



*The World Economic Forum Water Initiative*

# Water Security

### Water Security

##### The Water-Food-Energy-Climate Nexus

*“Water sits at the nexus of so many global issues . . . including health, hunger and economic growth. And sadly, water scarcity takes its greatest toll on society’s least fortunate. I am absolutely convinced that the only way to measurably and sustainably improve*

*this dire situation is through broad-scale collaborative efforts between government, industry, academia and other stakeholders around the world.”*

—Indra Nooyi,

Chairman and CEO of PepsiCo, Inc., Member of International Business Council, World Economic Forum

*“In 1911, John Muir observed how, ‘When we try to pick out anything by itself in nature, we find it hitched*

*to everything else in the Universe.’ A century later, a gathering of the World Economic Forum discovered the same phenomenon. Four hundred top decision-makers listed the myriad*

*looming threats to global stability, including famine, terrorism, inequality, disease, poverty, and climate change. Yet when we tried to address each diverse force, we found them all attached to one universal security risk: fresh water.”*

—Margaret Catley-Carlson, Patron, Global Water Partnership, 2008–2010 Chair of World Economic Forum Global Agenda Council

on Water Security

*“To make a difference on the water challenges we all face, governments, civil society and businesses must work together as never before. For business leaders in particular, we need to speak up, stand up and scale up our efforts on water sustainability.”*

—Muhtar Kent, Chairman and CEO, The Coca-Cola Company, Member of International

Business Council, World Economic Forum

*“Over the last few years, the scale and speed of response from a leading group of large companies to the water challenge has been impressive. As this book illustrates, their engagement*

*in partnerships with others to better understand how water works across the economy and how to manage water more efficiently as a result, can offer much potential.”*

—Professor Tony Allan, Kings College London, 2008 Recipient of the Stockholm Water

Prize, Member of the World Economic Forum Global Agenda Council on Water Security

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Partnerships bring visibility and insight to strategic decision-making on the most important industry- and cross-industry-related issues and the

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**Water Security**

The Water-Food-Energy-Climate Nexus

The World Economic Forum Water Initiative



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### chapter 10

**New Economic Frameworks for Decision-Making**

*An Integrated Sustainability Index for Effective Water Policy*

Rabi H. Mohtar, Director, Global Engineering Program; Professor, Agricultural and Biological Engineering Department, Purdue

University; Member, Global Agenda Council on Water Security

The interlinkages of the water system with other systems, such as food, en- ergy, climate change, and the economy, must be explicitly defined to enable the exact quantification of those relationships. This will then allow for com- prehensive, integrated management systems to emerge. For example, devel- opment of a “water value” for all sources of water (sea, surface fresh, deep aquifer, recycled water, etc.) to feed into such a system would include the cost associated with transporting the water to a specific destination for a certain need; it would also consider the environmental quality associated with the use of this specific water, such as long-term soil quality, pollution risk, and so forth.

Even though specific metrics exist that can address the status and progress of water resources, a wider benchmarking tool that can address multidimen- sional water systems and their interrelations to food, energy, and other closely related systems is yet to be established. Water data attributes identified in rela- tion to these interlinkages and their multi-scale processes are needed. These attributes should include, but not be limited to: water values, water pricing, water laws, environmental impacts, energy impacts, food security, ecological impacts, biodiversity, and air, soil, and water quality.

As we explore the architecture and the implementation possibilities of such an interlinked water system (perhaps better described as an integrated sus- tainability index for effective water policy), various types of data will help us to connect and define the interface between its separate components. These data types include system *input data*, such as weather/climate with its spatial



Figure 10.5 Cloud-to-Coast framework

and temporal variability in the short and long term; *system* data, such as soils, land use, geomorphology, socioeconomics, land management and tenure, governance system, social structure, indigenous knowledge, and the like; and system *output data*/*indicators*, such as the robustness of the system, the well- being of people being served, and the implications on food security, health, energy security, and so forth. Likewise, the development of an early warning system will also require system input and system parameters data; and for system sensitivities and evaluation, system output data are needed. A critical issue here is the quality of data, the standards/format, and their accessibility. Figure 10.6 is a simplified system for the elements of sustainability and includes explicit interlinkages. This system can be a starting point towards

sustainable water-food-energy systems.

It can be seen that a comprehensive, interlinked water security strategy will be complex and difficult to achieve. It can be attempted, however, using the perspective identified above, and based on relatively simple principles that focus on:

* + - multi-scale dimensions
		- metrics that are easily obtained
		- achievable benchmarking targets.

