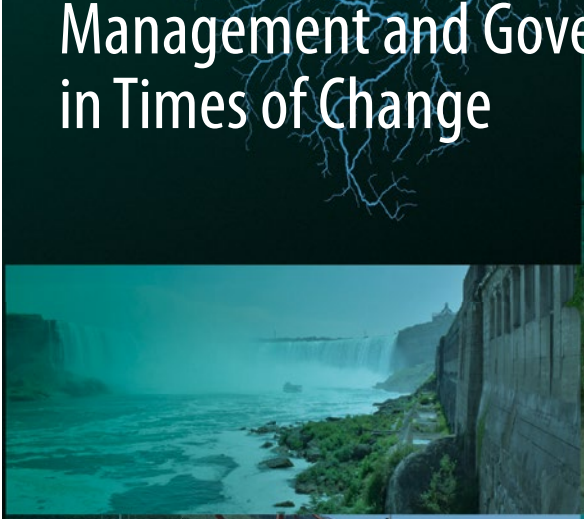
Julia Baird
Ryan Plummer
Editors

Water Resilience

Management and Governance in Times of Change



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Preface and Acknowledgements

Water is necessary for life and its management is, and continues to be, intertwined with human history. In the twenty-first century an unprecedented drama is unfolding. Crises of water abound: billions of people lack access to safe drinking water or sanitation; freshwater and other ecosystems are extensively transformed and degraded; concerns about water scarcity and insecurity are growing; water infrastructure is deteriorating; water related disasters are anticipated to increase; and development continues in an unsustainable manner. The prominent presence of water on *The 2030 Agenda for Sustainable Development*, adopted in 2015 by all Member States of the United Nations, is thus unsurprising. Goal Six ('the water goal') explicitly seeks to ensure availability and sustainable management of water and sanitation for all. It is evident that water actually underpins many of the sustainable development goals. The sustainability of our water is essential for both people and the planet.

The contemporary and future situation is not only unparalleled due to the severity of the water crises, but also because it is unfolding in the Anthropocene – an era in which the influences of humans are a major force of global environmental change. Climate change, along with other drivers, will exacerbate other stressors and is leading to a grim outlook on water futures. Accompanying advances in understanding of systems require re-visiting and re-evaluating past foundational assumptions about the stationarity of water systems. The fluctuation of natural systems within a predictable envelope of variability is unlikely. Complex interactions between social and ecological systems are expected as is interplay within and across levels and scales. At the same time, dialogue is occurring about water rights, responsibilities and values.

Against this backdrop, a confluence of professional experiences and scholarly developments gave impetus to this volume. Limitations of the command and control (government-led) approach to managing resources served as a departure point for much of our research. Consequently, we concentrated on alternative approaches to how people manage and govern aspects of water resources, especially at local scales. Our experiences made clear the variety of these approaches emerging in practice as well as the rich opportunities for them to concomitantly address

water-related issues while enhancing community vitality. It also became increasingly evident in our work that, despite the specific water issue, opportunity and/or scale, individuals and organizations were confronting matters of complexity, uncertainty and contested values. Social-ecological resilience resonated with us largely due to our observations from these early experiences and we started incorporating salient constructs from that scholarship into our water-related research. Of course, many others also saw the synergies between water and resilience, and it was only a matter of time until a 'new water paradigm' emerged in response to the contemporary situation and future challenges. While scholarship on water resilience is growing, it appears to be outpaced by enthusiasm 'on the ground' and in policy discussions about changing how we approach water. Consequently, we saw the need for a volume which deepens knowledge relating to management and governance dimensions of water resilience as well as more fully understand the implications for practice and policy.

We were extremely pleased with the generous response from our colleagues when we communicated the need for this volume and invited them to contribute to it. We sincerely appreciate the thoughtfulness, dedication and time each of the contributors gave to their chapters. What emerged from these contributions was two distinct but related approaches to the governance and management dimensions of water resilience. The first was an application of the water resilience concept to examine water systems. The five chapters contained therein come from a wide range of contexts, from the EU's Water Framework and Flood Directives to polycentric governance potential in South America to agricultural pollution reduction. The second approach that emerged was a focus on further development of the water resilience concept. The six chapters that complete this part cover a diverse range of topics including transformations, cross-scale governance and social learning, among others. We believe that the volume as a whole provides an overview of the current state of water resilience literature; delves into the question of how water resilience is applied in real world systems; and continues to move the conversation about water governance and management through a resilience lens forward. This is exactly what we hoped to accomplish with the volume and we thank our contributors for their support of this vision.

