



# **Data Drought:**

An Assessment of Global Hydrological Monitoring Systems

Convened by:

Duke University / The Aspen Institute /  
University of Oxford / Xylem

# Xylem: At a Glance



## WE ARE AN INDUSTRY LEADER WITH GLOBAL REACH ...

- Leading global water technology provider
- Unrivaled product portfolio with leading brands and solutions
- Approximately 16,000 global employees
- 300+ global locations; doing business in 150+ countries
- \$4.5 billion\* in annual revenues
- Provide solutions across the entire water cycle

**...UNIQUELY POSITIONED TO  
SOLVE OUR CUSTOMERS' CHALLENGES**

# Data Drought: Agenda

## **I. Overview of the Data Drought Challenge**

Albert Cho

Vice President, Strategy & Business Development, Xylem

## **II. Water Data System Gaps Analysis**

Alex Fischer

University of Oxford

## **III. Estimated Benefits from Investment in Water Data Systems**

Martin Doyle

Nicholas Institute for Environmental Policy Solutions at Duke University and The Aspen Institute

## **IV. Panel Discussion**

## **V. Q&A**

Greenland's ice sheet  
will be melting rapidly

Scandinavia/UK/Northern Russia/Greenland  
Compact high-rise cities would provide shelter for much of the world's population

Siberia  
Reliable precipitation and warmer  
temperatures provide ideal growing conditions  
for most of the world's subsistence crops

### Arctic passage

With no sea ice, this valuable shipping  
route is open all year, providing  
transportation links between  
habitable zones in Canada and Russia

### Canada

Reliable precipitation and warmer  
temperatures provide ideal  
growing conditions for most of  
the world's subsistence crops

### South-west US

Desertification led to the last  
inhabitants of this region  
migrating north. The Colorado  
river is a mere trickle. The  
land is used for solar farming  
and geothermal energy

### Peru

Deglaciation means  
this area is dry and  
uninhabitable

### Western Antarctica

Unrecognisable now. Densely  
populated with high-rise cities

### North Africa/Middle East/ Southern US

Solar Energy Belt stretches for thousands  
of kilometres, employing a mixture  
of photovoltaic and solar thermal  
energy. At frequent intervals a  
high voltage direct-current  
substation sends power north

### Amazon Desert

Africa  
Mostly desert, though  
some models show  
greening of the Sahel

### Patagonia

Melted glaciers revealed a  
new arable zone, although the  
poor soils needed preparation

### Southern Europe

Deserts have encroached on the  
continent, rivers have dried up and the  
Alps are snow-free. Goats and other  
hardy animals are kept at the fringes

### Asia

Most of the Himalayan glaciers  
have melted, with repercussions  
for many of the major rivers in the  
region. Bangladesh is largely  
abandoned, as is south India,  
Pakistan and Afghanistan. Isolated  
communities remain in pockets

### Southern China

Dried rivers and aquifers mean  
this region has been abandoned.  
Intense monsoons have helped  
erode the land, leaving a dustbowl

### Polynesia

Vanished beneath  
the sea

### Australia

In the far north and Tasmania,  
compact cities house people  
and crops are grown. The rest of  
the continent is given to solar  
energy production and uranium  
mining for nuclear power

### New Zealand

Unrecognisable. This densely  
populated island state has  
high-rise cities and intensive  
farming

# A robust water data system supports vital decisions

	Water Supply				Water Demand			
	1	2	3	4	5	6	7	8
Energy production	■	■			■			
Food production	■	■	■		■			■
Flood protection	■	■		■	■	■		
Insurance		■	■	■	■	■	■	
Water storage planning	■	■	■		■	■	■	■
Climate resilience	■	■	■	■	■	■	■	■
Water quality for human health		■	■		■	■	■	
Water quality for ecosystem health		■	■	■	■	■		■
Wastewater treatment		■				■	■	■
Infrastructure design	■	■	■	■	■	■	■	■

**Legend:**

- 1. Atmospheric, 2. Surface water, 3. Subterranean,
- 4. Oceanic, 5. Agricultural, 6. Industrial,
- 7. Domestic, 8. Environment

