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Multisystemic Resilience

An Emerging Perspective From Social-Ecological Systems

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Introduction

This volume presents remarkably rich and diverse scholarship on different perspectives on multisystemic resilience. Multisystemic resilience spans a wide range of fields, working in different domains and at different scales. This chapter sets out a perspective on multisystemic resilience from the interface of social-ecological systems and environmental social science, arguing for wider and more interdisciplinary research to account for the influence of the many different biological, psychological, social, built, and natural environmental systems that interact and influence processes of recovery, adaptation, and transformation when systems are under stress. It reviews the extent to which shared meanings and methods exist that can support systemic analysis. It explains how systems thinking has evolved and informed the development of theories of resilience and their application to practice, providing examples of how models of multisystemic resilience can be used to expand our understanding of solutions to complex human and environmental problems.

Crossing Disciplines

Resilience is a term with high levels of ambiguity. As shown throughout this volume, it is used across disciplines and fields ranging from engineering and ecology to psychology and public health. It is highly prominent in public discourse. The term, however, suffers from wide-ranging and not always compatible interpretation in lay and expert discourses. This ambiguity is, we suggest, both a good and a bad thing. On one hand, it means that different stakeholders and interests can come together and unite behind the construct of resilience;

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the term has traction and meaning for diverse audiences. On the other hand, it means there is scope for ongoing mis-interpretation and contestation about precise definitions, meanings, applications, and, in turn, its measurement.

The extent to which resilience can be successfully applied within and across different systems will depend in part on the extent to which common understandings and definitions—and metrics and models—can be developed. This section, therefore, discusses the opportunities and constraints to common understandings across disciplines, reflecting on current cross-disciplinary interactions. It starts by examining where there is interaction across fields and where more cross-disciplinary approaches to resilience are evident, and how this relates to multisystemic approaches.

Disciplines and fields that routinely use resilience concepts range from social-ecological systems analysis, human development sciences, well-being and development to disasters and natural hazards. Many have used and developed the concepts over five decades or more. While having distinct epistemologies and methods, Brown and Westaway (2011) suggest that diverse disciplines share central concepts in common. They found that there are important similarities in their evolution, and in addition to shared concepts, each field had undergone paradigm shifts to integrate subjective and relational aspects with more conventional and objective measures of change. These commonalities are around issues of scale, the recognition of nonlinearities, dynamic nature of systems that show resilience, and thresholds that must be reached before systems transform. They also include concepts such as assets and capacities for adaptation and windows of opportunity (Brown, 2016). Despite the distinctiveness of the fields themselves, there are a set of tensions within and across disciplines, which are stark reminders of the heterogeneity in how resilience is understood. Reading the chapters in this volume, these tensions relate to whether resilience is, in effect, a desirable trait of a system, a static property, or a process and whether it can actually be observed as an objective reality. Other tensions include whether a system that shows resilience adapts, transforms, or bounces back or bounces forward, how resilience is socially constructed, and whether resilience is a quality of the system that makes it "normal" or exceptional. Such tensions within and between disciplines have, in effect, led to divergence on the usefulness and desirability of resilience in terms of interventions in society and for individuals.

How much do these commonalities—and tensions—affect cross-disciplinary and interdisciplinary work on resilience, and how much overlap is there currently between the different scientific fields that engage with and use resilience concepts? One means to clarify the learning between disciplines is to document cross-referencing of ideas, concepts and methods. Baggio, Brown, and Hellebrandt (2015) analyze citations networks to identify where resilience ideas are used across the most common fields and found surprisingly little cross-referencing. Five distinct scientific fields were identified: social sciences (including economics), ecology and environmental sciences, psychology, engineering, and social-ecological systems, each with different practices and patterns of learning and publishing. No surprise, then, this current volume demonstrates that there are many subdisciplines within this list that themselves have unique understandings of what resilience means. Baggio et al. (2015) sought to understand whether resilience acts as a boundary object or bridging concept; in other words, is *resilience* a term with a precise meaning within fields but also used loosely across fields or purposely to integrate different fields? The analysis by Baggio et al. (2015) found that the large majority of studies refer to and cite exclusively within their own specific field, if not subfield.

