



## *New Integrated Urban Knowledge for the Cities We Want*

Xuemei Bai, Thomas Elmqvist, Niki Frantzeskaki, Timon McPhearson, David Simon, David Maddox, Mark Watkins, Patricia Romero-Lankao, Susan Parnell, Corrie Griffith, and Debra Roberts

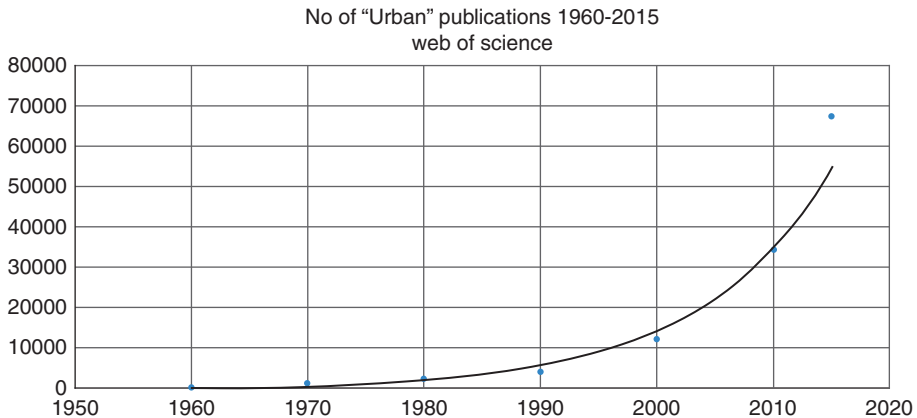
### **S.1 What Do We Know about *Urban*?**

We are already living on an urban planet (Chapter 1) and in the coming decades, about 2.6 billion more people will be added to world cities. Asia now has half of the world's urban population while Africa's urban population is larger than that of North America. Rapid urbanization in countries like China is considered to be one of the biggest human settlement challenges in human history, accompanied by profound social, economic, and environmental transformations (Bai et al 2014).

We also live in a time during which urban research and the development of urban theories are burgeoning, along with popular urban activism and practice. The past two decades, in particular, have witnessed an explosion of urban-focused literature with a rapidly increasing number of published research papers and practitioner reports (Wolfram et al. 2016).

Figure S.1 shows the trend in the number of publications with “urban” as keyword over the last five decades. In 1990, there were less than 5,000 papers published, whereas in 2015 nearly 70,000 papers were published.

What have these research efforts accomplished? At a macro level, we have established several key understandings. As highlighted in the Preface, Introduction, and many of the chapters, urbanization can be seen as a phenomenon that encompasses changes in demographic, land, and other resource use, environmental, social, cultural, and institutional aspects ranging across local, regional, and global scales (Box S.1) (Chapter 1). Urbanization is typically driven by traditional push and pull factors, but national policy is



**Figure S.1** No. of publications with "urban" as keyword 1950–2015 (Web of Science)

a critical driver shaping the process and outcomes (Bai et al 2014; Parnell and Simon 2014). Despite the multifaceted challenges, urbanization also brings about a unique window of opportunity for the cocreation and diffusion of innovative sustainable solutions. This parallels the growing recognition among policy- and decision-makers that cities have an important role to play in local and global sustainability.

Underpinning various aspects of these high-level understandings is knowledge and aspiration at a much finer scale. Each research-based chapter in our book takes a key element of urban knowledge and explores its state of the art, and probes the key knowledge gaps. Collectively these chapters showcase what we know about cities, where lie the frontiers and limits of urban research and practice, and the fault lines that point towards areas about which we need to know more.

But it is not only urban research that is flourishing. Cities around the world increasingly benefit from greater participation and activism by civil society, practitioners, and regular citizens. This activism has two key benefits. First, it facilitates the grounded practice of making better cities through not just knowledge but knowledge-based action and lived experience: the design of neighbourhoods, infrastructure, and open spaces – that is, places – that are better for both people and nature. Second, participation by urban citizens in decision-making and urban creation should be the driver in any connection between academic knowledge and policy. Indeed, what knowledge do cities themselves feel they need? Increased awareness of urban populations in the biophysical and urban design processes around them is key to building better cities by creating urban populations that demand better cities, and know what "better cities" can mean.

