019), acceleration of AMR in the environment has also become interwoven with globalized urbanization and the anthropogenic pressures that obscure inequalities. For example, Willis and Chandler (2019) show that AMU in humans, animals and the ecosystem obscures health inequities and the adverse impact of accelerated human activity in our modern era. Through ethnographic research in East Africa, they explore how AMU became interwoven with the dynamics of modern societies and economies, becoming a "quick fix" for care in fragile health systems; for poor hygiene infrastructure; for productivity at local and global scales for humans, animals and crops; and a "quick fix" for inequality in "landscapes scarred by political and economic violence"

(Willis and Chandler, 2019). As we consider antimicrobials as infrastructure entwined with global systems and local demands of modern life (Chandler, 2019), their role may obscure enduring health inequities and environmental pressures, suggesting that responses to AMR should also consider their underlying structural dimensions (Holmes et al., 2016). By jointly framing the adverse impact of AMU on animals and crops in terms of productivity at various scales, Willis and Chandler also provide an opportunity to frame AMU in relation to global governance and economic forces shaping social and political determinants of AMR, which aligns with the theoretical framework exploring UPEs of AMR adapted from Brenner and Ghosh's work (Brenner and Ghosh, 2022).

The acceleration of AMR can thus be linked to a multitude of urbanization forms and processes currently addressed by "quick fixes," which in turn relate to the anthropogenic pressures that produce the vulnerabilities (Broom et al., 2022) and socio-ecological transformations that are typically objects of UPE research.

In a predominantly urbanized world, a UPE lens shows that tackling AMR hotspots would entail their consideration as extended urbanization processes and forms subject to market pressures, international competition and hierarchies of global economies that shape AMR risks, while contending with the effects of CC and environmental degradation.

#### 4.2. Reorganizing socio-ecological governance arrangements at the interface of human-animal-environmental health systems

##### Addressing the externalities of AMR

UPE scholarship theorizes governance practices in the context of neoliberal organization of resources, practices of sustainability, circularity and resilience (Tzaninis et al., 2021). A UPE analysis of commodification and privatization of structural determinants of AMR is particularly relevant for developing socio-ecological governance approaches that address the externalities of AMR governance responses. The concept of an "eco-scalar fix" – in which governance arrangements are rescaled by integrating an ecological 'scale' or dimension - is relevant in theorizing UPE-informed governance as "a process of rescaling and reorganizing governance as a strategy of either internalizing or externalizing socio-environmental externalities, or both, and thereby displacing conflicts and crises, often through the construction of (purportedly "natural") ecological scales, which simultaneously depoliticize and repoliticize governance" (Cohen and Bakker, 2004; as cited in Tzaninis et al., 2021, p. 9). Examples of eco-scalar fixes include promotion and protection of greenbelts in the context of urban development (Keil and Macdonald, 2016), addressing CC through carbon governance, and considering access to/impact on water sources when planning new housing developments. These examples illustrate the potential of UPE to rescale governance arrangements that situate AMR risks in relation to its structural dimensions, as they relate to the effects of CC and environmental degradation, thereby *adjusting the drivers* advancing AMR. Rather than prioritizing rationales that focus on policy compromises or economic optimization (Cashore and Bernstein, 2022) governance responses designed to redress human-nature relations that accelerate AMR threats can use a UPE lens to make explicit connections between urbanization processes, infrastructure networks, global capital flows, resource distribution, environmental degradation, CC and emerging AMR/pandemic threats (Brenner and Ghosh, 2022; Treffers et al., 2021; Tzaninis et al., 2021; Hinchliffe et al., 2018; Nadimpalli et al., 2020; Kaika et al., 2022; Gandy, 2021; MacFadden et al., 2018; Petrie, 2021; Hinchliffe, 2015).

Rather than being informed by rationales premised on technical or market integration efforts (Hinchliffe, 2021), OH-AMR governance responses guided by socioecological approaches to health and development (Joshi et al., 2018; Nair et al., 2021) such as eco-scalar fix necessarily situate OH-AMR responses within broader concerns and responses to other global health threats (Petrie, 2021; OECD, 2020; Barker et al., 2022; Michael Fredenslund et al., 2023).