Across the fields where resilience is established, the greatest level of interdisciplinarity seems to be in analysis of social-ecological systems, where the majority of papers are cited at least 50% of the time outside of their own field, ranging from engineering to social sciences (as defined in Baggio et al., 2015). It is this pattern of multisystemic thinking, which offers clues to how other disciplines studying resilience might also advance a broader perspective of human and environmental transformation. Even within social-ecological systems studies, there remains, however, little crossover with psychology and human sciences (which themselves are quite insular in the research they cite) despite shared concepts. Such analysis of current and recent scientific practice confirms the rise of the term *resilience*, yet it shows that resilience does not seem to bridge all the scientific fields reflected in this volume where the concept of resilience is being explored.

One major issue in the use of resilience across fields is the tension between the term describing an accepted observable reality on the one hand, with its productive use as a boundary object, and its ambiguous nature on the other. Brand and Jax (2007) examine such tensions across fields of ecological and social sciences, highlighting how the distinctions between the descriptive use of resilience—originating from ecology—becomes blurred and often intertwined with more normative and extended uses to the extent that individual studies or papers often mix multiple meanings. They contend that the meaning of resilience becomes diluted and increasingly unclear in moving from a narrow ecological descriptive use to a broader normative definition, where resilience becomes a boundary object, "floating between descriptive and normative meanings" (p. 10). This has implications for development of multisystemic resilience which involves cross-disciplinary, cross-domain and cross-scale work. According to Brand and Jax (2007), the term *resilience* is used ambiguously *for fundamentally different intentions* in these contexts. They propose that the increased vagueness and malleability of resilience is in fact highly valuable to foster communications between disciplines and between science policy and practice. However, they argue for what they term "a division of labour in a scientific sense" (p. 10) between a descriptive resilience, a clear, well-defined, and measurable definition in ecological science, and social-ecological resilience as a boundary object used in a transdisciplinary approach and to foster interdisciplinary work.

What does this mean for multisystemic resilience? What key characteristics of resilience across disciplines are necessary to develop a systemic approach? What then, is multisystemic in this context? The term *system* signifies a set of interacting items or components that form an integrated whole. Multisystemic refers to interactions between multiple systems, each system itself a subordinate or supraordinate component of a co-occurring system. A genome, a family, an online community, a fishery, and a coral reef are all examples of systems that operate at different scales depending on one's point of view. A system is delineated by its spatial and temporal boundaries, surrounded and influenced by its environment, and is described by its structure and purpose and expressed in its functioning. It might be described as a set of interactions, linkages, and connections, which are often characterized by feedbacks and emergence. Feedbacks occur when outputs of a system are routed back as inputs and become part of a chain of cause-and-effect interactions that form a circuit or loop (human activity, natural ecosystems and computer networks, to name just a few different systems, all show these circuits in their behavior and structure). Emergence occurs when "the whole is greater than the sum of the parts," meaning the whole (system) has properties its individual parts do not have. Key features of systemic resilience are its focus on dynamic interactions. Distinguishing aspects then of a systemic approach would include multiple domains and components, complexity and dynamism in behavior, and cross-scalar interactions. These are key to understanding changes observed in human and environment interactions that have become increasingly complex and problematic. This means, for example, that in a systemic view, climate change is far more than an environmental problem. From the perspective of multisystemic resilience, it is also about culture, values, and identities (psychological and social processes), as well as governance (political and economic processes) and access to technology (engineered and built environments). The next section explores how the social-ecological systems field has developed a multisystemic approach to the analysis of resilience. This growing understanding of multiple systems and their role in resilience provides a potential way forward for other fields of study to broaden the systems they account for in their models of resilience.

Systemic Resilience in Social-Ecological Systems

Social-Ecological Systems: Lessons for Multisystemic Resilience

The study of social-ecological systems appears to have, as previously discussed, a higher level of learning and interface across scientific fields than many others. Analysis of social-ecological systems is inherently about phenomenon that cross multiple temporal and spatial scales and involves interaction between physical, biological, and social phenomenon and components. If such systems exhibit resilience they may, therefore, we suggest, represent a prototype set of characteristics and a role model for interdisciplinary engagement (see Chapter 36 of this volume for more details).