Ensuring the integrity of this volume was paramount to us as co-editors. Each of the chapters was subject to single-blind review by two subject matter experts. The feedback offered by the reviewers was critical and thought-provoking. Authors carefully considered and responded to their comments, which ultimately strengthen the overall quality of the work. We express our appreciation to the reviewers who wished to remain anonymous and to the following individuals: Jason Alexandra, Lena Blom, Matthew Colloff, Robin Craig, Jampel Dell'Angelo, Sherman Farhad, Catherine Febria, Jean Fried, Oliver Fritch, Stefan Gelcich, Margot Hurlbert, Marney Isaac, Åse Johannessen, Rolf Larsson, Leslie Morris-Iveson, Gül Özerol, Ryan Plummer, Panchali Saikia, Chandni Singh, Micaela Trimble and Barbara Veale. We also wish to thank Sherman Farhad and Ryan Plummer for offering insightful comments on the opening and closing chapters of the book, respectively.

Finally, this book would not have been possible without several sources of support. We are grateful for the assistance of Gillian Dale, Sherman Farhad, Amy Lemay, Amanda Smits and Stephanie Tulipano in the preparation and formatting of this book. From the Springer team, we wish to express our appreciation to Margaret Deignan for her immediate interest in this volume when we approached her in 2017 and her continued enthusiasm throughout the project. We also thank Malini Arumugam for her day-to-day support on all aspects of the book. Finally, Julia's involvement in this book was supported in part by the Canada Research Chairs program.

St. Catharines, ON, Canada Julia Baird
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March 2020

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Part I
Introduction

The Emergence of Water Resilience: An Introduction

Ryan Plummer and Julia Baird

Abstract Water quality and availability is critical for sustaining life on earth. However, lack of access to potable water and safe sanitation services for billions of people, deteriorating infrastructure, degradation of ecosystems, and impacts of climate change signal a global water crisis. This crisis is unfolding in the era of the Anthropocene, where human actions are a major driving force of change at a global scale. Instability and surprise are expected in this era, where the interactions and impacts of our decisions can have far-reaching and uncertain impacts. How do we navigate water management and governance in the face of these challenges? A new water paradigm – water resilience – has emerged that acknowledges and considers the complex, dynamic and uncertain nature of social-ecological systems. It emphasizes the need for systems to both persist and provide a set of functions and to adapt to changing conditions. Water resilience has been advanced in scholarship over the past 15 years and is gaining traction in practice and policy realms worldwide. Acknowledgement of the complex nature of water systems coincides with the recognition that the past, command-and-control approaches to management and governance, must give way to inclusive, adaptive and polycentric approaches. Considerable inroads are being made into how we advance management and governance approaches in this new water paradigm. The contributors to this volume represent voices that are making important contributions to the way forward.

1 Water in the Anthropocene

Water is essential to people and the planet. It is central to life processes and "although often perceived to be pretty ordinary, water is the most remarkable substance" (Chaplin, 2001, p. 54). Water enables biochemical functions, provides habitat,

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stabilizes temperature, supports economic sectors, and inspires artists, among other functions. Ultimately, water determines the sustainability of living systems and as such is "…the bloodstream of the biosphere" (Ripl, 2003, p. 1921).

The twenty-first century is being hailed as the century of the 'global water crisis' (Bunn, 2016, p. 1). Although water appears abundant on Earth, covering 70% of the surface, only two and a half percent of all water is freshwater (Guppy & Anderson, 2017), and less than one percent is available for human and ecosystem support (Randhir, 2012). Among the litany of evidence pointing to a water crisis: 2.1 billion people do not have access to safe drinking water (World Health Organization [WHO], & United Nations Children's Fund [UNICEF], 2017); surface freshwater systems are some of the most transformed systems on the planet (Carpenter, Stanley, & Vander Zanden, 2011); 4.5 billion people do not have safe sanitation services (WHO & UNICEF, 2017); cooperative agreements are absent in 60% of transboundary basins (Wolf, 2002); and, water insecurity is estimated to cost the global economy $500 billion dollars annually (WWAP, 2016). As opposed to a singular water crisis ahead, a plurality of water crises loom: water scarcity and insecurity; disasters related to water; drinking water, sanitation and health; destruction and deterioration of water infrastructure; unsustainable development; and, degradation of ecosystems (Guppy & Anderson, 2017).

Whereas concerns about water have been focused on the biophysical environment, this drama is unfolding in the Anthropocene (Bunn, 2016; Rockström et al., 2014; Vörösmarty, Pahl-Wostl, Bunn, & Lawford, 2013) where human influences on ecosystems are recognized as a major driving force of global environmental changes (Crutzen, 2002; Steffen et al., 2007). Rockström et al. (2014) connect the new level of global concern about water (Vörösmarty et al., 2013) to exponential increases in environmental impacts since the 1950s globally associated with the great acceleration, where population growth, economic activity and energy consumption have been increasing extremely rapidly (Steffen et al., 2005). Global trends in these stressors and others (arable land, deforestation, carbon dioxide concentrations) correspond with trends in water quantity (increasing water use) and decreasing quality (nitrogen fluctuations in coastal zones) over time (Zimmerman, Mihelcic, & Smith, 2008). Human processes and activities (demographic, economic and social drivers) impact water and are also shaped by a range of factors (innovations in technology, financial and institutional conditions, climate change) (United Nations World Water Assessment Programme [WWAP], 2009). While the list of human drivers exerting pressure on water is extensive, both natural and human drivers are inter-related and should not be considered in isolation (WWAP, 2009; Zimmerman et al., 2008).