To obtain the data to underpin the activities, a *water knowledge virtual hub* that can integrate new and existing knowledge (from research centers, universities,



Figure 10.6 Energy-Food-Natural Resources Continuum: System Challenge

industrial and private patents), as well as effective rural community indige- nous knowledge, is a good starting place. As well as developing a suite of water knowledge hubs (domestically or regionally) to help pool and sift intercon- nected data, a comprehensive state-of-the-art model design exercise should be explored to identify the various areas in interlinked water-food-energy policy- making, where these tools/frameworks can be of most help.

*Water Skin: A Global Multi-scale River Basin Decision-Support Framework for Collaborative Water Resource and Risk Management from the Planetary Skin Institute*

Juan Carlos Castilla-Rubio, President, Planetary Skin Institute; Managing Director, Cisco Systems Sustainability and Resources Innovation Group

Two powerful trends are reshaping the world. The first trend is *resource scarcity*, the result of explosive demand growth for resources (water, energy, food, land,

etc.) driven by growing populations and economic development. The second trend is *data abundance,* driven by huge but siloed data sets and increasing information processing capabilities, space-to-ground sensor networks, and emerging information and communication technologies.

Planetary Skin Institute (PSI) aims to address the challenge posed by the first trend with the opportunity presented by the second. In March 2009, Cisco and NASA agreed a multiyear R & D public private partnership to pool their capabilities and assets in a partnership based on joint and open innova- tion. Cisco has embedded the fruits of this partnership in the PSI, which was named one of *Time* magazine’s “Top 50 Inventions of 2009.”4 PSI is a unique R&D partnership between leading corporations, government agencies, and research institutions around the world.

PSI’s nonprofit status is intended to facilitate cooperation across institu- tional, disciplinary, and national boundaries and to create a space for flexible pooling of assets, capabilities, and ideas among stakeholders. PSI has recruited a global advisory council consisting of thought leaders in science, technology, economics, and innovation to guide this work.

PSI is currently working with selected corporate, government, and aca- demic partners in the US, EU, India, and Brazil to build working prototypes of resource and risk management *decision-support tools* that have the potential to increase food, water, and energy security and protect ecosystems such as tropical forests. These include the utilization of satellite data to analyse land use change and estimate greenhouse gas emissions; integration of sensor data and analytics to identify cost-effective pathways to significantly increase re- newable energy and energy efficiency adoption; and the use of satellite sen- sors, mobile networks, and analytic models to support smallholder agriculture productivity enhancement and accelerate crop insurance. A water component of this work is also under way.

Water Skin

The challenges facing the world’s water resources have been addressed in de- tail in this book. Yet society’s ability to manage these challenges is impaired by seemingly intractable informational, political, economic, and institutional challenges. Decision-makers need substantially more data and analytic support to reconcile water demands at local and regional levels and to build consensus among users for adaptive water resource and risk management. But data at appropriate spatial (i.e., subbasin) and temporal (e.g., seasonal) resolution are uncommon. More flexible, adaptable, and integrated decision-support tools are also required to reflect the highly localized and cross-disciplinary chal- lenges of water resource management. Consequently, and recognizing that every watershed faces unique challenges, some subset of the following five

capabilities will likely need to be built in order to create an overall supporting “skin” for water resource decision-making in any given location.

1. *Systems modeling*. How does the hydrology of the system work today? What are the major sources and the dynamics of supply and demand across all stock and flow categories, and how do they interact with natural features of the environment?
2. *Change modeling*. How are the mean and variance characteristics of supply and demand likely to change under various economic and climatic scenarios? What are the implications from the increasing frequency of weather extremes in the short term? What are the implications for risk prevention, mitigation, and transfer?
3. *Infrastructure optimization*. What infrastructure choices are available to manage change, and what trade-offs do they imply for the welfare of various stakeholders, including both economic and environmental considerations? What are the right infrastructure build-out linkages and sequencing decisions? What are the optimal demand-side infrastructural choices? How to optimize these choices for a systemic view of the water-food-energy-climate nexus?
4. *Policy optimization*. What policy choices (e.g., adaptive resource allocation) are available to manage change, and what trade-offs do they imply for the welfare of various stakeholders, including both economic and environmental considerations? What is the policy trade- off, for example, for homegrown production versus trade, and in terms of optimal crop choices for the environment?
5. *Ecosystem management*. Where are the different sources of ecosystem damage (pollution) in the water system, and how can policy-makers attribute responsibility to different stakeholders under a regulatory or market-based approach?