A social-ecological system is conceptualized as an intertwined system of humans and environment; it is a way of understanding people and the biosphere as interconnected and mutually interdependent. Resilience of social-ecological systems is generally understood to be the capacity to sustain human well-being in the face of disturbance and change, both by buffering shock and by adapting or transforming in response to change. In common with other systems, resilience involves responding to both shocks and to other types of change, and it is about persisting, adapting, and transforming—in other words about bouncing back to original states and potentially bouncing forward into new and perhaps more desirable states. These changes can occur at multiple systemic levels at the same time, or in sequence, but they seldom, if ever, affect only one system.

The concept of a social-ecological system, when first developed, represented a significant shift in thinking: traditionally, ecology and natural resources management viewed human systems as external drivers. Economics and the social sciences generally understood natural systems as nondynamic resources to be extracted for profit or to support subsistence. For 20 years or more, the benefits of social-ecological systems analysis were contested but have become now almost universally accepted in terms of their insights into why environmental degradation, inappropriate management, and such dilemmas persist (Holling & Meffe, 1996; Ostrom, 2009). Berkes and Folke (1998) represents a landmark in the development and application of social-ecological systems to analyze resilience in local natural resource management systems, involving the study the interactions and linkages between ecosystems and institutions, or the "rules-in-use" that govern them. The approach was designed to be able to understand the feedbacks between ecosystems and institutions and how best to manage them. Their framework inspired many subsequent developments and remains among the most-cited references.

The concept of social-ecological system has evolved over the past two decades to be used widely in both social and environmental sciences and in economics, psychology, arts, and humanities (Colding & Barthel, 2019). In its original conceptualization, the social-ecological system is an open system, with a number of influences on it, such as population growth, technological changes, markets, and trade. Political change and globalization were also considered important influences. From this developed the idea that the social-ecological system framework could be applied to understand how systems responded to change, and particularly their adaptability. Here, a social-ecological system became central to the analysis of resilience, in identifying how different components of a system responded to change and how novel challenges and shocks might impact on a system's ability to continue and be sustainable in the long-term.

While the original primary objective of social-ecological systems analysis was descriptive, subsequent development of the social-ecological system aimed to present a more analytical framework, which could also be used for comparative analysis. Anderies, Janssen, and Ostrom (2004) developed a simple model to analyze the robustness of social-ecological systems which aims to identify the key interactions within systems. This recognizes both the designed and self-organized components of a social-ecological system and how they interact. Ostrom (2009), for example, sets out a generic framework that could be applied and refined by scholars to clarify the structure of a social-ecological system to understand how any particular solution might affect management outcomes and sustainability and to build up a body of studies which could form the basis of large-n comparative analysis. Databases of regime shifts and marine-oriented social-ecological systems have been developed to test propositions around effectiveness of management, the propensity for major shifts, and the presence of thresholds using comparative methods (e.g., Ban et al., 2017; Rocha, Peterson, & Biggs, 2015). Ostrom further argued (Ostrom, 2009) for the need to embrace complexity and to develop better diagnostic methods to identify the combination of variables that affect the incentives and actions of different actors under diverse governance systems.

Social-Ecological Systems: Embracing Complexity

The application of systemic resilience to systems that involve people and the natural world increasingly embraces both the concept and the emerging science of complexity. This complexity has been a common theme throughout this volume, whether in discussions of computer architecture (Chapter 34, this volume) or organizations (Chapter 25, this volume) while being implicit in the analysis of biological (Chapter 2, this volume) and psychological (Chapter 6, this volume) systems. Complexity suggests a large number of components intricately related, and complexity theory has, at its core, the idea that independent components spontaneously order themselves into a coherent whole. Complex adaptive systems are therefore a set of independent agents that have the ability to learn from past experiences. Preiser, Biggs, De Vos, and Folke (2018) highlight the central notions of complexity, adaptability, and adaptation that are core to notions of systems themselves being adaptive. The principles they describe include recognition that systems are often open: their boundaries are not fixed, with components or actors being loosely or only indirectly affected by actions at the core. Further, the characterization of these systems relies on relationality—that systems are in fact characterized by interactions between components and that these agents are themselves not fixed, but defined in relation to context. Hence, for example, when adaptation of social-ecological systems such as forest landscapes to a changing climate involves feedbacks between new information, conservation goals determined by actors outside the system, and interannual climate variability, then the system itself adapts in complex ways that involve significant path dependency (Seidl & Lexer, 2013). To capture this complexity, Helfgott (2018) proposes a methodology for operationalizing systemic resilience, using insights from critical systems thinking and community operational research. This has developed from an international project to build community resilience, working across household, community and regional scales.

