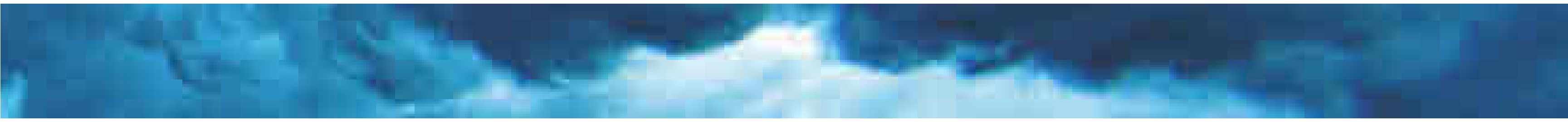
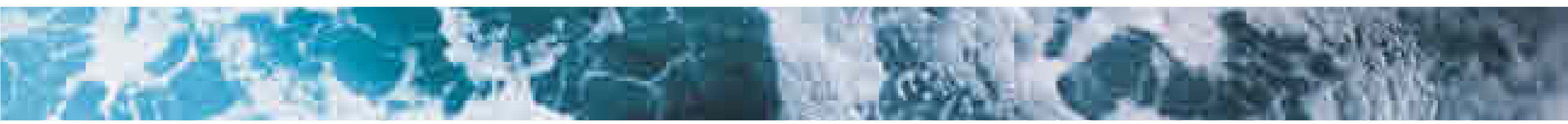
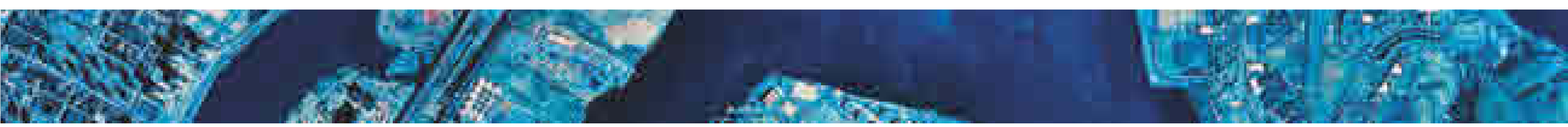
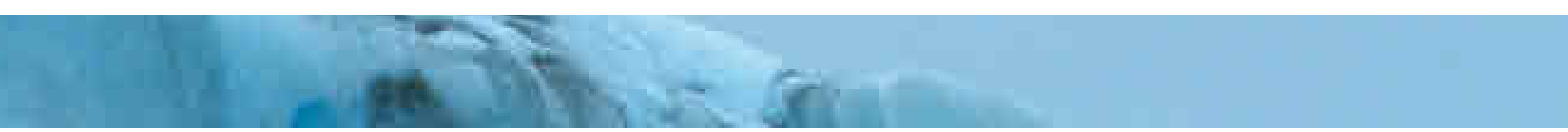


Water





A GLOBAL INNOVATION OUTLOOK REPORT



Water: A Global Innovation Outlook Report

WATER IS THE LIFEBLOOD OF THIS PLANET.

From the countless plants and animals that live in the oceans to the terrestrial species that drink the waters of our rivers, lakes and streams, all known forms of life require water to survive.

Humans, however, have a particularly complicated relationship with water. We rely on it for far more than simple sustenance. We generate power from it. We transport people and goods through it. We grow our crops with it. And we use it to cultivate medicine and manufacture products. In fact,

EVERY TIME A GOOD IS BOUGHT OR SOLD THERE IS A VIRTUAL EXCHANGE OF WATER.

For example, by some estimates it takes 246 liters of water to produce a kilogram of potatoes. It takes 10,855 liters to make one pair of jeans. And 378,500 liters are required to produce one average-sized automobile. This embodied water is known as “virtual water,” a measurement that attempts to calculate the net import and export value of water.

EVERY TIME WE INTERACT WITH WATER, WE CHANGE IT, REDIRECT IT OR OTHERWISE ALTER ITS STATE.

Though the total amount of water on this planet has never changed, the nature of that water is changing. Everything from where rain falls to the chemical makeup of the oceans is in flux. And these changes are forcing us to ask some very difficult questions about how and where we live and do business.

As a species, we have survived knowing very little about our water systems. We have always known where to find it and how to use it, but we never gained an intimate understanding of how to preserve or sustain these systems.

WE HAVE NEVER LEARNED HOW TO EFFICIENTLY MANAGE WATER.

But we will not have the luxury of this ignorance in the future.

RESEARCHERS, GOVERNMENTS AND BUSINESSES ARE CURRENTLY ENGAGED IN A MASSIVE GAME OF CATCH-UP

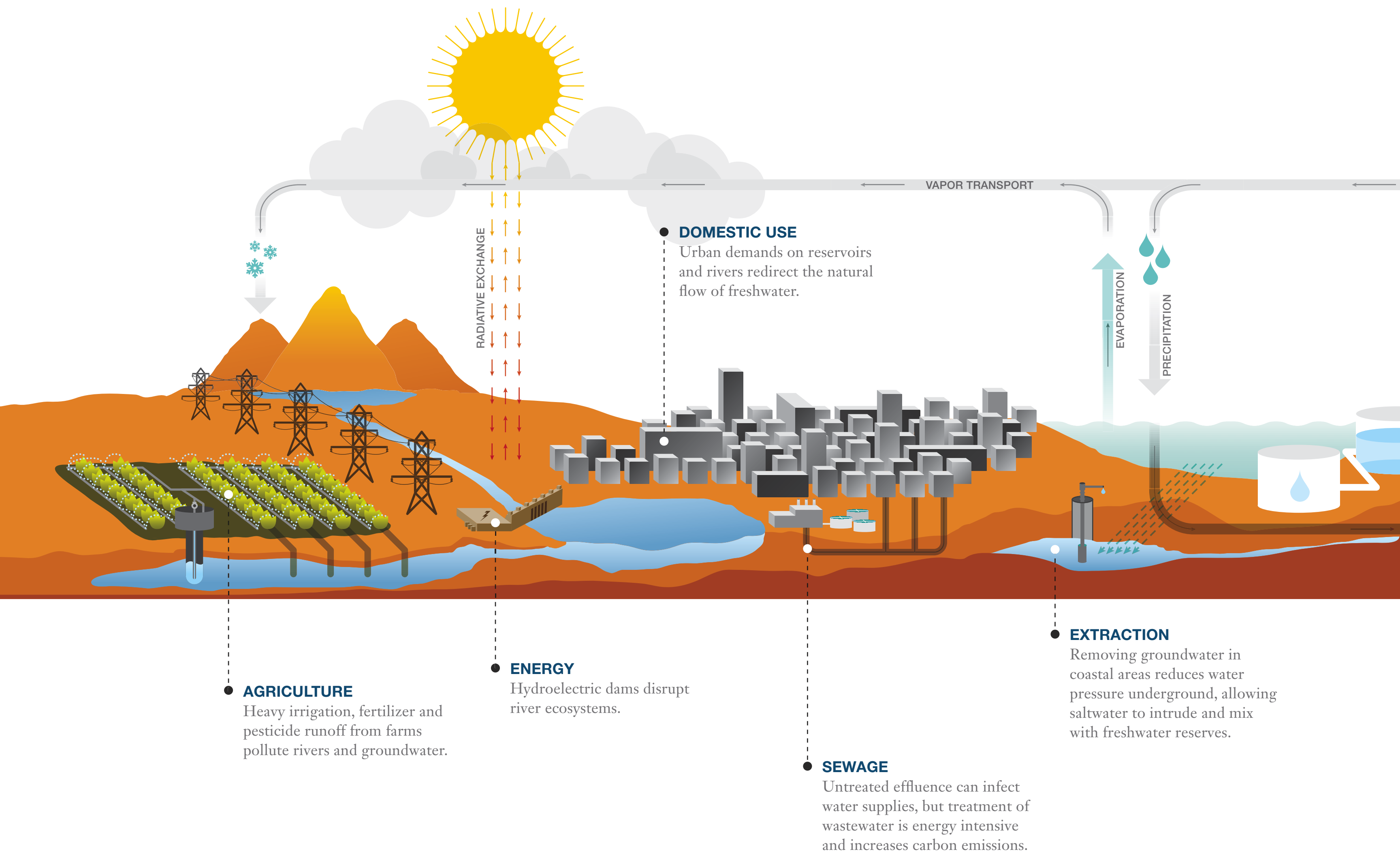
regarding water research. Some are trying to understand how the oceans sequester carbon dioxide. Others are looking at advanced water conservation techniques. And still others are studying how to more efficiently filter and treat nonpotable water for personal and industrial use.