Managing Water, Food, and Energy Interdependencies

Unlocking humanity’s ability to manage water resources will require, among other things, advanced decision-support capabilities that provide a shared ana- lytic and technical basis for cooperation. The Water Skin R&D program aims to engineer new decision-support capabilities that draw upon innovations in the sensing, the analytic and the collaboration layers to create the groundwork for integrated and adaptive water resource and risk management:

* + Innovations in the *sensing layer* are designed to leverage integrated configurations of ground-, people-, airborne-, and satellite-based technologies to monitor the state of land, catchments, rivers, defenses

and vulnerable areas in near real time. A common problem in resource management is the absence of data at temporal and spatial resolutions detailed enough to guide decision-making of both surface and underground water levels. Another has to do with data sharing across local and international boundaries. Water Skin will test innovations

in targeted low-cost sensor data from a variety of platforms (e.g., *in situ*, wireless water quality sensors, satellite sensing, UAV sensing) to evaluate their potential contribution to better decision-making.

* + Innovations in the *analytics layer* are designed to integrate and analyze data in the sensor layer to draw inferences that are useful to end users, enabled by a cloud-based compute and open modeling capability. The analytics layer will include cross-disciplinary analytic and modeling capabilities to support decisions in water resource management that require analyzing issues from a range of perspectives (e.g., decision- support systems to optimize water (re)allocation strategies; reservoir and water transport management; hydropower systems; energy generation strategies; demand-side management for devising short- term crop-planting strategies, for informing crop-choice optimization decisions, and for precision farming in agriculture, among others). Other examples in water risk management include early warning systems for floods and droughts to assess, for example, the reliability of flood infrastructure, to improve evacuation strategies, and to develop model-driven management strategies to predict and minimize the impacts of flooding and drought.
	+ Innovations in the *collaboration layer* are designed to provide meaningful, value-added and collaborative interfaces with local context for a myriad of end users and decision-makers in the public and private sectors and in local communities. Innovations in this space include advances in user interfaces, immersive geospatial visualization environments, collaboration capabilities, and end uses themselves (i.e., the creation and support of ecosystem market infrastructure).

Assessing the multiple risks that water shortages will create requires infor- mation integration across multiple disciplines and domains (e.g., economics, weather, hydrology, energy systems, crop-systems risk modeling), scenario- based and geo-spatially explicit modeling and analysis tools, and the ability to characterize information in terms of risk distributions and mitigation mea- sures. PSI is designed to address these challenges.

Consequently, the Water Skin is just one component of a broader set of sensing, analytic, and collaboration capabilities under the PSI decision- support framework and platform. This allows for the Water Skin to interface

natively with other PSI Energy, Agri-food, and Forestry resource decision- support management and risk systems to better understand the complex interactions, particularly the dynamic risk characteristics, and spatial dimen- sions of this interconnected challenge.

Currently, only rudimentary insights exist on when and where interlinked problems are likely to materialize, and under what assumptions and scenarios. Most analytic approaches to date are static, lack geo-spatial resolution, and do not incorporate effective risk analyses. But these features are precisely the capabilities that policy-makers, communities, businesses, investors, and asset operators need in order to make better resource allocation and risk manage- ment decisions.

When fully developed, the Water Skin will provide an immersive infor- mation-rich platform to better understand and model the complex interre- lationships between energy, water, land, agriculture, and other resources. In particular, the Water Skin decision-support platform, with a focus on the global public good, will be structured to allow open access and interoper- ability to specific areas of the platform by a broader set of cross-disciplinary experts across the public, private, and research sectors. Open data exchange standards will be published to allow research and development communities globally to integrate and access data and decision-support capabilities through Water Skin user collaboration inter-faces.

The Journey Ahead

The ambition is that a Water Skin R & D consortium of leading corporations, governments, space agencies, NGOs, foundations, and research academic in- stitutions codevelops new technical and institutional capabilities in the next three to five years that will substantially advance the ability of decision-makers in both water resource and risk management to meet changing needs in an environmentally sustainable and equitable fashion. Our plan is to prototype a next-generation set of capabilities for water resource managers and experts that can be replicated and scaled globally. By developing and testing innova- tions in sensing, analytics, and collaboration layers in several high-priority river basins of the world, Water Skin will demonstrate the art of the possible, yield significant benefits for participating communities, and generate a new set of research and development questions to be addressed iteratively over time.

#### Notes

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