INTEGRATED WATER RESOURCE MANAGEMENT

An Interdisciplinary Approach

NEIL S. GRIGG

Integrated Water Resource Management

Neil S. Grigg

Integrated Water Resource Management

An Interdisciplinary Approach

palgrave
macmillan

Neil S. Grigg
Civil and Environmental Engineering
Colorado State University
Fort Collins, Colorado, USA

ISBN 978-1-137-57614-9 ISBN 978-1-137-57615-6 (eBook)
DOI 10.1057/978-1-137-57615-6

Library of Congress Control Number: 2016952806

Cover illustration: © PhotoAlto / Alamy Stock Photo

Printed on acid-free paper

This Palgrave Macmillan imprint is published by Springer Nature
The registered company is Macmillan Publishers Ltd. London

Endorsement

'In this excellent book, Professor Neil S. Grigg, a world-class expert on water infrastructure, argues in favour of "science-to-practice" approach to Integrated Water Resources Management (IWRM). He reminds us that water supply is the highest priority service and that the lack of safe drinking water is the most pressing water issue globally.Water managers can promote good water governance by effective management practices and proper relationships among stakeholders. Integration begins when water and wastewater are operated as one utility. The management of water systems requires sound decisions, while public involvement is also essential. Water resources and services are parts of social systems that extend beyond technology, requiring a balance between competing social and political views. Although access to water is a basic human right, paying for services is also essential. Furthermore, water acts as a connector for security; for food production, environment, economy, and health.'

—**Tapio S. Katko**, UNESCO Chairholder, Adjunct Professor,
Tampere University of Technology, Finland

Foreword

As life on Earth becomes more complex, we need tools to sort out choices and galvanize collective action to solve our many shared problems. Integrated water resources management (IWRM) is such a tool and it can help us address rising demands for water and water services globally. IWRM can bridge gaps between the technical management of water and integrative approaches that consider systemic effects among users and natural water systems. It has a broad scope and its body of knowledge is shared among diverse groups across engineering, science, and the policy and management fields.

How well IWRM bridges gaps and unites disciplines depends on the clarity with which we explain it. Its body of knowledge has evolved from its early technical roots through the birth of the computer age to today's interdisciplinary approaches to complex issues in a changing world. I witnessed this evolution at Colorado State University from the 1960s onward, where a fertile arena to test interdisciplinary approaches unfolded, especially under the leadership of Professor Maury Albertson, who had a vision for water resources management and international development.

No single discipline or job category has a monopoly on IWRM, and a common vocabulary and body of knowledge are needed to forge interdisciplinary cooperation. This book offers these, and its test of effectiveness will be whether any discipline involved with IWRM can use it. The

challenge is that the complexities of IWRM make it hard to understand, no matter the vocabulary. Perhaps the remedy is in the phrase: "The vitality of democracy depends on popular knowledge of complex questions."[1] Translation: water managers must explain IWRM so that it can be understood by its practitioners, by water users, and by the public.

IWRM can seem abstract and hard to understand. No one actually holds the title "Integrated Water Resources Manager," and people holding different types of jobs engage in IWRM. To try to bring order into the discussion of IWRM, I have focused on real-world problems and jobs to show how theories apply to real situations. This problem-focused approach leads to the aims of the book: present a basic but comprehensive approach; explain technical, social, and policy analysis tools; present IWRM problem archetypes from developed and developing countries; and provide relevant summaries, problems, and discussion questions.

I have included examples from a number of countries at different levels of development, but many US examples are also given. This is due to my own background, where I have firsthand knowledge of many of them. My hope is that readers from non-US countries will find these examples to be valid because IWRM applies globally and is not restricted to a small number of experts. When examples from the USA and other high-income countries are used, I have added context to explain how they will apply in other situations where water management principles apply broadly. Adding context in this way is key to making IWRM work because IWRM does not depend on principles alone—it also depends on the ability of people and institutions to apply it.

Ultimately, the success of IWRM will depend on whether practitioners can use it to plan effective water management systems, use rational and social tools to support good decisions, and connect water plans to those of related sectors to develop integrated approaches. In today's rapidly changing and political world, this is a challenge, but a good start on it lies in our explanations of IWRM, why it is needed, and how to apply it.

Neil S. Grigg

[1] *McLure's* was an illustrated magazine of the early twentieth century. The quote is from Doris Kearns Goodwin, *The Bully Pulpit*, Simon & Schuster, New York, 2013.

Contents

List of Figures

List of Tables

1

Water as a Connector Among Societal Needs

Why Water Management Is Important

The importance of water is plain to see because every creature on the planet needs it to survive and prosper. In a perfect world, we would cooperate to manage it as a shared resource so that everyone has enough and water's condition is protected to benefit people and nature. Unfortunately, people do not cooperate that way and the management of water often involves more conflict than it does cooperation. This presents many challenges as we seek to provide access to healthy water supplies in a time of rapid global development and climate change.