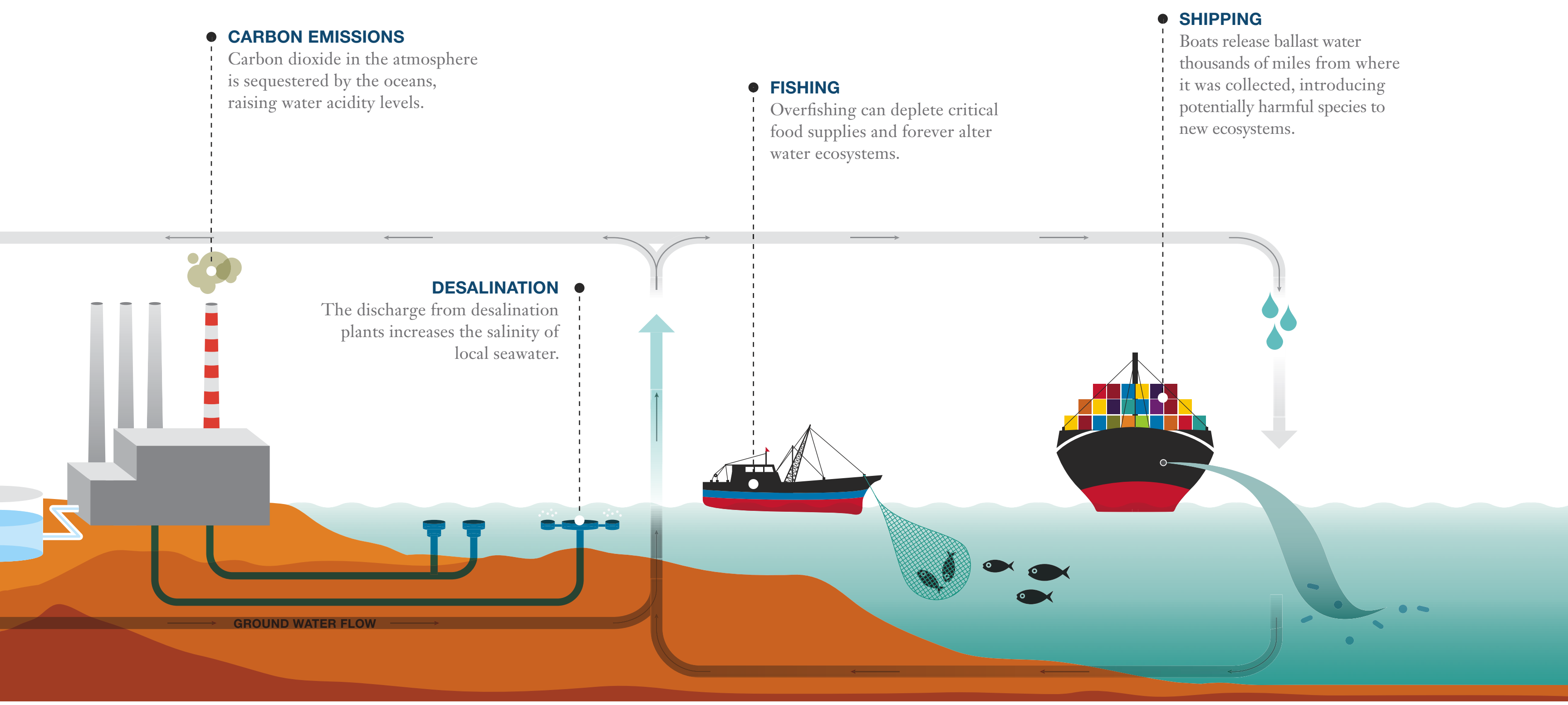
Throughout the course of the Global Innovation Outlook meetings on Water, IBM brought together hundreds of the world's leading water management experts—scientists, academics, businesses and governments—to share knowledge and combine resources. Many of the insights and recommendations from those discussions can be found in the pages of this report. As you read it, we encourage you to

CONSIDER THE WAYS WE CAN ALL BE SMARTER IN HOW WE USE, BENEFIT FROM AND PRESERVE THE WORLD'S WATER.

6.5 BILLION DROPS IN THE BUCKET

The hydrologic cycle has moved water around the world for thousands of years. But man's increasing interaction with that cycle has added several layers of complexity and consequence. Though the total amount of water on the planet will never change, each interaction with it potentially changes its direction, chemistry, usefulness or availability for some amount of time. All 6.5 billion people on Earth contribute to those changes.





GLOSSARY OF WATER TERMS

Acidification
The lowering of pH levels in the ocean, due to uptake of carbon dioxide from the atmosphere.

Aquaculture
The farming of freshwater and saltwater organisms under controlled conditions.

Blackwater
Domestic sewage and wastewater.

Carbon Sequestration
The removal and storage of carbon dioxide from the atmosphere, through natural or man-made means.

Catchment
The process of collecting and reusing rainwater.

Desalination
Any of the many processes used to filter salt and minerals from water.

Effluence
The discharge from industrial or domestic use.

Graywater
Nonindustrial wastewater generated through domestic use such as dishwashing, laundry and bathing.

Hydrologic Cycle (Water Cycle)
The natural process that moves water on, above and below the surface of the Earth.

Infiltration
The process by which water gravitates downward through soil.

Reverse Osmosis
A water-filtration method that forces water through a membrane to separate solute from solvent.

Saltwater Intrusion
When underground supplies of freshwater in coastal areas are invaded by seawater, usually due to over-extraction of coastal aquifers.

Transpiration
The evaporation of water from plant leaves, a process that triggers the absorption of water and nutrients up from the roots.

Virtual Water
A measurement of the amount of water used to produce a product.

DATA DROUGHT

Informing a new era of water management

For a species that prides itself on scientific discovery, we know startlingly little about the resource that is most crucial to our survival: water.

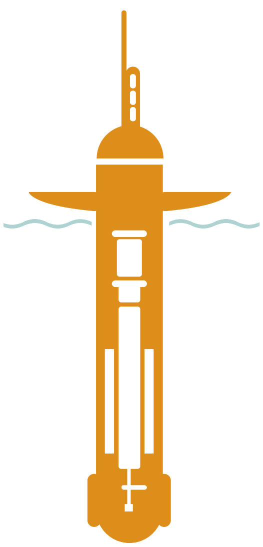
This lack of understanding applies not just to the layperson who unquestioningly consumes water. But also to the scientists, academics, businesspeople and policymakers who study water for a living.

"To make any progress, we experts must first admit our own ignorance," says John Cronin, Director and CEO of The Beacon Institute for Rivers and Estuaries. "We don't know enough about our oceans. We don't know enough about rivers and estuaries. We don't know where the fish are in real time or where they are likely to be tomorrow. The same is true for contaminants that threaten habitats or water supplies. We have to acknowledge these realities."

This urgent refrain was heard in every part of the world, from every type of professional. Groundwater, glaciers, river deltas and the deep ocean—every aspect of the hydrologic cycle is in critical need of purposeful data collection and analysis. Until that goal is achieved, management of fresh and oceanic water systems will continue to be inefficient and uncoordinated.

"You can't manage what you can't measure," says Doug Miell, a water resource management expert who advises the Georgia Chamber of Commerce on water policy. "We need all kinds of data collection, including real-time, because it is a lack of credible, available and viable data that is holding us back."

1. Measuring the Oceans



AUTONOMOUS FLOATS are able to sense currents, salinity and temperature 2,000 meters below the surface of the ocean. They automatically surface every 10 days to transmit data readings wirelessly.

If some scientists had their way, we would blanket the Earth with sensors, constantly culling data on everything from ocean temperature to air quality. And though this idea may seem impractical, it is nonetheless increasingly possible.

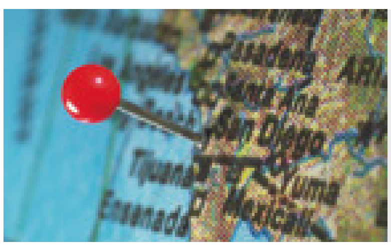
There are already many efforts underway to collect comprehensive data sets, some more ambitious than others. The Global Ocean Observing System (GOOS) is part of a massive, multi-country data-collection effort, involving satellite ocean topography, ships outfitted with sensors, water temperature buoys, and thousands of free-floating, untethered sensors bobbing up and down in oceans around the world, collecting data on currents, temperature and salinity. The information is critical for measuring changes in ocean climate, which affect everything from ocean life to shipping routes to weather patterns.

But experts worry that data-collection efforts that rely on government grants and nonprofit donations are not sustainable. "These programs need to continue for decades in order for us to see the patterns," says Dr. Tony Knap, Director and Senior Research Scientist at the Bermuda Institute of Ocean Sciences. "But governments are only in power for about four years. Priorities change. And these programs are big, international and expensive. It's going to take private sector involvement, in partnership with government and research institutions, to solve these problems."

In particular, Knap believes that data-gathering efforts must be part of revenue-generating, self-sustaining business models. In combination with government organizations, private companies can create markets with indefinite life spans, providing long-term incentives for the collection and use of data. For example, if carbon dioxide measurements can be taken by ocean sensors, the equipment could one day become a necessary part of a global carbon emissions cap-and-trade market. "The ocean is the place where the carbon dioxide will have to end up," says Knap. "And even a fraction of a percentage of each trade in a global emissions market would fund a global network of sensors."

> “You can’t manage what you can’t measure. We need all kinds of data collection, including real-time, because it is a lack of credible, available and viable data that is holding us back.”

Doug Miell
Water Resource Management Expert
Miell Consulting



San Diego has been living in drought conditions for more than a decade and imports 90 percent of its water from the Colorado River. It shares this water source with dozens of other communities, including the Imperial Valley region of southeastern California, one of the largest agricultural developments in the world.

REGIONAL VIEW:

San Diego GIO Deep Dive
September 18, 2008

32°72’N 117°16’W

POPULATION: 1,366,865

AREA: 372.1 SQ MI (963.6 KM²)

2. Sharing the Wealth

Not all data on water is expensive to collect. In fact, much of it already exists, in bits and pieces, all over the world. It just needs to be collected and coordinated.

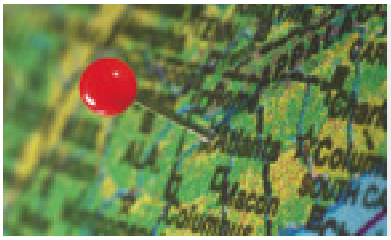
"You don't always have to start from scratch," says Sarah Das, Assistant Scientist, Geology and Geophysics, at the Woods Hole Oceanographic Institution. "There are databases everywhere; we just need a way to connect them."

It's an idea that GIO participants came to call the "grand bargain," in which academic and research institutions would partner with the private sector to collaborate on collecting and analyzing data. For decades, the private sector has collected data on water use in an effort to improve efficiency and reduce costs. These efforts, though costly, are profit driven and therefore sustainable.

But the academics and research institutions that could apply their analyses and insight to that information often struggle to fund their own data-collection efforts. Were the private sector to share its data resources with the academic community, both could benefit substantially.