Box S.1

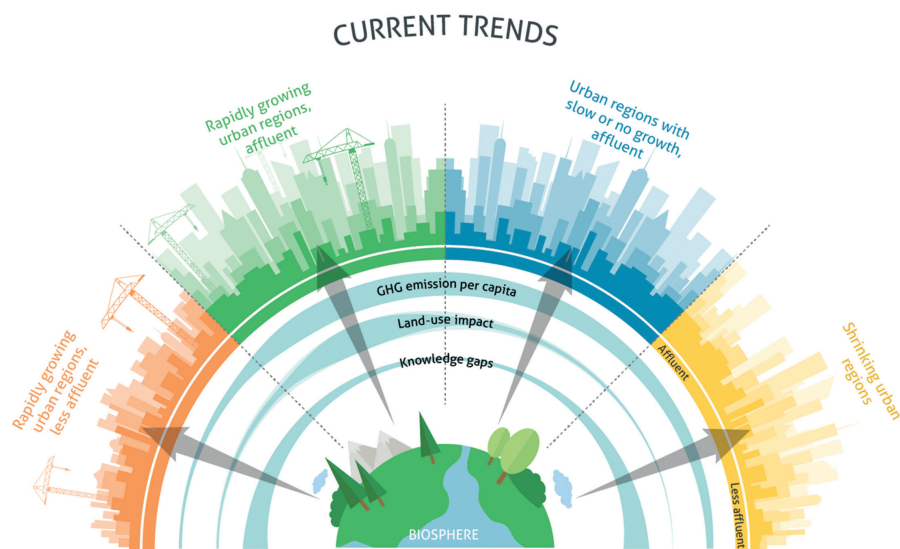


Figure S.2 Current trends

It is exceedingly difficult to generalize about urbanization and urban trends. Cities and city regions around the world are very different, and there is no such thing as one size fits all scenario (Jiang and O’Neill 2017). Cities are, for some, a specific form of human association that can be characterized based upon criteria of population size, built-environment form, and economic function (Wirth 1938; Minx et al. 2013; Seto et al. 2013; Chapter 9). Others understand urban areas as growth machines serving elite interests, inducing social inequality and damaging the environment (Harvey 2008; Heynen et al. 2006). Yet for others, cities are socioecological systems or sociotechnical systems, either of interacting biophysical and socioeconomic components, or social and technical components (McPhearson et al. 2016b).

While many cities in developing countries are growing rapidly, the pace of urbanization is slowing down in some countries, while some cities are shrinking. There is an absolute need for urban development policy to adapt to specific local and regional contexts. Here we illustrate current trends in urban development around the globe, based on two independent defining variables: (1) rate of growth, that is, whether a city may be rapidly growing, stable or shrinking and (2) economic state that is whether a city is less affluent or affluent. To describe some current trends, we have selected a few dependent variables: GHG emissions per capita, land-use impact, and

**Box S.1** (cont)

knowledge gaps, where there is at least some data available for analyses (Coulibaly et al. 2009, Bierbaum et al. 2010).

In general, the conclusion is that affluence is the main factor behind GHG emissions per capita, with emissions still being large in affluent cities, irrespective of rapid growth, stable, or with no growth. As far as GHG emission is concerned, the impact associated with rapid urban expansion is significantly larger in affluent rapidly growing urban regions than in other types of regions. However, for many variables that we would like to analyze and that are highly relevant for policy, such as governance challenges, health impacts, adaptation capacity to climate change, it is currently extremely difficult to conduct analyses due to particularly large knowledge gaps for rapidly growing less affluent cities as well as for shrinking cities and city regions.

While playing a critical role in shaping our common urban futures, the perspectives of civil society, practitioners, and regular citizens are often missing from traditional academic treatments of urban ideas. Each of these practitioner-based contributions explores an element of city building from the “street level” points of view of designers, artists, and practitioners in civil society.

## S.2 Highlights of the Four Parts of *Urban Planet*

### S.2.1 Part I: *Dynamic Urban Planet*

The knowledge base around urbanization and its dynamics – drivers, impacts to the environment and environmental change, our conceptual frameworks, data, models, and methods have all advanced over the last decade and the chapters in Part I are a testament to this, offering a variety of perspectives.

Urbanization follows diverse patterns and pathways, each presenting unique policy challenges. Some urban regions are growing rapidly but others are shrinking (Box S.1). While megacities often receive more attention in global urbanization debates, many smaller urban centers are growing more rapidly (Chapter 1).

Cities do not exist in isolation: they are open systems, with various processes linking cities and their global resource/environmental hinterlands (Chapters 1, 2, and 3). Urban areas have a vast reach, both direct and indirect, (whether its resources or GHG emissions or food/energy/water) and there are global

impacts/implications. On the other hand, urbanization is an opportunity to increase global sustainability. However, while we are making progresses, we still don't fully understand these systems interlinkages.

Scale is important in terms of how it impacts research and what we know, but also presents challenges or gaps (Chapters 2, 3, and 4). For example, a better understanding of the household or neighborhood scale is needed for reducing vulnerability (Chapter 4) or understanding variation in materials usage in cities/local or community levels that are rapidly growing.

There is a need for disciplinary integration, but particularly from the social sciences (integrative knowledge) – obvious in Chapters 4, 5, and 6. We've come a long way with more holistic approaches and frameworks, but knowledge gaps still remain when it comes to understanding politics and underlying power structures, political economy, urban macroeconomics, cultural traditions, preferences/behavior, and so on that influence urbanization.

Part I strongly suggests that there is a need for research to continue to develop and advance urban typologies and understanding of the different dimensions of urbanization at regional and global scales, both at medium- and long-term (beyond 2050) perspectives. However, at the same time there is also the need for knowledge underpinning very local, place-based solutions. How do we bridge the gap between the demand for these local and place-based solutions with the larger scale regional, global, and temporal insights on urbanization? We will return to this in Section S.3 of this synthesis.

### ***S.2.2 Part II: Global Urban Sustainability***

This part starts with Chapter 7 discussing and analyzing the word “sustainability.” What does it mean to create sustainability on the ground? To do this we must connect to local issues, not only global patterns, since no blueprint or master plan will be locally appropriate and legitimate. One way to focus the idea of “sustainable cities” is to prioritize the areas of greatest need, namely the urban poor and the areas they inhabit. This addresses the most urgent and often severe aspects of unsustainability and has the potential to make a clear difference. Doing so effectively, moreover, requires complex tools and patience to work with the respective communities through inclusive and participatory or coproductive approaches such as those exemplified above.

