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Interdisciplinary information for achieving water security

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A B S T R A C T

Water supply security can be threatened in hydrologic (water quantity and quality), engineering, economic, financial, environmental, social, political, and legal dimensions. Consequently, its protection requires interdisciplinary coverage monitoring all eight dimensions for trends threatening structural and nonstructural measures. This goal can be achieved with observatories that record time series of data on variables from all eight dimensions to confirm continuing acceptable performance, economic justification, acceptable risks, sustainability, and stakeholder expectations. We suggest parameters for covering socio-political and physical–chemical components and methodology for searching for feedbacks and applying principles from artificial intelligence to understand decisions recorded in case studies of past resolutions of diverse issues. Academic and management communities must join to establish observatories for measuring the significant parameters.

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1. Introduction

Governments employ facilities and incentives to support water resources management to enhance human welfare. However, river basins function in so many interactive dimensions that important relationships are commonly overlooked in securing desired services through lasting programs. Fortunately, advancing sensing and computational technologies can compile more "big data" to understand this "big picture." Utilizing our terminology (Table 1), this paper poses state variables in eight interactive dimensions (hydrologic, measures, economic, financial, environmental, social, political, and legal as defined in Table 2) to watch river basin functioning, suggest measurable variables for gathering data, and make a case for establishing observatories for gathering data needed to craft effective programs. Water system managers would then use that information in addressing five evaluation issues (performance in delivering desired services, worth studies balancing services against impacts, minimizing catastrophic failures, sustainability by resisting deterioration, and satisficing popular expectations as defined in Table 3) to secure water services. Unacceptable consequences in any of the eight dimensions would compromise water system security.

However, an observatory cannot collect "big data" to cover everything and needs to focus on useful information and representative locations to resolve three important issues: 1) which relationships to cover in data gathering, 2) how to limit data gathering to manageable levels delivering important information, and 3) how to proceed from current management practices to a future management system for multi-party, multi-dimensional decision making. We address these challenges by reviewing the current system, identifying associated threats to water security and concepts to consider for alleviating those threats, and posing a strategy for using observatories to monitor parameters indexing those concepts.

Table 1
Terminology.

Term	Definition
Dimension	A disciplinary perspective used in the evaluation of water resources management. Our presentation uses eight dimensions.
Evaluation	A process for assessing the merit of a proposed water resources management program.
Nonstructural Measure	An action taken for using water or land. Individuals act by choosing how, when, where, and how much water or land to use and select facilities (storage, piping, treatment, flood proofing, etc.) to expedite their choices. Governments implement programs to inform individual decisions or to modify them in the public interest.
Parameter	A conceptual criterion used to evaluate water resources management. Each dimension has "ideals" that reduce to "realistic" goals we call parameters. A dimensional evaluation may require several parameters.
State	The value assigned a given variable at a given time. Water resources management uses sets of states covering locations and time periods.
Structural Measure	A project constructed by a government to store, transport, or treat water. River basins may be connected through inter-basin transfers.
Variable	A measurable index used to approximate a parameter. Trends in variable values may be tracked over time or forecast into the future. Time series may be reduced to a present worth by discounting over a planning period.
Water Resources Management	A governmental program for integrating public and private structural and nonstructural measures and targeting an ultimate goal of water security.
Water Security	A situation in which concerned stakeholders and experts accept a management program as satisfying community water needs. Acceptance is earned by achieving positive evaluations in all relevant dimensions.