The features of complexity are, therefore, significant for systemic resilience analysis in a number of ways. First, the recognition of the openness and indeterminacy of system boundaries allows the incorporation and updating of analysis to bring in agents and actors that may seem peripheral. In political science, the concept of the "all affected principle" highlights that people distant in either space or time should be incorporated into decision-making, even when their representation is difficult. Future generations or future voters, for example, are not given formal recognition in representative democratic systems, a limit that leads to short-termism (Brown et al., 2019a). In systemic resilience, therefore, the recognition of agents that are not present or not directly observable in open systems presents a challenge both for how they should be incorporated, and for methods where indirect and indeterminate phenomena are affecting the systems.

A second major implication of the complexity of adaptive systems relates to notions of scale. Spatial and temporal scales are well recognized in many systems analyses, while scales of jurisdiction, the hierarchy of knowledge, or institutional scales are less well recognized (Cash et al., 2006). If systems are indeed open, then how system boundaries are defined, in effect, means that temporal, spatial, and institutional scales are in fact endogenous to the systems themselves. Who gets to define the appropriate cut-off point of the future or the jurisdictional scale? The long-standing critique of resilience science in ignoring power relations highlights this blindness to scale. So, for example, how can an economic community be resilient, when decisions about production, consumption, and the location of capital are taken in distant locations by agents never considered to be part of the system or community at hand

(MacKinnon & Derickson, 2013)? These same power dynamics are just as relevant to legal systems (Chapter 26, this volume), economic systems (Chapter 30, this volume) and health care (Chapter 4, this volume) and social justice systems for Indigenous peoples (Chapter 29, this volume). Such parallels across disciplines suggests that patterns of resilience will universally contend with dynamics of power even if disciplinary writing on resilience overlooks this dimension of positive change and development in a system over time.

Limitations of Social-Ecological System

Most representations of a social-ecological system present two sub-systems—the social and the ecological—interacting within a larger arena, the social-ecological system. Various linkages, interactions, and feedbacks between the two subsystems are posited. These are mediated by, for example, institutions such as property rights that govern people's access to and control over different components of the system. In many figures and diagrams in the literature, these are denoted as one-way and two-way arrows between the two subsystems.

Multisystemic resilience requires both realization that resilience relates to the interactions across the whole social-ecological system, rather than between specific ecological or social dimensions, and that resilience emerges from process. For example, Brown (2016) revisioned resilience to emphasize agency: that of human actors in the social-ecological system. This finds parallels with aspects of human determinism evident in psychological systems research (see Chapter 9, this volume). But agency might be extended beyond humans. For example, Dwiartama and Rosin (2014) propose that actor network theory might provide a useful starting point to extend agency to nonhumans to develop a more tightly coupled view of a social-ecological system. Christmann, Ibert, Kilper and Moss (2012) also consider actor network theory in relation to vulnerability and resilience. They view that emphasizing agency not just of individual actions, but of associations and networks as dispersed competencies, can inform and overcome social-ecological dichotomies within the social-ecological system concept.

Do nonhuman agents have agency in social-ecological systems? Dwiartama and Rosin (2014) argue that actor network theory can inform resilience analysis, by offering the opportunity of a more encompassing view of agency that extends beyond human intentionality. This focuses on the relationships in which agents participate and how these influence the shape of a network of relationships. In actor network theory agency can be extended to nonhumans, including animals, materials, ideas, and concepts. Thus diverse components of a social-ecological system, including plants and animals, minerals, and climate are system-forming entities. This enables perhaps the role of relations between humans (the social subsystem) and nonhumans (the ecological subsystems) in resilience dynamics to be viewed holistically and as an emergent property of the larger social-ecological system itself. It is this multisystemic perspective that will need further research as far too few papers account for more than one or two systems in their explanations of resilience. Indeed, even the chapters in this volume rarely manage to include human and nonhuman systems in the same models, although architects like Terri Peters (Chapter 32, this volume) and social ecologists like Katharine Hogan (Chapter 37, this volume) are making positive strides forward.

