



Networking urban science, policy and practice for sustainability

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Networks are increasingly important for advancing urban science, policy and practice. The complexity that cities present to stakeholders of all kinds demands systems-based and networked approaches to solving sustainability challenges. This article analyses the contemporary rise of global networks of urban science, policy, and practice. We provide an overview of urban science, policy, and practice networks followed by a detailed case study of the emerging Future Earth Urban Knowledge Action Network (Urban KAN), highlighting its vision, initial activities and impacts, and challenges and remaining tasks. Findings from the case study reveal that a network across science, policy and practice can make significant contribution in cutting-edge knowledge generation, global research agenda setting, timely contribution to global policy processes, catalyzing the formation of new national and thematic research-action networks, among others. In contrast, such a network also faces challenges, in terms of attraction and representation of the composition, maintaining initial momentum, turning the science-policy integration and collaboration into reality, and obtaining strong and continued financial and institutional support. We conclude that networks across the boundaries of science-policy-practice are still in their infancy, and deeper collaborations across sector, scale, and networks that enable the implementation of effective new actions will be key indicator in measuring the success of these networks.

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Introduction

Cities are central to a sustainable global future [1^{**},2,3^{**},4,5], and local and global networks — of people, organizations and cities are increasingly important for facilitating the exchanges and collaboration among urban science, policy and practice communities that can leverage local action into global impacts [6,7]. City networks are particularly important in showcasing and sharing experiences and lessons because municipal and local governments are the implementation level of national sustainability policy. Networked cities strengthen local actions by facilitating cross-city learning which in turn scales up and spreads impact globally. Networked cities can support communities of practice wherein cross-city interactions promote the dissemination across urban contexts of innovative urban practices. Such a cross-fertilization is essential to broadening and upscaling successful urban sustainability experiments [8]. For example, advancing nature-based solutions as a key tool for climate change adaptation in urban environments has required not only new research, but the development of peer-to-peer learning networks to share best practices, facilitate the identification of barriers, and speed adoption [9] [10]. The

complexity that urban stakeholders face in determining priorities for action, resource allocation, planning, policy, and management demands systems-based and networked approaches to solving sustainability challenges [11].

In the context of urban sustainability challenges, the concept of networks has multiple meanings, encompassing a range of social and institutional structures. Urban networks are not limited to those linking cities. Rather, within complex, multidimensional urban systems, actors, processes, and governance structures are intrinsically and intricately connected, within and across cities [11–13]. The idea of the networked city refers to the multiple infrastructure networks that support the functioning of modern cities [14^{*}], to the role of cities as global nodes in the flow of capital and information [15,16], and to their role in connecting other networks [7]. In each case, the concept transcends the city boundaries [17]. Taylor and Derudder [18] consider the “world city network as the ‘skeleton’ upon which contemporary globalization has been built”. Networks of spatially clustered cities with functional differentiation can form urban corridors [19], a series of smaller cities linked through transportation and economic activities between two major cities. Urban governance frameworks themselves occupy positions within systems of government networks—a recent study on the low-carbon transition in Shanghai revealed a nested structure of innovation which allows project-level learnings to be upscaled to influence city-level policy, and city-level learnings to inform national-level policy [8]. Numerous professional networks connect urban ecologists (e.g. Ecological Society of America), planners (e.g. American Planning Association; Planning Institute in Australia) and urban engineers (e.g. Institute of Engineers), as well as informal networks that connect across disciplines (e.g. The Nature of Cities).

Most networks — whether national or international networks with formal structures or more localized and informal networks that rely on ‘shadow systems and informal spaces’ [20] — tend to attract and engage like-minded individuals, typically working on the same domain and fulfilling similar functions. Much can be achieved via traditional networks, but the need to build and support new networks that cut across traditionally siloed disciplines and sectors is increasingly clear. Government agencies, for example, historically separated interlinked functions namely transportation, planning, health, buildings, and so on, and this separation remains apparent in modern governance structures [21,22]. However, many urban challenges cut across these silos and require coordination, knowledge exchange, and shared resources and leverage for effective resolution. Designing appropriate responses to climate-driven extreme events that are wreaking havoc on cities around the world, is such an example. The unsettling and

unprecedented cyclone that ravished Mozambique, Zimbabwe and neighboring countries in March 2019 revealed a myriad of global and local challenges, from climate to resilience, health, cultural tolerance, and race and gender inequality. These issues transcend functional divide in government and require coordinated interventions. As urban populations continue to grow at unprecedented rates and resulting in the growing number, size, and complexity of cities, the need to share knowledge and link resources is paramount to address global and local sustainability challenges in a concerted way.