A critical concern for water in the Anthropocene is climate change. Climatic drivers have and continue to be a major stressor on water (Bates, Kundzewicz, Wu, & Palutikof, 2008) and their interactions with other drivers will exacerbate other pressures. This has been highlighted by Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (Jimenez Cisneros et al., 2014). Among the key risks at a global scale identified by the working group: increasing concentrations of greenhouse gas significantly increase freshwater-related risks of climate change; renewable surface water and

groundwater is projected to be reduced significantly in dry subtropical regions, intensifying competition among users; variations in flood frequency is implied from projections; and, the frequency of droughts in present dry regions is likely to increase (Jimenez Cisneros et al., 2014). Climatic drivers, in concert with other pressures on water result in increasing scarcity, decreasing quality and serious concerns about the future of freshwater systems and the ecosystem services they provide (Jimenez Cisneros et al., 2014; Rockström et al., 2014). Projections about the future state of water are grim. The most recent annual study by United Nations World Water Assessment Programme (WWAP)/UN-Water (2018) observes: the deterioration of water quality is widespread and expected to continue; the greatest natural disaster risks of drought and soil degradation are likely to worsen; and, by 2050 water shortages may affect 4.8–5.7 billion people while 1.6 billion people will be at risk of floods.

Instability and surprise are new essential considerations of the emerging water agenda in the Anthropocene (Rockström et al., 2014). Rockström et al.'s (2009) planetary boundary framework seeks to define the dynamic boundaries for critical Earth System processes past which major tipping points may be crossed or fundamental preconditions for development (social and economic) altered in the context of the Anthropocene. Global freshwater use is one of nine planetary boundaries considered and initial analysis revealed it is presently in a safe operating space, but when considering future demands, freshwater may be fully committed already (Rockström et al., 2009). An updated assessment of global freshwater use confirmed it was within the planetary boundary (Steffen et al., 2015). However, the line of argument for the planetary boundary on freshwater has been critiqued as speculative and lacking evidence for the hypothesis or risks associated with crossing the boundary (Heistermann, 2017). Most recently, Jaramillo and Destouni (2015) argue that recent advances not considered imply the consumptive use of freshwater has passed this planetary boundary.

In sum, "the world continues to face multiple and complex water challenges that are expected to intensify in the future" (WWAP/UN-Water, 2018, p. 10). Water is foundational to achieving the 2030 Agenda for Sustainable Development, but unfortunately early indications on progress towards clean water and sanitation (Sustainable Development Goal 6) suggest 'the world is not on track' (WWAP/UN-Water, 2018). Navigating water challenges in the Anthropocene is essential for sustainability and urgently needed.

2 Water Resilience

A new water paradigm is emerging. This new paradigm is not an isolated response to contemporary and future challenges. As Pahl-Wostl, Jeffrey, Isendahl, and Brugnach (2011) observe, "many voices in science and policy have advocated a paradigm shift in water management—both from a normative (it should happen) and a descriptive (it happens, and how) perspective" (p. 837). It draws upon advances in understanding how the world works as well as broadening conversations about

what and whose values matter. Freshwater systems have complex interactions between social and ecological systems that are constantly being influenced by many forces, both internal and external, at a range of levels (Pahl-Wostl et al., 2011; Schoeman, Allan, & Finlayson, 2014). They are thus aptly conceived as social-ecological systems – a view stressing the linked nature of social and ecological systems and the integrated idea of humans-in-nature (Berkes & Folke, 1998).

In this new paradigm, social-ecological systems must persist, providing a set of functions, but also change – this tension between persistence and change is understood as 'resilience' (Folke, 2003; Rockström, Falkenmark, Lannerstad, & Karlberg, 2012; Walker, Holling, Carpenter, & Kinzig, 2004). 'Climate change has changed the water rules' (Appleton, Kabat & van Schaik, 2003) and past assumptions about the stability of systems upon which conventional water management was predicated are no longer valid (Milly et al., 2008). Whereas natural systems once tended to fluctuate within a predictable range of variability (i.e., stationarity), a new 'predictable envelope of variability' is unlikely in the future (Bates et al., 2008; Bergkamp, Orlando, & Burton, 2003; Milly et al., 2008).