In Chapter 8, the authors discuss the complexity of “the urban” and therefore the need to avoid oversimplification via measurement using simple indicators – hence the need for increasingly sophisticated indicators and efforts to ensure global relevance. Successive generations of indicators and multicriteria aggregation tools have improved our ability to capture urban complexity and dynamism, though there is often a trade-off between the increased

sophistication of more holistic and composite indicators and the availability of the requisite data. Both the emergent fourth generation of indicators and SDG 11, the targets and indicators of which were formulated and piloted through an unprecedentedly long and penetrating process, illustrate this well. Implementation and the measurement of progress will be challenging for many urban administrations.

More inclusive intergovernmental agency approaches within and outside the UN system are discussed in Chapter 9. UN-Habitat, the specialist human settlements agency, has taken a leading role, initially through successive sessions of the World Urban Forum and most recently through the SDG and New Urban Agenda (NUA) processes. While still bound by UN rules attaching preferential rights to national governments (“parties” in UN language), this has done much to engage previously marginalized stakeholders and groups, also ensuring that the final versions of the SDGs and NUA have far greater buy-in and legitimacy than previous such initiatives.

In Chapters 10, 11, and 12, the role of urban living laboratories, big data and citizen science, coproduction and other innovative approaches are discussed. There has been a worldwide flourishing of such innovative approaches that decenter traditional, top-down, and expert-led knowledge production and implementation, providing alternative and often more meaningfully participatory engagement by key stakeholder groups and exploring new types of data. For instance, citizen science is an umbrella term for numerous ways in which ordinary urban dwellers and community groups worldwide can engage in knowledge creation as active data collectors and submitters using everyday devices like mobile phones, while undertaking their normal daily activities, or carrying out specific surveys and reconnaissance activities to complement conventional research.

**Summary highlights from Part II:** Avoid implicit overgeneralization in the search for apparently simple answers and replicable lessons in an era of unprecedented urban complexity and wider uncertainty. Comparative research – much necessarily applied and practice-oriented – undertaken particularly through transdisciplinary teams that combine academic and diverse non-academic stakeholder groups, is one useful approach in this regard.

Overcome entrenched inertia and vested interests – especially sociotechnical agendas, for example, in smart cities discourses. Greater inclusivity and multi-stakeholder engagement do not, in and of themselves, overcome these barriers, although they might help to challenge them by engaging and perhaps empowering previously voiceless groups.

Consider the “deep” urban sustainability – via key features such as accessibility, greenness, and fairness – that is locally appropriate. It is important to

pursue and integrate the main facets of sustainability so as to address the spatial and social diversity of prevailing conditions in different parts of individual urban areas. While some conflicts are inevitable and consensus may not be feasible, this is far from a zero-sum game in that carefully targeted interventions can achieve multiple objectives and cobenefits.

### *5.2.3 Part III: Urban Transformations to Sustainability*

Part III explores the drivers and actors that play a role in urban transformations to sustainability. The introductory chapter sets the stage and identifies the main opportunities and challenges that city officials and private and civil society actors face in their efforts to develop governance solutions that support sustainable and resilient urban development (Chapter 13). The remaining chapters bring together four strands of urban research on urban transformations.

In Chapter 14, Frantzeskaki et al. illustrate how this changing role is evinced in contemporary case studies across Europe. In line with this, Pereira et al. (Chapter 16) extend our knowledge on where to search for and source innovative solutions for urban transformations by an extensive review and mapping of local initiatives that showcase positive transformations, being the seeds of the good Anthropocene. The evidence in these two chapters amounts to the understanding that living in an urban planet also means creating solutions that can be the stepping stones for positive trajectories to urban livability, inclusivity, resilience, and sustainability.

For counteractive nonsustainable and nonlivable urban futures, conflicts and contestations need to be examined and inform policy and planning – new urban realities between new sustainable solutions and conflicting or counteracting nonsustainable ones, create conflicts and contestations. In Chapter 15, Burch et al. provide an insight on the recent debates and knowledge on what governance for urban transformations to sustainability is all about, painting a rather different picture. Urban visions and pathways are always contested, given that they need to incorporate and accommodate interests and aspirations from multiple actors that are diverse. In this view, urban transformations become contested processes that will require new approaches and governance means to create collaborative outcomes to instigate, facilitate, and accelerate change. Next to this insight, Burch et al. introduce one more actor as paramount for urban transformations to sustainability: small-medium enterprises as the agile actor that can leverage innovations towards more systemic urban transformations.

In summary, Part III points to the need for a multi-actor governance and to new unusual “suspects” to play a role in transition processes, and proposes to

deepen research about relations between these urban change agents for new approaches and new collaborative and empowering means to facilitate urban transformations to sustainability. One common thread and perhaps at the core of these remaining challenges is the need for integration – integrating across disciplines, integrating other forms of knowledge, and integrating urban research into global policy processes.

