

Article

The Framing of Urban Sustainability Transformations

David M. Iwaniec ^{1,*}, Elizabeth M. Cook ^{2,3,†}, Olga Barbosa ^{3,4} and Nancy B. Grimm ⁵

¹ Urban Studies Institute, Andrew Young School of Policy Studies, Georgia State University, P.O. Box 3992, Atlanta, GA 30302, USA

² Urban Systems Lab, Environmental Studies Department, The New School, 79 Fifth Ave, 1605, New York, NY 10003, USA; elizabeth.m.cook@newschool.edu

³ Instituto de Ciencias Ambientales y Evolutivas, Avenida Rector Eduardo Morales Miranda s/n, Universidad Austral de Chile, Valdivia 5090000, Chile; olga.barbosa@uach.cl

⁴ Instituto de Ecología y Biodiversidad, Universidad de Chile, Las Palmeras 3425, Ñuñoa, Región Metropolitana de Santiago 7750000, Chile

⁵ School of Life Sciences and Julie Ann Wrigley Global Institute of Sustainability, Arizona State University, P.O. Box 874501, Tempe, AZ 85287, USA; nbgrimm@asu.edu

* Correspondence: diwaniec@gsu.edu

† These authors contributed equally in this work.

Received: 16 October 2018; Accepted: 9 January 2019; Published: 22 January 2019



Abstract: Transformational change is not always intentional. However, deliberate transformations are imperative to achieve the sustainable visions that future generations deserve. Small, unintentional tweaks will not be enough to overcome persistent and emergent urban challenges. Recent scholarship on sustainability transformations has evolved considerably, but there is no consensus on what qualifies transformational change. We describe variations in current discussions of intentional sustainability transformations in the literature and synthesize strategies from funding institutions' recent requests for proposals for urban sustainability transformations. Research funding initiatives calling for transformational change are increasingly common and are an important driver of how transformational change is articulated in research-practice in cities. From this synthesis, we present seven criteria for transformational change that provide direction for framing and implementing transformational change initiatives.

Keywords: sustainability; transformational change; funding institutions

1. Introduction

Exciting initiatives are unfolding to better design the grand urbanization experiments of the Anthropocene. In defiance of projections of a 4 °C warmer world, society must imagine smarter, greener, more equitable cities. However, it is not enough to trust that uncoordinated policies and actions will align with sustainable pathways. Small tweaks are not enough to overcome rapid, trend-breaking changes and urban challenges, such as food–energy–water security, persistent poverty, and human migration into cities from climate displacement [1,2]. Transformational changes will be imperative. However, there is no clear consensus on what qualifies as the transformational change needed to confront sustainability challenges as vexing as climate change [3].

Over a billion dollars are being invested in diverse programs for urban transformational change. These directives go beyond calls for studying transformations to actually engaging in solutions, including research initiatives such as *Transformations toward Sustainability* (Future Earth) and practice implementation initiatives such as *Big Bets: Climate Solutions* (MacArthur Foundation). Despite this investment, decision-makers, funders, and researchers do not have sufficient frameworks and evidence to pursue sustainability transformations.

This paper presents criteria for framing transformations to envision sustainable urban futures. First, we review the existing definitions and framings of sustainability transformations in the literature. Building on and moving beyond the literature, we present seven criteria for transformational change with exemplary strategies for implementing and achieving each criterion from funding institutions' recent requests for proposals (RFPs) for urban transformations. Research funding initiatives and their directives are a mechanism for articulating transformational change in research–practice. Through direct support of proposals, research funding initiatives support active experimentation in advancing transformational change in cities and lay a framework for transformative potential. The selected initiatives go on to become examples for other places through published literature and researcher–practitioner networks, and thus are at the forefront of driving intellectual development in research and practice on transformational change.

2. The Framing of Sustainability Transformations

Transformational change is not always intentional. Rather than pursuing positive visions of sustainability [4–7], much of the relevant literature focuses on unintentional, often undesirable, changes that typically follow a disruptive event (e.g., References [8–11]). Such studies ask, how will accelerating drivers, such as urbanization and climate change, transform cities or how do extreme events, such as Hurricanes Harvey and Maria, allow for transformation? The dominant framing around unintentional transformations focuses on forced transformations and mitigating undesirable changes or adapting to disturbance and returning to status quo [8,9]. At best, studies of windows of opportunity explore how disruptive events can open up opportunities for intentional transformation [10,12,13]. In contrast, in this paper we focus on development of intentional transformations toward a sustainable future that is deliberate and anticipatory, in that it does not necessitate the loss of human well-being, environmental integrity, and infrastructure. This approach brings clarity to the frameworks, knowledge, and evidence needed to implement visionary policies and actions.

Researchers and practitioners currently rely on vague definitions of transformational change. Definitions of human–environment transformations include core concepts of fundamental and systemic change [2,3,14–23]. However, researchers need better descriptions than: Big, mostly irreversible, radical departures from the status quo. More clarity is needed on what transformational change means.