Water resilience as a new water paradigm has gained traction in policy discussions, in practice and in scholarship. Water resilience has become a popular rallying cry for the urgent need for a different approach to water. Writing in the context of the World Economic Forum, Fred Boltz (Managing Director, Ecosystems, the Rockefeller Foundation) responds to the question "How do we prevent today's water crisis becoming tomorrow's catastrophe?" by making a case for freshwater resilience – "it's clear we need to change. It is time to embrace a new paradigm for solving our growing crisis: valuing water wisely, and managing it using principles of sustainability, inclusion and resilience" (Boltz, 2017, p. 1). Workman (2017), covering the same event explains "why understanding resilience is key to water management" in a piece for the International Water Association and highlights Johan Rockström's assertion that "…we need a mind shift by water professionals if we are to avoid a global disaster" (p. 1).

Water resilience is capturing the imagination of individuals, organizations, and agencies worldwide and starting to gain traction 'on the ground.' Confronted with severe drought and insufficient confidence in past approaches, Cape Town announced a new approach to water focused on resilience and developed a water resilience plan for the city. Although the predicted date the taps run dry or 'day zero' has been put off, "Cape Town's predicament provides a global warning about the difficulty of ensuring water resilience in a warming world, even if, as with Cape Town, climate change is firmly on the agenda of city managers" (Welz, 2018, p. 5). Patrick Decker, CEO of the international water business Xylem, on CNBC (2018) spoke to tackling global water challenges and asserted that "water resilience is a global issue" (online). The United States Environmental Protection Agency (2018, online) has framed their approach to water and wastewater utilities in terms of resilience and offers a 'Route to Resilience' tool to guide utility personnel. In January 2018 five cities (Amman, Cape Town, Mexico City, Greater Miami and the Beaches, and Hull) were selected to develop a global water resilience framework. The framework, overseen by representatives of prominent organizations (The Rockefeller Foundation, 100 Resilient Cities, the World Bank, University of Massachusetts-Amherst, the Alliance for

Global Water Adaptation (AGWA) and The Resilience Shift) will "…be a global standard for water resilience, which enables cities to diagnose challenges related to water and utilize that information to inform planning and investment decisions" (Adlington, 2018, p. 3).

Freshwater for Resilience: A Shift in Thinking, provides a scholarly entrée into the topic of water resilience. Therein, the fundamental shift in thinking that underpins it is set out by Folke (2003, p. 2028):

> It requires a shift in thinking from focusing on controlling change in an engineering fashion for optimal solutions to accept that change is the rule rather than the exception (Holling & Meffe 1996; van der Leeuw 2000). The old way of thinking implicitly assumes a stable and infinitely resilient environment. The new perspective recognizes that resilience can and has been eroded and that the challenge facing humanity is to try to sustain desirable pathways for development in the face of change (Carpenter et al. 2001; Folke et al. 2002). The concept of resilience shifts perspective from the aspiration to control change in systems assumed to be stable, to sustain and enhance the capacity of social–ecological systems to cope with, adapt to, and shape change and learn to live with uncertainty and surprise (Gunderson & Holling 2002; Berkes et al. 2003)

Scholarship on water resilience has since grown and shows strong associations with the core of the new water paradigm (e.g., Schoeman et al., 2014). While several voices advocate a paradigm shift in water management, a dominant theme is "the need to develop understandings of water resources and their management as a complex system" (Pahl-Wostl et al., 2011, p. 843). The substantial body of work by Johan Rockström and colleagues at the Stockholm Resilience Centre (e.g., Falkenmark, 2017; Falkenmark & Rockström, 2010; Rockström, 2003; Rockström et al., 2014, 2014) have considerably shaped how the area of study has developed. The 2014 book by Rockström et al. provided insights into 'water resilience for human prosperity' with a focus on green and blue water resources, land and water integration, social-ecological systems and resilience, reconnecting to the biosphere, and cross-scale interactions in the context of global change.

Key constructs in global change scholarship such as vulnerability and adaptive capacity (Miller et al., 2010; Smit & Wandel, 2006) are also addressed. Attention has been focused on specific disturbances including flooding (e.g., Baird et al., 2016; Liao, 2012; Morrison, Noble, & Westbrook, 2018) and drought (e.g., Falkenmark & Rockström, 2008; Rockström, 2003). Studies of water resilience in urban settings often connect with the challenges of flooding (e.g., Head, 2014; Jiang, Zevenbergan, & Fu, 2017), and some specifically address how the concept of resilience relates to water services and infrastructure (e.g., Johannessen & Wamsler, 2017; Kennedy, Baker, Dhakal, & Ramaswami, 2012). It is clear that the boundaries around these areas of focus are fuzzy; there are important relationships between and among them.