Pushing Boundaries: Emerging Perspectives on Systemic Resilience

The complex causation, emergent processes, context dependence, and dynamics of scale that characterize social-ecological systems present significant challenges for both descriptive and normative analyses. One solution to make analysis tractable is to focus on so-called middle-range theories, or contextual generalizations, that apply to a delimited set of cases rather than universal theories (Schluter et al., 2019). Perhaps an overarching theory of multisystemic resilience is unattainable—or even undesirable—and developing systemic approaches that bring together concepts from different knowledge domain and synthesize empirical findings across diverse contexts and scales might need to forge new approaches and combine methods in agile and adaptive ways. This section examines principles for managing and intervening in social-ecological systems, key elements of social-ecological resilience and how to measure them, and how to address pressing contemporary global challenges such as global change and inequality.

The underlying objective of social-ecological systems analysis is to address global scale threats and challenges to whole system integrity on which human and all life depends. Hence, key perspectives from this science are how to intervene and how to maintain system resilience in the face of both complexity of the system but the urgency of action. A desired set of system functions in the face of disturbance includes direct provision of food, fuel, and clean water; indirect services such as maintenance of soil fertility or regulation of flood and climate; and cultural services that provide spiritual, aesthetic, and recreational values. Principles for managing and intervening in social-ecological systems for resilience are categorically different for those that seek to maximize resource productivity or minimize risks to specific populations. Hence, there are apparent trade-offs between efficiency and resilience. Yet advocates point to system integrity as a long-term goal that is consistent with socially derived goals such as sustainable development (Eakin, Tompkins, Nelson, & Anderies, 2009). Principles for intervention and management are numerous: a synthesis by Biggs, Schlüter, and Schoon (2015), based on trials and a Delphi-style interrogation of researchers and managers in environmental management, identified principles such as ongoing monitoring of change, opening up system boundaries to maximize participation of all affected, and maintaining diversity, both in system structures and in ways of managing, based on principles of devolution and so-called polycentricity (Biggs et al., 2015).

A second boundary involves consilience between disciplines: a holy grail of many studies is to integrate social-ecological systems approaches to resilience with social science insights on, for example, risk, social, and cognitive psychological processes, political dynamics of power, and geographical analyses of scale and power (Brown, 2016). There are three important trends in such research. First, as the range of scientific papers throughout this volume shows, resilience is continuously becoming more mainstream and popular across many different disciplines that complement the work of social-ecological systems scholars (just as their work is now expanding the way resilience is conceptualized by human biological and social scientists): it has resonance and traction in science as well as in policy and public debate. Second, resilience is grounded in different fields of scientific inquiry, showing its theoretical, conceptual, and methodological richness (see Downes, Miller, Barnett, Glaister, &

Ellemor, 2013; Ungar, 2018). Third, there is convergence around the need for greater understanding of social dynamics of resilience, the use of narratives and constructivist approaches to understand the relationships between structure and agency, and how different factors converge and will produce different outcomes for different people in different contexts (Ungar, 2004). Constructivist approaches to understanding scale and in-depth inclusive methods, such as using narratives to study peoples' accounts, experiences, and stories to understand how they construct meanings of resilience, are all pushing boundaries for resilience research across disciplines (Brown et al., 2019a; Jones & d'Errico, 2019; Morrison et al., 2019).

When issues such as place, scale, power, and risk are incorporated into social systems, three key integrating features and boundaries emerge: resistance, rootedness, and resourcefulness (as further elaborated in Brown, 2016). Resistance recognizes agency by individuals in taking control of their destiny which often seems imposed by actors at different scales. Rootedness recognizes that context determinants of resilience—how elements are situated in place and time and how risk aversion and collective identity play out in complex systems. Resourcefulness suggests that social-ecological systems retain capacity for change, even toward radically altering or revolutionizing the system itself. This socially informed system view of resilience suggests strongly that resilience is a process by which change is negotiated and contested in complex social-ecological situations to make up every day experiences (Ungar, 2011).

