According to the World Health Organization (WHO), in 2009, about one fifth of the world's population lived in countries that did not have enough water for their use. By 2025, 1.8 billion people will experience absolute water scarcity, and by 2030, almost half the world will live under conditions of high water stress. Yet, only recently has the science of coupled human-water system been initiated (Partelow, 2016; Sivapalan & Blösch, 2015) and transdisciplinarity research utilized for societal sustainability problem solving (Polk, 2014). But, the understanding of needs for data and knowledge transfer bridging organizational boundaries, and technological aspects that challenge the praxis of policy making and planning are paradoxically increasing or even worse, lacking (Cash et al., 2003; Hinkel, Bots, & Schlüter, 2014; Polk, 2014; Thomson, El-Haram, Walton, Hardcastle, & Sutherland, 2007). For example, in a recent Water JPI (2014) paper presenting eight major water topics for Europe (Horizon 2020), while identifying the gaps and game changers, knowledge management was listed directly and indirectly in ALL of them. These real life issues and academic research gaps are the motivators for this handbook.

Managing knowledge more effectively and efficiently might be a solution to many of the critical water issues humans in the 21st century are, and will be, facing. Knowledge commons (e.g. Brewer, 2014) and virtual, digital spaces of learning (Niccolini, in this book) provide some unexpected and surprising rays of hope, of what might happen when knowledge is created and managed well. The Israeli experience (Jacobsen, 2016; Siegel, 2015) is an illustration of a water miracle (not phantoms) that can happen in the desert, and by extension, everywhere, where and when people will set their minds to it.

As the new knowledge-driven economy continues to evolve, knowledge is being recognized as a key asset and a crucial component of organizational, inter-organizational and national strategy. The ability to manage knowledge, therefore, is quickly becoming vital for securing and maintaining survival and success. As a result, organizations at all levels are investing heavily in Information Systems (IS) and/or Knowledge-Based Systems (KBS) technologies. Unfortunately, such investments frequently do not meet expected outcomes and/or returns. For the purpose of this handbook we will recognize Knowledge Management (KM) as a socio-technical phenomenon in which the basic social constituents such as person, team and organization require interaction with IS/KBS applications to support a strategy and add value to the organization (Russ, 2010) while improving the sustainability of a water system. Many organizations and their executives recognize that the critical source of sustainable competitive advantage is not only having the most ingenious product design, the most brilliant marketing strategy, or the most state-of-the-art production technology, but also having the ability to attract, retain, develop and manage its most valuable human assets (talent) and their knowledge and
innovation. Furthermore, such an interaction of talent, processes and systems is what enables organizations to develop and manage knowledge for success.

Sustainability has been defined as economic development that meets the needs of the present generation without conceding the ability of future generations to meet their own needs (e.g., Russ, 2014b.) With growing pressure from customers and regulators toward environmental and social issues, organizations and governments at all levels are increasingly expected to shoulder greater responsibility for making sustainable development a reality. Recent droughts and water shortages worldwide and the advanced scientific understanding and documentation of the impact of demographic and economic forces on water footprint and embedded water make the need for sustainable development and management of water systems only more acute. This requires policy makers, planners and executives to balance economic, business, social and environmental concerns and outcomes. For that to happen, leaders need to quantify the relationships of all those aspects across different time horizons and link their organizational knowledge-base to strategy and outcomes so they can consider the tradeoffs of different alternatives for their long-term success.

This book is envisioned as a manuscript that will provide a robust scientific foundation for an inter-disciplinary, multi-perspective theory and practice of knowledge management in the context of, and for the advancement of, sustainable water systems. The book goes beyond the current literature by providing a platform for a broad scope of discussion regarding KM4SWS, and, more importantly, by encouraging an interdisciplinary/transdisciplinary fusion between diverse disciplines. Specifically, the call for proposals for this book solicited chapter proposals from a multidisciplinary array of scholars to discuss socio-hydrology sustainable systems within the present political (legislative), economic and technological context from a number of disciplines/perspectives, including: Economic Development, Financial, Systems-Networks, IT/IS Data/Analytics, Behavioral, Social, Water Systems, Governance Systems and Related Ecosystems. Multi-level and multi-discipline chapters that synthesize diverse bodies of knowledge were strongly encouraged. When appropriate, plurality of empirical methods from diverse disciplines that can enhance the building of a holistic theory of KM4SWS were also encouraged.