The existing, but limited, literature on intentional transformations focuses on three features of transformations: capacities, processes, and outcomes of transformations. ‘Transformative capacities’ allow for systemic change by empowering (and providing for the various needs of) different actors and enabling transitions across scales [24]. Researchers have also identified two types of ‘adaptive capacities’ as part of this discourse relevant to transformational change [25]: Capacities to respond to specific changes and general capacities to enhance development and well-being. For example, adaptive capacities for specific changes might include developing responses to climate impacts or finance options for infrastructure. On the other hand, general capacities enhance human well-being through education, engagement, and social cohesion. These general adaptive capacities are particularly relevant in the context of transformational change. Yet, neither general nor specific adaptive capacities alone are enough for transformational change. Olsson and colleagues [26] highlight the need for interdisciplinary capacities and knowledge, including systemic social, ecological, and technological perspectives to navigate transformational change and build resilience. Even more so, transdisciplinary approaches allow for the knowledge necessary to foster desired transformational changes [27,28].

Other foundational bodies of work focus on the processes and outcomes of innovation toward desirable changes—some of which may be transformational [19,23,29]. Bridging resilience and transition research, Moore et al. [30] synthesize a framework for the process of transformational change through social innovation. This process comprises preparing for change, navigating the transition, and building the capacity for change while considering feedbacks, scale, triggers, visions, and institutionalization of the change. Given the myriad ways that the term transformational change is used and understood, it is essential to define the intended outcomes. Mitchell and colleagues [31]

articulate three broad outcomes of intentional transformation: changing the situation; developing transformative knowledge; and promoting mutual learning to guide the capacity and process for envisioned changes.

There is an extensive body of existing literature [3,6,26,30–37] that highlights and reviews key work on capacity, process, and outcomes of transformations. Despite the discussion in the primary literature, practitioners and funders are seeking guidelines to design and evaluate transformation initiatives [3,38] and may have distinct framings of transformational change. At the same time, funding mechanisms calling for urban transformational change are increasingly common and are an important driver of how transformational change in cities is articulated in research and practice. Funding mechanisms provide leadership to encourage action-oriented experimentation, innovative solutions, basic research, and offer tangible examples and strategies for transformational change. This article presents a new synthesis of criteria for urban sustainability transformation—inclusive of how funders frame the capacity, process, and outcomes of transformation—and opens the dialogue to guide the proactive development of sustainability transformations.

3. Criteria for Transformational Change

Building on existing concepts, we have identified seven criteria of sustainability transformations to envision sustainable futures for cities. To better understand how these concepts are framed, we have drawn from both the literature and eight RFPs from recent sustainability transformation initiatives. We do not intend to provide a formal review of the different strands of literature (see references above). Instead, we have highlighted key variation in framings of sustainability transformations from the primary literature to provide context and a point of reference to relate the strategies that were identified from funding institutions' recent RFPs for urban sustainability transformations. We individually performed the content analysis on each RFP document to extract information (i.e., recommendations, guidelines, explicit requirements, and evaluation criteria) on how sustainability transformations are framed in the document (inductive extraction). Regardless of whether a criterion appeared in the RFP as a capacity to facilitate transformation, a process for effecting the change, or as an expected outcome of transformational change, it was considered in this analysis. We then came together to identify thematic areas that are synthetic of the document narratives and examined how they are represented compared to the dominant discourses in the primary literature (inductive/deductive synthesis). We selected eight recent (within the past five years), prominent RFPs from countries in Africa, Asia, Europe, North America, and South America, representing different types of funding and recipient institutions. RFPs were selected based on: an urban transformation emphasis; requirements for research and practice products; and leading funding allocations (size of budget and years of funding). We have highlighted exemplary strategies from the RFPs (Table 1) and discuss divergences from the dominant framing in the literature. From the reviewed RFPs, we summarize seven criteria for sustainability transformation: persistent, open-ended, fundamental, normative, co-produced, evidence-based, and systems-based.

3.1. Persistent

Sustainability transformations result in lasting, persistent change, such that it is difficult to return to previous conditions [16]. However, persistence goes beyond just irreversible change. Rather than persistence of the current state, this criterion refers to the capacity to continue pursuing sustainability beyond the life of the project; to persist in a future trajectory toward sustainable transformations. That is, sustainability transformations are not endpoints [2]. Persistence should not only be considered a criterion for the last phase of an initiative. Throughout, transformation initiatives must build multiple capacities [25–27], iteratively evaluate, and engage in long-term changes.

Table 1. Criteria for framing urban sustainability transformations research, including a short synthesis description of each criterion and exemplary strategies identified in the reviewed requests for proposals (RFPs) to highlight tangible strategies and best practices.

