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Editorial Article:

Water Losses in Asia[1]

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With accelerating urbanization in Asia, management of the entire water cycle in urban context has become a priority consideration. The rapid rate of urbanization in the region is resulting in many Asian cities facing major challenges of providing their increasing populations with adequate and sustainable water services. Many cities are water stressed and the available water resources for these cities are dwindling rapidly. Not only are these cities now unable to reconcile the water requirements and the water resources, but also current utilization is often both inefficient and ineffective. Water losses are quite high. One of the major challenges facing water utilities in the developing countries of Asia is the high level of water losses (leakage) due to water pipe bursts and leakages, theft of water from the system, or water users not billed properly. In many Asian countries it is an issue that deserves close attention. Table 1 below gives a picture of non-revenue water of Water Utilities in various parts of the Asian region.

Table 1: Non-revenue Water of Water Utilities in countries of the Asian region

S.No.	Country	Name of the Utility	Status	Year of Reference	Overall Non-Revenue Water (per cent)
South Asia					
1.	Bangladesh	Dhaka	Public	2006	37
		Chittagong	Public	2006	28
		Sylhet	Public	2006	70
2.	India	Bangalore Water Supply and Sewerage Board, Bangalore, Karnataka State	Public	2005-2006	45.1
		Municipal Corporation of Jabalpur,	Public	2005-2006	14.3

S.No.	Country	Name of the Utility	Status	Year of Reference	Overall Non-Revenue Water (per cent)
		Jabalpur, Madhya Pradesh State			
		Kolkata Municipal Corporation, Kolkata, West Bengal State	Public	2005-2006	35.0
		Municipal Corporation of Greater Mumbai, Mumbai, Maharashtra, State	Public	2005-2006	13.6
		Nagpur Municipal Corporation, Nagpur, Maharashtra State	Public	2005-2006	51.9
		Varanasi Jal Sansthan (Water Board), Varanasi, Uttar Pradesh State	Public	2005-2006	30.0
		Greater Visakhapatnam Municipal Corporation, Visakhapatnam, Andhra Pradesh State	Public	2005-2006	14.5
		Municipal Corporation, Amritsar, Punjab State	Public	2005-2006	57.4
3.	Pakistan	Rawalpindi	Public	SEAWUN Bench-marking Database	30
		Karachi	Public		30
		Lahore	Public		42
4.	Sri Lanka	Water Supply	Public	2005	35.92 (Gt. Colombo) 30.86 (Regions)
Southeast Asia					
5.	Indonesia	TPJ	Private	2001	53
		Palyja	Private	2004	47.3
		DKI Jakarta	Public	2006	48
		Banjarmasin	Public	2006	30
		Malang	Public	2006	36
		Yogyakarta	Public	2006	31
6.	Philippines	Maynilad	Private	2004 2006	68.4 66.39
		Manila Water	Private	2004	47.6

S.No.	Country	Name of the Utility	Status	Year of Reference	Overall Non-Revenue Water (per cent)
				2006	31.74
		Dagupan Water District	Public	2005	30
		Orani Water District	Public	2005	19
		Magdalena (LGU managed Utility)	Public	2005	36
East Asia					
7.	PR China	Heze	Public	2005	94
		Liaocheng	Public	2005	3
		Zibo	Public	2005	72
		Weifang	Public	2005	18
8.	Kazakhstan	Almaty	Public	2006	10
		Aqtau	Public	2006	32
		Karaghandy	Public	2006	35
		Shchuchinsk	Public	2006	32
		Taldykorghan	Public	2006	29
Mekong Region					
9.	Cambodia	Phnom Penh	Public	2003 2007	17 6
		Sihanoukville Water Supply Authority	Public	2004	26.3
10.	Vietnam	Hanoi	SOE-One Member Company Ltd.	2003	44
		Ho Chi Minh	-do-	2003	39
		Hue	-do-	2003	21
		Haiphong	-do-	2006	22
		National		2002	36.8
Pacific Region					

S.No.	Country	Name of the Utility	Status	Year of Reference	Overall Non-Revenue Water (per cent)
11.	Fiji	Suva	Public	2007	70
12.	Samoa	Samoa Water Authority	Public	2002/ 2003	44

Strategies and Achievements in NRW reduction

It may be seen that non-revenue water of some of the utilities in South Asia is as high as 70%. In Indonesia, it varies from 30-53%, in Philippines from 19-68%, in China from 3-94% and in Vietnam from 21-44%. However, in Cambodia the water utility in Phnom Penh has been quite successful of reducing its non-revenue water to 6% in 2007. Box 1 explains as to how Phnom Penh water supply authority brought an effective control of non-revenue water.