# A robust water data system is vital to SDG 6

Targets for SDG 6	Water Supply				Water Demand			
	1	2	3	4	5	6	7	8
<b>6.1:</b> universal and equitable access to safe and affordable drinking water for all							■	
<b>6.2:</b> access to adequate and equitable sanitation and hygiene for all							■	
<b>6.3:</b> improve water quality globally		■	■	■				■
<b>6.4:</b> substantially increase water-use efficiency across all sectors		■			■	■	■	
<b>6.5:</b> implement integrated water resources management at all levels	■	■	■	■	■	■	■	■
<b>6.6:</b> protect and restore water-related ecosystems		■	■	■				■
<b>6.a:</b> expand international cooperation and capacity building support	■	■	■	■	■	■	■	■
<b>6.b:</b> strengthen local communities for improving water and sanitation management	■	■	■	■	■	■	■	■

**Legend:**

- 1. Atmospheric, 2. Surface water, 3. Subterranean,
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# The Value of Water Information

**Do we have the right public water data infrastructure to support resilience and adaptation to a changing world?**

## **Change drivers**

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- Climate change
- Population growth and urbanization
- Economic growth
- Aging infrastructure

## **Data needs**

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- Dense
- Discoverable
- Accessible
- Reliable





# Global Water Information

Is the global network of rain, river and water quality in situ measurement stations sufficient for public data benchmarking?



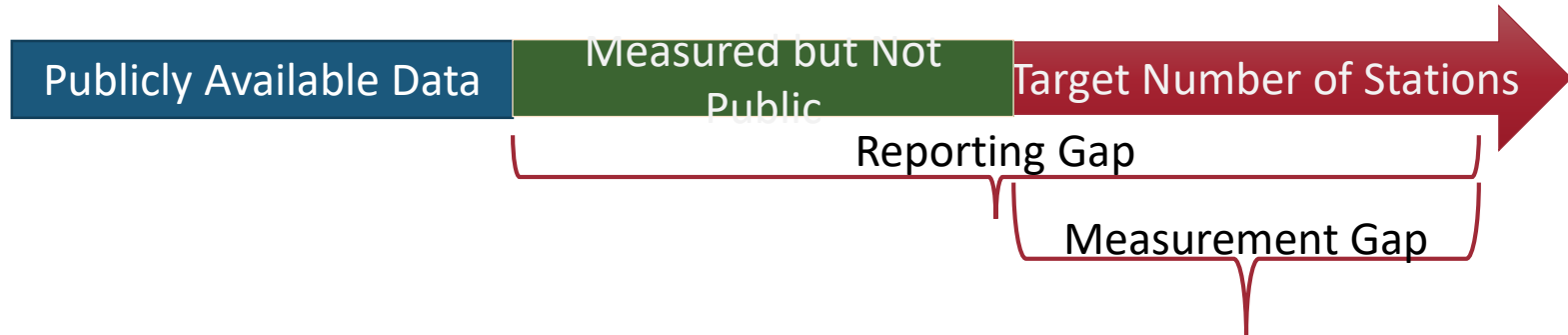
## What do we know about global monitoring?

Scientists, industry experts, and policy makers repeatedly state that there is an **insufficient and declining** availability of water information.

The exact gaps, reported decline and minimum target density for in situ monitoring stations have not been clearly defined.

Global and standardized databases for rain/climate, streamflow and water quality provide an initial basis for estimating global station coverage.

# How big is the gap?



- Reporting Gap:
  - The difference between the recommended stations defined by the 2008 WMO Guidelines and the number of stations being actively reported into the global databases.
- Measurement Gap:
  - The difference between the recommended station density defined by the 2008 WMO and the number of station estimated to be active through statistical models.

# Benchmarks for Minimum Station Density

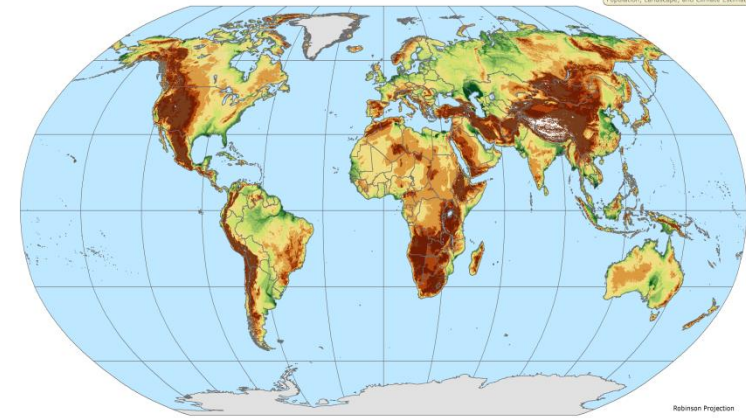
WMO's recommended minimum densities of hydrological stations

