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Grand challenges in sustainable cities: urban innovation for global climate and sustainability goals—from policy agenda to research needs

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1 Urban innovation: a new priority for global climate and sustainability goals

Urban innovation has emerged as a priority to address global climate and sustainability goals. As the world continues to urbanize, global organizations are encouraging cities to spearhead innovation to meet global carbon reduction targets and reduce inequalities (UN-Habitat, 2022). Finding new ways to build, manage and live in cities is critical to provide all humans with adequate nutrition, shelter, access to products and services including mobility, leisure, health, energy, and education (United Nations, 2023). Focusing on the potential role of urban innovation is logical—cities drive innovation by bringing diverse people, knowledge and resources together (Florida et al., 2018). In many ways urbanization represents the manifestation of new technologies and forms of social organization, from the hydraulic cities of Mesopotamia 7,000 years ago through to industrial and post-industrial cities today (Jacobs, 1969; Athey et al., 2008). However, while the link between cities and innovation is longstanding, the idea of “urban innovation” as a specific activity to discover new ways to develop, manage and inhabit cities in more sustainable ways is recent, distinct and less familiar. This framing of urban innovation reflects established approaches to governance for sustainability, layered over the distinctive characteristics and capabilities of cities. In this paper we define urban innovation as a directed activity that takes place in and is driven by cities as a way to address local challenges that will contribute to the delivery of global climate and sustainability goals. The emergence of the urban innovation as an influential global policy agenda pushes cities once more to the front of the battle against climate change. This paper examines the emergence of urban innovation as a discrete and influential policy goal to deliver global climate and sustainability goals and outlines a research agenda to help achieve this.

The paper is authored with leading global organizations in this space—the United Nations Climate Change Global Innovation Hub and the Global Covenant of Mayors. The United Nations is the leading global organization coordinating international action on key challenges including climate change. The United Nations Global Innovation Hub for Climate Change promotes innovation as a catalyst for achieving global climate and sustainability targets. Their first global dialogue series focused on cities specifically because of their potential to integrate technological, social, and policy innovations. The Global Innovation Hub emphasizes systemic approaches to urban innovation, fostering cross-sectoral collaboration and community engagement to create sustainable, climate resilient development in urban environments. The Global Covenant of Mayors (GCoM) represents an alliance of more than 13,000 cities combatting climate change. Through its Innovate4Cities initiative, launched in 2019 in response to the Edmonton Cities and Climate Change Science Conference (Oke et al., 2022), the GCoM alliance outlines the knowledge gaps and action priorities for urban innovation, research and implementation, sharing data and best practices, and unlocking financing for scalable urban innovation projects. Both work closely with the Mission Innovation Urban Transitions Mission, which launched at COP 26 in 2021. This organization empowers cities worldwide in their transition toward net-zero, resilient, and people-centered cities, mobilizing decision-makers across all levels of government to prioritize pathways enabled by clean energy and systemic innovation across all sectors and in urban governance (Urban Transitions Mission, 2024). The Urban Transitions Mission develops innovation systems capable of transforming cities to address climate change, including a focus on coordinating city level research and innovation challenges (European Commission, 2022).

These organizations form part of a Global Innovation Alliance (GIA), which is engaging cities and relevant partners to build a worldwide urban innovation policy agenda for climate and sustainability goals. This policy agenda is complemented by the Global Research and Action Agenda on Cities and Climate Change Science, which provides a cross-sectoral, systems-based foundation for knowledge to enable urban innovation. This document launched at the Cities and Climate Change Science Conference in Edmonton, Canada in 2018, and in its latest iteration following the 2024 Innovate4Cities Conference, serves as an evidence base for the knowledge and innovation outputs being co-created by researchers, governments, businesses, and civil society (Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne, 2024). These initiatives demonstrate the growing ambition for science to inform action and facilitates the exchange of knowledge to support stronger and more ambitious urban solutions and partnerships.

The priorities and initiatives of these international organizations individually and collectively show that urban innovation has become central to the delivery of global climate and sustainability goals at multiple levels of governance. Urban innovation is being promoted as a way to develop solutions to challenges in sectors ranging from energy and transport to housing and social justice. By cutting across domains, and more closely engaging economic and knowledge production, urban innovation represents an exciting new way to create more sustainable cities. However, as Bai (2024) notes in relation to the potential of cities

to deliver the SDGs, action on the ground requires clarity of roles. The term “urban innovation” is used widely now in policy and research, but in different ways by different groups to mean different things, not necessarily with sustainability or justice and equity as core values. Realizing the potential of urban innovation to deliver climate and sustainability goals requires greater clarity in defining what exactly it is, how it should be done in practice, and who is supposed to be doing it. Given the political weight and resource behind it, researchers have an important role to play in helping to ensure that urban innovation is an equitable and effective. Addressing rather than exacerbating inequalities and making sure successful innovations are actually transformative lie at the forefront of this challenge. This Grand Challenge article builds upon the high levels of current ambition and activity associated with key international initiatives like the Global Innovation Alliance and Global Research and Action Agenda on Cities and Climate Change Science to frame a broad and inclusive research agenda for sustainable cities and urban innovation.

2 Understanding urban innovation

Innovation relates to the development of new services, products or processes that generate value through being of use to customers or users. The concept of innovation was arguably first framed as a place-based agenda in scholarship and policies relating to regional innovation clusters. These often developed near universities, most famously in the case of the Silicon Valley innovation cluster in California that grew up around Stanford University. The focus was on supply-side technology development though, with little consideration of the demands of cities and their residents. The emergence of the idea of smart cities in the early Twenty-First Century dramatically changed this, positioning innovation as a key element of place-making. Urban innovation became an activity focusing on how to deploy digital technologies to improve cities and urban services (Angelidou, 2015). Successful examples include the replacement of traditional incandescent bulbs with LED for street lighting, and the adoption of digital information and payment platforms for citizens to engage with municipal authorities. Evidence suggests that cities investing in smart city projects tend to generate economic benefits associated with traditional innovation, gauged through measures such as numbers of patent filings (Caragliu and Del Bo, 2019). A rapidly growing body of work from China suggests a correlation between the innovative capacity of cities and their environmental performance (see for example Tan et al., 2022; Yang et al., 2022; Guo et al., 2023). Work in this context has also identified a positive relationship between the existence of a digital economy and the achievement of low carbon transitions in larger Chinese cities (Liu et al., 2024). However, it is the distinct idea of urban innovation as a directed process that brings different stakeholders together to develop solutions to problems in their own cities that has gained traction beyond smart cities. In relation to environmental policy, the need for practical action to complement international commitments on climate change and sustainable development, coupled with the emergence of world cities as major political actors (Bulkeley, 2013), has provided fertile ground for urban innovation to emerge as a potential driver of societal change. Urban innovation represents

the culmination of a longer-term metamorphosis of cities from being framed as sources of sustainability problems to sources of sustainability solutions (Angelo and Wachsmuth, 2020). In principle, urban innovation offers a way to situate and address the United Nation Sustainable Development Goals within the context of cities (Cheshmehzangi and Zou, 2024). In practice, the term urban innovation promises local governments a way to fix their own problems, politicians a tool to create sustainable and inclusive growth, and companies new markets for their products. It is no wonder urban innovation has rapidly become a priority to deliver global climate and sustainability goals.