Box 1: Effective Control of Non Revenue Water

In 1993, NRW in the PPWSA was incredibly high at 72%. By 2007. However, NRW had been reduced to 6%, of which 2-3% was estimated to be due to unauthorized consumption and commercial losses, and the rest due to physical losses mainly from leakages caused by road, drainage, and cable-laying construction. In 2004, road construction caused 75% of leaks, rising to 81% in 2005 and to 83% by 2006.

Commercial losses were addressed by metering all consumers and tackling the high incidence of illegal connections which had been widespread due to the high connection charge of $1,000. Illegal consumption was reduced by running a public awareness campaign, giving incentives to anyone providing information on illegal connections, heavily penalizing those connected illegally, and paying special attention to the removal and punishment of any PPWSA staff found associated with illegal connections. Physical losses were reduced by replacing old pipes, creating 41 leakage control zones based on district metering areas, and establishing NRW control teams in 2003. In 2005 0.4% of revenue was spent on repairing leaks and controlling the 41 zones.

There were three key factors in the success achieved: 1. the role of the PPWSA staff who were incentivized to become champions in themselves, 2. active public support, and 3. managing the 41 zones to control leakage.

Ek Sonn Chan, General Director of the Phnom Penh Water Supply Authority

Hai Phong and MWCI have each reduced their NRW levels to 21.5% and 26%, respectively, from levels beyond 60% in the last 10 years. MWSI on the other hand, has just been turned over to new owners and has identified NRW reduction as their main focus given the current levels at 69%. A NRW reduction strategy is currently being put in place with firm financial management commitment to support the program.

Realizing the need for reducing non-revenue water, organizations like WHO have been regularly monitoring volumes of non-revenue water. Table 2 gives estimates of worldwide NRW volumes and Table 3 provides estimated value of non-revenue water and its components.

Table 2: Estimates of Worldwide NRW volumes (billions of cubic meters/ year)

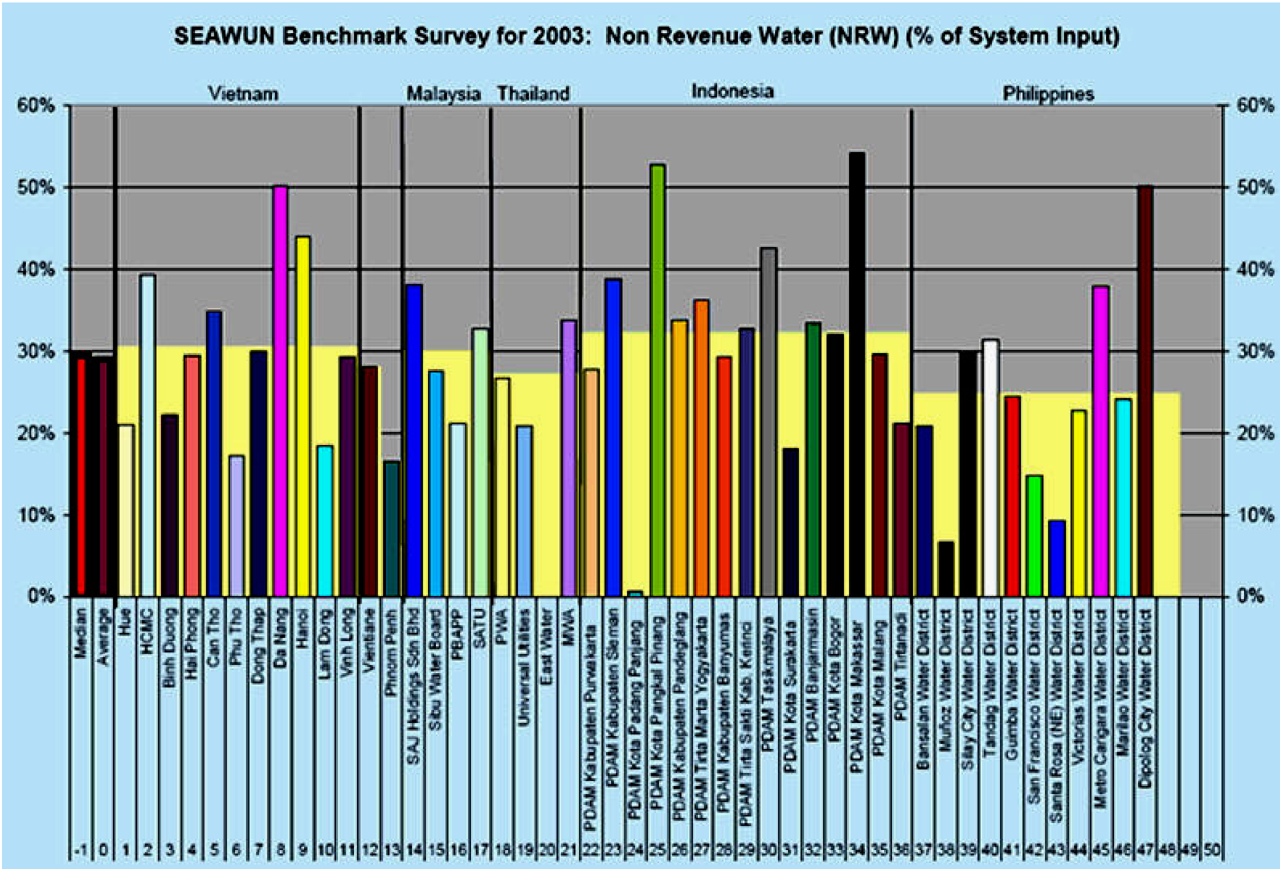
	Supplied population, millions (2002)	System Input I/capita/ day	Estimates of NRW					
			NRW as share of system input (%)	Ratio (%)		Volume, billion m^3/ year		
				Physical losses	Commercial losses	Physical losses	Commercial losses	Total NRW
Developed countries	744.8	300	15	80	20	9.8	2.4	12.2
Eurasia (CIS)	178.0	500	30	70	30	6.8	2.9	9.7
Developing Countries	837.2	250	35	60	40	16.1	10.6	26.7
					Total	**32.7**	**15.9**	**48.6**