An initial observation from the literature is that definitions of water resilience are rare. When the term water resilience is defined, it appears to capture slightly different concepts or have varied points of emphasis, but a common focus on social-ecological systems. For example, Rockström, Karlberg, and Falkenmark (2011) write that "building in water resilience – i.e. strengthening a water system's capacity

to cope with global environmental change while retaining essentially its same structure and function – will be equally important" (p. 133). A few years later, Rockström et al. (2014) elaborate:

> our focus is on the role of water in the resilience of social-ecological systems in an era of rapid global change. Our shorthand for this is the term 'water resilience' which should not be interpreted as the resilience of water, as our focus is the reverse, i.e., the role water plays in the resilience of ecosystems and societies. (p. 32)

Rodina (2019), recognizing water resilience is variously and poorly understood in terms of meaning, applications and implications, carried out a systematic mapping review of the associated peer-review literature form 1982–2017. Results capture the state of the literature (e.g., countries from which scholarship is published, journals in which it appears) and provide the following key insights.

- Resilience definitions varied considerably. The largest proportion drew upon the engineering conception of resilience, with a noticeable growth in the use of other definitions more recently.
- Water supply, water resources management and drainage/stormwater management were the domains to which resilience was most prominently applied. While water distribution systems emerged as the scale at which resilience was most applied, the multiplicity of applicable scales as well as lack of scale specificity and interactions were recognized overall.
- A majority of the literature concentrated on the resilience of built infrastructure systems, over two-thirds was unspecific as to the resilience of whom, and the most common drivers cited were climate change, drought and social-economic and political stressors.

Drawing on these conceptualizations and recognizing the key role that water plays in earth's systems, as well as the extent to which it has been degraded (Rockström et al., 2014, 2014), we define water resilience in similar terms as social-ecological resilience: "the capacity to adapt or transform in the face of change in social-ecological systems, particularly unexpected change, in ways that continue to support human wellbeing" (Folke, Biggs, Norström, Reyers, & Rockström, 2016, online) but with a focus on water systems in particular (Eriksson, Gordon, & Kuylenstierna, 2014; Rockström et al., 2011).

3 Resilience: An Emerging Perspective on Water Management and Governance

This book is about solving water challenges and realizing opportunities for sustainability in the Anthropocene. Altering our thinking about water is foundational to water resilience and has profound implications. Hence, the focus of this book is on the management and governance dimensions of water resilience.

It is important at the outset to recognize the success of 'conventional' approaches in some circumstances as well as their critiques. Tremendous success was achieved during the twentieth century in addressing some water challenges. Massive infrastructure construction dominated the twentieth century water agenda and this "hard path" resulted in greater hydropower generation, irrigation for agriculture, reduced the risk of droughts and flooding, and reduced the risk of water-related diseases, ultimately benefiting billions of people (Gleick, 2003). Marked progress in the twentieth century also came from the first generation of environmental policy and an emphasis on regulations:

> The regulations unquestionably produced dramatic environmental improvements. Many dirty waters became swimmable, fishable, and drinkable again. Boston Harbor, Galveston Bay, and the Connecticut River are all far cleaner. Even, Cleveland's Cuyahoga River, famous for its oily filmy and obnoxious smell – and for catching fire in 1969 – now sports tourist cruise ships and only occasional residue. (Kettl, 2002, p. 1)

And yet, as the opening section of this volume conveys, the contemporary as well as future status of freshwater is precarious. As Gleick (2003) observes, the 'hard path' approach which brought tremendous benefits also produced serious economic, social and ecological costs that were often unanticipated. These unexpected negative consequences underscore the pathology of natural resource management (sensu Holling & Meffe, 1996) as top-down (i.e., state-centred) command-and-control. Concerns about command and control approaches have been expressed for the substantial costs of enforcement and compliance, the polarization and conflicts accompanying regulations, and the lack of effectiveness in addressing challenges with properties of complexity and uncertainty (Durant, Chun, Kim, & Lee, 2004; Holling & Meffe, 1996; Kettl, 2002). More of the same command and control approach will not sustain water for ecosystems or humans in the future (Garmestani, Allen, & Cabezas, 2008; Gleick, 2003; Holling & Meffe, 1996; Milly et al., 2008; Pahl-Wostl et al., 2011).

It is also important to acknowledge that the shift to water resilience coincides with the broadening conversation about who and how decisions are made about water. Most poignantly, the Global Water Partnership (2000) asserted that "the water crisis is mainly a crisis of governance" (p. 16); an assertion echoed by the United Nations World Water Assessment Programme (WWAP, 2003) and most recently by the Organization for Economic Co-operation and Development (Organization for Economic Co-operation and Development, [OECD], 2018). Governance is "a social function centered on steering human groups towards mutually beneficial outcomes and away from mutually harmful outcomes" (Brondizio, Ostrom, & Young, 2009, p. 255). Governance emerged as a critical concern in the context of water in the first decade of the twenty-first century (Rogers & Hall, 2003; Scholz & Stiftel, 2005). de Loë, Armitage, Plummer, Davidson, and Moraru (2009) draw upon developments in environmental governance during this period and characterize water as undergoing a transition from government to governance. While not exclusive to water, Lemos and Agrawal (2006) highlight the general rise of alternative or hybrid forms of governance. These governance arrangements are required to

address integration, coordination, and multiscale considerations (Lockwood, Davidson, Curtis, Stratford, & Griffith, 2010) and create a 'fuzzy boundary' between natural resources management and governance (Plummer, Armitage, & de Loë, 2013). The study of water governance continues to intensify (e.g., Bakker & Cook, 2011; Biswas & Tortajada, 2010; Gupta, Pahl-Wostl, & Zondervan, 2013; Ingram, 2011; Pahl-Wostl, 2015; Woodhouse & Muller, 2017). Commitments to mainstreaming associated principles appear to also be gaining uptake. For example, 65 signatories from across sectors committed to implement the OECD (2015) principles of water governance.