In one competing vision of the future, there could be efficient and equitable management to apply water to its highest and best uses for a sustainable future. At the other extreme, global water supplies and quality could spiral downward toward scarcity and pollution and the disease and deprivation they will bring. The factors that will make the difference between these competing visions are the effectiveness of water resources management and the governance that supports it.

Demands for a healthy and adequate water supply are life-or-death issues for people and ecosystems, but only a tiny fraction of the world's water is

N.S. Grigg, *Integrated Water Resource Management*,
DOI 10.1057/978-1-137-57615-6_1

available as freshwater. The risk of a water crisis looms in many places that are facing water shortages and drought, rising sea levels, polluted water, floods, and environmental degradation, among other problems.

To respond to these challenges, methods for effective water resources management are being applied around the world at various levels of success. The context of applying them matters as much as the methods themselves because of large differences in requirements and capacities from one place to another. The widest gaps are between prosperous countries with highly-developed governance systems and those with struggling economies and societies where governance is largely ineffective. In between are many emerging nations where water management is a work in progress and needs are being addressed incrementally.

Depending on how it is defined, water resources management can fall short of the responses needed for a sustainable future. If it is defined as a mostly technical discipline which plans and builds infrastructure, it will certainly fail to respond fully to the needs of people and the planet. If it is focused more on nonstructural and regulatory tools, it may also fail by not providing the infrastructure needed to serve people and protect the environment. If it fails to respond to the urgent needs of water-related sectors such as food, health, and urban development it will also be inadequate. In short, the requirements of water resources management are demanding and it must be comprehensive and integrated with parallel management activities in other sectors.

Why an Integrated Approach Is Needed

Solutions are available, but current management systems fall short in meeting needs. Meanwhile, conflicts block progress and rapidly-increasing demands for water shortchange natural systems. Better approaches based on the best available practices must build on solid technical systems and infrastructure and extend to management systems that integrate water decisions with those in water-dependent sectors such as food, health and environment. The technical systems require tools from science and engineering, and integrative management tools draw from interdisciplinary founts of knowledge.

This book offers a three-level model of water management that includes technical approaches based on science and engineering, management and decision tools, and integrated approaches to link these with actions of water-dependent sectors. Integrated approaches require interdisciplinary inputs and the framework of Integrated Water Resources Management (IWRM) can be used to explain them.

The proven principles of water resources management endure and the tools and methods of the three levels of application apply globally. How they should be applied will depend on the contextual situations at hand. The examples and cases presented here range across different types of problems that occur at different levels of national development and in different cultures.

From Technical to Integrative Water Management

The three levels of water management from technical to integrative are (Fig. 1.1):

- A *technical level* of handling water, as in use of pipes, pumps and other water infrastructure and equipment. This can be called *water resources engineering* but it also includes a wide range of operations and maintenance activities and it can be focused on science issues, such as aquatic ecology for example.
- A *management level* involving decision-making about allocation of the resource values of water and the use of water infrastructure. This scope is often called *water resources management*. This might seem like the same thing as IWRM, but it must go further to deal with related sectors to reach the integrative level.
- An *integrative level* involving a broad set of activities to link water decisions to actions in water-dependent sectors, such as health, environment, and food. The intersection of water issues with those of another sector is sometimes called a nexus as for example the water-energy nexus. These linkages between water management and other sectors define the discipline of *Integrated Water Resources Management*.

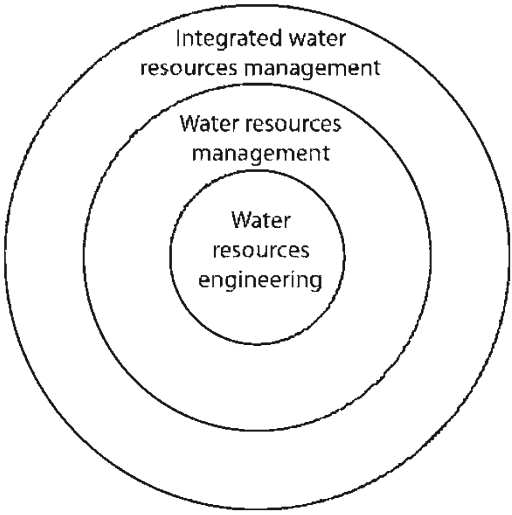

Fig. 1.1 Levels of water management from technical to integrative

Technical work is at the core of all levels; management inputs are needed for decisions involving funding and resource allocations; and the linkages with decisions of other sectors extend the concept to IWRM. Thus, anyone working in water management participates in IWRM at one level or another. While there are other ways to classify these levels, this approach can be used to explain the overall set of tasks involved in water resources management.