Source: World Health Organization

Table 3: Estimated value of NRW and its components

	Supplied population, millions (2002)	System Input I/capita/day	Estimated value (US$ billions/ year)		
			Cost of physical losses	Lost revenue due to commercial losses	Total cost of NRW
Developed countries	0.30	1.00	2.9	2.4	5.3
Eurasia (CIS)	0.30	0.50	2.0	1.5	3.5
Developing Countries	0.20	0.25	3.2	2.6	5.8
		Total	**8.1**	**6.5**	**14.6**

Organizations like Southeast Asian Water Utilities Network (SEAWUN) have been undertaking benchmarking surveys from time to time. The chart below presents results of SEAWUN benchmarking survey for 2003.



The role of water conservation and demand management measures for reduction of water loss and water utilization in all spheres of the water sector is, therefore, becoming increasingly important. In Malaysia e.g. the entire water supply distribution system comprises more than 91,247 km of water pipes of which 45,746 km or 50% are Asbestos Cement Pipes. These pipes have been extensively laid and have been in service for more than 30 years. The government under the 9th and 10th Malaysia plan is planning to replace about 12,000 km of water pipes – totaling to RM11.7billion to bring down NRW level to a target of 20% by the year 2015.

There is a felt need in Asia for networking among utilities for knowledge sharing experience that caters exclusively to the issue of water loss in Asia. There is also a need to encourage government supervision and private sector initiative to reduce NRW and also generate immediate operational and financial benefits.

Cities in Asia also need to build capacity and undertake the following:

(1) Establish a standardized water balance & calculate water loss performance indicators;

(2) Reduce commercial and physical losses;

(3) Produce an NRW Assessment and Management Action Plan; and

(4) Acquaint with the available NRW techniques and equipment.

Hai Phong and MWCI have each reduced their NRW levels to 21.5% and 26%, respectively, from levels beyond 60% in the last 10 years. MWSI on the other hand, has just been turned over to new owners and has identified NRW reduction as their main focus given the current levels at 69%. A NRW reduction strategy is currently being put in place with firm financial management commitment to support the program.

Reducing Water Losses: UN-HABITAT Efforts towards Water Conservation

UN-HABITAT in association with Rand Water of South Africa produced a Manual on Water Demand management, which has the following objectives.

- To introduce a standard terminology for component based leakage management and to encourage water utilities to calculate components of Non-Revenue Water and Water Losses using the standard annual water balance;
- To highlight the importance of adopting standard terminology and a standard approach to the complex issue of leakage in a water distribution system;
- To highlight and explain certain key issues which water utilities should be addressing even in situations where the available financial resources are insufficient to implement normally accepted international practices; and
- To identify and explain various issues and items of equipment that can be of specific use to the local situations in different regions.