Transformations Criteria	Short Descriptions	Exemplary Strategies from RFPs
Persistent	Capacity for the long-term pursuit of sustainability trajectories	Foster legacy and long-term viability of future outcomes [39]
Open-ended	Sustainability transformations are multiple and branched pathways of possible sustainabilities	Build scenarios of alternative futures and pathways; evaluate and engage changing goals, values, and conditions [40]; identify mechanisms to adapt and grow as new opportunities arise [39]
Fundamental	Radical (and desirable) departure from the status quo	Develop novel visions to overcome path dependencies [40]; Analysis of tipping points in social systems—rapid changes in behavior, priorities, and governance [41]
Normative	The values that underlie what makes an intervention just and desirable (for whom, what, where, and why)	Incorporate values and needs of vulnerable populations and for future generations [42–44]; Bring these values into the legitimate space of scientific inquiry, policy, and practice [40]
Co-produced	Collaborative, inclusive endeavor as full partners	Co-production throughout the entire process, including proposal development [40]; Engagement during the development of research questions and methodologies to ensure policy-relevant framing, establish demand, and build-on existing momentum [45]
Evidence-based	Critical and pluralistic incorporation of diverse forms of knowledge	Inclusive of humanities, traditional knowledge, and creative works [41,42]; Learn from the experiments and best practices of other urban areas in developing new or place-based effective strategies [44,46]
Systems-based	Holistic representation of the interdependent components across sectors, space, and time	Analysis of systemic changes, such as feedbacks among social, cultural, technological, political, economic and environmental processes [41]

In our synthesis of transformational change RFPs, funding calls rarely addressed the long-term persistence of initiatives beyond the funding cycle. Only one explicitly focused on the project’s expected legacy and long-term viability of future outcomes [39]. More common was an implicit focus on positive long-term outcomes, but these RFPs lacked guidance on how to pursue or evaluate persistence. Despite the implicit nature, the importance of persistence in transformational change is clear. All the reviewed RFPs highlight long-term capacity and collaborations. Capacity building is a tangible shorter-term goal (e.g., [40,45,46])—relevant to the average three-year funding cycle—that can lead to the creation of long-term responsive monitoring and evaluation needed to meet the persistence criterion.

3.2. Open-Ended

Sustainability transformations are not single trajectories bounded by uncertainties—there are multiple and branched pathways that are emergent and open-ended [19]. Rather than immutable targets, initiatives to guide transformations should seek to be adaptive, iterative [5], experimental [47], and explore multiple pathways to achieve positive futures [4,6]. For example, participatory scenario development can be used to explore diverse choices and tradeoffs or to inspire innovative solutions. The challenge is to design processes that offer flexibility to manage and explore changing conditions, goals, and values [19,48].

Open-ended initiatives can be a challenge for funding institutions given the need to assess project outcomes but allowing for the exploration of alternative futures is critical to achieve transformational change. RFPs that feature open-ended initiatives offer room for experimentation and examination of alternative outcomes [39,40,46] and to account for changing project goals [39,40,45].

3.3. Fundamental

In the literature, transformational change is often equated to a large, fundamental state change or regime shifts. Fundamental change results in system reconfiguration and a radical departure from the status quo—often with difficult tradeoffs [16,19,23]. Fundamental changes that are intentional

feature aspirational surprise, utopian thought, and far-sightedness [4]. Overall, fundamental changes are visionary and holistic—not first-aid.

The concept of fundamental is frequently used to describe transformational change in the literature, but surprisingly is not a common feature of the RFPs. Most of the reviewed RFPs only implicitly suggest fundamental changes by exploiting windows of opportunities to advance transformation, in particular, social transformation. For example, the Climate Resilient Cities in Latin America RFP [45] focuses on how “the rapid growth of small and medium cities in Latin America (can) be harnessed to deliver climate-resilient, transformational urban development.” The clearest guidance on what qualifies as fundamental change is a call for “novel visions” to “overcome path dependencies and entrenched self-interests and unjust power distribution” [40].

3.4. Normative

It is not necessarily desirable, or even feasible, to fundamentally transform everything. Instead, initiatives must deliberate on questions such as: what shall we transform? For whom, why, and how [4,19,21,26,49]? Intentional transformations address normative principles by: engaging marginalized and vulnerable stakeholders to enhance equity, well-being, and livelihood; avoiding the degradation of social-environmental conditions; reducing unintended consequences that diminish options for the future; and addressing the resulting trade-offs. In addition to minimizing consequences and tradeoffs, it is not only important to ask, ‘for whom?’, but also examine how the relationships, opportunities, and tradeoffs will change over the course of the initiative and beyond.

All of the RFPs highlight the importance of normative principles by considering diverse stakeholder perspectives and environmental trade-offs. In particular, many RFPs emphasize the value of including marginalized stakeholders in addressing inequities. The strongest examples are inclusive of cultural diversity [46], social justice and politics [40,42], poverty alleviation [43], educational attainment [43], and intergenerational needs [42–44].