While preparing for, and editing this book, a number of alternative theoretical frameworks were considered (e.g, Elliot, 2011). The multi-level framework that was adopted (described briefly below) is an amalgamation of a number of models reviewed (some are listed in the bibliography below) with the addition of models I developed regarding knowledge management over the last twenty years of teaching and studying the subject.

The first building block (see Figure 1.) is the model of co-evolution of the Human Systems (political, economic, technological, social; see discussions and indicators in, for
example: Partelow, 2016, Vogt, Epstein, Mincey, Fischer, & McCord, 2015; mostly based on Ostrom, 2009) and the Sustainable (in our case) Natural and Engineered Water Systems (see for example Sivapalan & Blöschl, 2015). Such co-evolution results, of course, from the impact human activities have (mediated by technology) on the systems and the responses and outcomes of the water systems to these activities. The co-evolutionary model (e.g. Sivapalan Blöschl, 2015) was modified and enhanced by adding on the human system side: the complexity of the different potential units of analysis involved on the human systems side, starting with an individual, teams, organizations and then going up in complexity to inter-organization, national, regional and global units and scales. Each unit has its own learning complexity and more complex units, issues, and boundary management aspects (see excellent discussions of the importance of this complex management in Cash et al., 2003). On the sustainable water system side, the different levels of the systems were added (e.g. household, city, river basins, etc.). Each one of them is connected to the framework by models that are used and/or understood by the human actors (see the interesting discussion in Sivapalan & Blöschl, 2015, about two models: stylized and comprehensive). Finally, Knowledge Management (KM) was added at the heart of the Human Systems’ section and the Co-evolution’s section (the two KMs are of course related and intertwined).

Figure 1. about here

The second level of the model is the construct of Knowledge Management (see Figure 2.). Here, the model developed by Russ, Fineman, and Jones, (2010) was used, with focus on the actors, (or talent), the process, or specifically the learning and decision making, and the systems, or in this case the knowledge based systems. The majority of the chapters in this book touch on all three factors and illustrate different aspects (e.g. content and process) of KM.

Figure 2. about here

In the third level of the model, each one of the three constructs used as building blocks for KM (listed above) was broken down into its specific models (see Figure 3.a.-3.e.). For example, learning, might focus on tacit knowledge using the Kolb active learning model (1976), or on codified learning using the virtual Ba model illustrated by Niccolini et al. in this book, or any mix of the two; or others as appropriate for the case; all, (potentially) using up to the three feedback loops of learning (e.g., Argyris’ double-loop learning, 2002; or the review in Tosey,
Visser, & Saunders, 2012 of triple loop learning). The human actors’, talent was modeled using the HC praxis model (Russ, 2014a) and the Knowledge-Based-Systems (KBS) using the six life cycle stages of KBS (e.g., Russ, Jones, & Jones, 2008), including the sustainability aspect of the KBS as well as consideration (Elliot, 2011).

Figure 3, about here

The complexity of the reality of KM in SWS are overwhelming, as they are illustrated in the chapters in this book. Such complexity is a result of the nature of knowledge management which could cut across ALL levels of the model, as well as across the unit of analysis in the water systems. Add to that the complexity of the diverse scientific areas and the diverse styles of learning and decision making of the different actors, and you can see a complex networked system at its best.

But the truth of the matter is that one aspect is still missing from this analysis and must be added to the proposed framework, thus adding the fourth level, time (see Figure 4.). Again and again, while teaching my KM classes, consulting with clients, researching and reading other practitioner and academic research, I was perplexed by the failures of all the constituencies to understand the importance of time, on its complexities for strategic decision making, managing knowledge or human capital, among many others aspects. Time is one of the hidden assumptions (dimensions) we have and use continually without giving it a second thought.