#### *S.2.4 Part IV: Provocations from Practice*

While the provocations focus on a myriad of different topics and themes, they all tend to hover around a limited set of key ideas. Central to many of the chapters is the idea that the political reality of local sustainability is often ignored by academic treatments of the subject. For Mahim Maher of Karachi, this means that the concept of sustainability as it stands in New York and London is attractive but meaningless for her hometown, where there have been long periods without a mayor, there is little organized city planning, and water is sold by the mafia. To her, the meaning of “sustainable” that fits is the one that lets people be, and that allows for the city to progress in time. Ideas that remain in the academic realm – are not translated in common language, are not reported outside of academic journals, are not matched with workable solutions, and often do not address the needs of decision-makers in cities. Rebecca Salminen-Witt of Detroit and Mary Rowe of Toronto both agree that local knowledge has a place to address these gaps. Policy needs a human scale, and so does knowledge. The academic knowledge will mean nothing if the lives of people are not improved. For some of our provocateurs, the core Western economic model is fundamentally flawed, or even broken. For example, Guillerma Ramirex, an indigenous leader from the Mapuche region of South America, believes that sustainability solutions without social reform are bound to fail. For many writing from the street view, there is a great distance between academic knowledge and effective practice and city and neighborhood scales.

Other pieces point to the fact that cities around the world increasingly benefit from greater participation and activism by civil society, practitioners, and regular citizens. This activism has two key benefits. First, it facilitates the grounded practice of making better cities through not just knowledge, but action: the design of neighborhoods, infrastructure, and open spaces that better serve the needs of both people and nature. Second, participation by urban citizens in decision-making and urban creation should be the driver in any connection between academic knowledge and policy. Indeed, what knowledge do cities themselves feel they need? Increased awareness of urban populations in the biophysical and urban design processes around them is key to building better cities by creating urban populations that demand better cities, and know



what “better cities” can mean. Diana Wiesner of Bogotá believes that a truly democratic city must empower its citizens and institutions as agents of change, through collective decision-making focused towards a common goal. This is a view of *democratic* knowledge-based cities that resonates among a number of these contributions.

Two things stand out when we take a step back and reexamine all the contributions in the book. First, there is lack of knowledge on and voices from from cities of the Global South compared to the Global North, which is an apparent and common knowledge gap demonstrated across all the academic chapters. Indeed, even in cases in which knowledge and experience from the Global South is well-developed, they often do not find its way into traditional academic forums, and even when they do, they tend to receive less attention and less prominent in traditional academic matrix. While cities in Global South are and will be the home for most of current and future urban populations, and they are confronted by very complex urban challenges, the reality is that more influential and dominant voices in academia are from the Global North. Books such as this one are an important advance, in which ideas and experience from the Global South are integrated into a book with global reach.

Second, there are drastically different perspectives between the provocations and the more academically oriented chapters. Here it is critical to note that there are many styles, sources, and uses of knowledge that typically exist in isolation from each other. In an attempt to pursuit more universal and scalable patterns and processes, academic knowledge can sometimes be agnostic on the idea of social values. It cannot remain so, as we are deeply fragmented, from Global North to South, and from rich to poor. As demonstrated by the diverse perspectives represented in the Provocations from Practice, various urban stakeholders other than researchers can hold deep insight into urban issues. Urban practitioners’ knowledge of what works and what doesn’t, based on long term experience of practice and context specific knowledge, can be equally important, and an invaluable complement to scientific knowledge. But, in traditional urban literature, these insights only receive peripheral acknowledgment at best. This is, in part due to the formalities of academic publishing, which discourage the “informality” of practice. But in general, there is a paucity of forums for sharing practice-based solutions among city and communities. This is starting to change, with books that summarize tools and practice, and international forums such as the Nature of Cities.

Some of the tensions revealed in this book, especially between the academic and practitioner worlds, present opportunities for synergies, while others represent fundamental frictions and clashes of world views and modes of knowing. The reason for such disparities vary across geography and communities of practice. It is not the intention of the book to present a thorough analysis of

the underlying factors (although this would be a worth direction of research). Rather, by presenting them side by side, we wish to showcase the diverse perspectives, contrast the state of research insight with lived realities in communities of practice, and present different forms of knowledge and ways of knowing.

By doing so we point to the need to resolve the gaps and produce new types of knowledge that integrate traditional academic knowledge and insights in other forms and types. Indeed, there are many more bridges to cross in order to connect knowledge and lived reality (which is reflected more in the provocations). For example, does research-based knowledge truly reflect reality or does it cater to policy and practical needs? To what extent academic knowledge is translated into practice, or, more importantly, *correctly* translated with all appropriate constraints and caveats? These are just a few of the important questions suggested by discussing research and practice in a single volume.

Further, tensions also exist among individual chapters and pieces. We argue that bringing these into one volume is itself a pioneering attempt, and hope that the creative tensions presented can serve as a spring board to further discussions. We must strive to produce integrated urban knowledge.