3.5. Co-Produced

The collaborative production of knowledge and action by diverse stakeholders is essential in the design and implementation of sustainability transformations. Co-production embraces transdisciplinary and participatory engagement among stakeholders and researchers (cf. [27,48–51]). Yet, there is a need to explicitly scrutinize the process of co-production: who are the actors and institutions that should be involved; what is the nature of their relationships; and, what are their roles in the design and governance of change [52]? Co-production is essential as part of the transformation process; it challenges status-quo thinking, the entrenched dominant narrative, and unjust power dynamics. Co-production of knowledge through collaborations of dominant and marginalized stakeholders creates new networks, sparks transformative ideas, and empowers agents with new capacities [53]. Yet, to mitigate challenges of co-production and ensure the best outcomes of the co-production process, rigorous collaborative process and standards are necessary [49,54].

Among the RFPs, transdisciplinary and participatory engagement are strongly represented as guidelines for successful proposals. However, only a few RFPs explicitly include requirements for co-production (i.e., [40,42,45]). Some provide guidelines for “two-way communication” and “knowledge exchange” while others require direct involvement of diverse perspectives throughout the project to empower a broad range of stakeholders. Exemplary guidelines for stakeholder involvement require co-production even in the development of the proposals themselves [40,42].

3.6. Evidence-Based

Looking to other perspectives, places, and times can provide examples and new pools of knowledge for sustainability transformations. That is, solutions for sustainability transformations are rooted in diverse examples that serve as evidence of the plausibility and implications of transformational policies and actions. The evidence base is more than just diverse modes of evidence

(e.g., models, narratives, and studies from other places); it entails the translation, negotiation, synthesis, and application to the local context [55]. Moreover, initiatives must seek evidence that inspires radically different visions of transformation and allows us to imagine aspirational and fantastical futures. Transformation initiatives must also embrace diverse sources of evidence, such as creative works, demonstration projects, marginalized perspectives, models and scenarios, other places and times, theoretical concepts, and traditional knowledge [4,6,48,53,56]. For those solutions that might not exist yet—the ones yet imagined—researchers must expand the pool of potential solutions from a greater diversity of values, needs, and experiences.

Many RFPs emphasize identifying best practices and learning from other places. For example, all RFPs call for or suggest cross-city networks [39–46] and highlight the role of comparative research and collaborative network approaches to share solutions, develop diverse perspectives, and synthesize knowledge. Only one RFP specified using creative works [42], and two emphasized the inclusion of humanities to push the boundary beyond what has been considered evidence-based knowledge in the past [41,42]. While it is not uncommon to give precedence to a particular knowledge domain (e.g., social sciences or sciences in general; [40,41,44,45]), the most exemplary guidelines emphasize the importance of plurality for sustainability transformations [39,42,46].

3.7. Systems-Based

Systems approaches incorporate myriad interdependent components of a city and examine how they behave holistically across sectors, space, and time. Transformational change initiatives need to ask, how will intended transformations impact interconnected priorities, adjacent and distant neighbors, and options for the future [48]? Transformational changes have complex outcomes beyond those that are intended, and a coordinated systems-based approach is imperative. Rather than a laundry list of uncoordinated policies and actions, sustainability transformations explicitly develop multifunctional social-ecological-technological goals and pathways [26,57].

The reviewed RFPs strongly encourage systems-based approaches, including accounting for coupled, multi-scalar processes and systems-based dynamics. Multidisciplinary approaches are a baseline requirement, yet notably, the social science-centric RFPs rarely emphasize the importance of environmental dynamics across multiple spatial and temporal scales. The RFPs with the more evident guidelines for systems-based processes and outcomes encourage systems analyses of “interconnected (social-ecological-technological) processes and feedbacks that operate within the urban system at multiple temporal and spatial scales” [39].

4. Re-Envisioning Sustainability Transformations as More than Just Big Changes

As the qualitative analysis of the RFPs suggests, the criteria for transformation are not achieved in isolation. At the same time, considering the ambitious task of fully adhering to any single criterion, it would be a challenge for transformational initiatives to successfully adhere to all seven criteria. The inclusion of any particular set of criteria in the RFPs’ guidelines for successful sustainability transformations initiatives varies widely, as seen in Figure 1 [39–46]. For example, some guidelines encourage the exploration of multiple pathways (open-ended) while others put more emphasis on the pursuit of long-term change (persistence). However, many of the criteria do appear together and may be closely interlinked. For example, co-production can be a means to elicit normative preferences, engage alternative evidence bases, or build capacity of other criteria.