Water Demand management is one of the key thrust area under the Water for Asian Cities Programmes. In India UN-HABITAT has been working in the four cities of Madhya Pradesh, India viz. Bhopal, Indore, Gwalior, and Jabalpur where the non-revenue water of the water utilities has varied from 50-65 per cent. For each city a Water Demand Management Strategy has been developed which aims at reducing the non-revenue water to a level of 15 per cent by the year 2010. The strategy includes technical aspects of water demand management and implementation plan together with the financial, institutional and policy reforms. The strategy is specific for each city and provides the basis for formulating effective water demand management policies.

Exploring a career in science policy at the National Academies

Priya Sreedharan, Ph.D., P.E.

National Academies Christine Mirzayan

Science and Technology Policy Graduate Fellow - Spring 2008

With a background in engineering, I have worked in the energy and environment field for more than a decade, in research, consulting and design capacities. I couldn't help but notice that the achievements and innovations in California, where I was working as energy engineer, is due in large part to good policy. The question of how to translate anomalous success stories, such as California's, more widely intrigued me. Surely, climate change mitigation and sustainable development cannot be achieved without good policy? These questions and an interest in viewing research out from under the trenches, where I had spent the previous four years completing my doctorate, convinced me to pursue the Christine Mirzayan fellowship at the National Academies.

Based in Washington D.C., the National Academies mission is to "improve government decision making and public policy, increase public education and understanding" in matters involving science, engineering, technology, and health. Due to its convening power, the National Academies attracts the world's top experts. Twenty-six of us arrived in Washington D.C. for the winter 2007 fellowship program, passionate and eager to learn about the world of science policy. The fellowship provides several graduate and post-graduate students with an opportunity to view their respective fields from a bird's eye view and provides a unique opportunity to interact with the world's brightest and most influential leaders in the areas of science, technology and health.

The fellowship is offered three times a year and is typically ten weeks long. Some fellows, including myself, remained for an additional ten weeks. The application process consists of an on-line application and phone interview. I was selected by the Science and Technology for Sustainability (STS) Roundtable. STS is a unique entity within the National Academies. It refrains from making policy recommendations, but hosts workshops and generates reports and white papers that address important issues that are cross-cutting to several different departments, or "boards" as they are called at the National Academies. The interdisciplinary nature of sustainability is reflected in the Roundtable composition. Experts across the private, public and academic sectors participate in the Science and Technology for Sustainability Roundtable.

The fellowship includes a one week orientation with a comprehensive introduction to federal government, policy, and the National Academies. It provides an opportunity to interact with other fellows. Our fellowship cohort included an impressive diversity of educational, cultural and professional backgrounds — ranging from biologists, neural scientists, engineers and lawyers, and a few international students. The daily breakfasts and lunches, and frequent happy hours facilitated getting to know one another! A key fellowship activity is the group project, in which the fellows select a relevant science policy subject and organize a public workshop. The selection of the topic was conducted in typical National Academies consensus building style. Several ideas were discussed thoroughly before selecting the topic. Three groups were formed. Our group chose to organize a workshop on renewable energy, with the purpose of exploring international lessons.

The core of the fellowship was the work I conducted with the Science and Technology for Sustainability Roundtable. I worked on two important issues, the sustainability aspects of biofuels and partnerships for sustainability. For biofuels, I conducted a variety of tasks, including research, attending and organizing workshops, writing briefing memos, and interacting with experts. With the global rise in food prices, concerns about climate change impacts, and a federal mandate to increase biofuels production, biofuels was a high profile and important policy topic to work on. For several years, the Science and Technology for Sustainability Roundtable has been investigating how partnerships, such as between the public and private sectors, can facilitate the transition of sustainability from concept to practice. With this project, I had an opportunity to compose a white paper that served as a primer for a *Partnerships for Sustainability* workshop that the Roundtable held in June.

Beyond the project work, the interaction with Science and Technology for Sustainability and National Academies colleagues provided a wonderful opportunity to hear firsthand about the world of science policy from those that have been engaged with public policy for decades.

The Christine Mirzayan fellowship was an invaluable learning experience that convinced me to return for more! Beginning in September I'll be a fellow with the American Association for the Advancement of Science (AAAS), working with the Climate Change Partnership Division on energy efficiency and renewable energy policy. With a summer to cool off (literally) in northern California, working at the Lawrence Berkeley National Laboratory, I am ready to plunge back into the excitement, frustration and chaos. After all, who could resist an opportunity to work on energy policy at a time when the federal government is likely to take climate change action!