### 5.3 Advancing New Integrated Urban Knowledge

So, where are the frontiers of urban knowledge production? What kind of urban knowledge is needed, how should we address these needs, and how would this knowledge be produced? New integrated urban knowledge will require new conceptual approaches, renewed understanding of the nature of urban knowledge, and new modes of knowledge production, all contributing to the ultimate goal of transforming towards more desirable urban futures. Such urban knowledge must first and foremost be based on a clear statement of the cities we want to create, and the values on which these creations are based, as discussed in detail in the following section. The new urban knowledge would need to extend our understanding of what contributes, instigates, and accelerates urban transformations. For example, understanding how systemic processes of change – urban transformations to sustainability and resilience – are triggered, amplified and/or facilitated by leverage points, emerging and often conflicting or counteracting change trajectories. What is the role of different actors (for example, civil society, small-medium enterprises, international organizations, global movements like Future Earth) in these urban sustainability transitions? What are conflicting and disruptive innovations or other developments within these trajectories?

Here we highlight three elements as crucial in future urban knowledge production, that is, (1) Systems approach, (2) Knowledge coproduction, (3) Solution-oriented research. We end this part with reflections on the inherent uncertainties about future trajectories we will have to address.

### *5.3.1 Systems Approaches*

Cities are classic examples of complex systems ( Batty 2007; Batty 2008; Bettencourt 2013; Pickett et al. 2001; Grimm et al. 2000; Bai et al. 2016a; this volume, Chapter 1.2) exhibiting emergent properties, some of which can be difficult to explain, such as nonlinear dynamics, feedbacks, and high interconnectivity and unpredictability, while also having modular interlinked sub-systems that can create redundancy and exhibit resiliency. These and other complex behaviors make urban systems challenging to understand and, what is more, to govern, when seeking to improve resilience while transforming towards more sustainable development pathways and patterns (McPhearson et al. 2016c). In some cases, the complexity of urban system processes and patterns both within and across interconnected urban regions – where sustainable choices made in one place are not truly sustainable if they create social, economic, or environmental trade-offs elsewhere – clearly represent “wicked” problems faced by today’s urban planners, policy-makers, and managers.

A systems approach can reveal the nonlinearity between drivers and effects of change that can be mapped and assessed and a broader understanding on where interventions can happen in tipping feedback loops and enabling structural shifts at system level. In this way, a systems approach can facilitate inputs across disciplines towards a deeper understanding of leverage points, driving forces and persisting feedback loops.

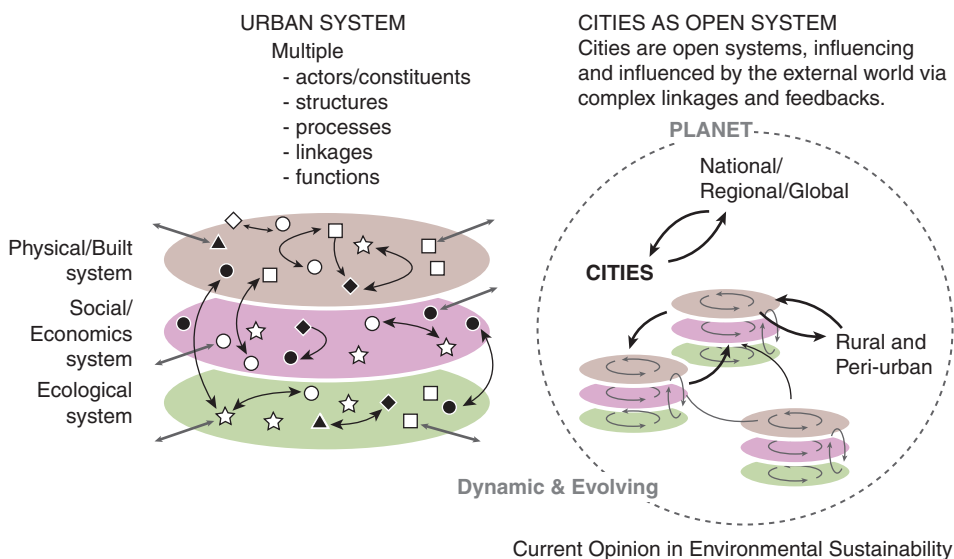
Many of the urban challenges, for example, natural resource, climate, energy, water, are not urban per se, but regional and global through urban metabolic processes (Chapter 3). Systems approaches are employed conjointly with other methods to investigate and dissect drivers of change in urban systems, identify patterns and metabolic flows as well as sourcing and evaluating of systemic solutions to achieve urban goals like sustainability, resilience, livability, and justice. For instance, Romero-Lankao et al. (Chapter 4) present a systems approach to urban risk and outline the necessary components of an interdisciplinary understanding of how environmental and societal processes such as global warming and urbanization contribute to sociospatial differences in exposure and in intra – and interurban vulnerability to heat waves, floods, droughts, and other hazards. Simon et al. (Chapter 7) support this in their chapter by highlighting that a systemic approach allows for analytical concepts like sustainability and resilience to integrate and better inform adaptation

and mitigation solutions addressing climate challenges facing cities. Gomez-Alvarez et al. (Chapter 8) also point at the need for systemic approaches as the basis for developing new indicator schemes that adhere to sustainability. They address the need to formulate indicator schemes that take human well-being and ecological health at the core and promote a decoupling of urban well-being from economic growth. From the description of how indicator schemes evolved to their third generation, the Cities Prosperity Index showcases not only a systemic understanding of the dynamics of cities but also the positioning of cities as transformative entities in the world contributing to global prosperity.