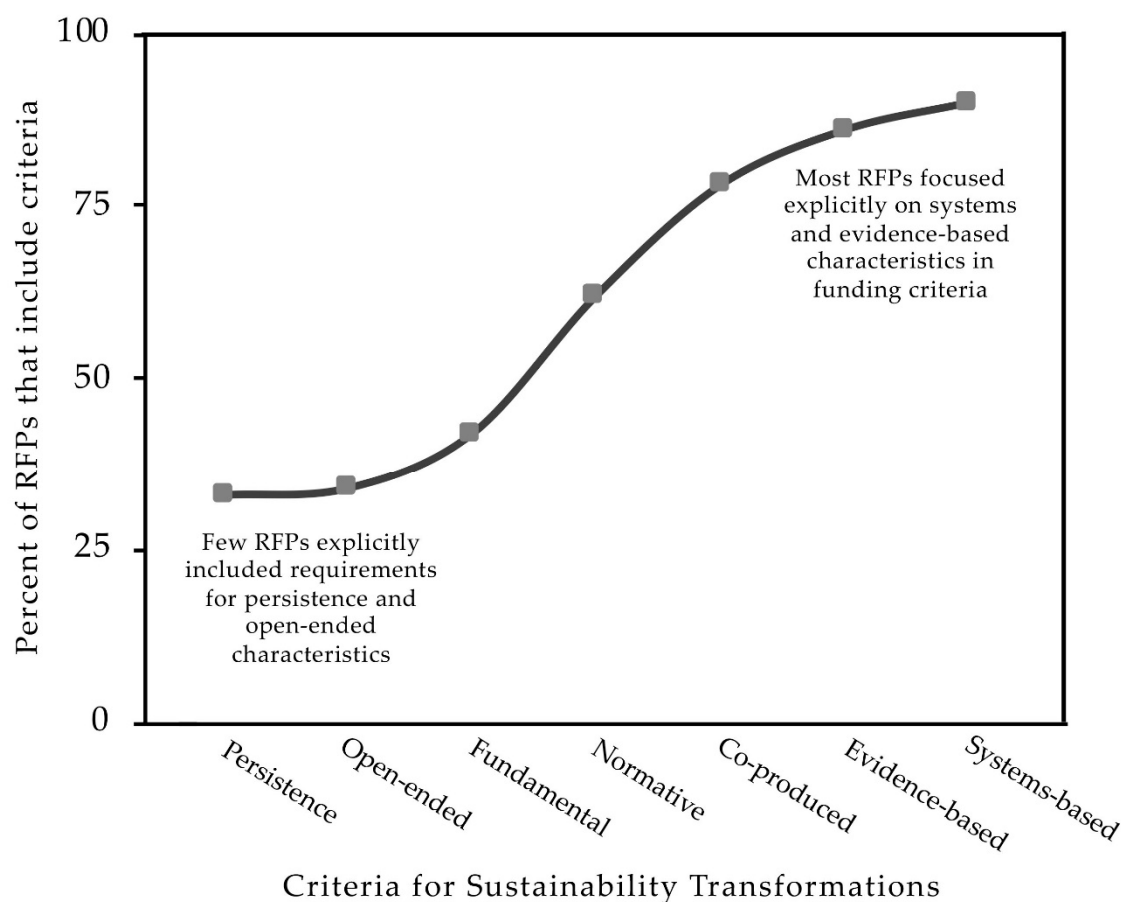


Figure 1. Each transformational criterion is imperative to envision intentional sustainability transformations. Each criterion was coded and rank-sorted based on explicit representation (0 = non-existent to 5 = very strong) among the requests for proposals (RFPs) of recent sustainability transformation funding initiatives. At 100% all 8 RFPs had “very strong” requirements for a criterion.

Yet, must all criteria be met in full to lead to a sustainability transformation? Or, is there a spectrum of possible combinations, pathways, and outcomes (cf. [58])? Through the interplay of criteria, as qualities of transformational change are added, we hypothesize that there is an increasing likelihood an initiative will be transformational. Future research should continue to examine the spectrum of conditions and possibilities that lead to successful transformations—affecting capacities to transform, processes for effecting change, and outcomes of transformational changes. In addition, leadership and strong networks will be imperative to ensuring sustainable transformations persist through changing conditions, capacities, and emerging challenges throughout the process [49].

We offer these criteria as a foundation to re-envision the interplay of research and practice to co-design sustainability transformations. However, even with strong adherence to these criteria, numerous factors can shape the capacity, process, and intended outcomes of a transformation initiative (e.g., local governance, available resources, researcher-practitioner networks). An inventory of ‘successful’ sustainability transformations is a vital next step to understand the different conditions that lead to positive futures. Yet, even with a stronger understanding and clear examples of successful transformations, researchers must depart from the classic approach of passively studying transformations and actively engage in transdisciplinary initiatives.

Transformation is at the heart of the sustainability agenda. The future of sustainability research and practice should focus on how to conduct ‘successful’ sustainability transformations. Transformation initiatives must question what should radically change, as well as how, and for whom, it is a change. Not everything will, can, or should be transformed. Transformational changes are not

necessarily realized uniformly by everyone or everything; a fundamental change for some might be a small tweak for others. Transformational changes will be contested. There will be winners and losers. The criteria presented here allow us to explore how funding institutions are framing this discourse and scrutinize if our visions represent the sustainability transformations we want.

Author Contributions: D.M.I. and E.M.C. conceived and designed the work, analyzed the data, wrote the initial manuscript, and oversaw comments and editing. D.M.I. and E.M.C. contributed equally. D.M.I., E.M.C., O.B., and N.B.G. participated in the synthesis and contributed comments, edits, and intellectual content.