To achieve global sustainability goals will require a pivotal shift in how global urban knowledge is produced and shared [5]. It will require bringing together scholars, thinkers, practitioners and policy-makers from disparate fields and sectors and reorganizing existing knowledge domains that are currently compartmentalized and professionalized [5,23–25]. It will require overcoming the inherent limits of our cognitive capabilities through the development of new network-based ontologies — new ways of representing combined spatial and social network flow data [26]. It will require building organic ‘networks of networks’ that harness new technologies and join diverse voices to transform complex urban systems towards sustainability and resilience. It will also require increased overlap between science and policy circles, and shortened cycles between theory and practice — a key outcome that can be expected from cross-domain networks.

The need for such cross-domain networks have been highlighted recently. For example, a global urban science Expert Panel convened by *Nature Sustainability* highlighted [26] the need for new inclusive networks that link ‘a wide range of experts, including non-academic actors such as NGOs, residents, consultancies, industry, international organizations, and city networks’ to advance urban sustainability science. Additionally, Future Earth, a 10-year global research initiative on sustainable development, promotes co-design and co-production as one of its core design principles, which has already played an important role in enhancing the profile of cross-sector approaches and interdisciplinary input into global policymaking.

Here we provide a brief overview of the approach to networks in urban literature and the rise and role of global networks in urban science, policy and practice, with a particular focus on those that bridge the science-policy-practice divide. This overview is followed by a case study of the Future Earth Urban Knowledge Action Network (Urban KAN) focusing particularly on the vision, composition, key initiatives and impact to date. On the basis of this case study, we distill several key barriers and

Table 1**Examples of urban science-policy-practice networks**

	Core areas	Examples of key initiatives
Global networks		
100 Resilient Cities	City action, resilience solutions, local leaders, global influence	100 Resilient Cities Network
C40 Cities Climate Leadership Group	Climate adaptation, mitigation implementation, air quality, energy & buildings, food, waste & water, transportation & urban planning	Deadline 2020
Cities Alliance	Global south cities, urban slums, cities and sustainable development	Innovation Programme
Coalition for Urban Transitions	Economics, policy options, finance	Financing the Urban Transition
Global Covenant of Mayors for Climate and Energy	Data, finance, innovation for addressing climate change	Innovate4Cities
ICLEI Local Governments for Sustainability	Low-emissions, nature-based, circular, resilient, equitable and people centered development pathways	Talanoa Dialogues, 100% RE Cities and regions network
Metropolis	Urban diplomacy and metropolitan advocacy, capacities for metropolitan governance	Metropolis Urban Innovation, Metropolis Observatory
United Cities and Local Governments (UCLG)	Metropolitan areas, intermediary cities, territories, Localizing SDGs	Learning UCLG
Urban Climate Change Research Network	Scientific assessment on urban climate change issues specific to urban climate change needs (UHI, air quality, urban design etc.)	Urban Climate Change Assessment (ARC3)
Urban Knowledge Action Network	Link urban science to urban policy and practise, capacity building for co-designing sustainable urban futures	Cities and Climate Change Science conference, Nature and the Urban Century Assessment, Urban Planet Book Project
Regional Networks		
African Center for Cities	Convener and central knowledge hub driving evidence-based policy influence across the African continent	City-lab programme, NOTRUC initiative, MOVE program
Federation of Canadian Municipalities	Organizer, convener and municipal funder representing all of Canada's municipalities	Municipalities for Climate Innovation

challenges for integrated urban science-policy-practice networks.