By mobilizing an "urban lens" (Acuto et al., 2020),



AM-Environmental stewardship can align with pandemic prevention governance pathways that seek to address related existential threats (Petrie, 2021; OECD, 2020). For example, AMR governance strategies could build on existing OH institutionalization efforts and link to broader concerns such as the Global Health Security Agenda, the Sustainable Development Goals or Universal Health Coverage plans (Joshi et al., 2021; Esiovwa et al., 2023). Strategies could also be integrated within global health responses to zoonotic and emerging infectious diseases or food safety issues (Nambiar, 2020; Chua et al., 2021; Kimani et al., 2019).

#### UPE and planetary urbanization

UPE scholars are engaged in reconceptualizing urbanization in a planetary framework that includes both traditionally urban and dispersed non-city geographies (Tzaninis et al., 2021; Kaika et al., 2022). As this includes an emphatic call for collective uses and the common good, UPE's theoretical contribution to a vision of planetary urbanization can inform a critical rescaling of socio-ecological governance arrangements in global health: not through prescriptive guidelines but rather by calling for a renegotiation of ecological, institutional and political perspectives on contemporary urbanization processes and forms that consider situated relationalities of urban life and polycentric forms of governance that look beyond pre-conceived scales and places (Ostrom, 2010, 2015; Simone, 2022). Camponeschi's research on integrative resilience in the face of technocratic responses to Covid-19 and CC offers examples on how similar approaches grounded in situated relationalities in cities inform interventions that are locally relevant, responsive and 'bioecological' (Ortenzi et al., 2022; Camponeschi, 2022).

Engaging communities, civil society and other non-state actors in clarifying the factors that produce the vulnerabilities accelerating AMR would configure whole-of-society approaches that increase the visibility and contributions of these communities while facilitating policy outcomes.

The integrated OH approach to research, design and implementation of interventions to achieve better public health outcomes is a well-established approach used to address global health challenges such as AMR (WHO, WHO, 2017). OH approaches also emphasize the importance of addressing health threats through joint work across multiple sectors. The Global Action Plan on AMR and subsequent UNEP and Tripartite guidance reflect OH approaches promoting the need for intersectoral engagements to rearticulate actions that address global health challenges at the human-animal-environmental interface (United Nations Environment and Programme, 2023; United Nations Environment Programme, 2022; World Health Organization (WHO), 2022; WHO and WOA, 2021).

The urban environmental dimension thus offers a salient interpretive frame, enhancing our understanding of how to rescale socio-ecological governance arrangements in response to the OH call to balance and optimize the health of people, animals and ecosystems by going beyond the organization of siloed governance arrangements within established OH sectors (Hinchliffe, 2015).

As national governments adopt intersectoral whole-of-government approaches to address the threat of CC and environmental degradation (Kanno-Youngs and Rapoport, 2022; Secretariat TB of C, 2017), integration of AMR governance strategies within extant and expanding environmental stewardship presents opportunities to mobilize resources and leverage whole-of-government environmental stewardship measures that support AMR strategies and produce co-benefits to human and planetary health. Just as the concept of "health in all policies" emphasized taking health implications into account in all public policy development (across sectors, and at local, state, and global levels) (Ortenzi et al., 2022; Ollila, 2011), the mobilization of UPE in governance arrangements to address AMR would call for taking other sectors into account using an intersectoral whole-of-government approach that fosters shared CC-AMR governance pathways. A global commons

perspective on AMR further compels society to consider the global implications of local actions.

At a community level, examples of responses that could inform whole-of-society approaches addressing the vulnerabilities triggering AMU in cities as they contend with other existential threats, could be informed by examples of community resilience-building, disaster response and preparedness, and CC planning initiatives (Camponeschi, 2022). Existing intersectoral OH platforms could be leveraged to consider intersections of health equity and sustainable development (Joshi et al., 2021) to support equitable distribution of health and environmental outcomes across targeted groups and populations. Integration of AM-Environmental stewardship approaches through whole-of-government efforts could – for example – support enabling environments that address different aspects of global antibiotic infrastructures (Kirchhelle et al., 2020) beyond food supply chains (Hughes et al., 2021) or the agricultural sector (Barker et al., 2022; Michael Fredenslund et al., 2023). Although shifting agricultural practices into more sustainable models is a challenge resisted within this sector as it would drive up costs and reduce efficiencies, incentives combined with judicious use of information systems within and across sectors, regulations and enforcement within enabling policy environments integrating AM-Environmental stewardship could progressively diminish antimicrobial use and support the necessary shift in approach (see Fig. 1 for an illustration of an enabling policy environments logical framework).