Figure 4, about here

In practice, the misalignment of time horizons (present and future) and time frames of events, makes an enormous difference, but is rarely explicitly identified as an issue and/or studied (see a rare very recent exception in Myllykoski, 2017). In our context of KM4SWS, the key players that take actions or make decisions, not only might have a diverse set of expertise, understating and knowledge of the subject at hand, but they also operate in a different time “space”. Politicians’ time horizons of the relevant future for their decision making is different from that of the farmer, the hydrologist and the weather scientist. Their understanding of an event (and it time frame) and the implication the event might have within a complex system, including the impact of time-lags and complex feedback loops, could be startlingly different and diverse (from others) within the realm of their intentions, goals and their time horizon. This
factor (of time) can explain by itself why knowledge is not used effectively regarding important aspects of the sustainability of water systems. Corralling all the different actors into a single space of knowledge and coherent time for the purpose of advancing sustainable water systems can happen rarely if at all. One case in which all of this might potentially happen is in a major disaster. Recent history should tell us that even in the vast majority of the cases of disaster this is not sufficient to create such a coherent space. To illustrate the praxis of such situations, an updated model of the “garbage can model of decision making” (Cohen, March, & Olsen, 1972) is proposed here, where time is a multi-dimensional construct having a synchronized (or not) time horizon, time frame, and event-time, or what I would define as the “quantum model of organizational time”. This model advances the model of time described by Myllykoski (2017) (building on Hernes, 2014) in which she described the past and the future as a stream of events, that get their “true” meaning at the present time, resulting from a stream of events, creating or enabling a decision to be made, seeing time as agentic (p. 23). Events, or the bits of information perceived by the observer that are remarked by the actor as events, are seen as collapsing at the time of the decision. As such, it enables us to freeze an understanding of the past, from the present perspective and the planning for the future, confirming a present rational for the decision regarding the future (Tsoukas, 2016). Viewing time as agentic, and seeing the stream of bits of information coming from the past and going toward the future, collapsing at a time of a decision into one interpretation, brings Schrödinger’s cat from the quantum realm into individual decision making, and results in what I would call, the “individual quantum model of decision making”. Adding the complexity of multiple key actors with different time frames, etc. results in an “organizational quantum model of decision making” which is illustrated in Figure 4. Finally, one plausible explanation for the success of role playing (Sivapalan & Blöschl, 2015) and simulation-based learning (Deegan et al., 2014) in a complex context as described here, is because it allows for the time horizons of the participating individuals and the time frame of the event they engage with to become coherent, enabling an improved process of decision making.

The chapters in this book not only illustrate the framework proposed above, and suggest new venues for improving our water systems; more than that, they illuminate opportunities to eliminate the risks of a thirsty world.

Acknowledgment

The call for chapters for this book stimulated the authors to synthesize multi-level and multi-discipline diverse bodies of knowledge by encouraging an interdisciplinary fusion between diverse disciplines. The authors were invited to contribute chapters to the book based on proposals approved by the editor. Each complete chapter received external, blind review in addition to the editor review. The editor thanks Kelly Anklam for her assistance in editing this introduction and number of chapters. He wishes to thank also Dr. Vallari Chandna for editing number of chapters, as well as the reviewers for their in depths reviews. Finally the editor want to thank the Philip J. and Elizabeth Hendrickson Professorship in Business at UW-Green Bay for partial financial support. As always, all mistakes are his.
Bibliography


Figure 1. The coevolution of human and water systems
Figure 2. Knowledge management in sustainable water systems
Figure 3. The three elements of knowledge management in sustainable water systems (detailed)

3a. The four phases of Nonaka’s SECI model, adapted to fit the inter-organizational ontological level within a virtual environment. Source: Bertolacci et al., 2016.

3b. First, Second & Third Loop Learning

3c. Kolb’s Active Learning

3d. KBS Life-Cycle

3e. HC Praxis
Figure 4. The time aspect of the quantum organizational decision making model.