Networked approach in urban research and practice

Over the last decade, urban science, practice and policy networks have exploded [27], in terms of quantity, the diversity of actors, and areas of focus vis-à-vis urban sustainability. More than 200 urban-oriented networks exist globally, collectively playing an active role across many fronts, including shaping international relations [28]. Table 1 highlights some of the many prominent examples of urban science-policy-practice networks.

The rapid growth of urban networks changed the science, practice and policy landscape — actors traditionally operated within static, siloed environments are now adapting to straddle multiple system boundaries with respect to urban governance, knowledge creation and action in cities [29]. Network approaches

have often proven better suited than more formal organizational approaches in cities, because they improve the quantity and quality of relationships and knowledge exchange between people or nodes in the network [30]. This allows greater opportunity for collaboration and co-creation, while facilitating and scaling impacts throughout the reach of the network [31]. Empirical evidence suggests that collaborative urban networking can be valuable for cities: urban performance improves with the degree of connectivity within the network, and scales with the level of active participation [32].

Networks can facilitate multi-directional communication and learning among stakeholders occupying different roles along the science-policy-practice spectrum. For example, universities with resources such as libraries and data repositories are well positioned as boundary organizations to support collective ownership and management of project-derived knowledge within the

'knowledge commons'. Indeed, universities play a significant role in co-design and co-production of knowledge for urban sustainability [33–35].

It has been noted that knowledge is socially constructed and that exchange, particularly across sectoral or disciplinary domains, implicitly involves a struggle to define a spectrum of solutions [36]. Networks thus need to incorporate continuous social/triple-loop learning, recognizing that policy learning is a contest between competing 'frames' or discourses. Furthermore, given the complexity of urban sustainability challenges and the feedbacks latent within network structures themselves, approaches rooted in systems thinking, including simple model-building, can be powerful tools for transdisciplinary engagement and policy learning across networks [37]. When properly developed (e.g. when diverse, deliberative, and reflexive), networks can build common cause, social capital, and stronger trust-based relationships among diverse stakeholder groups [38,39]. In ideal circumstances, networks can shape needed institutional innovation, expanding the world views and solution spaces of decision makers to encompass new options that are both feasible and desirable. Indeed, it is apparent that decision-makers are increasingly prepared to engage in collaborative decision-making with stakeholders and communities [40].

There are limitations to current networked approach, in terms of the composition, effectiveness, and potential risks. Most existing networks are driven by stakeholders of a particular domain, although many aspire to stronger science-policy-practice linkages. There is a relative lack of effective global/regional urban policy-driven fora and there remains a crucial disconnect between city network activity and national policy learning. Lee and Jung [41], for example, found that not all city-to-city (C2C) networks for climate change action are currently active or effective. Their analysis suggests that C2C climate networks with functions beyond networking and information sharing—potentially including lobbying, research, climate planning, and monitoring—are more likely to develop continued collaboration with member cities [41]. The effectiveness of transnational municipal networks in global climate governance can also be limited by a membership skewed toward developed countries, the differentiated responsibilities and respective capabilities for emission reductions, and the lack of monitoring schemes [42,43]. Frantzeskaki *et al.* [44**] identified potential risks of overreliance on external inputs in identifying local policy priorities and solutions, based on an in-depth analysis of the intermediating role of ICLEI in urban biodiversity governance, and calls for a balanced approach between global targets and pressing local issues.

Such limitations, however, do not overshadow the roles of networks as in practice, city learning is most effective through peer-to-peer interaction. Good practices can spread within and among cities, just as social practices are adopted across contexts through the formation of shared expectations and norms [43]. Network building within specific cities can also allow for certain network styles and methods of practice to flourish which are appropriate for the contexts of specific municipalities [45***]. Urban networks can provide important mechanisms for building 'horizontal linkages' which are crucial to supporting and scaling innovative urban sustainability experiments and achieving sustainability transitions [46,47].