The emergence of urban innovation as a driver of sustainability and climate goals has been accompanied by significant amounts of research and innovation funding, notably in Europe but also India, the US and China. Much of this funding has been provided to partnerships usually led by municipalities to trial new solutions in order to demonstrate and learn how they work in real world settings, propelling methodologies like urban living labs into the mainstream of urban practice (Evans et al., 2016). Although a huge range of sustainability solutions have been trialed in cities, even successful projects have struggled to scale up beyond their initial implementation. This so-called “pilot paradox” (Van Buuren et al., 2018) has prompted a focus on the wider setting in which projects take place, and the need to build the capacity of cities to both innovate internally and adopt innovations piloted elsewhere. As Geels (2024) notes, concrete examples of successful urban transformations that help deliver global climate and sustainability goals remain elusive.

In response, the current policy agenda articulated in the activities of leading global organizations promotes urban innovation as a system rather than a discrete activity. The systems approach to urban innovation comes from a synthesis of systems thinking (Cory and Forrester, 2018) and innovation studies (Godin, 2010), building upon the associated concept of an innovation ecosystem. An innovation ecosystem refers to a network of interconnected actors, institutions, and resources that work collaboratively to foster the development and diffusion of new ideas, technologies, and products (Jackson, 2011). Entities such as universities, firms, governments, and research institutions interact within a regional or global context to enable innovation through knowledge sharing, collaboration, and co-evolution (Granstrand and Holgersson, 2020). Understanding urban innovation as an innovation ecosystem brings into focus a range of supporting functions that city regions provide (Huggins et al., 2024). For example, educational organizations can provide skilled local populations, investors provide funding, and municipalities can help attract talented workers through improving liveability. The systems approach renders urban innovation governable by suggesting ways to shape and support the innovative capacity of cities while understanding the complexity and interconnectivity with other elements of urban life.

Policy at subnational, national and supranational levels has shown a resurgence of interest in innovation as a tool to drive growth and address major societal challenges (Wanzenböck and Frenken, 2020), and the attraction of urban innovation is very much as a driver of systemic change. Urban innovation can address complex place-based challenges holistically by bringing people and organizations together. Systemic change is critical in the context

of delivering climate and sustainability goals, which require rapid, large-scale transformations of all aspects of how we live, but hard to achieve without participatory governance and clear economic benefits at city level (Barrett et al., 2024). Policy often frames innovation within the context of technological advancements (Reid et al., 2023)—smart grids, sensor networks, data-driven platforms, and other “hard” solutions. However, this narrow focus overlooks the social, cultural, and political dimensions that are equally critical for driving sustainability transitions. Evidence suggests that social problems have become a major driver of urban innovation alongside environmental challenges (Trencher, 2019). Urban innovation is not merely about deploying new technologies or implementing isolated projects but about fostering systemic change through the collective understanding of development needs and deployment of new technologies, spaces, ideas, businesses, policies, financial instruments, and cooperative approaches that span sectors (Geels, 2024).

The European Union has designated urban innovation for net zero transitions in cities by 2030 as one of their innovation “missions” (Mazzucato, 2018), instituted in the Urban Transitions Mission. The systemic character of urban innovation ecosystems makes them more suited in principle to address “transformer” missions targeting societal change, like those relating to sustainability and climate goals, rather than more narrowly framed “accelerator” type moon-shot missions (Uyarra et al., 2023). Implementing missions requires new forms of governance at the national, sub-national and city levels, with distinctive approaches that can cut across traditional silos of activity (European Commission, 2023; Buylova et al., 2025). Most importantly here, mission-based innovation must be properly articulated into specific urban contexts for it to succeed (Uyarra et al., 2025). The key challenge facing the urban innovation agenda concerns what happens when larger scale societal innovation priorities, like meeting climate change and sustainability goals, meet local urban conditions (Brett et al., 2023).

3 Policy priorities and research needs

Urban innovation is understood in global policy as being: (i) best governed as an innovation ecosystem, and (ii) able to drive transformative missions oriented toward delivering major societal goals. Urban innovation clearly differs from other modes of innovation; it is place-based, happening in cities rather than R&D labs or industrial clusters, and involves different stakeholder groups, including communities directly affected by changes where they live. Like all urban processes, urban innovation is explicitly political and requires local buy-in. The rejection of many technology-led smart city projects shows the dangers of failing to secure legitimacy for projects as local populations and governments have resisted solutions they see as being imposed on them (Karvonen et al., 2019). Urban innovation is also cross-sectoral rather than focused on the needs of a specific sector. These qualities make urban innovation better suited to develop the kinds of holistic, locally sensitive solutions required to be both sustainable and transformative, but more complex. The provision and use of transport, energy, and housing involve countless stakeholders for example. Whether these differences make urban innovation

qualitatively different to other forms of innovation, and the degree to which urban innovation can be managed using existing concepts like innovation ecosystems and mission-led innovation, remain open questions the co-authoring organizations seek to address with the constituents of the urban innovation research community globally. Better understanding is required of both how urban innovation takes place in practice, the modes of urban innovation that are successful in solving urban problems and driving societal transformation, and the broader macro-conditions (such as education, legal rights, wealth and so forth) that are conducive to successful urban innovation.

The policy agenda for urban innovation coalesces around three widely accepted themes: (i) governance; (ii) scaling; and (iii) capacity building. The first of these themes reflect broader thinking about how to achieve sustainability goals over the past few decades, but acquires specific nuances in the urban context. The second has emerged from specific challenges urban innovation proponents have faced in delivering broader changes through activities in urban settings. The third represents current orthodoxy around how to produce conditions that enable urban innovation. The remainder of the paper reviews the key elements of each theme and identifies research priorities to help progress them.

3.1 Governance

Governance forms the primary focus of the urban innovation policy agenda. Traditional top-down approaches, whereby local governments coordinate urban innovation efforts, are increasingly supplemented with bottom-up engagement strategies to ensure innovation processes include all affected groups (Martin et al., 2018). The third iteration of the Global Research and Action Agenda for Cities and Climate Change Science emphasizes that multilevel governance, communication and coordination between all levels of government and stakeholders are essential for meeting the Sustainable Development Goals and addressing accelerating change (Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne, 2024). Policy emphasizes collaboration with communities, businesses, and other stakeholders to develop solutions tailored to the needs and complexities of specific places (Kroh and Schultz, 2023).

As for public participation in decision-making more generally, the democratization of urban innovation secures legitimacy, improves outcomes, and ensures benefits are more equitably distributed. Innovation that includes and benefits all residents is a priority for urban innovation, but raises a series of challenges. Practically it is hard for cities to know who should be involved in the identification of complex problems and solutions, how to overcome barriers to involving disadvantaged groups, and the effectiveness of different models of community engagement in different settings (Menny et al., 2018). These concerns sit within the wider political context in which cities and local authorities operate. The centralization of political power and adoption of market-led principles, which tend to emphasize efficiency over equity, make it more complicated to involve stakeholders in decision-making. New actors are emerging on the urban stage as traditional municipal

functions are devolved to special purpose agencies or private firms (Judd et al., 2021). Consultants and corporations play increasingly important roles in influencing policy directions, especially in smart cities (Dunleavy et al., 2006). The consultancy class act as knowledge brokers between research and practice, often helping to create transnational networks of cities that they work with. While the implications of these new institutional arrangements have been considered for participatory democracy (for example, Cardullo et al., 2019; Datta, 2023), the extent to which they shape the nature and scope of urban innovation has received little attention.