Funding: This research was funded by US National Science Foundation grant numbers SES-1444755 (Urban Resilience to Extremes Sustainability Research Network) and DEB-1637590 (Central Arizona-Phoenix Long-Term Ecological Research Program), CONICYT-FONDECYT grant number 3150290 and CONICYT-AFB 170008 (Science, Technology, Knowledge and Innovation Ministry of Chile).

Conflicts of Interest: The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

References

1. Ehrlich, P.R.; Ehrlich, A.H. Can a collapse of global civilization be avoided? *Proc. R. Soc. B* **2013**, *280*, 20122845. [[CrossRef](#)] [[PubMed](#)]
2. Childers, D.L.; Pickett, S.T.A.; Grove, J.M.; Ogden, L.; Whitmer, A. Advancing urban sustainability theory and action: Challenges and opportunities. *Landsc. Urban Plan.* **2014**, *125*, 320–328. [[CrossRef](#)]
3. Brown, K.; O'Neill, S.; Fabricius, C. Social science understandings of transformation. In *World Social Science Report 2013, Changing Global Environments, Chapter: Social Science Understandings of Transformation*; OECD Publishing and UNESCO Publishing: Paris, France, 2013; pp. 100–106.
4. Wiek, A.; Iwaniec, D. Quality criteria for visions and visioning in sustainability science. *Sustain. Sci.* **2014**, *9*, 497–512. [[CrossRef](#)]
5. Bennett, E.M.; Solan, M.; Biggs, R.; McPhearson, T.; Norström, A.V.; Olsson, P.; Pereira, L.; Peterson, G.D.; Raudsepp-Hearne, C.; Biermann, F.; et al. Bright spots: Seeds of a good Anthropocene. *Front. Ecol. Environ.* **2016**, *14*, 441–448. [[CrossRef](#)]
6. McPhearson, T.; Iwaniec, D.M.; Bai, X. Positive visions for guiding urban transformations toward sustainable futures. *Curr. Opin. Environ. Sustain.* **2016**, *22*, 33–40. [[CrossRef](#)]
7. Gaziulusoy, A.İ.; Ryan, C. Roles of design in sustainability transitions projects: A case study of Visions and Pathways 2040 project from Australia. *J. Clean. Prod.* **2017**, *162*, 1297–1307. [[CrossRef](#)]
8. Folke, C.; Carpenter, S.R.; Walker, B.; Scheffer, M.; Chapin, T.; Rockström, J. Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecol. Soc.* **2010**, *15*. [[CrossRef](#)]
9. Crépin, A.-S.; Biggs, R.; Polasky, S.; Troell, M.; de Zeeuw, A. Regime shifts and management. *Ecol. Econ.* **2012**, *84*, 15–22. [[CrossRef](#)]
10. Herrmann, D.L.; Schwarz, K.; Shuster, W.D.; Berland, A.; Chaffin, B.C.; Garmestani, A.S.; Hopton, M.E. Ecology for the Shrinking City. *BioScience* **2016**, *1*, 1–9. [[CrossRef](#)]
11. Grimm, N.B.; Pickett, S.T.A.; Hale, R.L.; Cadenasso, M.L. Does the ecological concept of disturbance have utility in urban social–ecological–technological systems? *Ecosyst. Health Sustain.* **2017**, *3*, e1255. [[CrossRef](#)]
12. Solecki, W.; Pelling, M.; Garschagen, M. Transitions between risk management regimes in cities. *Ecol. Soc.* **2017**, *22*, 38. [[CrossRef](#)]
13. Tongur, S.; Engwall, M. Exploring window of opportunity dynamics in infrastructure transformation. *Environ. Innov. Soc. Transit.* **2017**, *25*, 82–93. [[CrossRef](#)]
14. Olsson, P.; Folke, C.; Hahn, T. Social-Ecological Transformation for Ecosystem Management: The Development of Adaptive Co-management of a Wetland Landscape in Southern Sweden. *Ecol. Soc.* **2004**, *9*, 2. [[CrossRef](#)]
15. Carpenter, S.R.; Folke, C. Ecology for transformation. *Trends Ecol. Evol.* **2006**, *21*, 309–315. [[CrossRef](#)] [[PubMed](#)]
16. Chapin, F.S., III; Kofinas, G.; Folke, C. (Eds.) *Principles of Ecosystem Stewardship. Resilience-Based Natural Resource Management in a Changing World*; Springer Verlag: New York, NY, USA, 2009.

17. Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Iii, F.S.C.; Lambin, E.F.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.J.; et al. A Safe Operating Space for Humanity. Available online: <https://www.nature.com/articles/461472a> (accessed on 6 July 2018).
18. Brown, V.A.; Harris, J.A.; Russell, J.Y. *Tackling Wicked Problems Through the Transdisciplinary Imagination*; Earthscan: London, UK, 2010; ISBN 978-1-84407-924-7.
19. Leach, M.; Stirling, A.C.; Scoones, I. *Dynamic Sustainabilities: Technology, Environment, Social Justice*; Routledge: London, UK, 2010; ISBN 978-1-136-54167-4.
20. Kates, R.W.; Travis, W.R.; Wilbanks, T.J. Transformational adaptation when incremental adaptations to climate change are insufficient. *PNAS* **2012**, *109*, 7156–7161. [[CrossRef](#)] [[PubMed](#)]
21. Hackmann, H.; Moser, S.C.; Clair, A.L.S. The Social Heart of Global Environmental Change. Available online: <https://www.nature.com/articles/nclimate2320> (accessed on 16 July 2018).
22. Redman, C.L. Should sustainability and resilience be combined or remain distinct pursuits? *Ecol. Soc.* **2014**, *19*. [[CrossRef](#)]
23. Rotmans, J.; Loorbach, D. Complexity and Transition Management. *J. Ind. Ecol.* **2009**, *13*, 184–196. [[CrossRef](#)]
24. Wolfram, M. Conceptualizing urban transformative capacity: A framework for research and policy. *Cities* **2016**, *51*, 121–130. [[CrossRef](#)]
25. Eakin, H.C.; Lemos, M.C.; Nelson, D.R. Differentiating capacities as a means to sustainable climate change adaptation. *Glob. Environ. Chang.* **2014**, *27*, 1–8. [[CrossRef](#)]
26. Olsson, P.; Galaz, V.; Boonstra, W.J. Sustainability transformations: A resilience perspective. *Ecol. Soc.* **2014**, *19*, 1. [[CrossRef](#)]
27. *Conference of the Swiss Scientific Academies. Research on Sustainability and Global Change—Visions in Science Policy by Swiss Researchers*; Swiss Academy of Science: Bern, Switzerland, 1997.
28. Page, G.G.; Wise, R.M.; Lindenfeld, L.; Moug, P.; Hodgson, A.; Wyborn, C.; Fazey, I. Co-designing transformation research: Lessons learned from research on deliberate practices for transformation. *Curr. Opin. Environ. Sustain.* **2016**, *20*, 86–92. [[CrossRef](#)]
29. Loorbach, D.; Rotmans, J. Managing Transitions for Sustainable Development. In *Understanding Industrial Transformation*; Olsthoorn, X., Wiczorek, A.J., Eds.; Environment & Policy; Springer: Dordrecht, The Netherlands, 2006; pp. 187–206. ISBN 978-1-4020-3755-9.
30. Moore, M.-L.; Tjornbo, O.; Enfors, E.; Knapp, C.; Hodbod, J.; Baggio, J.A.; Norström, A.; Olsson, P.; Biggs, D. Studying the complexity of change: Toward an analytical framework for understanding deliberate social-ecological transformations. *Ecol. Soc.* **2014**, *19*. [[CrossRef](#)]
31. Mitchell, C.; Cordell, D.; Fam, D. Beginning at the end: The outcome spaces framework to guide purposive transdisciplinary research. *Futures* **2015**, *65*, 86–96. [[CrossRef](#)]
32. Loorbach, D.; Rotmans, J. The practice of transition management: Examples and lessons from four distinct cases. *Futures* **2010**, *42*, 237–246. [[CrossRef](#)]
33. Smith, A.; Fressoli, M.; Thomas, H. Grassroots innovation movements: Challenges and contributions. *J. Clean. Prod.* **2014**, *63*, 114–124. [[CrossRef](#)]
34. Pereira, L.; Karpouzoglou, T.; Doshi, S.; Frantzeskaki, N. Organising a Safe Space for Navigating Social-Ecological Transformations to Sustainability. *Int. J. Environ. Res. Public Health* **2015**, *12*, 6027–6044. [[CrossRef](#)] [[PubMed](#)]
35. Wolfram, M.; Frantzeskaki, N. Cities and Systemic Change for Sustainability: Prevailing Epistemologies and an Emerging Research Agenda. *Sustainability* **2016**, *8*, 144. [[CrossRef](#)]
36. Wolfram, M.; Frantzeskaki, N.; Maschmeyer, S. Cities, systems and sustainability: Status and perspectives of research on urban transformations. *Curr. Opin. Environ. Sustain.* **2016**, *22*, 18–25. [[CrossRef](#)]
37. Few, R.; Morchain, D.; Spear, D.; Mensah, A.; Bendapudi, R. Transformation, adaptation and development: Relating concepts to practice. *Palgrave Commun.* **2017**, *3*, 17092. [[CrossRef](#)]
38. Dinshaw, A. What is the Role for Transformation in Adaptation? 2014. Available online: <http://www.wri.org/blog/2014/04/what-role-transformation-adaptation> (accessed on 11 April 2014).
39. National Science Foundation (NSF). Sustainability Research Network (SRN). 2014. Available online: <https://www.nsf.gov/pubs/2014/nsf14534/nsf14534.pdf> (accessed on 1 April 2017).
40. International Social Science Council (ISSC) Transformations to Sustainability. 2014. Available online: <http://www.worldsocialscience.org/documents/call-transformative-knowledge-network-proposals.pdf> (accessed on 1 April 2017).