In the context of this complexity and additional urban challenges, can we understand the dynamic socioecological, institutional, and infrastructural complexity of urban systems? Can we understand this complexity well enough to inform and improve decision-making for transitions towards more resilient and sustainable cities? Advancing urban sustainability and resilience agendas requires expanding the scope of inter- and transdisciplinarity approaches. It may require conceptually bridging two different disciplines, for example, urban ecology and industrial ecology through demonstrating how empirical evidence from one domain can contribute to revealing fundamental ecosystem characteristics of cities (Bai 2016), or moving beyond the often separate social-ecological and socio-technical approaches to jointly study socioecological technical infrastructure systems in cities (McPhearson et al. 2016c). A true systems approach in cities needs to embrace cities as complex, dynamic, and evolving system with multiple actors/constituents, structures, processes, linkages, and functions, all embedded within broader ecological, economic, technical, institutional, legal, and governance structures, and often causally interlinked, delivering in intended or unintended outcomes (Bai et al 2016a; Simon 2016) (Figure S.3). In light of achieving the New Urban Agenda and SDGs, where cities will be confronted by and measured against multiple targets and numerous indicators, pursuing synergies and avoiding trade-offs via systems approach is perhaps the only feasible way forward.

### *S.3.2 Knowledge Coproduction*

New urban knowledge integrates across different scientific disciplines but also across multiple knowledge bases (for example, McPhearson et al 2016a). Connecting knowledge across societal spheres and positioning knowledge as a boundary object are considered findings and developments at the frontier of urban research. An active participation of different knowledge holders with the aim to coproduce knowledge that is actionable, reliable, and socially relevant is at the heart of the new urban science (for example, Palmer



**Figure S.3** Urban system structure and interlinkages. The symbols represent various actors/constituents, structure, and processes across physical/built, social/economics, and ecological subsystems. The arrows represent complex processes and linkages within and between cities, and between cities and their hinterlands. The actors and constituents are typically self-organizing, and the structure, processes, and linkages and functions are dynamic and evolving, with nonlinear pathways. Source: Bai et al. 2016a.

and Walasek 2016). Diverse approaches have emerged over the last decade that respond to the need to connect urban knowledge from multiple actors to scientific processes that create knowledge legitimacy. These approaches help to integrate social, economic, and ecological needs/demands from cities and their citizenry to science and policy, supporting new agendas and development pathways. Urban knowledge in this way is a connective concept across multiple societal spheres and a boundary object for sociopolitical debate, contestation, and applicability.

Cities are ideal places to integrate different domains of knowledge, and indeed there has been a long history of codesigning and coproducing knowledge in urban settings. Participatory urban planning and design is one such example. Rather than oversimplifying complex and challenging situations, such an approach embraces complexity and uncertainty, and aims to find solutions together with the local actors and stakeholders.

The way knowledge is coproduced and the role it plays in addressing urban challenges and contributing to sustainable urban futures is a topic discussed by several contributions of our book. MacClune et al. (Chapter 12) point to a new model for urban citizen science, and the ways citizen science operates across scales, connecting local knowledge, contextual dynamics and contributes to an engaged citizenry that values knowledge coproduced. Burch et al. (Chapter

15) implicitly also address the ways we understand and create knowledge for governance for urban sustainability transformation, and point to the need to further integrate and therefore facilitate not only patterns of collaboration but also allow for contestation and conflicts in the urban sphere to surface. Thinking of urban transformations as multi-actor processes of innovation also points to settings of experimentation for coproducing actionable knowledge as well as trial systemic solutions for urban futures.

There are also settings where knowledge co-production for urban agenda setting and navigating solutions and perceptions have been tested. Examples include urban experimentation with living labs (see Chapter 10), with transition management arenas and with envisioning and scenario work in cities. Appreciation of multiple types of knowledge (tacit and explicit, global and indigenous) has been a foundation principle in designing such foresight arenas of urban agendas or development. The new urban science capitalizes, builds upon, and extends this line of coproduction processes as an indication of how processes that connect, integrate, and equalize multiple forms of knowledge come into play for understanding the urban planet and articulating ways to achieve the urban SDG and other local and global urban goals.

### 5.3.3 Solutions-Oriented Thinking and Approaches

Knowledge has no power unless it is shared and applied. When urban knowledge is examined in the light of application, a different and perhaps much more complex set of questions emerges. How do these topical or sectoral ways of knowledge interact with each other? When contradicting suggestions are presented from different research, each focusing on a particular task, how can they be incorporated into decision-making? For example, reducing urban energy use would suggest a higher density residential development, often translated in practice as much smaller lot single-standing house without backyard, or high-rising buildings. On the other hand, research shows that green backyards in old suburbs often have high biodiversity and provide important connectivity to wildlife habitats. In practice, decisions are often made focusing on one linkage and not on both. Solutions are required that take multiple interactions into account rather than partially addressing urban complexity and challenges. How to produce cutting edge, but also *integrated, actionable knowledge*, is an urgent task for urban researchers.

The notions of urban sustainability experiments and learning from practice are important in solution-oriented urban knowledge production (Bai et al. 2010; Palmer and Walasek 2016; Webb et al. 2017). Cities can be considered as living labs with many experimentations for cocreation of systemic urban solutions, which are created by civil society and its networks, contributing actively

to more sustainable urban present and futures (Chapter 10). Civil society can be a transformative agent innovating, testing, and showcasing systemic solutions contributing actively in transformations in cities towards sustainability (Chapter 14). Analyzing the *seeds of good Anthropocene*, which are emerging solutions produced from civil society, businesses, public sector actors that illustrate the potentials for sustainable urban futures, provides a new way of understanding how systemic solutions emerge and how we can source inspiration and motivation from them (Chapter 16).