Traditional economic orthodoxy frames innovation as a lever of national growth, largely ignoring the role of places and societal challenges as driving forces (Ahokas et al., 2024). This is problematic, as urban innovation for climate and sustainability goals always takes place through existing governance structures and associated institutional, political and socio-economic histories of different places (Uyarra et al., 2023). While the principles of good governance are broadly known and accepted, cities have often “struggled to move beyond generic recommendations for improving governance to context- and place-specific recommendations about how to foster change on the ground” (Castán Broto and Westman, 2020, p. 11). This has led to the emergence of new forms of governance that are more adaptive, experimental and responsive to local needs. Urban living labs, demonstrations, pilot projects, regulatory sandboxes, and innovation districts permit opportunities for experimentation with policy, strategy, technologies, and services that traditional forms of governance do not (Marvin et al., 2018). They represent place-based responses to the need to bring stakeholders together to foster urban innovation. Digital technologies can play a transformative role, enabling citizens to participate in urban governance in deeper and broader ways that can drive more effective and place sensitive forms of innovation (Przebyłowicz and Cunha, 2024). A vast literature has emerged around urban experiments and living labs, but there are still major gaps in our understandings of how place-based modes of innovation integrate or trade-off social, environmental and economic factors (Coenen and Morgan, 2020), and drive transformation in different urban settings (Castán Broto et al., 2022).

The problems that most cities struggle with, embodied in the SDGs, are more mundane but no less fundamental, like providing adequate housing and dealing with waste systems, which can inspire paradigm-shifting innovation. Like research on urban sustainability (Nagendra et al., 2018), research on innovation tends to focus on cities in the Global North, privileging formal actors and processes, notably the state and business sector. Although the vast majority of the world’s urban population live in cities in the Global South, the roles of urban informality, indigenous knowledge and alternative belief systems in urban innovation are less adequately covered in comparative examination of their needs and priorities. In practice, this means that while the context for urban innovation is different in the Global South, approaches and policy choices around urban sustainability challenges tend to reflect those of the Global North (Haswell et al., 2024).

The importance of grassroots innovation, where civil society often leads innovation and the state plays a less visible role (Mavhunga, 2014), has been flagged by development scholars for

some time in relation to the formulation and achievement of the SDGs (Leach et al., 2012), and is equally crucial but less emphasized in the urban sphere. Indigenous innovation rooted in non-Western knowledge systems, practices and beliefs can provide novel solutions to sustainability challenges. Indigenous communities have developed sustainable farming techniques like agroforestry, which integrates crops and trees to preserve ecosystems, or used traditional farming practices to adapt to the impacts of climate change (Nzeadibe et al., 2012). Frugal innovation (or Jugaad) is about creating affordable, efficient, and effective solutions using limited local resources (Radjou et al., 2012). Examples abound, but in relation to transport include retrofitting trikes with electric motors in India to cover greater distances, or adapting motorbikes with trailers for cargo transport in Africa. In the context of urban informality, city dwellers often provide infrastructure like shelter and energy for themselves in incremental and creative ways (Silver, 2014). This urban innovation is harder to capture and govern using concepts such as innovation ecosystems when not associated with formal actors. Inclusive innovation focuses on new solutions that benefit disenfranchised groups, like the proliferation of small-scale informal urban agriculture in peripheral spaces of urban Africa (Odame et al., 2020) and their formalization in places like Detroit (Adams, 2024). The need for innovation that both includes and benefits wider social groups is equally pressing in Global North and Global South contexts (Parsons et al., 2024), reflected in recent efforts to include citizens in the programming of regional innovation challenges (Butzin et al., 2024).

For urban innovation to address global climate and sustainability goals more fairly and quickly, researchers must help broaden the scope of what constitutes innovation (and by extension its governance and multilevel governance). Foster and Heeks (2013, p. 333) argue that while, “(s)ystems of innovation are shown to be an appropriate frame for conceptualization of inclusive innovation... the conventional content of this framework must be modified to allow for the nature of innovations required, the actors involved and their interrelations, the type of learning they undertake, and the institutional environment in which they operate.” Alongside a conceptual broadening, empirical work is required to understand where and how alternative forms of innovation, like frugal innovation, exacerbate or alleviate poverty (Knorringa et al., 2016). A similar priority has been identified in the literature on urban transformation, whereby broadening the scope of what counts as innovation is critical to developing new forms of governance and rationales based on more intersectional and decentralized processes of innovation (Jeannerat and Lavanchy, 2024).

Finally, while policy makers and scholars have tended to focus on innovation as a way to create new solutions, cities are playing a leading role in accelerating the decline of incumbent, unsustainable, technologies including Internal Combustion Engines, fossil fuel heating, unhealthy diets and so forth. Strategies that encourage phase-out, divestment and disengagement from unsustainable technologies and services can be viewed as governance innovations in themselves, as well as ways to drive innovation to fill the gap that is left (Rosenbloom and Rinscheid, 2020). Examples include cities that have tried to phase out unsustainable transport technologies (Graaf et al., 2021). Work on the governance of “urban exnovation”, or the purposeful

phase out of technologies in cities, is nascent but represents an important research topic concerning urban innovation for climate and sustainability goals.

3.2 Scaling

The need for a rapid societal change to achieve climate and sustainability goals has prompted a policy focus on how successful initiatives can scale up to drive broader transformation. Individual projects can address challenges in a specific place in a joined up way, but the resulting solutions are hard to implement more widely as the governance of cities (and societies) tends to divide management of different sectors. In consequence, one of the main challenges of place-based approaches is “scaling up” successful local initiatives beyond the individual experiment to amplify its impact by prolonging or accelerating its effect, extending it into more places and/or changing structures, values and mind-sets (Moore et al., 2015; Torrens and von Wirth, 2021; Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne, 2024). In the context of smart cities, Nilssen (2019) identifies technological, organizational, collaborative and experimental dimensions of innovation that cities need to think about together in order to accelerate the identification, development, and effective deployment of solutions across multiple different types of actors at scale. Scaling innovation is not simply a matter of replication, but requires a deep understanding of local contexts and the specific needs of urban populations (Evans et al., 2016). In this sense, scaling becomes an intricate process of alignment, where diverse actors and institutions must negotiate shared goals while adapting to local contexts. This involves designing strategies and roadmaps that integrate individual projects into a long-term strategy of transformation (Mirte et al., 2024), securing legal, political, social and institutional support (Bason, 2010), and fostering a culture of cross-sectoral collaboration. Ensuring alignment in these three dimensions is challenging in practice and research as they cut across concerns that are usually treated separately.

Key bodies including the UN and EU are emphasizing the role of creativity, culture and knowledge in driving urban innovation and scalability. This broader conceptualization can bridge the gap between technical and community-driven approaches, fostering inclusive forms of innovation. Literature on environmental change increasingly recognizes the importance of the personal sphere in shaping transformation, including the “subjective beliefs, values, worldviews and paradigms that influence how people perceive, define or constitute systems and structures, as well as their behaviors and practice” (O’Brien, 2018, p. 156). Capturing peoples’ imaginations through working with faith organizations, creative industries and other cultural institutions constitute levers to scale urban innovation in more inclusive and socially resonant ways. For researchers this means going beyond the usual focus on municipalities and policy to grapple with less familiar innovation actors and enabling processes.

Finally, scaling requires new models for business, participatory governance funding and policy interventions on both the supply and demand side of innovation governance (Barrett et al., 2024).