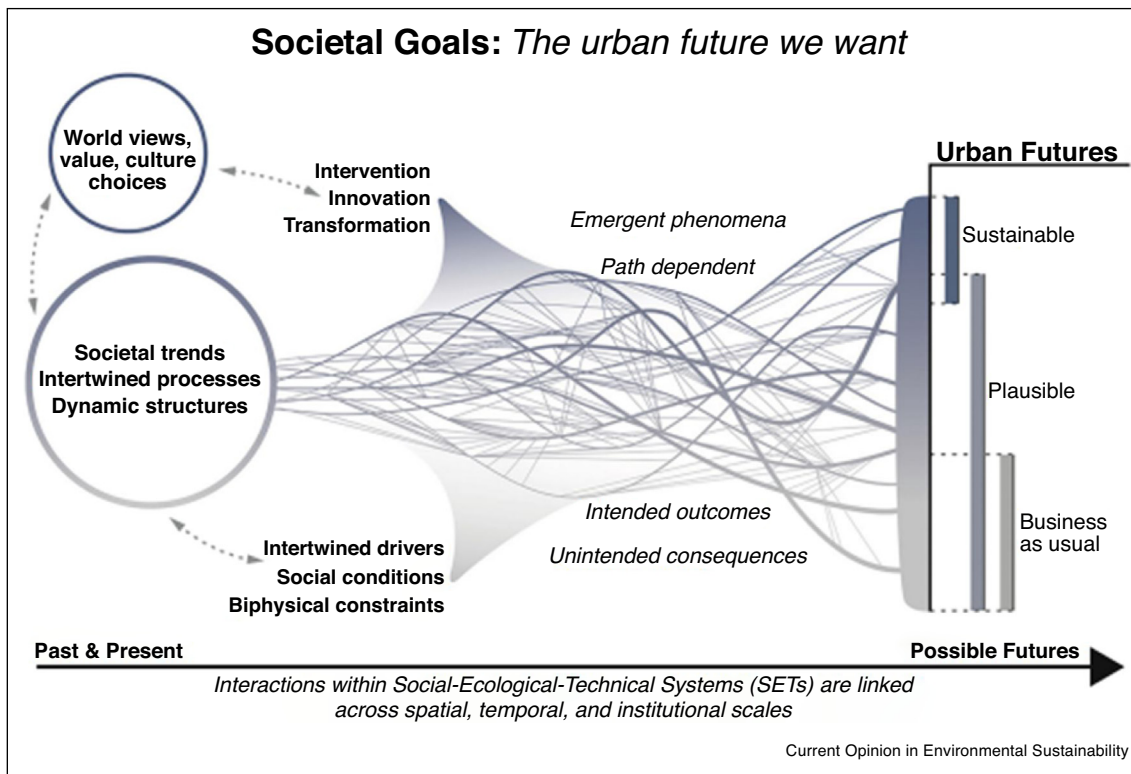
Developing an integrated urban knowledge-action network

Here we take the emerging Future Earth Urban Knowledge Action Network (Urban KAN) as a case study, to explore the promises and effectiveness as well as the limits and the remaining challenges for integrated urban science policy practice networks.

Future Earth Urban Knowledge Action Network: vision, principle, aspiration

Future Earth's Urban Knowledge Action Network (Urban KAN) was launched in 2016 at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador. The Urban KAN aims to accelerate the production and implementation of cutting-edge, actionable knowledge in and about cities, in support of real-world transitions and transformations towards sustainability by bringing together researchers, and other stakeholders including national and subnational policy and decision-makers, urban planners and practitioners, representatives from non-governmental organizations, business, the private sector, and playing an active role in relevant global science and policy processes. Two of the Urban KAN's fundamental working principles are: a) the recognition of cities as complex systems wherein numerous **Figure 1** factors and processes interact across geographic, institutional, and governance scales and time frames [11]; and b) the promotion of co-design and co-production of urban knowledge among the stakeholders. Urban KAN aspires facilitate research on, and provides a global platform for, positive examples and innovative practices of sustainability in cities that transcend business as usual, based on the recognition that discourse around urban and global futures tends to be dystopian and not informing planning and policymaking for more optimistic urban futures (**Figure 1**) [48**]. As such, it challenges researchers, practitioners, policy makers and others to envision the urban transformations that will provide needed direction, inspiration and motivation to the world's cities, while actively working towards urban implementation toward global sustainability.