While governance has taken centre stage in the context of water and coincided with increasing interest in resilience, it is only recently that an attempt was made to gain consensus about the key attributes for governing aquatic ecosystems to ensure resilience. Plummer et al. (2014) conducted a two round Delphi of global experts on water governance and resilience with the objectives of gaining consensus on "1) governance attributes that indicate specified resilience; 2) governance attributes that denote general resilience; and, 3) practices or activities that enhance governance ability to respond to shocks and disturbances" to consolidate the state of thinking about governance of aquatic systems and resilience (p. 3). Attributes and activities for which agreement was established are summarized below, with references to specified resilience (SR), general resilience (GR) and practices and activities.

Specified and general resilience attributes of aquatic system governance

- Participant diversity and equity (SR) and inclusive participation (GR)
- Effective (SR) and strong (GR) leadership
- Polycentric governance with boundary organizations (SR), decentralized governance (GR)
- Social memory (SR)
- Capacity for self-organization (SR)
- Adaptability, flexibility of planning processes (SR) and institutional flexibility (GR)
- Precautionary risk assessment and reduction strategies (SR)
- Planning strategies that include a wide range of ecosystem services (GR)

Practices and activities that enhance governance resilience

- Forums for participation
- Improved transparency of decision-making
- Planning processes that are participatory and deliberative

Rodina's (2019) systematic mapping review complements the Delphi study by Plummer et al. (2014) and provides a synopsis of the features or characteristics of resilient water systems from the literature. She initially identified the system characteristics by categories (systems in general, social systems, built/natural systems) and then explores in greater details the institutional, governance and practical dimensions. Water resilience literature has clearly focused on technical solutions, with over half of the papers containing no mention of institutional or governance

processes. In focusing on these aspects, she revealed the 17 governance institutional processes through which resilience is achieved – the four most common attributes being unspecified (57% of all papers), collaborative processes (24% of all papers), stakeholder engagement (20% of all papers) and government-led top down (16% of all papers). Interestingly, building resilience is framed by a majority of the papers as the responsibility of water managers and conventional actors in water governance. Further examination of these papers leads Rodina (2019) to observe that "…stakeholder engagement and participation tend to be seen as processes that help get buy-in or social acceptance of resilience building actions that remain predominantly decided on by governments and water managers. This implies that participation tends to be seen as important only in later stages of resilience-building, not necessarily in the planning and strategic decision-making ones" (p. 6).

While the Delphi study by Plummer et al. (2014) and review by Rodina (2019) sought to bring together a consolidated position on the subject, they also provided a glimpse into just how intertwined the area of scholarship is with other concepts and future directions in water management – a trend that is clearly continuing (see Akamani, 2016; Cosens & Gunderson, 2018; Schoeman et al., 2014). Plummer et al. (2014) identified approaches to management, governance and resilience that illustrate some of the points of coalescence and/or cross-fertilization among resilience and water scholars in this regard.

Adaptive management is one of the first approaches advocated as a way to bring ideas of governance and resilience together (Plummer et al., 2014). As initially conceived (e.g., Lee, 1993; Walters, 1997; Walters & Holling, 1990), adaptive management is oriented to 'learning by doing' through iterations of assessing opportunities, designing policies as experiments, implementing actions, and adjusting course in light of monitoring and evaluation. Adaptive management has thus given impetus to social learning as an imperative in water resources (e.g., Ison, Roling, & Watson, 2007; Pahl-Wostl, Mostert, & Tàbara, 2008). Catalyzing adaptive water management requires major transformation processes as current approaches are rigid and inflexible – built on the legacy of command and control (Pahl-Wostl, 2007) and are slow to change due to inertia and path dependence of prevailing regimes (Pahl-Wostl, 2007; Pahl-Wostl, 2008).