As an example, a reservoir operator may use well-defined engineering criteria to make decisions about releases of water. Then, the analyst who advises on allocating the water to farms or cities would support water management decisions by also considering resource values of the water. At the IWRM level, planners would also evaluate how water decisions are linked to community development and goals of other sectors.

Using such examples, it is clear that IWRM should be of practical use as well as useful for academic discussions. To apply it effectively, a manager must implement effective infrastructure systems and management programs, ensure that these are managed well, and work successfully with water-dependent sectors to meet their needs.

Water resources engineering has evolved over centuries as humans sought to put water to work to meet needs for drinking, farming, and providing energy. The concept of management principles for complex decisions came

later, along with emergence of modern systems of governance. IWRM is the most recent paradigm of water resources management and is evolving in response to complex and interconnected problems of society. Practitioners in other complex fields are also seeking to develop integrated approaches, such as in health care, education, and the environment.

Paradigms for Integrated Management

As IWRM has evolved, it has come to replace or expand earlier concepts with similar purposes. Examples of earlier concepts are multipurpose, comprehensive, and holistic water management. Multipurpose water management was a popular concept decades ago, and the World Bank used the term comprehensive in development of its policies during the 1990s. Holistic water management focused on water management in developing countries and applied mostly to the irrigation sector with emphasis on interagency coordination, performance standards for water users and staff, use of indigenous knowledge, local participation for corollary activities; top-down and bottom-up coordination and the linkage between water and agriculture policy.

The recent concept of Total Water Management (TWM) is similar to IWRM, but its concepts have not been extensively developed and it was not designed for development situations. It was developed within the membership of the American Water Works Association (AWWA) and builds on their understanding of the needs of utility managers. A definition of TWM was developed by a group of water industry professionals: "Total Water Management is the exercise of stewardship of water resources for the greatest good of society and the environment. A basic principle of Total Water Management is that the supply is renewable, but limited, and should be managed on a sustainable use basis. Taking into consideration local and regional variations, Total Water Management: encourages planning and management on a natural water systems basis through a dynamic process that adapts to changing conditions; balances competing uses of water through efficient allocation that addresses social values, cost effectiveness, and environmental benefits and costs; requires the participation of all units of government and stakeholders in

decision-making through a process of coordination and conflict resolution; promotes water conservation, reuse, source protection, and supply development to enhance water quality and quantity; and fosters public health, safety, and community good will" (Grigg 2008).

This definition was crafted by a group of highly-experienced managers and each phrase in it was chosen carefully. A short explanation of TWM was provided by John Young (2006), Chief Operating Officer of American Water, who wrote that it is to "…assure that water resources are managed for the greatest good of the people and environment and that all segments of society have a voice in the process." Currently, AWWA has shifted to a concept of One Water, which is interpreted as managing water no matter what form it is in, whether as raw water, water in pipes, recycled water, or groundwater.

Comparing TWM to IWRM shows the importance of nuances to explain differences in concepts that seem similar. At a high conceptual level, TWM and IWRM seem to have the same goals for meeting needs and being good stewards of water. However, TWM focuses on management in the context of water utility decisions and IWRM focuses on the nexus connections among sectors, even as wise decisions about water are made. As a result, IWRM concentrates more on the issues of linked issues among sectors.

Combining technical and non-technical tools requires a more sophisticated approach to water management than in the past. Technical tasks are better-defined than non-technical tasks but still require complex tools, while non-technical skills range across the policy, management and decision science fields and focus on social capacity and collective action. Given these needed skills water management must be interdisciplinary and not limited to a single academic field. Rather than try to invent a new, interdisciplinary field, the more viable course of action is to work within existing specialty areas and build capacity for the solution of problems by interdisciplinary cooperation.

How the Paradigm of IWRM Evolved

The origins of IWRM are in water resources engineering and management, which stem back to the 19th Century rise of science and empiricism as problem-solving methods. Prior to about 1970, these were mostly

technical fields dominated by engineers. Their complexity grew with rising expectations and new technologies, and in response they blended social and environmental objectives with structural solutions to water problems. Now, it is recognized that water management involves more than water as a resource and is also a connector among sector issues in health, food, energy, and environmental protection.

How this interdisciplinary focus developed can be traced to global attention to human issues of equity and opportunity and water issues such as climate change, species diversity, and shared international waters. After the devastation of World War I and the failed League of Nations, World War II created enormous hardships and led to the formation of the United Nations in 1945. As the UN confronted global issues, a series of international conferences addressed needs of the environment, women, and social development. These were followed in 1977 when first UN Water conference was held at Mar del Plata, Argentina and the stage was set for emergence of the IWRM concept. In parallel, the 1970s were an activist decade in environmentalism and multi-sector planning, such as use of environmental impact statements and awareness of social issues was rising globally.