Transnationally, ensuring the World Organization for Animal Health, World Health Organization, World Trade Organization, Food and Agriculture Organization of the United Nations and UNEP recognize the inequities and environmental injustices of AMR as existential risks would reinforce national AM-Environmental stewardship governance approaches.

UPE scholarship can also assist in mapping ecologies of urbanization by *redressing societal relations with nature* that reorient AMR policies beyond a global health security logic of surveillance and behavioural change, towards redressing the health inequities and environmental injustices which produce the vulnerabilities that contribute to AMR and broader environmental threats across human-animal-environmental systems. In summary, UPE scholarship assists in reorganizing non-city geographies or urbanization by *rescaling socioecological governance arrangements* that integrate the local and structural determinants of AMR alongside broader environmental concerns into whole-of-government and whole-of-society efforts.

#### 5. Mobilizing UPE to inform OH responses to AMR and environmental threats

Despite progress in the implementation of OH-AMR governance approaches (Bardosh et al., 2020; Kimani et al., 2019; Gongal et al., 2020; Machalaba et al., 2018), and growing recognition of the co-benefits generated by measures jointly addressing human-animal-environmental health (Guidry et al., 2018; OECD, 2020; Desai et al.,

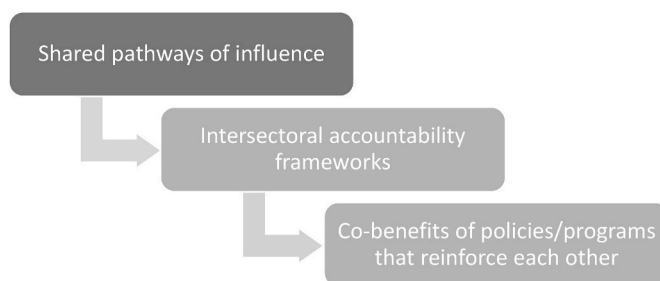


Fig. 1. Enabling policy environments would be based on shared governance pathways that inform intersectoral accountability frameworks and produce co-benefits.

2022; Cullet and Bhullar, 2022), effective institutionalization of these governance approaches remains a challenge. Common barriers to effective institutionalization include market failures that externalize the costs of AMR and impact other structural drivers (Kirchhelle et al., 2020; Moran, 2019), and include public AMR governance responses characterized as fragmented, lacking in OH intersectoral coordination (Moran, 2018; Hoffman and Van Katwyk, 2019). European Union guidance to reduce agricultural impact on CC has been met with challenges (Vallet, 2022; Pronczuk and Moses, 2023). Given the political resistance, reluctance to address such issues in other states has hampered progress, suggesting the need for more consultative, supportive and anticipatory regional and state governance and policy approaches to address the concerns of groups adversely affected.

UPEs of AMR could inform the integration of AMR governance and Environmental stewardship measures that consider existing governance externalities and fragmentation.

Resulting synergies of shared governance pathways would enhance opportunities for the design and implementation of whole-of-government/whole-of-society AM-Environmental stewardship, which would generate co-benefits to human and planetary health (Cole and Desphande, 2019). A logic model and associated framework for enabling policy environments would enhance governance and foster the progressive realization of reinvigorated stewardship measures. In practice, efforts to design enabling policy environments for AM-Environmental stewardship measures could be modeled on incentive-disincentive frameworks (Nijsingh et al., 2019; Morel et al., 2020) similar to Environmental stewardship efforts focused on green and resilient economic recovery (OECD, 2020), or on channels of influence and mutually

supporting frameworks (Petrie, 2021). Strategies include industry self-regulation in response to consumer demand in Canada (Bean-Hodgins and Kiarie, 2021). Box 2 (adapted from Petrie, 2021) outlines challenges that could become opportunities for governments to pursue AM-Environmental governance pathways that support intersectoral accountability frameworks.