A second, longstanding and foundational approach (introduced in 1977 at the United Nations Conference on Water) is *integrated water resources management* (IWRM) (Grigg, 2008; Rahaman & Varis, 2005). The Global Water Partnership (Agarwal et al., 2000) defines IWRM as "…a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (p. 22). IWRM has been criticized (e.g., Biswas, 2004, 2008; Hering & Ingold, 2012; Jeffrey & Gearey, 2006), for example, for the approach's inability to address the increasing lag between reforms put forth by policy makers and understanding freshwater resources and their governance (Galaz, 2007). Galaz's reassessment of IWRM in this light encourages rethinking key components to better enable addressing challenges of complexity and change. Others have continued to build on and extend the initial

conceptualization of IWRM. For example, Rockström et al. (2014) argue that "… the evidence of rising water-related shocks and interactions in the Anthropocene requires the emergence of a deeper social-ecological resilience-based approach to integrated land and water-resource management" (p. 1250).

Finally, use of the term *adaptive governance* has grown significantly since being introduced by Dietz, Ostrom, and Stern (2003) and Folke, Hahn, Olsson, and Norberg (2005), although neither consistent use of the term nor an explicit research agenda have coalesced (see Chaffin, Gosnell, & Cosens, 2014 for a summary). Adaptive governance "is an outgrowth of the theoretical search for modes of managing uncertainty and complexity" and championed in response to the need for:

> …new approaches to environmental governance capable of confronting landscape-scale problems in a manner both flexible enough to address highly contextualized SESs and dynamic and responsive enough to adjust to complex, unpredictable feedbacks between social and ecological system components. (Chaffin et al., 2014, online)

Plummer et al. (2014) elaborate upon this challenge and identify varied terms (e.g., adaptive co-management, collaborative management, resilience management) used to capture particular aspects of governance and resilience. Folke (2003) anchored this suite of approaches by sketching out the social dimension of freshwater management, social features for resilience, and multi-level governance of catchments. Considerable inroads are being made from conceptualizing alternative approaches to water management and gaining experience from novel governance strategies suited to addressing problems characterized by complexity, uncertainty, and contested values (e.g., Cosens et al., 2017; de Loë & Patterson, 2017; Fish, Ioris, & Watson, 2010; Huitema et al., 2009; Innes & Booher, 2010; Moss & Newig, 2010; Plummer et al., 2014, 2017; Rodina, 2019).

Opportunities abound to deepen knowledge relating to management and governance dimensions of water resilience, extend scholarship into new areas, and better understand the implications for practice and policy. Navigating change is paramount in the Anthropocene and cultivating capacities for adaptation and transformation is essential.

4 Aims and Organization

This volume responds to the need for a consolidated, interdisciplinary approach to the management and governance dimensions of water resilience for scholars, resource managers and policy makers. Four objectives guide this book on water resilience: (1) to capture current knowledge and understanding of management and governance in the context of water resilience; (2) to advance theory through synthesis of research and experiences from a variety of disciplinary perspectives; (3) to illuminate the implications of theory and experience for innovation in practice and policy; and, 4) to explore the frontiers of water resilience and set an agenda for future research.

This opening chapter of the volume introduced the subject of water resilience. It provides a rationale for the undertaking and also orients readers to scholarship upon which the contributors build. In so doing it provides a departure point for the chapters that follow.

As opposed to focusing on just one of the aforementioned objectives, the chapter contributors tend to address them in concert. That is, they build on present knowledge as well as draw upon research and applied experiences to advance theory, practice and policy. Moreover, the objective of giving voice to a variety of disciplinary perspectives emerged organically. All of the chapters in the volume are collaborative efforts, with most spanning one or more conventional disciplinary boundary. The diversity of perspectives and collaborative approach is indicative of this area of scholarship.

Contributors to the chapters engage with that vast and rich conceptual ground that needs to be considered in deepening knowledge relating to management and governance dimensions of water resilience. Cosens and Gunderson, for example, draw attention to legal aspects attendant for resilience and reconciliation. Transformations and transitions are focal constructs for Blythe, Armitage, Bennett, Silver and Song in their consideration and cautions about ocean governance. Trimble, Jacobi, Olivier, Zurbriggen, Pascual, Garrido and Mazzeo draw on the concept of anticipatory governance in relation to resilience.

Johannessen and Wamsler focus on social learning in governance that can accommodate the extraordinary era of the Anthropocene. Mirumachi, White and Kingsford use a conceptualization of five paradigms of water to explore governance over time in three major river basins. Others build upon established resilience scholarship and extend it new areas. Baird, Plummer, Quinlan, Moore and Krievins consider factors underpinning persistence, adaptive capacity and transformative capacity and their relationships in the watershed context. Reilly, Bennett, Adamowski and Hickey consider how resilience thinking can move management from a focus on the individual to collective action in agriculture.

The chapters in the volume strongly reflect the pertinence of water resilience worldwide and diverse circumstances of water management and governance. Contributors draw upon cases from Asia, Australia, Europe, North America, South America, and South Africa. The cases range considerably in size and focus. For example, from large transboundary river systems (e.g., Mekong, Columbia, Saint John) to small scale fisheries to urban centres. A fulsome variety of management and governance situations are also addressed. For example, Kochskämper and Newig examine experiences with the European Union Water Framework Directive. Marshall and Lobry de Bruyn identify a key role for non-governmental organizations in river basin governance in Australia. Roberts, Milman and Blomquist discuss challenges of bringing water resilience into existing governance approaches in California.