New Frontiers for Resilience Science

Applications of resilience in social-ecological systems have evolved to tackle grand and thorny challenges about the future integrity of the Earth following a great acceleration of human interventions and exploitation. The varied and rich insights throughout this volume strongly suggest that resilience insights can illuminate complex issues and point to how human biological systems, social systems, and engineered and built systems need to be part of this global challenges conversation if we are to address wicked problems that will plague our generation and generations to come. This section discusses contemporary global challenges to sustainability and how a multisystemic analysis of resilience potentially brings greater insights and helps to identify potential solutions. The first illustrative challenge is around places and communities facing multiple crises that challenge the core ability of societies to function and for governments to secure their populations. A second challenge is to explain and seek to intervene in the arena of massive disparities in wealth, income, power, and ecological footprint apparent at multiple scales, from the Global North and South, through to localized inequalities within societies. These two phenomena are related, but each is complex, highly dynamic, and characterized by change at multiple scales and rates. In this way they each demand a multisystemic approach, one that crosses boundaries and pushes new science and new engagement.

Interlocking Vulnerability and Multiple Crises in Fragile Contexts

Countries, regions, and societies are on the edge of breakdown in many parts of the world. States are fragile, and in places where trust is scarce, ungoverned spaces experience organized violence and disruptions that create displaced populations and trap others in cycles of insecurity. Sometimes crises result from major ecological disruptions and extreme events, exacerbated by local state failure. For example, more than 20 million people are displaced annually over the past decade by weather-related disasters. Framed in relation to multisystemic resilience, a key shared characteristic of such crises is that of marginalization. Such dynamics occur where environmental shocks and stresses exacerbate existing economic, social, and spatial inequalities contributing to downward spirals of social and economic impoverishment, psychological and physical vulnerability, and degradation of both built and natural environments (as identified, for example, by Leach et al., 2018). Such marginalization results in traps, populations unable to move, and individuals and places trapped in poverty where long-term development opportunities are curtailed (Haider, Boonstra, Peterson, & Schlüter, 2018; Nayak, Oliveira, & Berkes, 2014). There is an increased recognition that shocks and stresses evolve from the interplay and coupling between social and ecosystem changes across multiple scales (Galaz, Moberg, Olsson, Paglia, & Parker, 2011; Rocha, Peterson, Bodin, & Levin, 2018). The outcomes of such stresses are population displacement, food insecurity, and health and livelihood declines. Resilience science should now be applied to identify and quantify the capacities necessary to escape traps and reverse marginalization dynamics. This new science has the tools to measure and analyze resilience processes from the individual to global scale and their positive and negative interactions. It needs, though, to integrate transboundary effects, such as emergencies whereby the interconnectedness of nations increases the chances of the effects of poorly managed shocks and stresses in any single country being transferred rapidly throughout the wider region (Liu et al., 2018).

What methods could be used to analyze the systemic risks linked to land use, political instability, climate change, and disaster response? Integrating methods to analyze interacting, cascading, and cross-scale effects in environmental thresholds and stresses are required (Reyers, Nel, O'Farrell, Sitas, & Nel, 2018; Rocha et al., 2018). These innovative methodologies, gleaned from across disciplines, would need to build on methods to measure resilience capacities from individual (Theron, 2016), community (Brown, 2014), and system scales (Reyers et al., 2015) to develop new multisystemic resilience understanding (Helfgott, 2018; Ungar, 2018). Understanding system dynamics and resilience capacities would, however, yield significant benefits, for early warning of crises, for conflict resolution, and for incorporating environmental dimensions into reconstruction from disasters and preventing conflict based on shared understandings of multisystemic resilience.