Figure 1



Envisioning positive futures from McPhearson *et al.* [48**].

Member composition and distribution

The Urban KAN has approximately 300 members from diverse disciplines, affiliations, geographies and cultural backgrounds. Figure 2 overlays those diverse member affiliations across their respective geographic locations using Social Network Analysis (SNA) software GEPHI to create an illustrative visualization of the network composition. Reported affiliations, or fields of expertise of members were recorded from survey data. The key insights depicted in the visualization are the wide range of types of members in the network. Disciplines from basic sciences in hydrological, atmospheric, ocean, land, ecosystem, climate, health, geography, to monitoring and modeling tools such as GIS and remote sensing, and to the management, planning, policy and governance of cities, just to name several. The greatest number of members are from North America, but South America, Europe, Asia and Oceania also have substantial representation. Increasing representation from the Global South will be essential, especially in light of the enormous gap between knowledge needs and availability in rapidly growing cities of the developing world [3]. Forty six percent of members are affiliated with universities and other research institutions, with other notable actors including NGOs (10%), civil society (6%), private sector (6% and city

government 4%). This distribution highlights that while some progress has been made in terms of cross-domain reach, effectively engaging practitioners and policy makers remains a challenge.

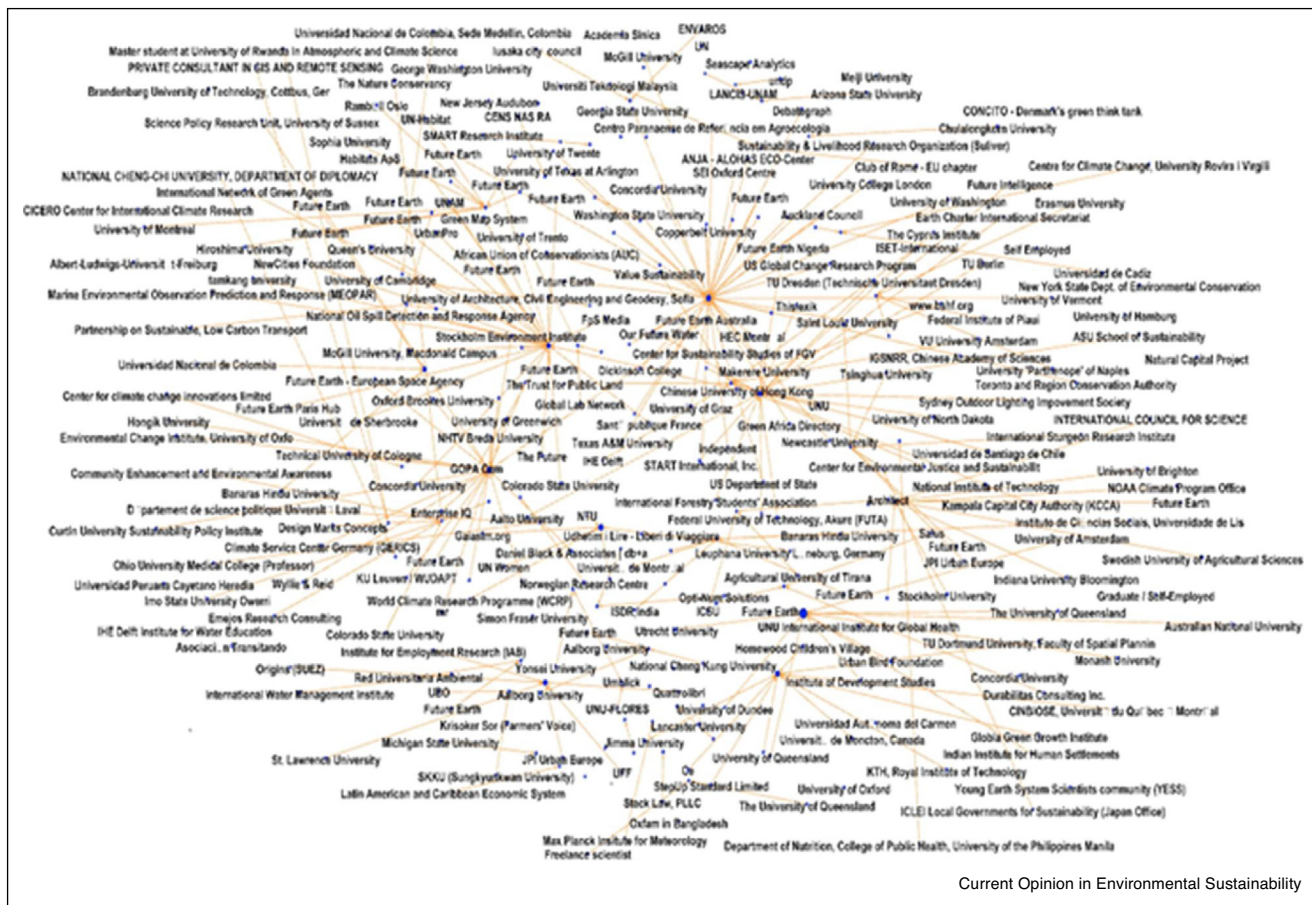
Key activities and contributions

The key initiatives and contributions of Future Earth Urban KAN so far is reviewed under the following four categories, namely knowledge generation, input to high level policy processes, science visioning in key areas, catalyzing national and thematic research network development.

Knowledge generation

One of the initial initiatives of the Urban KAN since its preparation stage was The book *Urban Planet* [2], published by Cambridge University Press in late 2018. The book featured contributions from more than 100 urban researchers, policy makers, and practitioner into one place, to synthesize the state of the knowledge and practice towards sustainable cities. The Urban KAN also provided a platform for researchers to exchange ideas and form new research collaborations, which led to many high level publications including in top academic journals (see for example, [3–5,10,49***,50,51,52**,53,54]).

Figure 2



This social network visualization of the Urban KAN overlays member affiliation across geographic location, highlighting the various size, strengthen and composition of the nodal points in the network.

Input to key policy processes