In the past, competitive concerns, even among academics, have restricted the flow of information between organizations. But that is changing. The Beverage Industry Environmental Roundtable is a group of 12 international corporations in the beverage industry—including Diageo, Nestlé Waters, Anheuser-Busch InBev, The Coca-Cola Company and PepsiCo—all endeavoring to collect and share data and best practices around water conservation and resource protection.

"We needed to benchmark ourselves against similar industries," says Dr. Paul Bowen, Water Technology Director, Environment & Water Resources at The Coca-Cola Company. "So we tried to collect data. And we had some people that had no data, and some people who reported in liters per product, or gallons per dollar revenue, hectares, square feet, etc. There was no way to benchmark the data because it varied so much."



Atlanta has a population of more than 500,000 and has been under Level 4 drought restrictions mandated by the government for most of the last two years. These restrictions ban the use of water outdoors, among other things, and reduced water usage in the northern Georgia area by 1.8 million gallons a day.

REGIONAL VIEW:
Atlanta GIO Deep Dive
September 23, 2008
33°45'N 84°23'W
POPULATION: 519,145
AREA: 132.4 SQ MI (343 KM^2)

But in a year's time, the group had established a common framework whereby the companies could share information on water reduction, reuse, drought preparedness and water stewardship. "We talk the same language now," says Bowen. "We use the same metrics, and we're better able to communicate them to others outside the group." The next step is to invite academics, researchers and even governments to share in the process to get the most out of the data we already have.

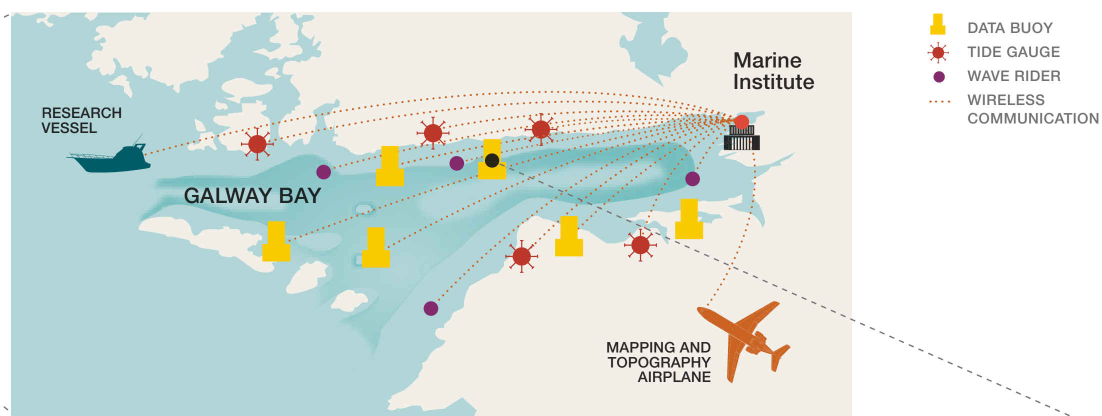
3. Making Data Pay

Some data has obvious business benefits. However, the return on much of the information collected for and about water management has often been unclear or difficult to justify, politically or economically.

But the gap between corporate strategy and social good has been narrowing of late. More than ever before, governments, businesses and nonprofits understand that their goals are aligned. And the value of data collection for all parties is increasingly obvious.

Nowhere is this truer than on the west coast of Ireland, in the county of Galway. The Marine Institute, Ireland's national agency for marine research, is working with IBM, Intel and other private sector companies to gain an unprecedented understanding of Galway Bay. The project, known as SmartBay Galway, will collect a steady stream of real-time data on water quality, aquaculture, chemical content, wave energy and tidal movement, all intended to inform and support not only major policy decisions, but also a host of industries in and around Ireland.

“These are novel areas of technology and business opportunity for Ireland and its partners,” says Eoin Sweeney, Manager of Marine Technology at the Marine Institute. Sweeney says the program will easily justify its own costs through the business return from fisheries, biotechnology, tourism and most important, alternative energy.



The information the SmartBay project collects will also be useful for shaping policy, of course. But the potential for economic return makes the program more palatable for both businesses and government, and allows for greater scope. “Without the benefit to industry, we would scarcely be able to embark on a program as ambitious as this,” says Sweeney.

SmartBay Galway

In Galway Bay, Ireland, data is collected from a variety of sources and used to inform a host of industries.

DATA COLLECTION:

- WEATHER DATA
- WATER DATA
- WAVE DATA
- TIDAL DATA
- CURRENT DATA
- SEA FLOOR MAPPING AND TOPOGRAPHY

RESTAURANTS

Fishing boats can communicate with local restaurants to inform them of when they will dock and with what catch.

AQUACULTURE

Farmers cultivating shellfish need information on salinity, temperature and water quality, especially harmful algae blooms that may threaten a crop.

ALTERNATIVE ENERGY

Energy companies are particularly interested in data on the potential energy in waves.

COMMERCIAL FISHING

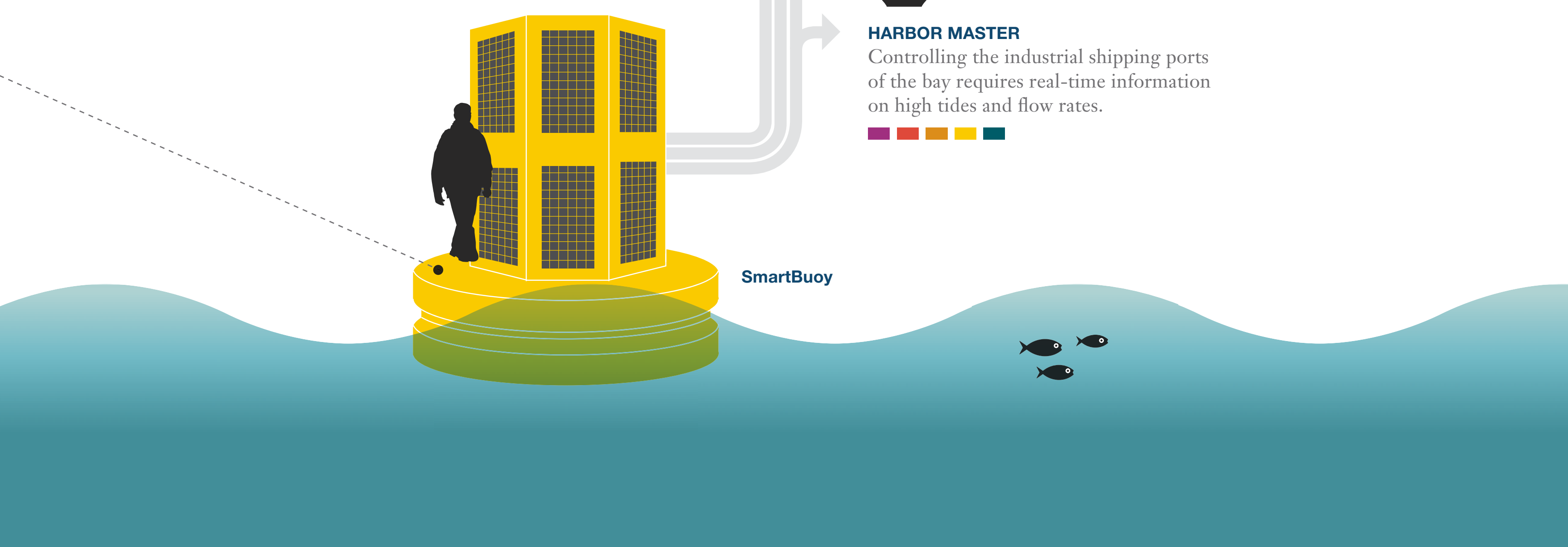
Fishing boats are mostly interested in weather and water-quality data, to better locate catches and ensure safety.

TOURISM

The Irish Water Safety Association can close beaches or alert lifeguards to dangerous water conditions, like jellyfish or rip tides.

HARBOR MASTER

Controlling the industrial shipping ports of the bay requires real-time information on high tides and flow rates.



Case Study:
The Beacon Institute for Rivers and Estuaries

The Hudson River, which courses 315 miles from the Adirondack Mountains of eastern New York down to the western shoreline of Manhattan, is among the most dynamic and diverse bodies of water in the world. For decades it was the primary trade route to the Midwest. It is used for drinking water, heavy industry, fishing, navigation and recreation. And its watershed is home to countless varieties of fish and as much as 5 percent of the human population of the United States.

Yet the study of this important river system has been limited, using data-collection methods that are sporadic at best. “If you are trying to manage a system that is changing dynamically, you need to work with data that is equally dynamic,” says John Cronin, Director and CEO of The Beacon Institute for Rivers and Estuaries. “You need to be able to monitor and observe the system in real time.”

To that end, The Beacon Institute is working with IBM to develop the River and Estuary Observation Network (REON), a system of sensors and observation platforms that will feed a constant stream of data to scientists and analysts. REON will measure and monitor chemical, biological and physical data throughout the Hudson ecosystem using a combination of floating platforms, submerged buoys, and even semiautonomous underwater robots.

The goal is to be able to understand, in real time, how the river responds to everything from storms to droughts to human interaction. With that information, a new level of eco-management would

1.3 MILLION

pounds of industrial waste known as polychlorinated biphenyls (PCBs) contaminated the Hudson River in the 1960s.

be possible. For example, industrial intake from the river could be better planned to coincide with optimal water conditions, like avoiding intake during the spawning season of critical endangered species. Or if man-made waste was polluting an area used for public drinking supply, appropriate action could be taken.

Cronin, a world-renowned conservationist for more than 30 years, says partnerships with the private sector are essential if we are to apply advanced technologies to environmental challenges; it is the new nature of the relationship between business and society. "It's foolish to keep the private sector at arm's length," he says. "Industry spends millions hiring and nurturing genius. That talent must be brought to bear on global environmental problems. Working with the private sector is just smart."

The Hudson River discharges

606

cubic meters of freshwater into New York Bay every second.