Physiographic unit	Description	Precipitation (Area in km <sup>2</sup> per station)	Streamflow (Area in km <sup>2</sup> per station)
Small islands	Island states or territories with area 500km <sup>2</sup> or less.	250	300
Coastal	Areas within 100km from the coastline.	9,000	2,750
Arid / Polar	Areas classified as 'Dry system' or 'Polar system' by the Köppen-Geiger climate classification system	100,000	20,000
Mountainous	Areas with elevation of 1,500m or greater.	2,500	1,000
Interior plains	Areas with elevation of 200m or less.	5,750	1,875
Hilly / Undulating	Total area not classified as Coastal, Mountainous, or Interior plains.	5,750	1,875

Source: WMO 2008.

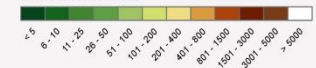
## Population, Landscape and Climate Estimates, v3: Elevation Zones, Global

National Aggregates of Geospatial Data Collection



Digital elevation data were obtained as a 1 kilometer resolution elevation/bathymetry raster product from ISciences, L.L.C. Elevation zones were created by aggregating ranges of land elevation values into 12 thematic elevation classes, as described below. ISciences' TerraVital product combines NASA's Shuttle Radar Topographic Mission (SRTM30) digital elevation data with bathymetric values to produce a seamless, globally consistent land elevation and marine depth layer. Gaps and voids in the original SRTM (v1) data were supplemented by elevation data layers from the NOAA GLOBE project to provide a high-quality global coverage of all land surface areas.

Meters above sea level:



Center for International Earth Information Science (CIEIS), 2012. The Trustees of Columbia University in the City of New York. Center for International Earth Science Information Network (CIESIN)/Columbia University 2012. National Aggregates of Geospatial Data Collection: Population, Landscape, and Climate Science Information Network. Database, Version 3 (PLACE III, Population, NY, NY). Metadata: Data and Applications Center (DAC). <http://datacenter.columbia.edu/datacenter/geographic-population-landscape-climate-estimates-3/>

Publication Date:  
May 2012

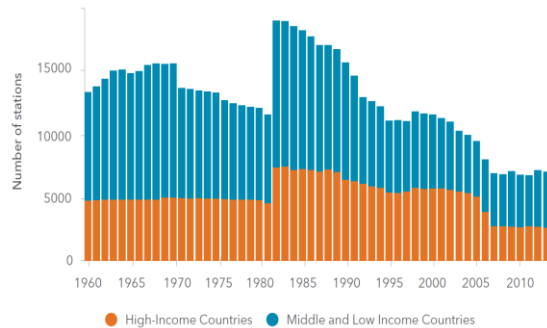


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# Trends From Public Global Databases | Declining Reporting

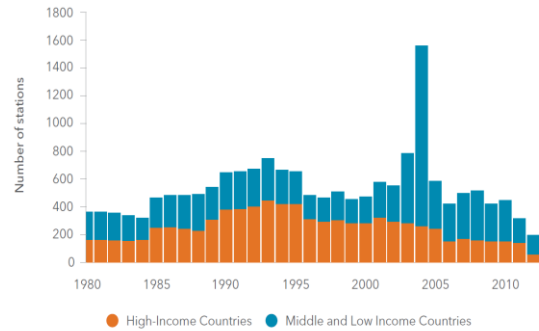
## Precipitation

Temporal distribution of global precipitation stations (NOAA's NCEP & NCDC, 1960 - 2013)



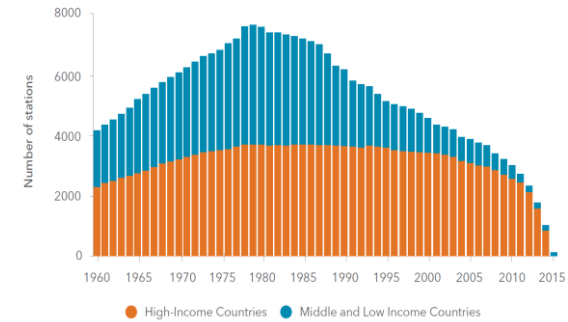
## Water Quality

Temporal distribution of global water quality stations (GEMS-Water 1980 - 2015)