Urban KAN provided input to the development of New Urban Agenda launched by UN in its Habitat III Conference, through a focus group discussion and collaboration with the key stakeholders developing the New Urban Agenda. In two publications generated via this process and a direct input document to the policy process, the KAN members argued for a stronger role of science in shaping the urban agenda [5], and a systems approach in urban science and policy [11]. A contingent of more than 100 people represented the Urban KAN (then attending under the Future Earth umbrella) at Habitat III, taking up various speaking roles at the Habitat III panels, side events, media conferences. Another example is Urban KAN's contribution to the Convention on Biological Diversity through its role in the first two rounds of research development in the Nature and the Urban Century Assessment, which was launched at 14th Conference of the Parties in December 2018. Numerous Urban KAN members contributed to other global science-policy interface via organized

sessions and individual participation in COP, IPCC, IPBES, SDG HLP, World Urban Forum.

Shaping global research and action agenda

The Urban KAN also played a pivotal role in the IPCC Cities and Climate Change Science Conference, held in Edmonton, Canada in March 2018, through leading the development of the scientific vision, leadership roles in the Scientific Steering Committee and Organising Committee, and in developing the *Research and Action Agenda on Cities and Climate Change Science* [55] which was prepared at the request of the IPCC after the conference, and has been noted by the panel during its 48th session in October 2018. The report, together with several high level publications led/coauthored by Urban KAN members [45^{***},47,53,54], is expected to inform the IPCC AR6 report and the planned IPCC special report on cities early in the AR7 round.

Catalyzing national and thematic research networks

The Urban KAN has been playing a catalyzing role in the formation of new research networks. As part of Future Earth Australia (FEA)'s priority theme, aligning with the Urban KAN's strategic direction, an interdisciplinary network of Australian-based researchers initiated a co-design exercise during 2015–17 with urban stakeholders from national, state, regional and local levels, which became the Australian Urban Systems Transformation (AUST) initiative [24]. The initial objective was to see how urban challenges could be framed and addressed in a more holistic and collaborative way to help drive transformational change. Participants of an FEA-convened workshop in May 2018 proposed that FEA co-develop, with the urban research community and a broad range of stakeholders, a National Strategy for Australia. This process is now under way, including workshops in each Australian state and territory capital city. A primary objective of the National Strategy is to further test the potential for the development of 'knowledge action networks' (KANs), at national, state/territory, metropolitan/regional, and local levels.