NEXT STEPS

The technology to measure, monitor and build intelligence into water systems of all kinds exists in abundance today. Far rarer are the business models that align profit with social benefit. Governments cannot bear the solitary costs of and responsibility for information gathering and analysis of these systems. The private sector has an unprecedented opportunity to explore the profitable collection and use of water data that has obvious secondary benefits to local communities.

THE BUSINESS OF WATER

Valuing the world's most precious commodity

Water has always been a critical component in the success of any economic endeavor. Virtually every manufacturing business relies on a steady supply of water.

The agricultural business would not exist without irrigation. And historically, the world's great centers of commerce have had two things in common: access to an abundance of freshwater supplies and proximity to water-based trade routes.

"It has been said that thirsty cities cannot grow," says Sharon Nunes, Vice President of Big Green Innovations at IBM. "And the same goes for businesses. If you don't have water, you don't have a business."

Despite this simple truth, the economics of water can be complex and confounding to most businesspeople. Whether you're building a business around it or attempting to invest directly in it, water often defies common business sense. "We've studied the relationship between the cost of water and its availability in a given area, and find almost zero correlation," says Jeff Fulgham, Chief Marketing Officer at GE Water & Process Technologies.

That is not to say there is no commercial opportunity in water, however difficult it is to identify. Business models and technologies built around cleaner, more efficient and more sustainable water are blossoming. And the most successful of these solutions help save both water and money.

1. The Paradox of Value

In many parts of the world, water is free. There may be costs associated with procuring, distributing and treating it. But the resource itself—arguably the most important resource on the planet—has no price. This contradiction is known by economists as the paradox of value (or the diamond-water paradox), in which the usefulness of a commodity has no bearing on its exchange value.

"A lot of investors tell me they want to invest in water," says Rod Parsley, a partner at Perella Weinberg Partners, a New York-based financial services firm. "I tell them, 'Okay, open up the paper and tell me where it's trading at today.' There is no market for water. And yet it is the world's most important commodity."

The question of whether water is a basic human right or a commodity in need of a market is not easily answered. It is a debate that is highly political and emotionally charged. Many believe that water is the same as food, a staple of life whose price should be controlled by market forces. Others believe water is like air: abundant, open to abuse and free to all. The truth is that water is somewhere between the two—free but costly to distribute and process.

One example of this is the "free water" that has been provided to villages across India. Experts point out that though the water is free, there are many opportunity costs associated with its procurement. Villagers can spend half a day traveling to a standpipe, waiting in line, and transporting the water back to their homes. Some of them need to do this every day.

That's why many GIO participants felt that without an accurate and fair pricing model to provide a monetary incentive for infrastructure build and efficiency of use, the issues of wastefulness, pollution and scarcity would never be mitigated. "The cheaper water is, the more we'll use," says David Zetland, an economist at the University of California, Berkeley. "But if we raise the price to where people start paying attention, individuals, farmers and businesses will quickly realize that the more water they use, the less profit they get from it."

> "A lot of investors tell me they want to invest in water. I tell them, 'Okay, open up the paper and tell me where it's trading at today.' There is no market for water. And yet it is the world's most important commodity."

Rod Parsley
Partner
Perella Weinberg Partners

Zetland advocates a tiered pricing model that doesn't preclude free rights to water. The model would assign each individual, business and farmer a limited "human right" allotment of water at no charge. As usage increases above that allotment, however, the cost quickly scales up, until the price eventually exceeds the value of the water and lowers demand for discretionary activities such as watering the lawn or washing the car.

A solution such as this could fund the infrastructure build needed to run pipes directly into people's homes. And it would require fairly sophisticated, real-time metering and billing technology. But it would have an immediate impact on water efficiency for two important reasons: 1.) It would raise awareness of usage patterns, and 2.) It would directly affect the bottom line.

Constantly under siege from three converging rivers prone to flooding and rising tides from the sea, Amsterdam survives using an intricate system of dikes, dams and canals that steer water in and around the urban area. The Netherlands is in the process of "climate proofing" itself for the next 200 years.

REGIONAL VIEW:

Amsterdam GIO Deep Dive

November 6, 2008

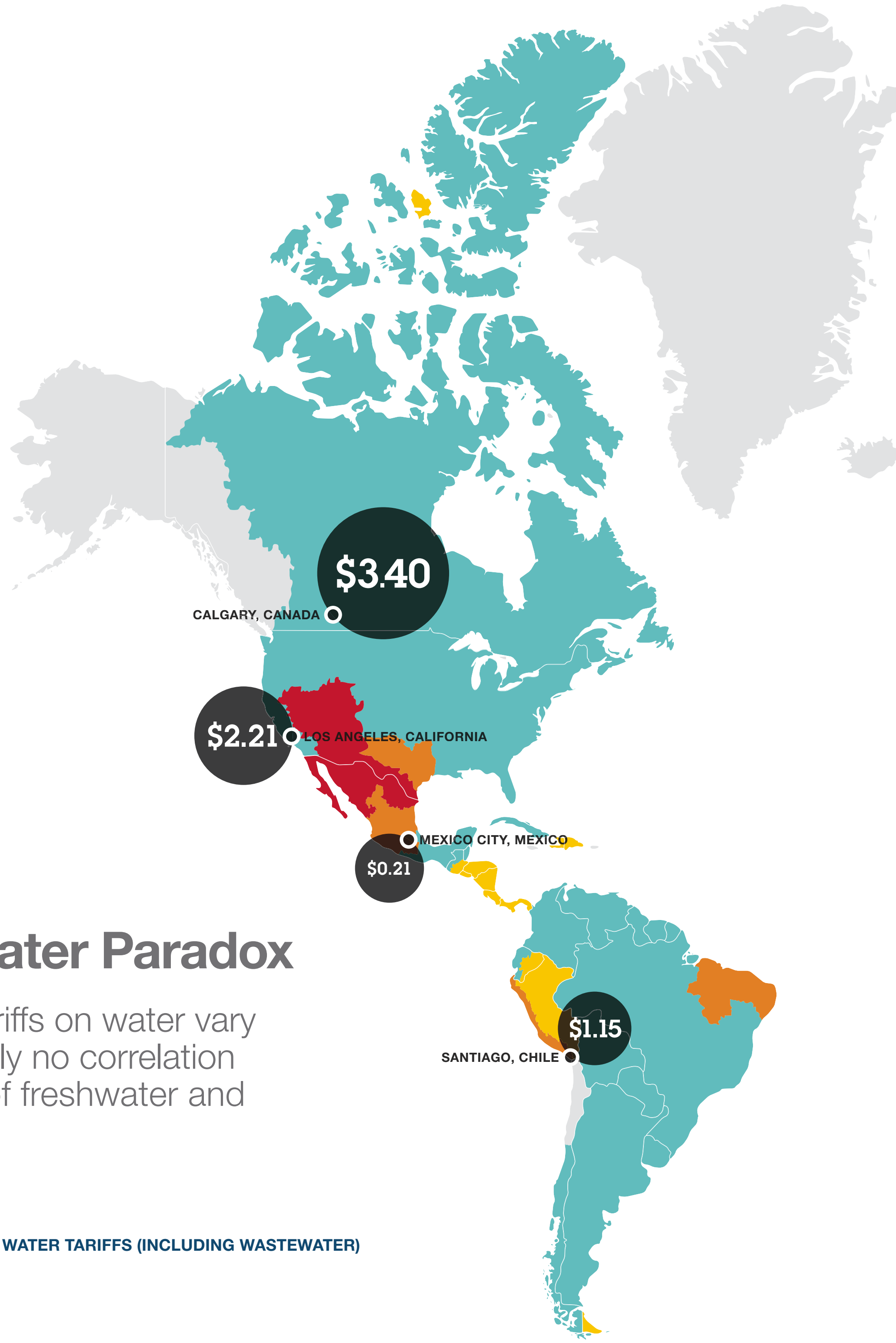
52°22'N 4°53'E

POPULATION: 755,269

AREA: 84.6 SQ MI (219 KM²)