## Streamflow

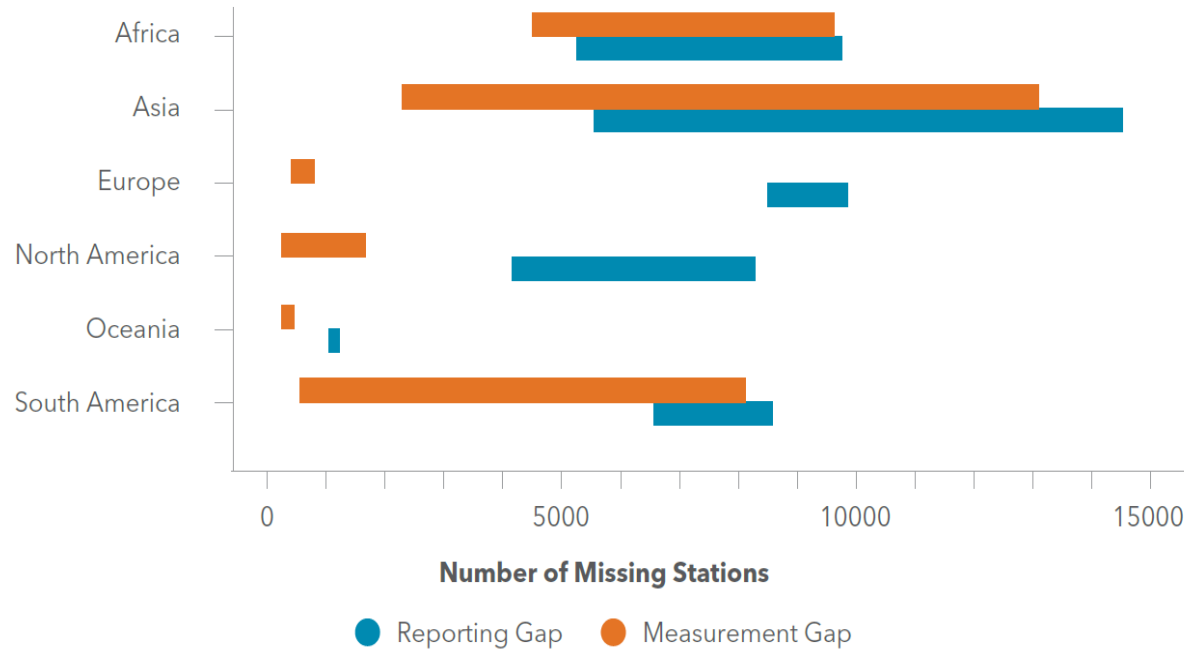
Temporal distribution of GRDC stations with river discharge data



# Reporting Gaps Assessment

	Station Reporting	Country Reporting	Reporting Gap
Streamflow (GRDC)	By 2010, stations decline 40% since peak reporting in 1979	Declined from 142 countries in 1979 to less than 40 after 2010	Gap of 30,938 to 52,058 in current global data base
Precipitation (NOAA)	By 2010, stations decline 31% since peak reporting in early 1980s	Over 180 countries reporting since the mid-1800s	Gap of 6,416 to 14,773 in current aggregated database
Water Quality Stations (GEMS)	By 2010, stations decline 41% since peak reporting in 1993	Total of 83 countries reporting since 1965, but only 16 after 2010	Not calculated as no targets by parameter.

# Measurement Vs Reporting Gaps for Streamflow Stations



Global Reporting Gap: Maximum of 52,000 stations.  
Potential Global Measurement Gap: Maximum of 33,000 stations

## Key Findings

### Reporting Gaps

- Continued declines in voluntary reporting and inconsistent temporal coverage of stations.
- Precipitation databases have the largest network of reported in situ stations.
- Water quality has the fewest reported number of stations.
- Reporting gaps are high for all regions.

### Measurement Gaps

- The gaps are smaller when estimating coverage of active stations.
- Measurement gaps remain most severe in low-income countries.
- Many climate and water quality stations are reported as existing but not sharing data.

# Acknowledgements

This work was done in collaboration with Marc Levy and Paola Kim-Blanco at the Center for International Earth Science Information Network, Earth Institute at Columbia University.