Funding and regulatory constraints on city-scale action are unresolved challenges in the climate research and response journey. Public procurement and policy are key levers at the city and city-regional levels to create markets for urban innovations to deliver climate and sustainability goals (Flanagan et al., 2023; Pihlajamaa and Valovirta, 2024; Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne, 2024). Transformative change requires innovation to deliver value across a broader spectrum of stakeholders, including the public and private sectors, as well as civil society, and over a longer time-period than standard commercial approaches. To achieve this, venture capital firms, development banks, and other financial entities must reconfigure their strategies to support initiatives that prioritize long-term sustainability rather than short-term gains (Sørensen and Torfing, 2011). Outcome-based financing models tie funding to the achievement of specific sustainability outcomes. In the case of performance-based contracts for energy-efficiency retrofits, payment to contractors depend upon the verified energy savings achieved through building retrofits. Equitable resource distribution must involve decentralized access to climate finance, demanding greater flexibility and responsiveness from the National Designated Authorities of multilateral climate-focused funds (notably the Global Environment Facility, Green Climate Fund, Adaptation Fund, Loss and Damage Fund, among others), including blended finance packages for investment (Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne, 2024).

In the urban context, challenge based policies and innovation accelerators, and their physical counterparts like incubators and innovation parks, have a pivotal role to play. These entities are not merely financial enablers; they act as focal points for knowledge transfer and skill development, providing the networks necessary for start-ups to grow and for innovative solutions to scale (Cohen, 2013). Their role in urban innovation for sustainability, particularly in relation to finance and business models, is recognized but less well understood. For example, circular economy models would involve product-as-a-service, including shared mobility services (e.g., e-bikes, scooters) and furniture-as-a-service for urban apartments (Koide et al., 2022). Material and product passports track the composition and lifecycle of materials or products (Honic et al., 2021). In buildings and infrastructure, for example, that would allow for better deconstruction and reuse and reduce carbon emissions and waste in the construction industry (Tzani et al., 2022). Scaling urban innovations is the reverse of adapting societal challenges into the specificities of place, and often agents responsible for scaling must exploit local benefits that were created in partnership (Roebke et al., 2022). This process requires clear expectations at the outset of innovation processes that can also be handled through specific third party vehicles like innovation accelerators.

3.3 Capacity building and evidence

The third urban innovation policy focus relates to the cultivation of key skills, including entrepreneurial capability,

cultural competency, and brokering to build the capacity of cities to innovate. Wu et al. (2018) define policy capacity as the resources, practices and procedures that are used to formulate and implement policies. Capacity building has a well-established lineage in relation to environmental policy. Wieszczeczynska et al. (2024) show how key international summits on climate change and sustainability, notably the first annual Forum on Capacity Building (2011), UNFCCC (2015), and UN-Habitat (2016), prompted rapid growth in research on urban climate adaptation and capacity building. Recent attention has shifted toward assessing the readiness of stakeholders within and across cities and local governments to innovate. The Climate Innovation Readiness Navigator—a methodology recently launched by the Global Covenant of Mayors for Climate and Energy (2024) in partnership with Arup—represents a good example. The Navigator aims to produce regional and national profiles of climate innovation readiness at their respective urban scales, and describes urban climate innovation readiness as “the ability of urban stakeholders to govern, generate, adopt and implement new or improved products or processes to increase [their] resilience...to the challenges presented by climate change.” Placing local governments at the center of this process helps highlight the policy applications of urban innovation, while enabling valuable engagement from civil society, business, and academia in the process. The Climate Innovation Readiness Navigator is designed to prompt reflection from those focused on governance and finance systems within the public sector on how their work impacts upon other systems and dimensions of climate resilient development across the communities within their jurisdiction. The EU Cities Mission represents another influential and important governance innovation intended to help cities drive the required energy/climate transition by providing tools for them to break down silos (Buylova et al., 2025). The ways in which such capacity building plays out, including its strengths and weaknesses, and ability to change business as usual are critical research questions.

Emerging digital technologies offer real time data and digital twins of urban environments that can increase the capabilities of cities to understand problems and model potential solutions (Batty, 2018). Data can give cities a better understanding of both problems and the impacts of innovations to address them, but can be resource intensive to gather (Evans et al., 2024) or not available to cities in ways that they can use (Acuto, 2018). For example, in many cities the most detailed transport data is held by private companies like Uber. Other forms of socio-economic and environmental data are fragmented and hard to combine limiting insights. Beyond this, major dimensions of urban sustainability have little data available. Researchers and universities are playing increasingly important roles helping municipalities to collect, collate and analyze urban data. The potential of data, digital twins, AI and modeling to improve urban management is well known, but needs to be human-centric (Kitchin, 2014). Embedding employees from municipalities in urban research programmes can help ensure technologies respond to the priorities and experiences of citizens, and seed new forms and practices of governance that are more responsive to local conditions and needs (Rogers et al., 2023). Such partnerships can also enhance the ability of cities to understand and use scientific data, which represents a bottleneck in realizing

smarter urban governance (Mora et al., 2025). Instances in which partnerships like these have generated transformative sustainability benefits represent important areas for research.

The capacity of cities to innovate also depends on their ability to learn from their innovation activities and evaluate what works. In relation to the European New Deal, McCann and Soete (2020) advocate a learning system that can capture and reflect the local dynamics of innovation including its effects on people and places. Evidence concerning how trade-offs are managed are necessary to understand how to balance goals like innovation with sustainability and social justice (Henderson et al., 2024; Newell et al., 2022). Impact evaluation measures the actual impact of the initiative on the pre-defined indicators. This might require rigorous evaluation designs, such as randomized controlled trials or quasi-experimental methods, to isolate the effect of the initiative from other factors. Evidence concerning the roles played by different factors in urban innovation ecosystems is required to help cities understand where to invest their capacity building efforts. Process evaluation assesses the implementation process itself, including stakeholder engagement, communication strategies, and resource allocation (Rossi et al., 2019). This would help identify bottlenecks and improve future initiatives. Finally, more effective learning from urban experiments is necessary (Ersoy and Bueren, 2020).

Existing studies tend to focus on individual factors, such as the role of universities or policy in specific settings for example, rather than understanding the inter-relationships between different factors and their impacts on innovation for climate and sustainability goals (Guo et al., 2023). Longitudinal studies and detailed evaluations of real-world cases reveal not only the successes and failures, but deepen our understanding of the psychological shifts necessary for sustained urban innovation (Evans et al., 2021). Cities, as collective entities, must adopt mind-sets that foster innovation—a shift that requires organizations to transform not only their practices but also their structures and identities. Public administrators, political scientists, and urban planners must engage with the deeper processes of organizational change and governance restructuring (Meijer, 2023). The concept of transformative capacity, which is the ability to disrupt existing organizational structures and practices is not a simple top-down process, but involves a bottom-up reconfiguration of the relationship between public authorities, the private sector, and third-sector actors (Wolfram, 2016; Borrás et al., 2024). Clearly urban innovation projects are a rich source of lessons and experiences to shape and drive this process (Torfing and Ansell, 2020).

In their review of transformative innovation policy more widely, Haddad et al. (2022) identify building up the capacity of policy makers to enact and evaluate transformative outcomes as a key priority. Innovations can be appropriated by communities, with intermediary actors playing a range of critical if sometimes accidental roles in the process. During the COVID-19 lockdown in India, neighborhood-based women-centric self-help groups became multipliers for the local governments by connecting with the low-income communities and elderly households through mobile apps to deliver food, medicine and emergency health care (Chatterji et al., 2024). Effectively evaluating transformations, whether of systems, places or communities, is hard but necessary to understand what works and why (Molas-Gallart et al., 2021).