The Diamond-Water Paradox

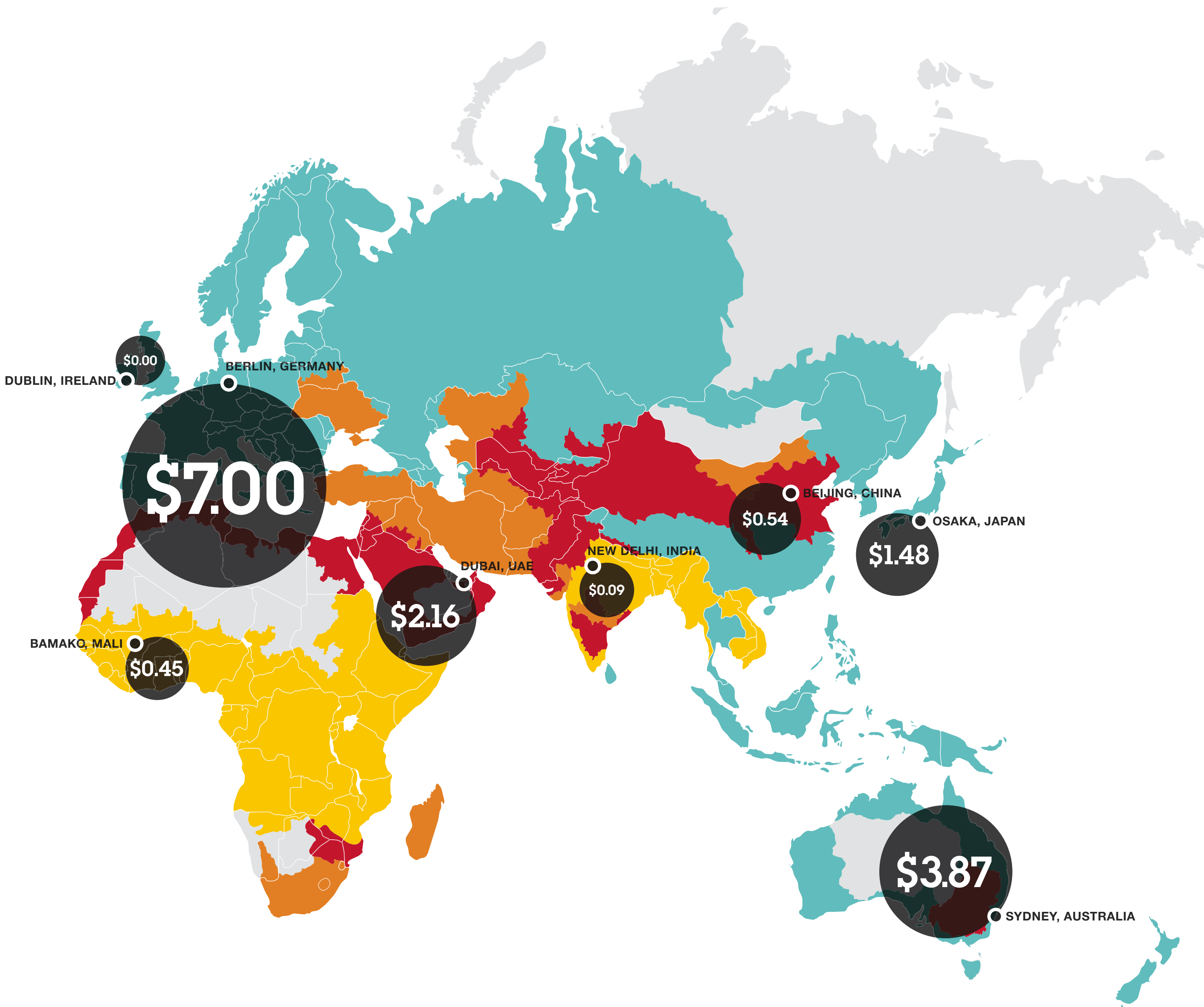
Throughout the world, tariffs on water vary wildly. And there is virtually no correlation between the availability of freshwater and its price.



2008 GLOBAL WATER SCARCITY VS. AVERAGE WATER TARIFFS (INCLUDING WASTEWATER)

- PHYSICAL WATER SCARCITY
- APPROACHING PHYSICAL WATER SCARCITY
- ECONOMIC WATER SCARCITY
- LITTLE OR NO WATER SCARCITY
- NOT ESTIMATED

Source: International Water Management Institute, Global Water Intelligence


$0.00
DUBLIN, IRELAND
BERLIN, GERMANY
$7.00
DUBAI, UAE
$2.16
BAMAKO, MALI
$0.45
NEW DELHI, INDIA
$0.09
BEIJING, CHINA
$0.54
OSAKA, JAPAN
$1.48
$3.87
SYDNEY, AUSTRALIA

2. Adventure Capital

The fact that water is not a commodity product is only part of the reason it's a tricky investment. Water is treated as if it is ubiquitous; it is often grossly undervalued and largely managed by governments. All of which means that the products and services that procure, process and supply water have yet to establish the kind of market that energizes investors and attracts capital.

"We need a Google of water," says Thomas Schulze, Chief Executive Officer of Cleantech Europe, a Munich-based venture capital firm. "We are still looking for that outstanding innovator, that brand that defines the sector and excites the market."

Despite this shortcoming, there are exciting technologies and opportunities emerging in water. Desalination, rainwater catchment and treatment, and industrial reuse are enjoying modest boom markets at the moment. But the technologies used in these applications are all designed to increase supply, an undeniably important part of the equation. Far more promising, both socially and economically, is the less-developed market for technology that decreases demand.

"We take a slightly different approach to investing in water, something we call demand-side investing," says Steve Vassallo, Principal at Foundation Capital, a California-based venture capital firm. "We look at using information technology, overlaid on our existing infrastructure, to help commercial and industrial customers save energy and use less water."

Vassallo believes that by making water systems smarter, for both domestic and industrial use, investors can make money and save water. This can be accomplished through careful metering and a regulatory environment that rewards conservation (similar to carbon trading or net metering for electric utilities). In the GIO deep dive in Atlanta, Vassallo introduced the idea of the "negaliter," which, like the "negawatt," would be a hypothetical, tradable unit of saved water.

"When you make an investment in the demand side, you improve the baseline for the next generation of infrastructure," says Vassallo. "It's the same with energy. You don't rip out your more efficient boiler when the price of oil goes back down below $40 a barrel. And we love that permanence you get from demand-side management."

> "We need a Google of water.
> We are still looking for that outstanding innovator,
> that brand that defines the sector and excites the market."

Thomas Schulze
Chief Executive Officer
Cleantech Europe

3. Industry and Water

Every business has a different relationship with water. Some use it to process raw materials and manufacture goods. Some use it to cool or clean equipment. And some use it as a central ingredient in the product they sell.

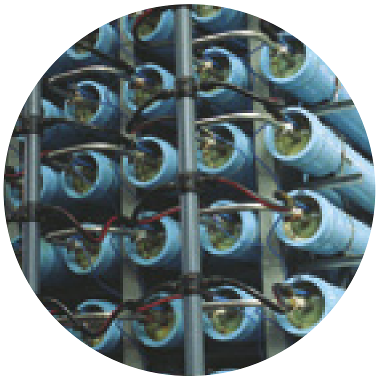
"Virtually every business has a water imperative," says Rod Parsley, a partner at Perella Weinberg Partners, a New York-based financial services firm. Many GIO participants felt the time had come for every company to appoint a Chief Water Officer. And some are convinced that soon all public companies will be required to disclose water efficiency in their annual reports. Consequently, most companies have begun to look more closely at their corporate water footprint. But perhaps none has looked closer than The Coca-Cola Company.

To say that Coca-Cola is sensitive to water issues is an understatement. The company uses about 300 billion liters of water a year, only 40 percent of which is contained in actual beverage products. It is headquartered in Atlanta, Georgia, an area of the United States with several water issues. And it is a member of nearly every foundation and nonprofit organization charged with reducing water use and improving water conditions around the world.

For years, The Coca-Cola Company has been in the vanguard of industrial use water. The company has squeezed every drop of water from its manufacturing processes. It harvests rainwater from the roofs of many of its plants for nonpotable use. It scrutinizes the sources of its water for products, analyzing the impact on local environments and populations. And now it is embarking on perhaps the most difficult of water management challenges: managing water throughout its lengthy supply chain.

Coca-Cola is working with the WWF to reduce the water used to produce the sugar, coffee and citrus contained in its products. Sugar cane is a particularly thirsty crop, requiring 12 months and 1 million liters of water to produce 12.5 tons of cane. So the first step is working with the WWF and a nonprofit group called The Better Sugarcane Initiative to establish standards, evaluate suppliers and set goals for the procurement of sugar.

"To support our society and economy, we have to extract water from the environment, which has an impact on people and nature," says Jamie Pittock, Research Associate at the WWF. "But we should do that transparently, and make explicit judgments about the economic production and the social benefits."



Case Study: The Dow Chemical Company

Way down on the southwest tip of the Netherlands, in the province of Zeeland, lays the small, water-stressed town of Terneuzen. The town is home to 55,000 residents, a major manufacturing facility for The Dow Chemical Company, and one of the most extraordinary public-private partnerships in the area of water management.

Approximately two years ago, Dow began working with town officials to treat and reuse municipal wastewater effluence. Working in conjunction with a local water company, Dow consumes 7,500 cubic meters of treated wastewater from the Terneuzen community every day. And the benefits of this arrangement are widespread.

In the past, the Dow facility in Terneuzen used desalinated water for its steam generation and industrial processes. Meanwhile, the municipal effluence from residents was treated and then released into the nearby Western Scheldt estuary. Today, the municipal waste—which is less expensive and requires 65 percent less energy to demineralize than saltwater—is treated using reverse osmosis and sent directly to the Dow plant for industrial use.

"Everyone benefits," says Peter Paul van de Wijs, Global Government Affairs and Public Policy Expertise Leader at The Dow Chemical Company. "The town gets its water treated, Dow has a less expensive source of industrial water, and a precious natural resource is being well managed."

Van de Wijs believes that the partnership Dow created with the municipality of Terneuzen can be easily duplicated throughout the world, and is working with the Zeeland Water Board and the Dutch central government to offer it as a solution to water-scarce regions.

Q&A

Peter Paul van de Wijs, Global Government Affairs and Public Policy Expertise Leader

The Dow Chemical Company

The Dow Chemical Company, a Global Innovation Outlook Partner, is a $54 billion company with more than 46,000 employees around the world. It uses water in its industrial processes and also makes products that distribute and treat water. Since 1995, the company has reduced the amount of wastewater produced per pound of product by 35 percent. And it reduced its freshwater intake by more than 55 billion gallons per year. Peter Paul van de Wijs, Global Government Affairs and Public Policy Expertise Leader at The Dow Chemical Company, answers our questions on the relationship between business and water.

Q What is industry's responsibility in the future of water management?

Water is the single most important chemical compound for the preservation of human life; it is also a key enabler of the creation of wealth. Yet today, billions of people and essential agricultural and industrial production processes are all impacted by water scarcity. Accepting that society and industry success are inseparably linked, industry has at least three key roles to play in water management: Optimize its own water use and minimize water pollution; create and improve technology solutions that are effective and commercially viable; raise awareness and share its knowledge globally.

Q How should each individual company, whether it consumes 300 billion liters of water per year or 300 liters, go about doing its part?

Any water management strategy of any company should be based on detailed knowledge of both its own water use as well as the local water situation (availability, quality and demands from other users). It should be driven by both a need to maximize water efficiency (and minimize costs) within the company as well as a desire to reach local sustainable water management targets.

Q How should the private sector engage with government and nonprofits to further good water management practices?