The NATURE-based Solutions to Urban Resilience in the Anthropocene (NATURA) project is also about to be launched from within an emerging working group of the UKAN. This project, funded by the US NSF Accel-Net program will focus on nature-based solutions for urban resilience. NATURE is a network of worldwide networks, who through exchange of knowledge, sharing data, and enhancing communication among research disciplines and across the research–practice divide, will accelerate understanding of how to prepare for the growing threat of extreme weather events, and facilitate direct knowledge exchange with those who need to use it.

Key challenges and remaining tasks

The initial activities and achievements of the Future Earth Urban KAN as illustrated above indicate promising roles an integrated science-policy knowledge-action network can play. However, there are also challenges and remaining tasks for the Urban KAN to fulfil its vision. First of all, several of the successes were made possible due to the coinciding key international processes such as UN Habitat and IPCC Cities and Climate Change Science Conference. How to maintain the momentum in the lack of major external drivers is a challenge. Second, a broader and more balanced membership across sectors and geographic balance is needed. This is challenging given the time constraints as well as the lack of recognition and incentives on both academic and practitioner end, and in some cases, the difficulty of participating and take active role in a global network that are primarily communicated in a foreign language. Third, for the co-

design and co-production principle to change from an aspiration to a norm in urban science and practice, the Urban KAN needs to accumulate evidence and distill how it would work despite many of the well-known challenges. Forth, the Urban KAN will require stable and sufficient funding and strong institutional support to survive and thrive. Many of the previous challenges are related to this point, as well as the much needed pursuits of more strategic initiatives such as training of young researchers and practitioners.

Lessons learnt and way forward

Networks across the boundaries of science-policy-practice are still in their infancy. Though ever-increasing knowledge and inter-connectivity between diverse actors in cities has been a positive outcome of the networked approach, it has not necessarily led to increases in implementation of effective action which serves the needs of the diversity of urban citizens, and significant barriers persist to effectively translate knowledge into action. There is still an urgent need for stronger science-policy-practice interactions, and shortened cycles between theory and practice, given rapid rates of urbanization and the associated brief window of opportunity to transition to more sustainable urban development patterns [55]. Knowledge-action networks must be multi-party, multi-scale, cross-sectoral, and informed by urban research, incorporating useful data (increasingly comprehensive and real time) and long-term modelling [39]. They can, in principle, have functions that range across 'certification, assembly and synthesis, translation and delivery' [39]. They also should be created in a way that allows for flexible boundaries and develops multiple strong nodes and good connectivity to provide even balances of power, resilience to change, and free flows of information. Network analysis techniques can be used to assess the extent of some of these characteristics in practice. These can be important roles for boundary organizations, such as Future Earth in support of the Urban KAN [11].

In conclusion, our analysis shows that such integrated networks can be highly successful in terms of generating cutting-edge knowledge, enabling new research collaborations, catalyzing national or thematic research networks, setting science agendas, influencing policy processes at various scales. While still facing challenges such as insufficient representation of practitioners and policy makers. Future growth, effective mobilization of and continued engagement of membership in co-design and co-production activities require financial and institutional support [49***], which can be a challenge for such networks. A key indicator of progress will be whether the networks can move beyond peer-to-peer information sharing and lobbying for policy influence and into the development and use of new knowledge, via effective

collaborations to frame, develop, and implement solutions, as well as review and monitor the process. Greater collaboration between networks at and across various scales will also assist in consolidating learning and aligning action. Learning scalable innovations can be fostered across different levels of government (vertical) or different cities (horizontal scaling). Networks will help us to co-design desirable urban futures at the pace required to meet the urgency of the challenges we face on this urban planet.

Conflict of interest

Nothing declared.

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- of special interest
- of outstanding interest

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