A solutions-oriented approach is also emerging in cities with a number of frameworks enabling this development. Signs of solutions-oriented approaches include the concepts of ecological design, water-sensitive cities, smart cities, and the recent work on nature-based solutions. While solutions-oriented approaches offer a way forward for cities as places where transformations can be accelerated towards sustainability, there are also critical views. For example, the development of smart cities as urban responses to resource challenges should also voice the different social aspects that often are inadequately addressed by the smart cities agenda, such as the digital divide across generations when smart technologies are adopted among many. However, a solutions-oriented approach may help in addressing questions on ways forward that invite multiple disciplines to contribute and advance our urban knowledge about and of those solutions.

Searching for sustainable solutions requires a broader view and exploration that looks across civil, public, and market actors. The evidence from recent years shows that civil society initiatives and the partnerships they create have the potential to reshape cities towards sustainability by changing practices, lifestyles, ways of organizing and forming new social relations (Frantzeskaki et al. 2016). Examining the way civil society interacts with other actors and the way it scales innovation can be a way forward to liveable urban futures.

### ***5.3.4 Understanding Path Dependency and Transformation***

As stated multiple times in the book, cities are already experiencing effects driven by climate change, and the extent to which cities will need to cope with these challenges will continue to increase dramatically 2050 and beyond. The need to develop urban strategies for flexibility to address the uncertainty and continuous state of change may, for example, lead to dramatically increased investments in innovative integration of gray, green, and blue infrastructure. In this context, urban strategies for flexibility based on a complex system view may be greatly inspired by advances in evolutionary theory to guide the future design of new urban infrastructure and the redesign of existing structures. Several decades ago, in a seminal paper in *Science*, the French evolutionary

biologist and philosopher Francois Jacob pointed out how evolution is proceeding distinctly differently from a process that is de novo designed and engineered (Jacob 1977). He labeled this evolutionary process “tinkering” being primarily based on modifying and molding existing traits and occasionally resulting in totally shifting functions when conditions changed (for example, divergent evolution of base extremities to function as fins in water, legs on land, or wings in air). This contrasts greatly with a conventional designed and engineered process, which starts with tailor-made material and tools and always with a specific function in mind. Urban tinkering, as an approach, has the potential for moving beyond conventional urban engineering by replacing predictability, linearity, and design for one function, with anticipation of uncertainty and nonlinearity and design for a potential of shifting and multiple functions. There is a challenge with strong urban path dependencies where investments in infrastructure to fulfill one function often may prove to be a lock-in situation lasting decades or even centuries. An urban tinkering approach may help reduce such lock-ins, by designing infrastructure with an inherent potential to change function in the future if needed/desired. An urban tinkering approach may also help invent new functions of existing infrastructure and thus facilitate needed transformative processes (Elmqvist and McPhearson 2018).

## 5.4 Visions of the Cities We Want

Albeit long overdue, urban issues started to receive unprecedented attentions from policy arena in the last couple of years. The role of cities in preventing and abating climate change has gained official recognition, and cities are recognized as a legitimate key actor in achieving the Paris Agreement. A stand-alone urban goal is included in the 17 UN Sustainable Development Goals, and the New Urban Agenda was adopted in the UN Habitat III conference in 2016, both reflecting strong collective aspirations towards building the cities we want. Although the New Urban Agenda is aiming for 2030, it is important to note that principles for the cities we want does not stop at 2030, and we use the term the cities we want here with broader interpretation including NUA.

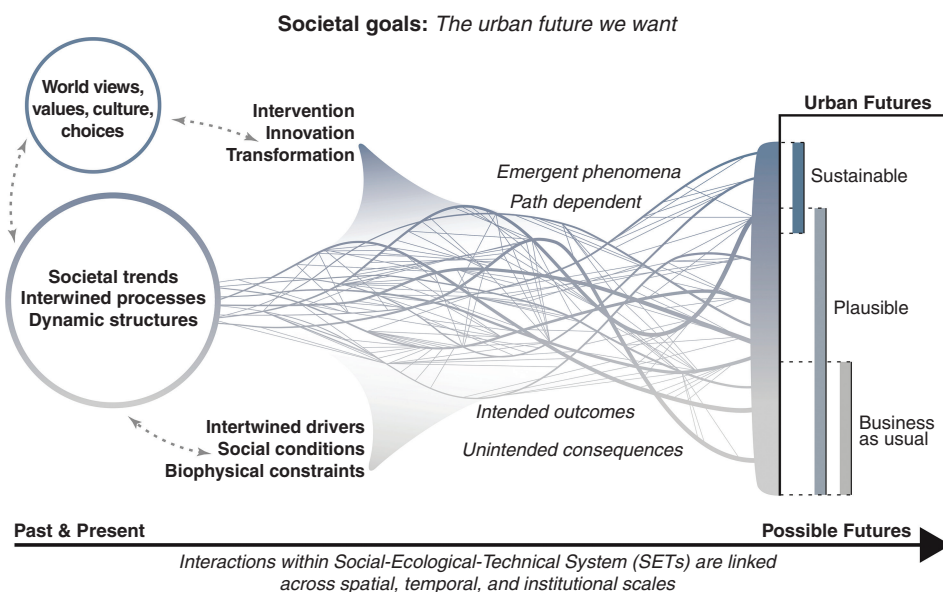
We argue that realizing these high-level policy goals and beyond would require *science* – a new integrated urban knowledge, *imagination* – formulating and utilizing collective visions of the future, and an *open mind* – understanding and embracing deep uncertainties and risks into the future. We also depict that *science needs to support* both *imagination* and an *open mind*.