Finally, building urban innovation capacity needs global networks to disseminate evidence and scale successful approaches. Coordination of data and evidence concerning the successes and failures of initiatives has been highlighted as being of critical importance to building the capacity of cities to address sustainability and climate challenges across a number of sectors, from air quality to health (Kumar, 2021). City-to-city learning networks and transnational collaborations allow local solutions to travel across geographic boundaries and to be adapted in diverse contexts. Large-scale programs such as the European Union's Horizon 2020 Smart Cities and Communities initiative or the National Urban Innovation Hub in India offer promising models for how urban innovation can be coordinated at national and supranational scales. These programs are essential in creating the platforms necessary for cities to share knowledge, pool resources, and build capacities across borders (Haarstad, 2016). However, despite the growing number of transnational city networks focused on global challenges such as climate change, assessment of the effectiveness of these networks is often limited to hard policy outcomes such as contributing to the delivery of carbon reduction goals (Bansard et al., 2017). If city networks are to play a meaningful role in addressing global urban challenges, we need more rigorous process evaluations of how effective transnational collaborations and frameworks for systemic transformation are in enhancing innovative capacity (Acuto and Leffel, 2021).

4 Conclusions: a global research agenda for urban innovation

Urban innovation has become central to global policy responses to sustainability and climate change. Framed as a way to transform societal systems, policy on urban innovation converges around the themes of governance, scaling, and capacity building. This paper has identified a series of questions concerning how these themes play out in specifically urban settings. We conclude with three research priorities to support urban innovation for global sustainability and climate challenges:

- Alternative models of innovation. To be globally transformative, urban innovation requires a broader understanding of what constitutes innovation and who should be involved. Key research areas include the co-production of urban innovation, including the effectiveness of different models of engagement in different settings. This includes interventions and approaches that go beyond the traditional scope of research on innovation, for example to include innovation led by civil society and/or shaped by citizens and non-Western knowledge systems, and research on the role of managed decline.
- Building capacity to scale. Scaling must overcome financial, technical, social, governance, and institutional challenges. Urban innovation is often about adopting and adapting solutions from elsewhere, which requires technical capacity and needs to leverage digital technology. Examples and understandings of how personal, social, and societal

transformations work together are required. Broader understandings of scaling need to encompass cultural and creative approaches, while research should focus on examples of successful scaling rather than successful pilots.

- **Evaluation and evidence.** Evidence and data are needed to support urban innovation to identify and address challenges more effectively. A fuller evidence base concerning how urban innovation can deliver global climate and sustainability goals under different conditions around the world is required. This includes evaluation of the impacts of strategies and interventions to promote urban innovation on different communities, particularly concerning trade-offs and longer term impacts.

Urban sustainability researchers are well equipped to contribute to this agenda. Urban innovation for climate and sustainability goals cuts across all aspects of how we manage and live in cities, so requires interdisciplinary understandings that broaden how we approach innovation and scaling in urban contexts. Urban innovation privileges the role of cities in driving societal change, providing fresh impetus for cities as key players in global climate and sustainability action. The urban innovation agenda aspires to be inclusive, fair, and socially meaningful—characteristics that urban sustainability shares. A significant community of researchers participate in making initiatives to improve cities, both professionally and as residents, and have an important role to play in supporting more inclusive and responsible forms of place-based urban innovation (Trencher et al., 2014). Finally, innovation is a close cousin to research and is by definition knowledge-intensive. The heightened importance of evidence, skills, evaluation and learning to accelerate urban innovation for sustainability and climate change opens up a greater role for educational and research institutions in orienting urban innovation ecosystems toward sustainability and climate goals. Leveraging systems approaches that utilize city-level models and data to deliver just and equitable action in climate resilient development require cross-sector co-creation of knowledge. In parallel, approaches that integrate multiple case studies, including databases, can facilitate the identification of trends and lessons.

The challenges outlined here require a rethinking and broadening of our conceptual, practical and methodological toolkits. The degree to which urban innovation can be managed purely using existing concepts like innovation ecosystems and mission-led innovation, remain open questions. In many places, the elements of urban innovation ecosystems are being increasingly incorporated into the concerns and mechanisms of mainstream urban governance. In others, urban governance simply does not fit well with this conceptual approach. Work on urban informality provides a rich source of concepts and cases, but is more challenging to govern in formal innovation policy and strategy. Important but hard to capture goals like long-term transformation, cross-sectoral collaboration, personal, cultural,

and organizational change require wider domains of research to be drawn into the urban innovation agenda. In line with the principles of the Montréal Call to Action on Cities, Climate Research and Governance, this agenda needs research that is co-produced with stakeholders and freely available to all, allowing cities, municipalities, communities, companies, and NGOs open access to evidence, insights, and case studies. Frontiers in Sustainable Cities was founded on a commitment to creating and sharing knowledge to help cities become more sustainable. Cities are innovating around the world but do not have the time or resources to reinvent the wheel. Our role as a global research community is to supply evidence and insights that help make urban innovation as effective and fair as possible.

Author contributions

JE: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. DC: Conceptualization, Writing – original draft. TC: Writing – original draft. AI: Writing – review & editing. BJ: Writing – original draft. CO: Writing – review & editing. MT: Conceptualization, Validation, Writing – review & editing. GT: Writing – original draft, Conceptualization, Validation, Writing – review & editing. EU: Writing – original draft. MY: Writing – original draft.