Private and public sectors simply have to work together. Today, availability, quality and security are all critical challenges to water. These issues are admittedly complex, but solvable. And that's why the solutions will require multiple types of stakeholders. The primary driver for success is the willingness of the private and public sectors to work together using an integrated approach that goes beyond technology to include the will and commitments of all stakeholders: Government must have the will to drive pragmatic, integrated policies that ensure affordable water across entire watersheds; society must have the will to conserve and reuse existing supplies; businesses must have the will to create technology solutions that solve problems and make economic sense.

Dow has reduced its wastewater per pound of product by

35%

NEXT STEPS

Many businesses are well aware that though water often has no price, procuring, processing and treating it can be very expensive. But without enabling all their business processes to collect accurate data on water use, like any other precious resource, they will not be able to manage costs most efficiently. Companies that analyze and understand both sides of their use and waste equation will achieve competitive advantages. Working with local water agencies to conserve and harmonize use in a way that protects the resource and reduces costs is one way to accomplish this.

THE INFRASTRUCTURE IMPERATIVE

Managing water for the next generation

Whether you live in a part of the world with too much or too little water, the challenges and costs of managing that supply are significant.

And the majority of those costs go directly to building and maintaining water infrastructure.

"We're facing a triple threat in terms of water supply," says Laura Shenkar, Principal at The Artemis Project, a San Francisco-based investment firm that specializes in emerging opportunities in water management. "We've got scarcity and floods, climate change and a total breakdown of infrastructure."

Expensive, difficult to maintain and politically unpalatable, infrastructure is the water imperative that's most easily ignored. Water infrastructure is three times more expensive to build and maintain than electricity infrastructure. Much of it runs underground, out of sight of the average consumer. But neglecting it can be even more costly. In some cities 15 to 20 percent of water is lost to leaks. In developing countries, it's worse.

"Latin American cities lose from 30 to 35 percent of the water that comes into the network," says Adalberto Noyola, Director at the Instituto de Ingenieria, Universidad Nacional Autónoma de México. Sprawling cities, old infrastructure, excessively high water pressure in some points and inaccurate system maps all contribute to the loss, says Noyola. "This water is not reaching the consumers, and it is an enormous loss for water utilities."

Building and repairing water infrastructure is disruptive, inconvenient and time-consuming. But it must get done. And there are many opportunities to not just fix or rebuild existing infrastructure, but to do it better and smarter, adding intelligence and instrumentation into the systems.

1. Urban Outfitting

For better or worse, the world's cities are growing in both popularity and population. In 1900, only 13 percent (approximately 220 million) of the world's population lived in urban environments. By 2030, it is expected that 60 percent of the world's population, or nearly five billion people, will live in cities, putting an overwhelming strain on already overburdened water infrastructure.

"People are flocking into the cities because of better job prospects and the promise of a more exciting life," says Chee Kiong Goh, Director of Cleantech at the Singapore Economic Development Board. "To many of them, it doesn't matter even if the cities are overcrowded and polluted…they're coming. So we need to provide solutions to address urbanization."

Some of the solutions for solving urban infrastructure problems are simple and decidedly low-tech. Because water is not the only utility that will need to be modified to accommodate the urban influx, it makes sense that electricity, telephone, gas and water utilities should work in concert and share the costs of retrofitting infrastructure. "When one utility digs up a street to upgrade its infrastructure, all of the other utilities that share that underground space should take the opportunity to upgrade their own infrastructure," suggests Larry Hirst, Chairman of IBM Europe, Middle East and Africa.

In addition to common sense, technology will play an important role in supplying water to the billions of future urban dwellers. So-called "green cities" are springing up across Asia, Africa and the Middle East. Many of these eco-friendly developments are being built in water-scarce areas, and therefore employing some highly advanced water management practices.

Alongside solar power, wind turbines and energy-efficient buildings, these smart cities will include dew catchers, rainwater harvesting, low-energy desalination and electronic sensors to detect leaky pipes. Graywater will be used to water urban crops, grown in vertically stacked high-rise plots, and the water that is not used by plants will be recovered and reused.

These cities also must build in a certain degree of flexibility to account for nascent technology that may require additional development, like setting aside space for algae ponds for biofuel production. Green cities are part residential, part experimental. But the hope is that the technologies employed and lessons learned will provide substantial benefit to other cities, both developed and developing, around the world.

Rio de Janeiro has an abundance of freshwater reserves, but struggles with infrastructure challenges, particularly in the “favelas,” or slums that line the hillsides of this seaside city. Illegal tapping, leakage and sanitation issues plague low-income communities throughout Brazil.

REGIONAL VIEW:

Rio de Janeiro GIO Deep Dive

November 11, 2008

22°54’S 43°11’W

POPULATION: 7,145,472

AREA: 486.5 SQ MI (1,260 KM²)

Smarter Cities, Smarter Water

Cities must simultaneously address increasing populations and deteriorating infrastructure. Here is a sampling of some of the techniques and technologies they will use to manage water procurement, distribution and treatment.

1

SOLAR POWER AND WIND POWER

Renewable energy is a critical part of water management because considerable energy is required for desalination and wastewater treatment.

2

RAINWATER COLLECTION

Storm runoff can be collected at the individual or municipal level. The rainwater can be treated and used for industrial and domestic use, or used to recharge stressed groundwater reserves.

3

DEW HARVESTING

Condensers and dew catchers have the potential to significantly add to freshwater supplies in arid regions.

4

URBAN AGRICULTURE

Using graywater, hydroponics and farming plots that are stacked vertically, cities can grow significant amounts of food without using excessive water or land.

5

DESALINATION

Though still too energy-intensive to supply an entire city, desalination will continue to be an important source of freshwater for coastal areas.

6

SMART METERS

By monitoring real-time water use—even at the individual level—cities can gain a greater understanding of water use patterns and build awareness around conservation.

7

PIPE SENSORS

Acoustic sensors equipped with GPS can locate even the smallest of leaks before major water losses occur.

2. Sense and Respond

Engineers know that many of the world's water pipes have fallen into disrepair. They just don't know which ones.

"Usually municipalities estimate how many pipes need replacing, based on age, soil type, load history and incident statistics. But the actual condition is mostly unknown," says Helge Daebel, Technology Specialist at Emerald Technology Ventures in Zurich. Emerald recently invested in a company that does electromagnetic and acoustic pipe inspection—The Pressure Pipe Inspection Company Ltd.—and often finds that only 4 percent of aging pipes really need to be replaced. The rest can be repaired or reinspected years later. "Helping decision-makers better plan their expenditures is hugely valuable," says Daebel.

Leak detection and automatic repair substantially reduce the cost of retrofitting aging water infrastructure. It used to be that leaks and breaks were identified only after water poured out of the pipe and into the street. But borrowing heavily from technology that has been used in the oil and gas industry for years, leak detection and auto repair make finding and fixing leaks smarter and more efficient.

Using sophisticated acoustic sensors, the city of Boston has been able to save more than three million gallons of water a day by detecting leaks early. The technology ranges from stethoscope-like devices that are pressed against the asphalt to hear leakage, to miniature sensors that are inserted into the water mains, flow with the water over long sections of pipe, and hear leaks as small as a quarter of a gallon per hour. These sensors can pinpoint the exact location of the leak and even contribute to more up-to-date maps of the piping system.

Larger leaks will always require excavation, but some of the smaller leaks may be able to take advantage of new repair technology. Yorkshire Water, a private water company in the U.K. that manages more than 40,000 miles of water and sewer mains, is testing a new technology that works like blood platelets sealing a wound. The material is injected into a pipe and collects around leaks as large as 50 millimeters in diameter.

There are millions of miles of water pipes around the world, many of which are more than 100 years old. But with a thoughtful combination of planning and new technology, maintenance and repair of water infrastructure could take a quantum leap.

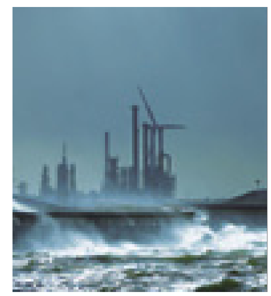
3. Climate Proofing

While most water infrastructure projects endeavor to supply people and businesses with more water, some have quite the opposite agenda. Experts estimate that about half of the world's population, or about three billion people, live in low-lying coastal areas and cities that are vulnerable to river flooding and storm surge. And global warming and rising sea levels are quickly rendering traditional flood defenses for these areas insufficient.

Perhaps no area is more familiar with flooding than the Netherlands. Nearly 60 percent of the 16 million residents of the country live at or below sea level. It is built largely upon land reclaimed from the deltas of three major rivers: the Rhine, the Maas and the Scheldt. And for 2,000 years, the Dutch have been developing, refining and exporting their mastery in managing an overabundance of water.

Recently the Netherlands embarked on a massive effort to "climate proof" the entire country. In 2007, the Dutch parliament approved a 100-year infrastructure plan at a cost of $1.5 billion a year to extend the coastline, reinforce dikes and build more huge storm barriers like the behemoth Maeslant Barrier that protects Rotterdam. The government is also exploring the possibility for floating communities—including residences, farms and industries that would be able to bob atop rising flood levels—as well as ceding huge swaths of land back to the water by lowering and removing some dikes.

The Dutch are already building a global export industry around advising other low-lying cities on flood control. Rising sea levels and unpredictable weather patterns will only increase the need for these kinds of services.



MAESLANT BARRIER
Protecting Rotterdam from floods is the Maeslant Barrier, one of the largest moving structures on Earth.

Case Study:
Durban, South Africa

The city of Durban, on the northeast coast of South Africa, is home to some 3.5 million citizens that range in socioeconomic status from extremely wealthy to desperately impoverished. And all of them have been promised free, basic water by the municipal government.

"We have a developed and developing world mix here," says Chris Buckley, Leader of the Pollution Research Group at the University of KwaZulu-Natal Howard College Campus. "But it's the previously unserved together with the rural urban drift and large informal population that create some real challenges around water and sanitation."