41. New Opportunities for Research Funding Agency Cooperation in Europe and Belmont Forum, (NORFACE-BF). Transformations 2 Sustainability (T2S). 2017. Available online: <https://www.norface.net/wp-content/uploads/2017/03/T2S-Call-for-Proposals-v1.3.pdf> (accessed on 1 November 2017).
42. Joint Programming Initiative (JPI). Connecting Climate Knowledge for Europe Joint Call for Transnational Collaborative Research Projects. 2013. Available online: <http://www.jpi-climate.eu/media/default.aspx/emma/org/10832327/CPI+CLIMATE+CALL+COMPLETE+DOCUMENTS> (accessed on 1 April 2017).
43. Economic and Social Research Council-National Research Foundation (ESRC-NRF). Newton Call for Collaborative Research, Urban Transformations in South Africa. 2015. Available online: <http://www.esrc.ac.uk/files/funding/funding-opportunities/newton-fund/esrc-nrf-newton-call-for-collaborative-research-urban-transformations-in-south-africa/call-specification/> (accessed on 1 April 2017).
44. Economic and Social Research Council-National Nature Science Foundation of China (ESRC-NSFC). Developing Financial Systems to Support Sustainable Growth in China. 2015. Available online: <http://www.esrc.ac.uk/files/funding/funding-opportunities/esrc-nsfc-call-specification/> (accessed on 1 April 2017).
45. Climate and Development Knowledge Network (CDKN). Climate Resilient Cities in Latin America. 2016. Available online: <http://www.uoguelph.ca/research/sites/default/files/public/Climate-Resilient-Cities-in-Latin-America-research-call-TOR.pdf> (accessed on 1 April 2017).
46. Rockefeller Foundation. 100 Resilient Cities (100RC). 2014. Available online: <http://www.100resilientcities.org/pages/100-resilient-cities-2014-challenge-official-rules#/> (accessed on 1 April 2017).
47. Sengers, F.; Wiczorek, A.J.; Raven, R. Experimenting for sustainability transitions: A systematic literature review. *Technol. Forecast. Soc. Chang.* **2016**. [CrossRef]
48. Advisory Committee for Environmental Research and Education. *Sustainable Urban Systems: Articulating a Long-Term Convergence Research Agenda. A report from the NSF Advisory Committee for Environmental Research and Education*; 2018. Available online: <https://www.nsf.gov/ere/ereweb/ac-ere/sustainable-urban-systems.pdf> (accessed on 1 February 2018).
49. Lang, D.J.; Wiek, A.; Bergmann, M.; Stauffacher, M.; Martens, P.; Moll, P.; Swilling, M.; Thomas, C.J. Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustain. Sci.* **2012**, *7*, 25–43. [CrossRef]
50. Grove, J.M.; Childers, D.L.; Galvin, M.; Hines, S.; Muñoz-Erickson, T.; Svendsen, E.S. Linking science and decision making to promote an ecology for the city: Practices and opportunities. *Ecosyst. Health Sustain.* **2016**, *2*. [CrossRef]
51. Lemos, M.C.; Morehouse, B.J. The co-production of science and policy in integrated climate assessments. *Glob. Environ. Chang.* **2005**, *15*, 57–68. [CrossRef]
52. Muñoz-Erickson, T.A. Co-production of knowledge–action systems in urban sustainable governance: The KASA approach. *Environ. Sci. Policy* **2014**, *37*, 182–191. [CrossRef]
53. Galafassi, D.; Daw, T.M.; Thyresson, M.; Rosendo, S.; Chaigneau, T.; Bandeira, S.; Munyi, L.; Gabrielsson, I.; Brown, K. Stories in social-ecological knowledge cocreation. *Ecol. Soc.* **2018**, *23*. [CrossRef]
54. Few, R.; Brown, K.; Tompkins, E.L. Public participation and climate change adaptation: Avoiding the illusion of inclusion. *Clim. Policy* **2007**, *7*, 46–59. [CrossRef]
55. Tengö, M.; Brondizio, E.S.; Elmqvist, T.; Malmer, P.; Spierenburg, M. Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach. *AMBIO* **2014**, *43*, 579–591. [CrossRef] [PubMed]
56. Game, E.T.; Tallis, H.; Olander, L.; Alexander, S.M.; Busch, J.; Cartwright, N.; Kalies, E.L.; Masuda, Y.J.; Mupepele, A.-C.; Qiu, J.; et al. Cross-discipline evidence principles for sustainability policy. *Nat. Sustain.* **2018**, *1*, 452. [CrossRef]
57. Iwaniec, D.; Childers, D.; VanLehn, K.; Wiek, A.; Iwaniec, D.M.; Childers, D.L.; VanLehn, K.; Wiek, A. Studying, Teaching and Applying Sustainability Visions Using Systems Modeling. *Sustainability* **2014**, *6*, 4452–4469. [CrossRef]
58. Ostrom, E.; Janssen, M.A.; Anderies, J.M. Going beyond panaceas. *PNAS* **2007**, *104*, 15176–15178. [CrossRef]