The UN declared the 1980s as the International Water Supply and Sanitation Decade and interest in water management increased further with the 1990s formation of the World Water Council, which was initiated at the VIIIth World Water Conference organized by the International Water Resources Association. The Global Water Partnership (GWP) grew out of these meetings and was founded in 1996 to foster IWRM and link it with development goals. At the 6th World Water Forum in 2012 twelve priorities for action were identified, including one (No. 2.1) for IWRM "Balance multiple uses through Integrated Water Resource Management" (Biswas 2011; World Water Council 2015).

A Vocabulary for IWRM

As IWRM emerged, its practitioners realized that the faced a challenge created by the different vocabularies that emerge from separate disciplines. For this reason, definitions are needed to provide common ground for

cooperative work, starting with the definition of IWRM itself. The most common definition is by the GWP (2015), which was organized to foster the development of IWRM.

The GWP defined IWRM as: "…a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment." The concept of IWRM as a process provides flexibility through a conceptual framework for responding to diverse water demands in many situations as they are coordinated with needs of multiple sectors.

While the GWP was organized to promote IWRM, other groups also embrace it and its acceptance as a conceptual framework seems to be increasing. For example, the American Water Resources Association (AWRA 2015) established an IWRM technical committee in 2014 with the goal to lead a conversation about making it standard practice and to promote common understanding of what people mean by IWRM. AWRA adopted a position statement for water management goals, policies, programs, and plans to be organized around the concept of IWRM and defined it as the "coordinated planning, development, protection and management of water, land and related resources in a manner that fosters sustainable economic activity, improves or sustains environmental quality, ensures public health and safety, and provides for the sustainability of communities and ecosystems."

The multi-faceted nature of IWRM is explained by Fig. 1.2 by showing demand processes on the left (water for economy, society, and environment) and supply processes on the right with water systems and managers working under systems of regulation and supported by an enabling environment. Many contextual situations occur where water is needed for different purposes and requirements in water-dependent sectors, including natural ecosystems. The governance forces are represented by policy and regulation for controls with the enabling environment supporting the processes.

This concept explains how IWRM is different from traditional water management due to its web of connections and nexuses across multiple sectors. Given this broad scope, it is a mechanism for collective action

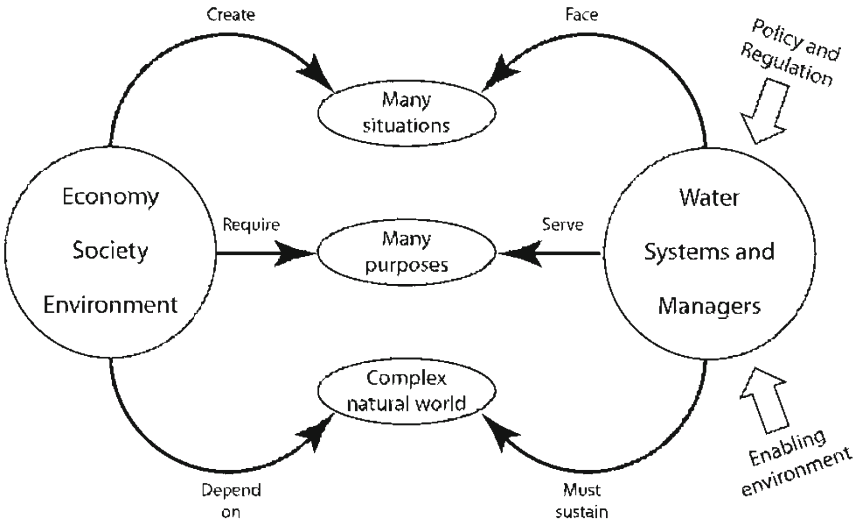

Fig. 1.2 Many facets of IWRM

and is not the job of only one entity called the IWRM Department. There is normally not a job description for an "IWRM Manager," but there are job descriptions which, when summed up, lead to IWRM.

The Nexus Between Water and Other Sectors

The concept of IWRM as a multi-sector activity explains how it provides a nexus approach where water is a connector with other water-dependent sectors, such as in the water-food-energy nexus. The nexus concept requires water governance to be inter-sectoral to address its multiple purposes and require integrative work among sectors. This makes water unique as a connector among policy issues to create policy linkages such as these:

- Water supply to poverty, health, and social policy
- Wastewater to housing, health, social policy, and environment
- Irrigation to food policy
- Flood to disaster and emergency management