To solve these problems, Durban has instituted some forward-thinking solutions with the potential to revolutionize water and sanitation infrastructure in developing countries. All households are allotted 300 liters of free, basic water per day. In some parts of town, the water is delivered in the middle of the night through a system of pipes, water meters and tanks with automatic valves designed to operate at low pressure.

"The city had to challenge the criteria for delivering water," says Buckley. Traditionally, water pressure and capacity in urban pipes are designed to enable fire-fighting. But the greater the pressure, the greater the flow. Reducing the pressure in the piping system reduces the flow of water through leaks. The holes do not become bigger. When the water pressure in these residential areas is reduced, "we get less leakage and less expensive infrastructure," says Buckley.

To handle the wastewater in these communities, Durban has installed more than 60,000 urine diversion toilets. The toilets have two chambers that keep

Each household in Durban is allotted

300

liters of free basic water per day.

yellow waste separate from black waste. The urine requires no water for flushing, and can be collected and later used for fertilizing urban crops (urine is sterile and high in phosphorous and nitrogen). In addition, the city services about 60,000 ventilation improved pit (VIP) latrines, which can store black waste for up to five years before requiring emptying. This material is being evaluated for use in urban agroforestry.

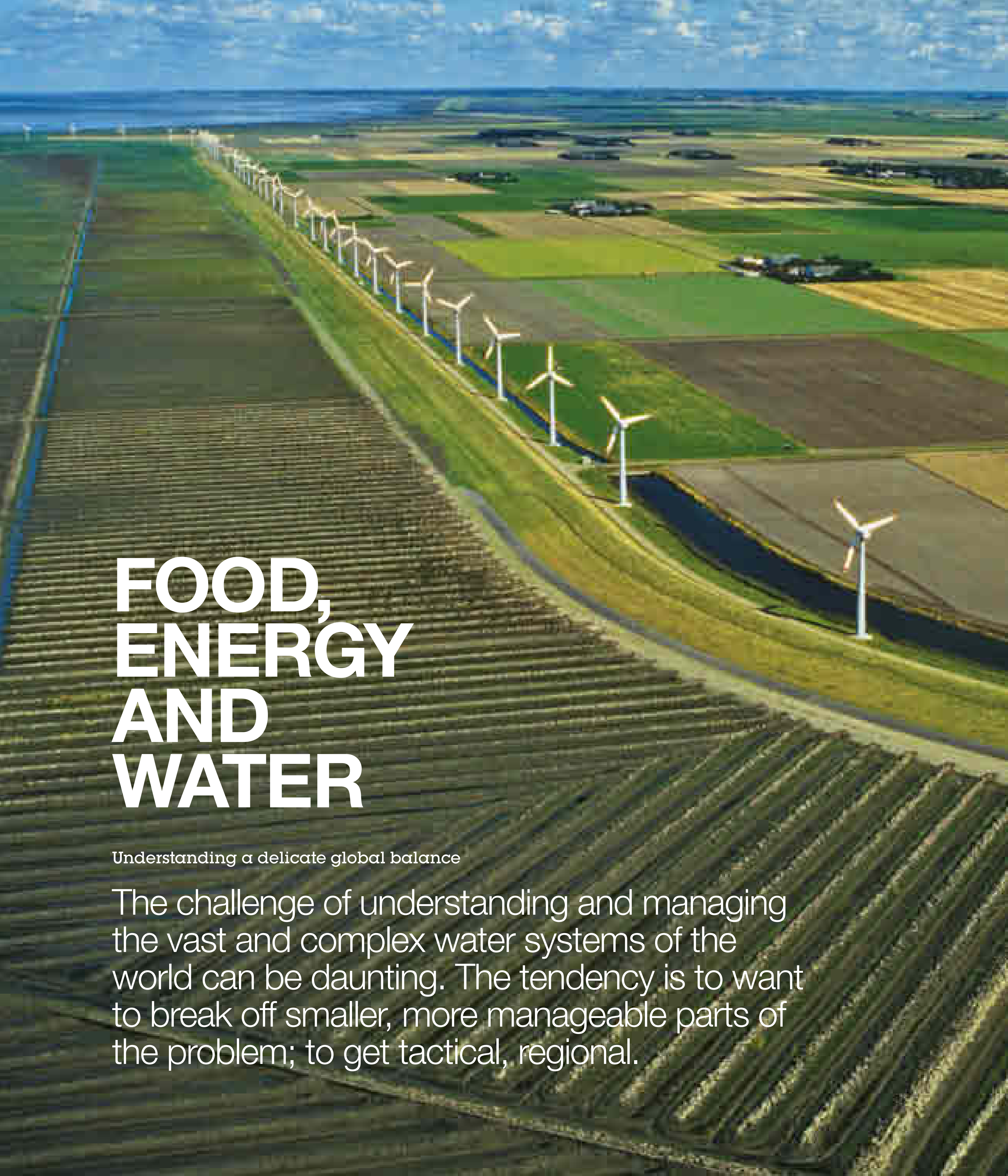
"I don't pretend that we have all the answers yet," says Buckley. "But we're providing basic sanitation, reusing the nutrients in the waste, and trying to make the provision of water and sanitation an opportunity and not a financial millstone."

60,000

urine diversion toilets have been installed throughout the city.

NEXT STEPS

Whether upgrading old infrastructure or building new, thoughtful planning and coordination is an essential first step. Municipalities must improve the monitoring, mapping and measurement of existing water systems, thereby informing decision-making and prioritization. In addition, water infrastructure upgrades must be coordinated with other infrastructure projects, including utilities upgrades, roads and highways, and wastewater and sanitation.



FOOD, ENERGY AND WATER

Understanding a delicate global balance

The challenge of understanding and managing the vast and complex water systems of the world can be daunting. The tendency is to want to break off smaller, more manageable parts of the problem; to get tactical, regional.

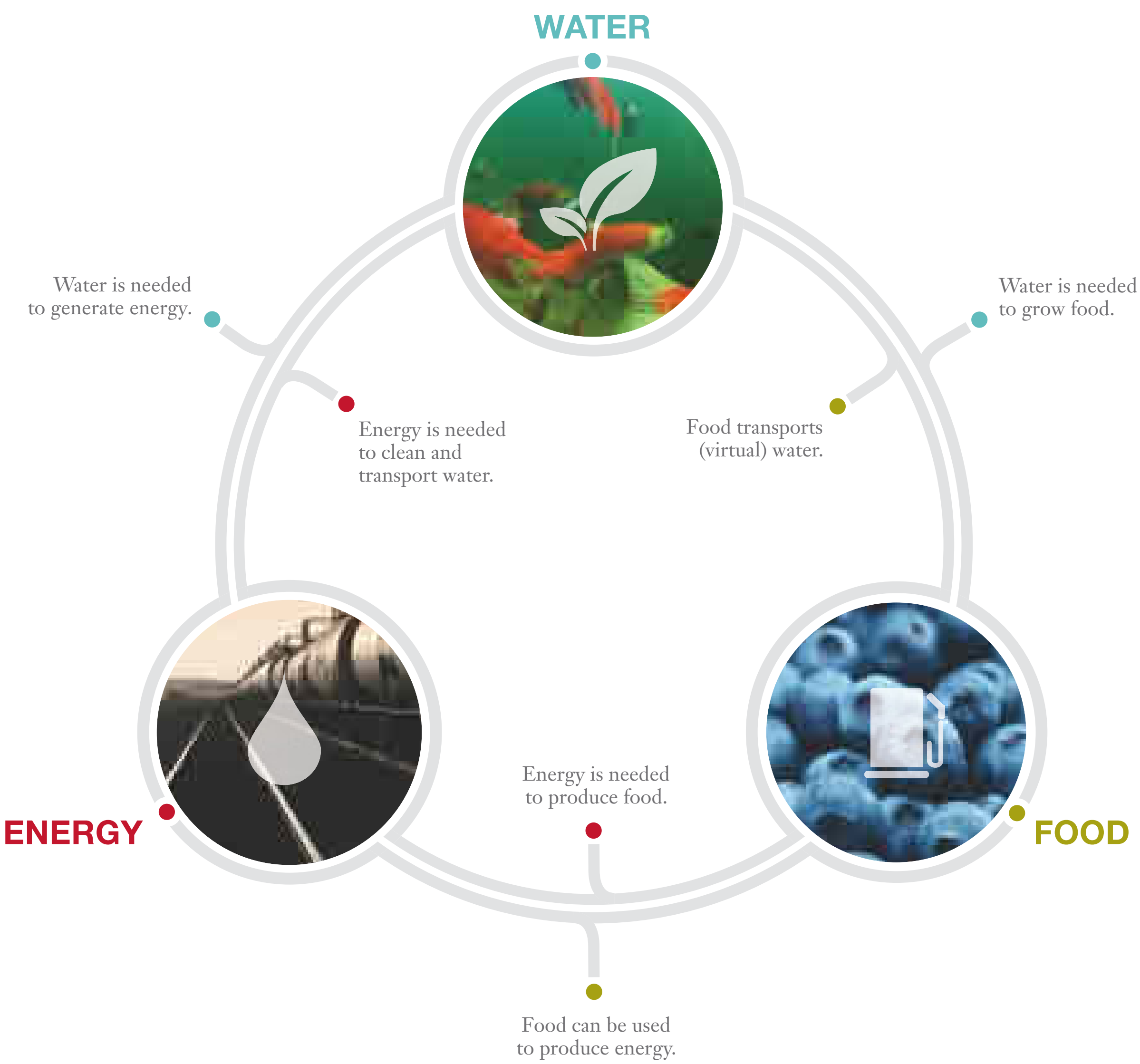
And though water is undeniably an issue that must be addressed at the local level, GIO participants were adamant that the scope of this challenge must also be widened to include the many other vital systems that water affects.