The final section is forward oriented and directs readers to future concerns and issues with water resilience. Integrating ideas and concepts as well as applied experiences are stressed with the necessity of moving to a new water paradigm. The final chapter synthesizes the salient ideas made by the various contributions in the

volume and highlights directions for further research, implications for practice and considerations for policy.

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Part II
Examining Water Systems Through the Lens of Resilience

Water Policy and Governance in Transition: The EU Water Framework Directive

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Abstract The 2000 EU Water Framework Directive (WFD) set a turning point in European water governance: mandated participatory planning substituted conventional top-down approaches, the ecology of aquatic environments became the WFD's focal point, and the river-basin scale was institutionalized as the central governance unit. In 2007, the Floods Directive – a 'daughter directive' to the WFD – incorporated aspects of resilience through flood risk management. The two directives attempted a transition towards a sustainable and resilient water governance system; however, almost two decades later, it remains unclear whether the directives were instrumental in fostering such a transition. We report on several case studies in European water governance. These highlight the complexities of furthering change towards sustainability: institutional adaptation towards the new governance modes was slow and mandated participatory planning not instrumental for ground-breaking results. The European experience shows that adding more governance does not automatically bring about fundamental change.

1 The Visionary Ambitions of the EU Water Framework and Floods Directive

With the new millennium, the EU Water Framework Directive (WFD Directive 2000/60/EC) set a turning point in European water governance: the European Member States were envisioned to harmonize and transform their water policy regimes by acknowledging the ecology of aquatic environments and by integrating all related water aspects holistically (Boeuf & Fritsch, 2016; Kaika, 2003; Voulvoulis, Arpon, & Giakoumis, 2017). The systemic approach is reflected in the

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embracement of integrated water resources management that focuses on the river basin as the main governance unit (Voulvoulis et al., 2017). The required river basin management (WFD, Art. 1) meant a shift from predominantly top-down structures of Member States towards decentralized governance arrangements (Woodhouse & Muller, 2017). The Directive's ambitious goal is to bring all European ground and surface waters into a predefined 'good' status in terms of quantity and quality until 2015 and no later than 2027 (Art. 1). In comparison to former, target-oriented environmental EU directives, the WFD puts stronger emphasis on proceduralization by introducing required policy instruments while affording considerable leeway in their implementation to Member States (Liefferink, Wiering, & Uitenboogaart, 2011). Based on this holistic approach with a focus on the river basin as the system of interest, the WFD was perceived as the first European directive targeting environmental sustainability (Carter, 2007; Johnson, 2012; Tippett, 2005) with the potential of a prototype for future directives (Josefsson, 2012).

The EU Floods Directive (FD 2007/60/EC), that came into force seven years later, clearly followed this approach, and was subsumed under the overall WFD framework as a daughter directive (European Communities [EC], 2009). The FD, attempting to enhance the protection of human health, the environment, cultural heritage and economic development from flooding events, is not exclusively addressing environmental sustainability. Different from the WFD, the overall goals of the FD are not linked to clear targets. Hence, an even stronger proceduralization lies at the core of the Directive. Both proceduralization and decentralisation can be seen as responses to deficits in the successful implementation of European environmental policies (Challies, Newig, Kochskämper, & Jager, 2017). A central policy approach that embraces the two concepts is mandated participatory planning (MPP) (Newig & Koontz, 2014). The participation of non-state actors or 'interested parties' as stated in the directives (WFD, Art. 14; FD, Art.10) is mandatory in their implementation. Having considerable leeway in how they implement participatory planning, Member States are required to ensure information supply and consultation while 'active involvement' in planning is only 'encouraged'. EU guidance documents, however, stress active participation "as a means to improve decision-making" (EC, 2003, p. 14) and to increase acceptance and thereby the delivery of decisions in WFD and FD implementation (EC, 2009). Such "proper implementation" (EC, 2009, p. 18) is seen as decisive to increase the resilience of European water systems.

All in all, it can be argued that the two directives attempted a transition towards a sustainable and resilient European water governance system. Nonetheless, almost two decades later, it remains unclear whether the directives were instrumental in fostering such a transition. Currently, 60% of all surface water bodies are not achieving good status; only 20% of them have improved their status, while the overall ecological status of surface water bodies has slightly worsened from 2009 to 2015 (EC, 2019). The Directive's overall effectiveness is therefore questioned (Boscheck, 2006; Moss, 2008), aggravated by the lack of evidence on the effects of the newly introduced policy instruments (Boeuf & Fritsch, 2016). Participation as the most studied topic of WFD scholarship represents a major example, since the link to