Find out more about the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program and many other career opportunities available from the National Academies at <national-academies.org/grantprograms.html>.

Author's Profile:

Priya Sreedharan is a recent graduate from the University of California, Berkeley, with a Ph.D. in mechanical engineering. She will be an AAAS fellow with the Environmental Protection Agency, Climate Change Partnerships Division, starting September 2008.

Adaptive water resources management in a changing climate

Shaleen Jain

Assistant Professor

University of Maine

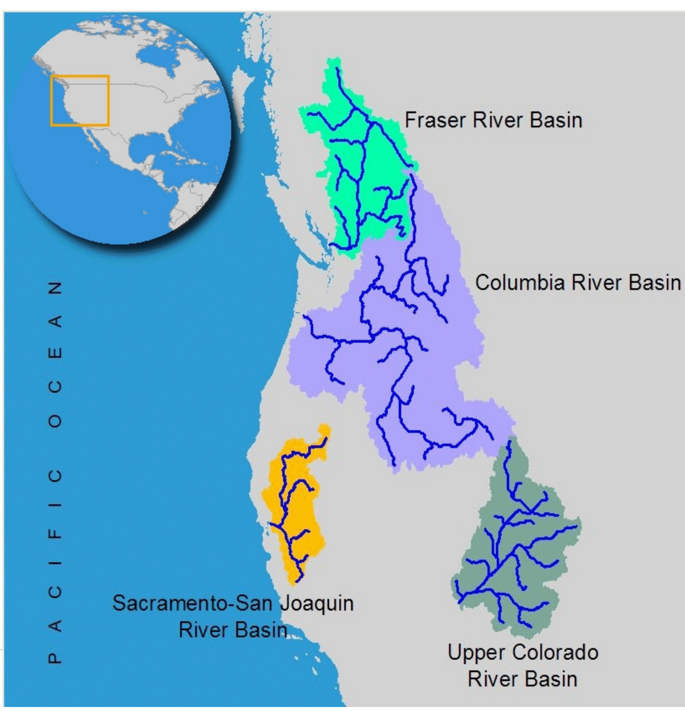
Across the world, managing water resources is becoming an increasingly contentious issue. Numerous natural and human-induced forces continue to reshape floodplains at an unprecedented rate—the regional expression of climate variability and change, land-use changes, and water needs stemming from rapid development are some of the key drivers in this regard. While the ability to provide reliable water supplies is constrained by the quality and quantity of available water, developmental trajectories that stymie ecosystem services are on a path that is not only unsustainable but in some cases irreversible.

Through a variety of biogeochemical cycles, ecosystems services support a habitable environment. In river systems, hydrologic alteration limits the natural range of seasonal and longer-term variations in river flow, thus disrupting the natural rhythms of river and riparian ecosystems. Regulation of river flows for human use is primarily accomplished by dams, reservoir operations, hydraulic structures that divert or withhold water. From the standpoint of adapting and possibly determining a sustainable path toward the management of water resources, a first step involves understanding the climate-induced changes in water supplies and clarifying the linkages between weather and climate variations and river flows, especially ones that sensitively impact ecosystems health.

Western North American river systems exemplify a unique blend of complexity—highly managed and dammed, heavy reliance on water supplies, climatic influences, increasing water demand, and at-risk ecosystems. Two examples from ongoing research are discussed briefly. In both cases, questions are derived from the analysis of the past and current adaptive management efforts in these basins. Adaptation to climate variability and change is being examined with a goal to understand the multiple time scales of hydro climatic variability. As noted above, the identification of climate precursors and characterization of their potential predictability (and associated uncertainty) is likely to facilitate development of illustrative models (with a few variables) that are amenable to quick decision-analysis and promote an effective, iterative dialogue between decision-makers and scientists.

Western North American River Basins

A late-twentieth century emergent trend toward increasing year-to-year variance (decreasing reliability) of stream flow across the major river basins in western North America—Fraser, Columbia, Sacramento-San Joaquin, and Upper Colorado—have been noted in recent studies. Simultaneously, a disproportionate increase in the incidence of synchronous high and low flows across these basins has resulted in expansive water resources stress. The observed trends have analogues in wintertime atmospheric circulation regimes and ocean temperatures, raising new questions on the detection, attribution, and projection of regional hydrologic change induced by climate.