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References

- Acuto, M. (2018). Global science for city policy. *Science*. 359, 165–166. doi: 10.1126/science.aao2728
- Acuto, M., and Leffel, B. (2021). Understanding the global ecosystem of city networks. *Urban Stud.* 58, 1758–1774. doi: 10.1177/0042098020929261
- Adams, B. (2024). “From urban gardens to agrihoods: the rise of agricultural neighborhoods in Detroit.” *One Earth*. Available online at: <https://www.oneearth.org/from-urban-gardens-to-agrihoods-the-rise-of-agricultural-neighborhoods-in-detroit/> (accessed June 6, 2024).
- Ahokas, J., Järvenivu, p., and Toivanen, T. (2024). Ideas behind transformative innovation policy: Economists confronting missions and sustainability transition in Finland. *Environ. Innov. Societ. Transit.* 53, 100927. doi: 10.1016/j.eist.2024.100927
- Angelidou, M. (2015). Smart cities: a conjuncture of four forces. *Cities*, 47, 95–106. doi: 10.1016/j.cities.2015.05.004
- Angelo, H., and Wachsmuth, D. (2020). Why does everyone think cities can save the planet? *Urban Stud.* 57, 2201–2221. doi: 10.1177/0042098020919081
- Athey, G., Nathan, M., Webber, C., and Mahroum, S. (2008). Innovation and the city. *Innovation* 10, 156–169. doi: 10.5172/impp.453.10.2-3.156
- Bai, X. (2024). Post-2030 global goals need explicit targets for cities and businesses. *Science* 385, eadq4993. doi: 10.1126/science.adq4993
- Bansard, J. S., Pattberg, P. H., and Widerberg, O. (2017). Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. *Int. Environ. Agreements Pol. Law Econ.* 17, 229–246. doi: 10.1007/s10784-016-9318-9
- Barrett, B. F., Trencher, G. P., Truong, N., and Ohta, H. (2024). How can cities achieve accelerated systemic decarbonization? Analysis of six frontrunner cities. *Sustain. Cities Soc.* 100, 105000. doi: 10.1016/j.scs.2023.105000
- Bason, C. (2010). *Leading Public Sector Innovation* (vol. 10). Bristol: Policy Press.
- Batty, M. (2018). *Inventing Future Cities*. Cambridge: MIT Press.
- Borrás, S., Haakonsson, S., Hendriksen, C., Gerli, F., Poulsen, R. T., Pallesen, T., et al. (2024). The transformative capacity of public sector organisations in sustainability transitions. *Environ. Innov. Societ. Transit.* 53, 100904. doi: 10.1016/j.eist.2024.100904
- Brett, N., Magnusson, T., and Andersson, H. (2023). From global climate goals to local practice—mission-oriented policy enactment in three Swedish regions. *Sci. Public Policy* 50, 603–618. doi: 10.1093/scipol/scad010
- Bulkeley, H. (2013). *Cities and Climate Change*. Milton Park: Routledge.
- Butzin, A., Rabadjeva, M., and Terstriepe, J. (2024). Anchoring challenges through citizen participation in regional challenge-based innovation policies. *Environ. Innov. Societ. Transit.* 52, 100856. doi: 10.1016/j.eist.2024.100856
- Buylova, A., Nasiritousi, N., Bergman, J., Sanderink, L., Wickenberg, B., Casiano Flores, C., et al. (2025). Bridging silos through governance innovations: the role of the EU cities mission. *Front. Sustain. Cities* 6, 1463870. doi: 10.3389/frsc.2024.1463870
- Caragliu, A., and Del Bo, C. F. (2019). Smart innovative cities: the impact of Smart City policies on urban innovation. *Technol. Forecast. Soc. Change* 142, 373–383. doi: 10.1016/j.techfore.2018.07.022
- Cardullo, P., Di Felicianantonio, C., Kitchin, R. (2019). *The Right to the Smart City*. Bingley: Emerald Publishing Limited. doi: 10.1108/9781787691391
- Castán Broto, V., and Westman, L. K. (2020). Ten years after Copenhagen: reimagining climate change governance in urban areas. *Wiley Interdiscip. Rev. Clim. Change* 11, e643. doi: 10.1002/wcc.643
- Castán Broto, V. C., Ortiz, C., Lipietz, B., Osuteye, E., Johnson, C., Kombe, W., et al. (2022). Co-production outcomes for urban equality: learning from different trajectories of citizens’ involvement in urban change. *Curr. Res. Environ. Sustain.* 4, 100179. doi: 10.1016/j.crsust.2022.100179
- Chatterji, T., Götz, G., Harrison, P., Moore, R., and Roy, S. (2024). Capacity in motion: comparative COVID-19 governance in India and South Africa. *Territory Pol. Govern.* 12, 1601–1621. doi: 10.1080/21622671.2022.2154829
- Cheshmehzangi, A., and Zou, T. (2024). *Cities of Tomorrow: Urban Resilience and Climate Change Preparedness*. Cham: Springer.
- Coenen, L., and Morgan, K. (2020). Evolving geographies of innovation: existing paradigms, critiques and possible alternatives. *Norwegian J. Geogr.* 74, 13–24. doi: 10.1080/00291951.2019.1692065
- Cohen, B. (2013). Sustainable valley entrepreneurial ecosystems. *Bus. Strat. Environ.* 22, 1–14.
- Cory, D., and Forrester, J. (2018). “A Pioneer on the next frontier: an Interview with Jay Forrester,” *Systems Thinker*, Vol. 11. Arcadia: Pegasus Communications.
- Datta, A. (2023). The digitalising state: governing digitalisation-as-urbanisation in the global south. *Prog. Hum. Geogr.* 47, 141–159. doi: 10.1177/03091325221141798
- Dunleavy, P., Margetts, H., Bastow, S., and Tinkler, J. (2006). *Digital Era Governance—IT Corporations, the State and e-Government*. New York: Oxford University Press.
- Ersoy, A., and Bueren, E. V. (2020). Challenges of urban living labs towards the future of local innovation. *Urban Plann.* 5, 89–100. doi: 10.17645/up.v5i4.3226
- European Commission (2022). *Net-Zero, Resilient and People-Centred Cities Action Plan of the Urban Transitions Mission*. Brussels: European Commission.
- European Commission (2023). *EU missions—Implementation at the National Level*. Brussels: Office of the European Union. Available online at: <https://data.europa.eu/doi/10.2777/788981>
- Evans, J., Pregolato, M., Rogers, C. D., Harris, J. A., and Topping, D. (2024). Environmental data, governance and the sustainable city. *Front. Sustain. Cities* 5, 1355645. doi: 10.3389/frsc.2023.1355645
- Evans, J., Vácha, T., Kok, H., and Watson, K. (2021). How cities learn: from experimentation to transformation. *Urban Plann.* 6, 171–182. doi: 10.17645/up.v6i1.3545
- Evans, J., Karvonen, A., and Raven, R. (2016). “The experimental city: new modes and prospects of urban transformation,” in *The Experimental City* Milton Park: Routledge, 1–12.
- Flanagan, K., Uyarra, E., and Wanzenböck, I. (2023). Towards a problem-oriented regional industrial policy: possibilities for public intervention in framing, valuation and market formation. *Reg. Stud.* 57, 998–1010. doi: 10.1080/00343404.2021.2016680
- Florida, R., Adler, P., and Mellander, C. (2018). “The city as innovation machine,” in *Transitions in Regional Economic Development* (Milton Park: Routledge), 151–170.
- Foster, C. G., and Heeks, R. B. (2013). Conceptualising inclusive innovation: modifying systems of innovation frameworks to understand diffusion of new technology to low-income consumers. *Eur. J. Dev. Res.* 25, 333–355. doi: 10.1057/ejdr.2013.7
- Geels, F. W. (2024). *Advanced Introduction to Sustainability Transitions*. Cheltenham: Edward Elgar Publishing.
- Global Covenant of Mayors for Climate and Energy (2024). *Climate Innovation Readiness Navigator for Cities and Local Governments*. Available online at: <https://www.globalcovenantofmayors.org/wp-content/uploads/2024/09/CIRN-110924.pdf> (accessed March 3, 2025).
- Global Covenant of Mayors for Climate and Energy, UN-Habitat and University of Melbourne (2024). *Accelerating Next-Generation City Climate Action: Findings from the 2024 Innovate4Cities Conference and Update to the Global Research and Action Agenda on Cities and Climate Change Science*. Brussels: Global Covenant of Mayors for Climate & Energy
- Godin, B. (2010). “Innovation studies: the invention of a specialty (part I and II),” in *“Innovation Studies”: Project on the Intellectual History of Innovation, Working Papers No. 7 and 8*. Montreal: Urbanisation Culture Société Research Centre.
- Graaf, L., Werland, S., Lah, O., Martin, E., Mejia, A., Muñoz Barriga, M. R., et al. (2021). The other side of the (policy) coin: analyzing exnovation policies for the urban mobility transition in eight cities around the globe. *Sustainability* 13, 9045. doi: 10.3390/su13169045
- Granstrand, O., and Holgersson, M. (2020). Innovation ecosystems: a conceptual review and a new definition. *Technovation* 90–91, 102098. doi: 10.1016/j.technovation.2019.102098
- Guo, J., Fu, Y., and Sun, X. (2023). Green innovation efficiency and multiple paths of urban sustainable development in China: multi-configuration analysis based on urban innovation ecosystem. *Sci. Rep.* 13, 12975. doi: 10.1038/s41598-023-40084-x
- Haarstad, H. (2016). Where are urban energy transitions governed? Conceptualizing the complex governance arrangements for low-carbon mobility in Europe. *Cities*, 54, 4–10. doi: 10.1016/j.cities.2015.10.013
- Haddad, C. R., Nakić, V., Bergek, A., and Hellsmark, H. (2022). Transformative innovation policy: a systematic review. *Environ. Innov. Soc. Transit.* 43, 14–40. doi: 10.1016/j.eist.2022.03.002
- Haswell, F., Edelenbosch, O. Y., Piscicelli, L., and van Vuuren, D. P. (2024). The geography of circularity missions: a cross-country comparison of circular economy policy approaches in the Global North and Global South. *Environ. Innov. Soc. Transit.* 52, 100883. doi: 10.1016/j.eist.2024.100883
- Henderson, D., Morgan, K., and Delbridge, R. (2024). Delivering micro-missions in public food transitions: harnessing tensions for creative outcomes. *Environ. Innov. Soc. Transit.* 52, 100873. doi: 10.1016/j.eist.2024.100873
- Honic, M., Kovacic, I., Aschenbrenner, P., and Ragossnig, A. (2021). “Material Passports for the end-of-life stage of buildings: challenges and potentials. *J. Clean. Prod.* 319, 128702. doi: 10.1016/j.jclepro.2021.128702
- Huggins, R., Thompson, P., and Prokop, D. (2024). “Technological innovation and sustainable transitions,” in *Urban Sustainability*, eds. A. Cheshmehzangi, S. Gosh, and S. Majumdar (Cham: Springer).