A new integrated urban knowledge will play vital roles in achieving these policy goals. A stronger voice of researchers in the formulation of the global policy processes is called for in light of the development of the New Urban



Agenda (McPhearson et al 2016a). More importantly, the new integrated urban knowledge needs to contribute towards the design, monitoring, implementation, and evaluation of policy measures towards achieving these goals.

Pathways towards more desirable urban futures require concerted actions across jurisdictions (from global to local) and sectors (private, governmental, and social) (Figure S.4). The high-level international policy processes will inevitably trickle down, bringing more policy attention into urban issues at national and subnational levels, and eventually requiring each and every city to find out pathways towards the contextualized vision of the cities we want. Ideally, this should involve a process of identifying common societal goals, via exploring and identifying the plausible and desirable futures, and taking into account the diverse worldviews, values, cultures, and choices (Bai et al. 2016b). The lack of connection of policy and science to the attachment to *place* by people is repeatedly highlighted in the provocations in this volume. Visions need to be cocreated in inclusive experimental settings, varying from demonstrators, to civil society initiatives, to seed-projects and to urban living labs across cities in the globe. Uniform across all types of cities, is the need to create conditions for inclusive, just cities in which voices and aspirations across social



**Figure S.4** Conceptualization of the interlinkages between factors and dynamic processes shaping urban futures. Visions are represented as societal goals influenced by worldviews, value systems, politics and power, culture and choices, and play an important role in intervention, innovations, and transformation that can lead to alternative and more desirable urban futures. Source: McPhearson et al. 2017, modified from Bai 2016b.

groups are heard and considered and citywide visions like smart cities are democratic and open for debate.

Visions, particularly shared positive visions, can play a critical role in shaping desirable futures (Figure S.4). We believe our book shows that visions alone are not enough, and that there is urgent need for action-oriented research and practice that links positive visions to on the ground transitions and transformations. While we acknowledge that the formal attribution of transformational change as a causal result of visioning is entangled with a myriad of social, political, cultural, ecological, and technological factors, examples of successful implementation of positive visions provide nodes of optimism and empirical basis for replication and scaling up of the cities we want.

Despite all efforts and massive knowledge generation, there are deep uncertainties about the Urban Planet in the long-term (2050 and beyond). As stated in the Introduction to the book, within this timeframe, the planet will face a complexity of drivers and interactions, with the potential of many of them interacting in unexpected ways, for example, migration, climate change, political instability, disruptions in financial systems, energy supplies, and pandemics to cite some. Although predictions about overall demographic growth and rates of densification of settlements may have a reasonably high certainty also in the long term, the way this will play out in spatial patterns by 2030, let alone much beyond 2030, is highly uncertain. The spatial pattern may be much more dispersed than we project today due to the number of factors that may disrupt and cause change, for example, constraints in scaling of renewable energy, global economic crises, and pandemics.

We need to fully embrace uncertainty and change from local to global scale in the long term, in particular addressing the multiple risks associated with hyper-cohesion. In an increasingly (and at increasing rates!) economically, digitally, socially, and ecologically globally connected network, there might be several risks associated with an ever more hyper-cohesive world (for example, increased vulnerability with over-connected power grids where outages cascade through energy systems to create widespread blackouts). At the same time, lack of connectivity can create risk by missing needed redundancy and availability of back-up systems characteristic of the resilience of the system. Intermediate modularity and connectivity in systems could provide an important new target for urban regional resilience building where energy, economic, and even social systems have protections in place for limiting impacts of failure in one part of the system while remaining connected. The Internet is a useful model for intermediate modularity and connectivity where protections such as firewalls are in place at multiple scales from individuals, to institutions, to nation states to protect subsystems in one part of the system from failing when subsystems fail in another part.

Achieving the critical, but extremely challenging task of transforming social, economic, ecological, and technical infrastructure systems towards global sustainability in the long term will require more than adding up combined efforts of cities to transform. No matter how transformative urban sustainability and resilience building efforts are, we cannot assume that *global sustainability* will be a granted end result. In fact, there are likely to be significant trade-offs, unforeseen side effects and consequences of urban sustainability initiatives at all scales. To address these challenges, globalization may have to take on a new face with a multipolar world developing, where thriving local and regional social, cultural and ecological diversity and governance is more central, and a new urban-rural regional integration is possible. Moving forward requires flexibility, understanding of what determines resilience, learning, visions and imagination, and open-mindedness to deal with the unexpected and deep uncertainties. This has all to evolve at the same time, on the foundation of a new intensity in generating innovative and integrated urban knowledge.

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