# The Value of Public Water Data



# Benefits of Public Water Data

Agriculture – improving irrigation decisions

Energy production – improving planning and real-time decision-making

Forestry – optimize operational decisions for harvesting

Manufacturing – increase efficiency through optimized recycling/reuse

Transportation – optimize shipping/logistics; increased use of water traffic

Tourism – river/ski forecasts; weather forecasts

Public safety – disaster preparedness

All in addition to public health, water service providers, and ecosystems



# Benefits of Public Water Data

The water sector—policy community, academia, private industry—has rarely quantified the economic benefits and costs of public water data

With unknown/unspecified and presumed benefits  
public sector has under-invested in water data



# ASPEN INSTITUTE DIALOGUE SERIES ON WATER DATA

Sharing and Integrating Water Data for Sustainability



## ABOUT THE DIALOGUE SERIES

### PURPOSE

The Dialogue Series focused on how to create a better water data infrastructure to access and connect publicly collected and reported sources for data starting with quantity, quality and use information.

### PARTICIPANTS

The Dialogue Series brought together a select group of 30 water experts, managers, policy makers, regulators, and representatives from the private and social sectors.

### PARTNERS

The Dialogue Series was convened by the Aspen Institute in partnership with the Nicholas Institute for Environmental Policy Solutions at Duke University and Redstone Strategy Group.

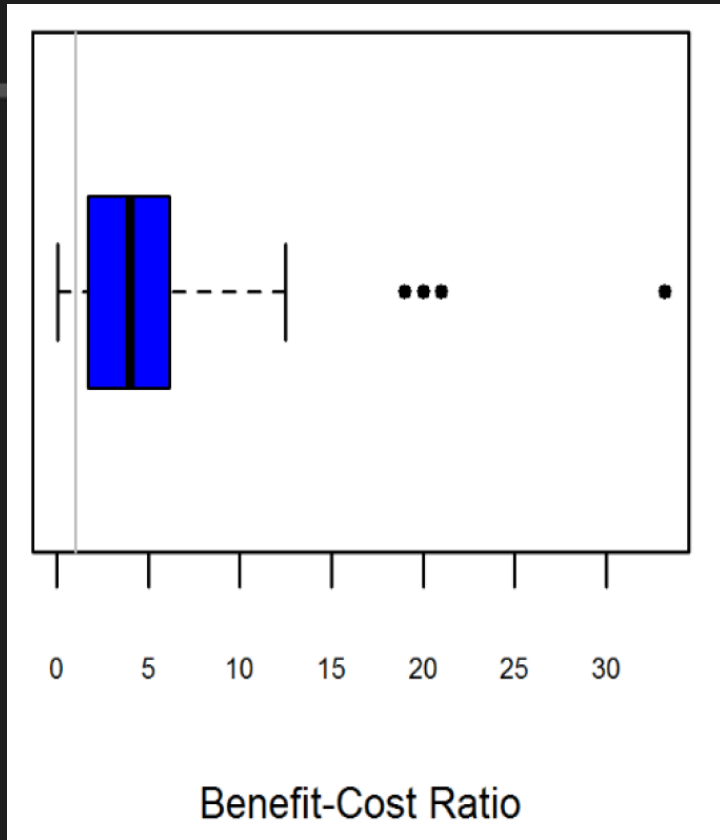
**REDSTONE**

  
THE ASPEN INSTITUTE

**Duke**  
NICHOLAS INSTITUTE  
FOR ENVIRONMENTAL POLICY SOLUTIONS 

# Key Findings from the Dialogue Series

- 1** Water is undervalued, water data even more so. The value of open, shared, and integrated water data has not been widely quantified, documented, or communicated.
- 2** Watershed management decisions are being made without adequate data. Making existing public water data open is a priority. There has to be data available for there to be sharing and integration.
- 3** The internet shares information between entities across the world, revolutionizing society. Similarly, developing an “Internet of Water” – a network of interconnected data producers, hubs, and users – could revolutionize how water is managed.



- 29 published studies of benefit-cost ratio of public water data
- Ranged up to 35
- **Median benefit-cost ratio ~4**

# Dialogue Recommendations

## ACTION 1

Articulate a  
Vision for  
Why Open  
Water Data  
are Needed

## ACTION 2

Enable Open  
Water Data

## ACTION 3

Create an  
Internet of  
Water

# Value of Water Data

We didn't know the potential value of digital road infrastructure data  
Until Google Maps, Waze, ....

If 'traditional' water data has 4:1 value, what might be value of 21<sup>st</sup> century version of water data?



A large, industrial-grade stainless steel fermenter or bioreactor is shown in a factory setting. The machine is cylindrical with a large circular opening on the left side, revealing a white mesh interior. It is supported by a metal frame. The background shows a warehouse with shelves and other equipment.

**Thank you**