- Jackson, D. J. (2011). *What is an Innovation Ecosystem?* Alexandria: National Science Foundation.
- Jacobs, J. (1969). Strategies for helping cities. *Am. Econ. Rev.* 59, 652–656.
- Jeanerath, H., and Lavanchy, P. (2024). Transformative social innovation in, of and by the city: beyond mission-driven policy rationales. *Environ. Innov. Soc. Transit.* 52, 100890. doi: 10.1016/j.eist.2024.100890
- Judd, D. R., McKenzie, E., and Alexander, A. (2021). *Private Metropolis: The Eclipse of Local Democratic Governance (Vol. 32)*. Minneapolis: University of Minnesota Press.
- Karvonen, A., Cugurullo, F., and Caprotti, F. (2019). *Inside Smart Cities* (Milton Park: Routledge), 9781351166201-1
- Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *Geof.* 79, 1–14. doi: 10.1007/s10708-013-9516-8
- Knorrina, P., Peša, I., Leliveld, A., and Van Beers, C. (2016). Frugal innovation and development: aides or adversaries? *Eur. J. Dev. Res.* 28, 143–153. doi: 10.1057/ejdr.2016.3
- Koide, R., Murakami, S., and Nansai, K. (2022). Prioritising low-risk and high-potential circular economy strategies for decarbonisation: a meta-analysis on consumer-oriented product-service systems. *Renew. Sustain. Energy Rev.* 155, 111858. doi: 10.1016/j.rser.2021.111858
- Kroh, J., and Schultz, C. (2023). The more the better? The role of stakeholder information processing in complex urban innovation projects for green transformation. *Int. J. Project Manage.* 41, 102466. doi: 10.1016/j.ijproman.2023.102466
- Kumar, P. (2021). Climate change and cities: challenges ahead. *Front. Sustain. Cities* 3, 645613. doi: 10.3389/frsc.2021.645613
- Leach, M., Rockström, J., Raskin, P., Scoones, I., Stirling, A. C., Smith, A., et al. (2012). Transforming innovation for sustainability. *Ecol. Soc.* 17, 6. doi: 10.5751/ES-04933-170211
- Liu, M., Li, S., Li, Y., Shi, J., and Bai, J. (2024). Evaluating the synergistic effects of digital economy and government governance on urban low-carbon transition. *Sustain. Cities Soc.* 105, 105337. doi: 10.1016/j.scs.2024.105337
- Martin, C. J., Evans, J., and Karvonen, A. (2018). Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America. *Technol. Forecast. Soc. Change* 133, 269–278. doi: 10.1016/j.techfore.2018.01.005
- Marvin, S., Bulkeley, H., Mai, L., McCormick, K., and Palgan, Y. V. (2018). *Urban Living Labs: Experimenting with City Futures*. Milton Park: Routledge.
- Mavhunga, C. C. (2014). *Transient Workspaces: Technologies of Everyday Innovation in Zimbabwe*. Cambridge: MIT Press.
- Mazzucato, M. (2018). *Mission-Oriented Research and Innovation in the European Union a Problem-Solving Approach to Fuel Innovation-Led Growth*. Brussels: European Commission.
- McCann, P., and Soete, L. (2020). “Place-based innovation for sustainability,” in *JRC Working Papers (No. JRC121271; JRC Working Papers)*. Joint Research Centre (Seville site). Available online at: <https://ideas.repec.org/p/ipt/iptwpa/jrc121271.html> (accessed March 3, 2025).
- Meijer, A. (2023). “Urban Innovation,” in *Global Encyclopedia of Public Administration, Public Policy, and Governance* (Cham: Springer International Publishing), 13112–13117.
- Menny, M., Palgan, Y. V., and McCormick, K. (2018). Urban living labs and the role of users in co-creation. *GALA-Ecol. Persp. Sci. Soc.* 27, 68–77. doi: 10.14512/gaia.27.S1.14
- Mirte, M., Pel, B., Wittmayer, J., and Sengers, F. (2024). Transformative social innovation in, of and by the city: beyond mission-driven innovation. *Environ. Innov. Soc. Transit.* 47:100828.
- Molas-Gallart, J., Boni, A., Giachi, S., and Schot, J. (2021). A formative approach to the evaluation of Transformative Innovation Policies. *Res. Eval.* 30, 431–442. doi: 10.1093/reseval/rvab016
- Moore, M. L., Riddell, D., and Vocisano, D. (2015). Scaling out, scaling up, scaling deep: strategies of non-profits in advancing systemic social innovation. *J. Corpor. Citizensh.* 67–84. doi: 10.9774/GLEAF.4700.2015.ju.00009
- Mora, L., Gerli, P., Batty, M., Binet Royall, E., Carfi, N., Coenegrachts, K. F., et al. (2025). “Confronting the smart city governance challenge,” in *Nature Cities* (New York: Nature Publishing Group), 1–4.
- Nagendra, H., Bai, X., Brondizio, E. S., and Lwasa, S. (2018). The urban south and the predicament of global sustainability. *Nat. Sustain.* 1, 341–349. doi: 10.1038/s41893-018-0101-5
- Newell, P. J., Geels, F. W., and Sovacool, B. K. (2022). Navigating tensions between rapid and just low-carbon transitions. *Environ. Res. Lett.* 17, 041006. doi: 10.1088/1748-9326/ac622a
- Nilssen, M. (2019). To the smart city and beyond? Developing a typology of smart urban innovation. *Technol. Forecast. Soc. Change* 142, 98–104. doi: 10.1016/j.techfore.2018.07.060
- Nzeadibe, T. C., Egbule, C. L., Chukwuone, N. A., Agwu, A. E., and Agu, V. C. (2012). Indigenous innovations for climate change adaptation in the Niger Delta region of Nigeria. *Environ. Dev. Sustain.* 14, 901–914. doi: 10.1007/s10668-012-9359-3
- O’Brien, K. (2018). Is the 1.5°C target possible? Exploring the three spheres of transformation. *Curr. Opin. Environ. Sustain.* 31, 153–160. doi: 10.1016/j.cosust.2018.04.010
- Odame, H. S., Okeyo-Owuor, J. B., Changeh, J. G., and Otieno, J. O. (2020). The role of technology in inclusive innovation of urban agriculture. *Curr. Opin. Environ. Sustain.* 43, 106–111. doi: 10.1016/j.cosust.2019.12.007
- Oke, C., Assarkhaniki, Z., Walsh, B., Jance, B., and Deacon, A. (2022). *City Research and Innovation Agenda: Priorities and Policy Mechanisms*. Melbourne: University of Melbourne.
- Parsons, K., Delbridge, R., Uyarra, E., Waite, D., Huggins, R., and Morgan, K. (2024). Advancing inclusive innovation policy in the UK’s second-tier city-regions. *Rev. Res. Res.* 44, 313–336. doi: 10.1007/s10037-024-00209-9
- Pihlajamaa, M., and Valovirta, V. (2024). The potential of innovation contests in articulating demand for system-level transformation: the case of the Helsinki Energy Challenge. *Environ. Innov. Societ. Trans.* 53, 100916. doi: 10.1016/j.eist.2024.100916
- Przebylłowicz, E., and Cunha, M. (2024). Governing in the digital age: the emergence of dynamic smart urban governance modes. *Gov. Inf. Q.* 41, 101907. doi: 10.1016/j.giq.2023.101907
- Radjou, N., Prabhu, J., and Ahuja, S. (2012). *Jugaad innovation: Think Frugal, be Flexible, Generate Breakthrough Growth*. Hoboken: John Wiley and Sons.
- Reid, A., Steward, F., and Miedzinski, M. (2023). *Aligning Smart Specialisation with Transformative Innovation Policy. Lessons for Implementing Challenge-led Missions in Smart Specialisation*. Luxembourg: Publications Office of the European Union, JRC1344.
- Roebeke, B., Frantzeskaki, N., and Loorbach, D. (2022). Assessing change agency in urban experiments for sustainability transitions. *SSRN Electron. J.* Available online at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4069227 (accessed April 10, 2025).
- Rogers, C. D., Grayson, N., Sadler, J. P., Chapman, L., Bouch, C. J., Cavada, M., et al. (2023). Delivering sustainable, resilient and liveable cities via transformed governance. *Front. Sustain. Cities* 5, 1171996. doi: 10.3389/frsc.2023.1171996
- Rosenbloom, D., and Rinscheid, A. (2020). Deliberate decline: an emerging frontier for the study and practice of decarbonization. *Wiley Interdiscip. Rev. Clim. Change* 11, e669. doi: 10.1002/wcc.669
- Rossi, P. H., Lipsey, M. W., and Henry, G. T. (2019). *Evaluation: A Systematic Approach, Eighth Edition* (New York: Sage Publications).
- Silver, J. (2014). Incremental infrastructures: material improvisation and social collaboration across post-colonial Accra. *Urban Geogr.* 35, 788–804. doi: 10.1080/02723638.2014.933605
- Sørensen, E., and Torfing, J. (2011). Enhancing collaborative innovation in the public sector. *Administr. Soc.* 43, 842–868. doi: 10.1177/0095399711418768
- Tan, F., Yang, L., Lu, Z., and Niu, Z. (2022). Impact of urban innovation on urban green development in China’s Yangtze River Economic Belt: perspectives of scale and network. *Environ. Sci. Pollut. Res.* 29, 73878–73895. doi: 10.1007/s11356-022-21042-y
- Torfing, J., and Ansell, C. (2020). “Strengthening political leadership and policy innovation through the expansion of collaborative forms of governance,” in *Political Innovations* Milton Park: Routledge), 37–54.
- Torrens, J., and von Wirth, T. (2021). Experimentation or projectification of urban change? A critical appraisal and three steps forward. *Urban Transform.* 3, 8. doi: 10.1186/s42854-021-00025-1
- Trencher, G. (2019). Towards the smart city 2.0: Empirical evidence of using smartness as a tool for tackling social challenges. *Technol. Forecast. Soc. Change* 142, 117–128. doi: 10.1016/j.techfore.2018.07.033
- Trencher, G., Yarime, M., McCormick, K. B., Doll, C. N., and Kraines, S. B. (2014). Beyond the third mission: exploring the emerging university function of co-creation for sustainability. *Sci. Public Policy* 41, 151–179. doi: 10.1093/scipol/sct044
- Tzani, D., Stavrakas, V., Santini, M., Thomas, S., Rosenow, J., Flamos, A. (2022). Pioneering a performance-based future for energy efficiency: lessons learnt from a comparative review analysis of pay-for-performance programmes. *Renew. Sustain. Energy Rev.* 158, 112162. doi: 10.1016/j.rser.2022.112162
- UNFCCC (2015). *The Paris Agreement*. United Nations Framework Convention on Climate Change. Available online at: <https://unfccc.int/process-and-meetings/the-paris-agreement> (accessed April 10, 2025).
- UN-Habitat (2016). *New Urban Agenda*. United Nations Conference on Housing and Sustainable Urban Development (Habitat III). Available online at: <https://unhabitat.org/sites/default/files/2019/05/nua-english.pdf> (accessed April 10, 2025).
- UN-Habitat (2022). *Annual Report 2022*. United Nations Human Settlements Programme. Available online at: <https://unhabitat.org/annual-report-2022> (accessed April 10, 2025).
- United Nations (2023). *Follow-up to the Implementation of the New Urban Agenda and Strengthening of UN-Habitat*. Report of the Secretary-General.