## 6. Conclusion

In an urbanized and interconnected world, global AMR governance remains characterized by fragmented, complex non-linear arrangements that often lack intersectoral coordination (Moran, 2018; Hoffman and Van Katwyk, 2019; Bernstein and Cashore, 2012). By fostering a lens on urban life, UPE clarifies connections between AMR and broader concerns affecting all life on earth and the systems upon which it depends. A UPE lens not only addresses the structural determinants of AMR as local and global drivers, it also situates them in relation to planetary urbanization forces and to existential threats addressed in commitments to pandemic prevention and environmental stewardship. Advancement of shared governance pathways through a “whole of government” approach informed by a UPE lens presents an opportunity to engage global forces shaping the co-determinants of antimicrobial threats and environmental degradation. Intersectoral accountability frameworks would strengthen action of sovereign strategies that move beyond rhetoric to adopt and implement international agreements, align and synchronise departmental mandates, budgets and operational plans that would foster more collaborative, equitable and sustainable approaches by adjusting the structural drivers of AMR. As a “new frame for

### Box 2

#### Challenges in fostering shared AMR-Environmental governance pathways

- 1- Build evidence of win-win solutions rather than trade-offs between AMR governance strategies and other commitments to planetary health (i.e., the Pandemic Treaty, Climate Change and Greening Government Strategies, whole-of-government Environmental Stewardship approaches, and other economic and social goals). Address AMR-related environmental degradation while promoting sustainable production and consumption patterns (United Nations Environment Programme, 2022; OECD, 2020).
- 2- Clarify co-benefits of AMR-environmental policies, e.g., global-, state- and societal- level measures to reduce environmental pollution affecting AMR include fostering sanitation systems in LMICs that reduce transmission and evolution of AMR while promoting biodiversity gains (United Nations Environment Programme, 2022; OECD, 2020).
- 3- Public R&D in the development of new technologies that catalyze private sector involvement in solutions to address AMR in the environment, e.g., AM-Environmental stewardship could be accompanied by subsidies to monitor and treat environmental pollution, e.g. untreated waste and antibiotic manufacturing pollution in the environment (Larsson and Flach, 2022; United Nations Environment Programme, 2022; Nijsingh et al., 2019).
- 4- Clarify the increasing cost and risk of inaction on environmental threats to human health related to AMR. AMR is a leading cause of death worldwide, with higher burden in LMICs (Murray et al., 2022) that will lead 24 million people into extreme poverty by 2030. Expected global benefits of AMR containment are far greater than the investment costs. “Assuming that just 50 percent of AMR costs will be avoided by vigorous AMR containment efforts, the expected cumulative global benefits from AMR containment in 2017–2050 range between \$10 trillion and \$27 trillion, far greater than the investment costs of \$0.2 trillion (World Bank, 2017).” The cost of investment in climate action and protecting biodiversity to prevent pandemics caused by similar health threats occurring at the intersection of humans, animals and the environment was reported as much less than the cost of a pandemic (Global Leaders Group on Antimicrobial Resistance (GLG), 2021; OECD, 2020; Dobson et al., 2020).
- 5- Increase awareness of fiscal risks for governments from AMR-related environmental degradation, e.g., ignoring the fiscal impact of government policies and subsidies that affect the environmental dimension of AMR obscures the role of governments enabling spatial and relational vulnerabilities associated with environmental dimensions of AMR (i.e., the financial dimension of AMR).
- 6- Increase recognition of the inequities of AMR associated with climate change and environmental degradation, both in terms of who causes and is most impacted by AMR (Walker et al., 2009; Nadimpalli et al., 2021; Global Leaders Group on Antimicrobial Resistance (GLG), 2021).
- 7- Greater transparency of AMR-related environmental risks and their potential economic and financial impacts strengthens incentives to mitigate the risks through changes in risk premia on government bonds, a tax on antimicrobials, regulation of AMU reinforced by audit and enforcement.
- 8- ‘Frame’ AMR-Environmental initiatives in ways that foster political coalitions for difficult policy change, e.g., presenting win-win options; the increasing costs of inaction; earmarking revenues from environmental and AM taxes to specific incentive programs, including re-configuration of agricultural processes and compensation for those most negatively affected.



understanding the relationship between cities and the environment in contemporary urban policy” (Angelo and Wachsmuth, 2020), integrating UPE as both an epistemological frame and a guide to practical politics of sustainability and human-nature relationships contributes an understanding of how AMR and other systemic threats may be confronted in policy and practice.

## Declarations

### Ethics approval and consent to participate

Not Applicable.

### Competing interests

We have no financial or non-financial competing interests to be declared.

### Credit author statement

Raphael Aguiar: conceived the original idea and wrote the manuscript draft. Mary Wiktorowicz and Roger Keil made substantial contributions to the conception and design of the manuscript and substantially revised it.

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