Inequality as a Threat to Sustainable Development

A body of work has emerged in the last decade that demonstrates how global income or wealth inequality has grown rapidly over the past century at the expense of the environment and the world's poorest nations. The seminal paper by Srinivasan et al. (2008) describes the "ecological debt of nations" and demonstrates how the costs of global environmental change associated with climate change, ozone depletion, agricultural expansion and intensification, deforestation, overfishing, and mangrove conversion are disproportionately borne by poorer nations. Furthermore, as articulated by Turner and Fisher (2008) commenting on the Srinivasan study, the benefits in terms of increased consumption, wealth generation, and enhanced well-being have overwhelmingly accrued to the richest countries. This prompts

Turner and Fisher to suggest that "we must better understand the complex relationships between ecological, social and economic systems. . . . And how and why current economic paradigm produces such inequalities; who pays the costs, and how they can be made more socially and ecologically more sustainable" (p. 1068).

Currently these issues play out in international scientific and policy debates on global climate change. An editorial in *Global Environmental Change* in 2017 Sonja Klinsky et al. (2017) argue that—rather than skirting around normative issues as some commentators and policy makers insist—we need rigorous analysis of equity and justice to inform political decisions on climate change at all scales. This is what we see emerging in policy documents and from think tanks and civil society groups around a whole range of debates about fairness, climate justice, and equity in implementing a post-Paris agenda for action.

Reflecting this emerging, multisystemic thinking, two key papers have been published that move beyond one-dimensional and linear analysis of ecological inequality. First, a review paper published by the Beijer Institute Young Scholar Group led by Maike Hamann (Hamann et al., 2018) applies a social-ecological systems perspective to explore linkages between rising inequalities and accelerating global environmental change. Most research to date has only considered one-dimensional effects of inequality on the biosphere, or vice versa. But their analysis highlights the importance of cross-scale interactions and feedback loops between inequality and the biosphere. A second paper is authored by the Future Earth Science Committee and led by Melissa Leach. The authors argue that it is no longer possible or desirable to address the dual challenges of equity and sustainability separately. They highlight the interlinkages between, and the multiple dimensions of, equity and sustainability. Again, they use a social-ecological systems lens to illustrate how equity and sustainability are produced by interactions and dynamics of coupled social-ecological systems. Their approach emphasizes equity as multidimensional, thus moving beyond an emphasis on distributional aspects of the crisis and instead examining the question of equity of what and equity between whom.

A multisystemic approach to resilience understands the relationship between inequality and sustainability as being highly dynamic, operating through a series of complex mechanisms and pathways, at different scales ranging from the psychological to the environmental, and with interacting slow and fast variables and feedbacks. This means that there is not one intervention point, but many, but how and when they are made is important. For example, interventions to effect change in patterns of consumption may have limited impact unless accompanied by changes in broader moral framings and values (Brown et al., 2019b). Yet these slow drivers—perhaps constituted as social norms—might be powerful tipping points to shift behavior (Nyborg et al., 2016).

Both of these frontier issues involve resilience embracing normative dimensions of the science, highlighting what is desirable and undesirable system features, and making explicit claims on where system boundaries are drawn and the type of disturbance identified. Recent calls to operationalize systemic resilience (e.g., Helfgott, 2018) argue strongly that resilience science should be framed by directly addressing the questions of resilience of what, to what, for whom and over what timescale. Helfgott (2018) and others are becoming more explicit that significant social and environmental challenges could and should be best addressed through building resilience at lower levels, such as facilitating local ownership of issues through iterative and reflexive processes including future visioning and building social cohesion and empathy between agents.

Conclusion

This chapter has approached multisystemic resilience from the perspective of social-ecological systems resilience, demonstrating that by taking a systems approach we are more likely to explain the processes by which systems recover, adapt and transform when stressed. Clearly, extending this understanding to many more human, biological and engineered systems can add to our understanding of the dynamic processes that create solutions to large scale issues which are challenging our world today. The more multisystemic our thinking becomes, and the more interdisciplinary our research, the more likely we are to understand how to manage multiple systems to produce the constructive changes required to save our planet and ourselves.

Key Messages

1. Multisystemic resilience can inform and expand conceptualizations of resilience and fields like social-ecological systems expand, blend and interrogate defintions across disciplines.
2. Methodological diversity is required to study resilience.
3. Significant challenges facing humanity today require new ways of thinking to identify complex multisystemic solutions that can be informed by the emerging science of resilience.
4. The chapters in this volume provide a forum for thinking multisystemically about resilience and the similarities and differences in how the concept is researched and applied.

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