Available online at: <https://digitallibrary.un.org/record/4069871> (accessed April 10, 2025).

Urban Transitions Mission (2024). *Global Innovation Summit 2024*. Urban Transitions Mission. Available online at: <https://urbantransitionsmission.org/global-innovation-summit-2024/> (accessed April 10, 2025).

Uyarra, E., Bugge, M. M., Coenen, L., Flanagan, K., and Wanzenböck, I. (2025). Geographies of mission-oriented innovation policy. *Environ. Innov. Soc. Transit.* 24, 100970. doi: 10.1016/j.eist.2025.100970

Uyarra, E., Wanzenböck, I., and Flanagan, K. (2023). The spatial and scalar implications of missions: challenges and opportunities for policy. *MIOIR Working Paper Series, (2023-04)*. Manchester: Manchester Institute of Innovation Research.

Van Buuren, A., Vreugdenhil, H., van Popering-Verkerk, J., van Leeuwen, C., Breman, B., Ellen, G. J. (2018). "The pilot paradox: exploring tensions between internal and external success factors in Dutch climate adaptation projects," in *Innovating Climate Governance: Moving Beyond Experiments* (Cambridge: Cambridge University Press), 145–165.

Wanzenböck, I., and Frenken, K. (2020). The subsidiarity principle in innovation policy for societal challenges. *Global Transit.* 2, 51–59. doi: 10.1016/j.glt.2020.02.002

Wieszczyńska, K. A., Tollin, N., and Spaliviero, M. (2024). Capacity building within urban climate resilience in the Global South—a literature review. *Front. Sustain. Cities* 6, 1380936. doi: 10.3389/frsc.2024.1380936

Wolfram, M. (2016). Conceptualizing urban transformative capacity: a framework for research and policy. *Cities* 51, 121–130. doi: 10.1016/j.cities.2015.11.011

Wu, X., Ramesh, M., and Howlett, M. (2018). "Policy capacity: conceptual framework and essential components," *Policy Capacity and Governance: Assessing Governmental Competences and Capabilities in Theory and Practice* (Berlin: Springer), 1–25.

Yang, J., Xiong, G., and Shi, D. (2022). Innovation and sustainable: can innovative city improve energy efficiency? *Sustain. Cities Soc.* 80, 103761. doi: 10.1016/j.scs.2022.103761