Increased variability is accompanied by a tendency toward synchronous extremes, wherein the four river basins simultaneously experience excesses or deficits in water supply. Statistical analysis of stream flow records reveals sensitivity to tropical oceanic temperatures, and a correspondence between the trends in these two disparate regions. One implication for water resources management is that increased year-to-year variability in flows implies a larger reservoir volume to meet the water demand. Thus, a reassessment of the adequacy of the water resources infrastructure will be an important step in determining the systemic reliability. Furthermore, more frequent hydrologic extremes, especially over the entire region highlight the changing reality for resources allocation and response for disaster relief.

Adaptive environmental management in the Grand Canyon region of the Colorado River Basin

Climatic drivers of episodic to multi-decadal variations to the observed changes in the flood magnitude, timing and spatial scales affect the sediment inputs to the Colorado River ecosystem. Since the 1963 closure of Glen Canyon Dam, the dominant sole major supplier of sand to the Colorado River in the upper portion of Grand Canyon is the Paria River, which supplies about 6% of the pre-dam supply of sand at the upstream boundary of Grand Canyon National Park. Sand is delivered by the Paria River during short-duration (< 24 hours), large magnitude (up to 300 m^3/s) floods that occur primarily during the warm season (July-October).

The planning and decision processes in the Glen Canyon Dam Adaptive Management Program (GCD-AMP) strive to balance numerous, often competing, objectives, such as, water supply, hydropower generation, low flow maintenance, maximizing conservation of the tributary supplied sediment, endangered species recovery, and cultural resources. A key concern identified by the AMP, related to the timing and volume of sediment input into Grand Canyon. Adequate sediment inputs into the river ecosystem in the Canyon combined with active flow management (in the form of strategically timed bypass releases from Glen Canyon Dam) support the restoration and maintenance of sand bars, habitat and in stream ecology. An improved understanding of the relative role of eastern North Pacific tropical storms, tropical Pacific sea surface temperatures, and subtropical moisture sources is allowing development of predictive tools for flood forecasting (and related sediment supplies) to support the AMP efforts.

On longer time scales, structured variations in the sediment supply imply a changing baseline for mean ecological and geomorphological conditions in the Canyon, counter to the static view taken in the current environmental impact assessments. Better understanding of the coupled climate-hydrologic variations on multiple time scales is increasingly recognized as critical inThursday, September 11, 2008put for adaptive management (both passive and active). In collaboration with the Glen Canyon Dam Adaptive Management Program (GCD-AMP), a deliberate effort is made to identify the entry-points for predictive hydro climatic information at appropriate lead times.

For the active adaptive management program, lead climate information allows scientists and managers to anticipate geomorphic response from critical tributaries, in turn triggering large-scale, experimental releases from Glen Canyon Dam. Current studies are attempting to understand the ecosystem's sand supply and the spawning success and recruitment of endangered humpback chub. This is a collaborative work with scientists at the U.S. Geological Survey’s Grand Canyon Monitoring and Research Center in Flagstaff, Arizona and National Oceanic and Atmospheric Administration’s Earth System Research Laboratory in Boulder, Colorado.

Towards integrative approaches with involvement of the users of scientific information

Resource management and planning concerns can be systematically studied within the context of users, institutions, retrospective assessments of management and programmatic actions, and adaptive management programs. From such work, identified knowledge gaps and translated research questions have a disproportionately higher potential to hit the mark. Furthermore, user-inspired applied and basic research on problems such as hydro climatic change, water and ecosystems management is most likely to benefit from illustrative models and tools that allow users to explore and pursue “virtual” experiments with generated scientific information. This allows users to assess incremental benefits, develop a revised set of questions and knowledge gaps, and in the process impart native knowledge from the trenches of resource management, ordinarily unavailable in the applied science realm.

Author's Profile:

Shaleen Jain is an Assistant Professor of Civil and Environmental Engineering and a Cooperating Assistant Professor at the Climate Change Institute at the University of Maine. He completed undergraduate work at the Indian Institute of Technology and graduate work at Utah State University. His current research is broadly focused in the following area: Hydro climatology, Environmental Flows, Climate Variability and Change, Hydro systems Modeling, Adaptive Management and Decision Analysis.

Shaleen Jain gave a poster presentation on the similar topic at the National Academies during its Sackler Colloquia. The Arthur Sackler Colloquia of the National Academy of Sciences addresses scientific topics of broad and current interest, cutting across the boundaries of traditional disciplines.