"We have to start addressing these systems—water, energy and agriculture—in a more strategic and integrated way," says Joppe Cramwinckel, Sustainable Development Lead at Royal Dutch Shell. "We need to use a broader perspective."

This broader perspective is known as "integrated resource management," and it requires a truly global approach to managing the planet's food, energy, water and even climate. Make a local change to one of these systems and consequences will be felt throughout the global chain. For example, freshwater can be produced through desalination, but it consumes a great deal of energy, which negatively affects the climate. And energy can be produced from biofuels, but that can strain global food supplies and requires large quantities of water, and so on (see chart, next page).

"These are not separated systems, and we have not been looking at them in an integrated way," says Mike Saunders, Director of the NUS Environmental Research Institute (NERI) at the National University of Singapore. "We need to connect all the dots, and start treating these problems in a holistic way."

A Delicate Balance



1. More Crop Per Drop

Nearly 80 percent of the freshwater resources available to people around the world are used to grow food. Farmers are often given first priority to municipal water supplies and their water costs are commonly subsidized by governments. But waste is rampant. The WWF estimates that the global agricultural industry wastes nearly 60 percent of the 2,500 trillion liters of water it uses each year.

"In all cultures we value the farmer in a very special way," says Laura Shenkar, Principal at The Artemis Project, a San Francisco-based investment firm that specializes in emerging opportunities in water management. "So we have not forced them to take on new technology, implement conservation capabilities and optimize the amount of land and water it takes to produce calories."

Today there is an abundance of technology and techniques available to help farmers to reduce this waste (see Case Study: Israeli Agriculture, page 48). But one of the most basic and effective things that farmers can do is match their crops to their climate. Every crop requires an ideal mix of temperature, soil, sunlight and water. Those criteria, however, do not always dictate what is grown where.

About 30 years ago, Saudi Arabia launched a program to encourage local farmers to grow wheat by guaranteeing purchase at nearly $1,000 a ton (almost three times the global price at the time). Wheat is one of the thirstiest crops, requiring about 1,300 liters of water to produce one kilogram. Despite the extreme heat and aridity of the Arabian Peninsula, the program was a success, generating enough wheat to supply the entire country and have some left over for export.

Earlier in 2008, however, with its underground water supplies dwindling, the Saudi Arabian government began decreasing its subsidies of wheat farming, and ultimately announced its intent to eliminate wheat production entirely by 2016. The country will eventually import 100 percent of its wheat and wheat products. Of course, this requires the shipping of food from abroad, which has energy implications of its own. This is just the first of many difficult tradeoffs governments and farmers will be forced to make in the coming years, and these decisions should not be made without a well-researched model of the implications for each of the food, energy and water systems.

"In dry parts of the world, the water that goes to producing thirsty crops like sugar cane or cotton needs to go to more economically valuable products," says Jamie Pittock, a Research Associate at the WWF. "So countries need to consider how much crop per drop they are really getting."

2. Ocean Source

As global population soars, food, energy and freshwater are increasingly scarce. Though it is clear that each of these resources can be produced and managed more efficiently, it is equally obvious that we must identify new sources of supply as well. To many, the answer is all around us.

"There are huge opportunities in the ocean," says Dr. Tony Knap, Director and Senior Research Scientist at the Bermuda Institute of Ocean Sciences. "From wave power to new organisms that could be used for pharmaceuticals or biofuel. It's all there."

It is tempting to look at the ocean as the answer to all our problems. Energy is already being harvested from its waves and currents, freshwater is widely produced through desalination, and aquaculture is a rapidly developing field. But without a thoughtful and integrated approach to these pursuits, even a resource as vast and abundant as the ocean can sour.

"There are huge opportunities in the ocean. From wave power to new organisms that could be used for pharmaceuticals or biofuel. It's all there."

Dr. Tony Knap
Director and Senior Research Scientist
Bermuda Institute of Ocean Sciences

"The big problem is that if we take everything out of the ocean that we like, and we throw everything into it that we don't like, we will turn this ecosystem of clear water and large animals into a soup of microbes and jellyfish," says Enric Sala, a Fellow at National Geographic Society. "We must be careful not to change the chemistry of the water."

In some locations this is already happening. Oceans have long been naturally sequestering carbon dioxide from the atmosphere. But the increase in carbon emissions in recent decades is causing the pH level in the water to drop, resulting in something called "ocean acidification." And widespread desalination along coastal regions can significantly increase salinity levels of local waters when the brine is discharged back into the sea. These trends affect the marine life in the area, hurt the fishing industry and can increase the prevalence of harmful organisms.

That's why Sala recommends that any future ocean-oriented innovations or businesses should practice biomimicry, or follow the examples that nature has already set. "Ecosystems are like markets," he says. "They are composed of many interacting parts—species and individual organisms—that compete with each other for resources. For hundreds of thousands or millions of years these systems have evolved to become the most efficient markets on the planet. There is no waste in natural ecosystems, and we need to learn from that."

For example, Sala points to water filtration technology that uses the same techniques oysters and other shellfish have perfected through evolution to produce ultra-pure water for industry. "The best designs are already found in nature," he says.

3. Think Globally, Act Locally

Nearly every basic resource or product in the world today can be trucked, shipped, piped or flown to wherever it is needed. Oil is piped thousands of miles to eager markets. Food is shipped from one hemisphere to the next without spoiling. And with the help of the Internet, even the retail and services industries have gone global.

But not water. Consistently undervalued and expensive to transport, water remains one of the few resources that is strictly regional in its use, despite the global implications of its misuse. There is no global market and very little international exchange. “Water is about quantity, quality, space and time,” says Ian Cluckie, Professor of Hydrology and Water Management at the University of Bristol. “Whether you have a big problem or not depends entirely on where you live.”

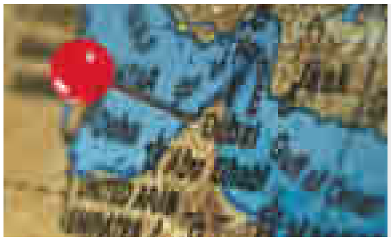
This is, for better or worse, the regional reality of water. For this reason, many GIO participants cited the need for more global coordination of existing regional water management practices. For example, a framework for sharing best practices among regions with similar water profiles—urban, coastal, arid; or rural, river-fed, subtropical, etc.—could combine the positive effects of local water management practices for a global influence.

Countries in close proximity that share a common water resource must not only share best practices, but also form the governance systems necessary to protect and fairly distribute the resource. The Nile Basin Initiative, which provides a forum for ongoing cooperation along the Nile River among its nine member states (Egypt, Sudan, Ethiopia, Uganda, Kenya, Tanzania, Burundi, Rwanda and the Democratic Republic of Congo) is an early success story. The high-level negotiations have produced a basin-wide shared vision for water use, a power-trading agreement, training and agricultural best-practices program, all of which has reduced the prospect of water-related conflict in the Nile basin significantly.

“These transboundary efforts, couched in terms of regional development, are designed to avoid the downside of security disruptions,” says Geoffrey Dabelko, Director, Environmental Change and Security Program at the Woodrow Wilson International Center for Scholars. “But they start by assessing each country’s water needs, how they are using it, and then taking the political boundaries off and asking, ‘Well, how do we share the benefits within the river basin?’”

> "Water is about quantity, quality, space and time. Whether you have a big problem or not depends entirely on where you live."

Ian Cluckie
Professor of Hydrology and Water Management
University of Bristol



Though Dubai is located in the Arabian Desert and receives less than six inches of water per year, its residents are among the heaviest users of water in the world, at about 550 liters a day per person. As such, it relies heavily on energy-intensive desalination of water from the Persian Gulf.

REGIONAL VIEW:

Dubai GIO Deep Dive
October 21, 2008

25°15'N 55°18'E
POPULATION: 2,262,000
AREA: 1,588.4 SQ MI (4,114 KM²)

OIL AND WATER

Those unfamiliar with the subtleties of global water management are often tempted to apply the practices of oil procurement, distribution and exchange to the world's water shortages. But water and oil—while both precious resources in their own right—differ in some very important ways.

WATER IS FAR MORE ABUNDANT THAN OIL

Though these numbers are hard to pin down for obvious reasons, crude oil reserves are estimated at 221,000 trillion liters. In contrast, there are an estimated 1.3 trillion cubic kilometers of water on the planet (each cubic kilometer contains 1 trillion liters of water.) That's 5.8 billion times the amount of oil on the planet, though currently only 1 percent of that is freshwater.

OIL IS A FINITE RESOURCE

The hydrologic cycle is nature's water processing treatment. It quickly returns water that has been used back into the system. Oil, on the other hand, has no such cycle. Once it is used—as fuel, lubricant or an ingredient in plastic, paints or rubber—it is effectively lost forever. It would take eons for the right conditions and sufficient biomass to produce more fossil fuels.

OIL IS A COMMODITY

Unlike water, oil has a well-established (if a bit volatile) international market for trade and exchange. Though its price fluctuates regularly, oil generates commerce, which justifies the expense of infrastructure to procure and distribute it. Water enjoys no such luxury, and many still believe that water is a basic human right that should be free to all.

Case Study: Israeli Agriculture

Farmers in Israel are perfecting the art of producing more with less. Since 1964, the year the National Water Carrier of Israel began regulating the water supply throughout the country, Israeli agriculture has fed a population that has nearly tripled to its current seven million. During that time, farmers have increased their water consumption by only 3 percent, while producing more than nine times the amount of food.

With scarce and unevenly distributed water supplies, cultivating crops in Israel's arid climate has always been difficult. But farmers have thrived using an astounding portfolio of water-conserving technology. Drip irrigation, the crop watering technique that waters only the soil closest to a plant's roots, was invented in Israel in 1959. Since then, Israeli farmers have refined and automated the process, linking data on temperature, radiation, humidity and soil-water content to not only control where water is released, but when, and how much is needed to meet a plant's need for transpiration.

"We don't want to provide the soil with water, we want to provide the plant with water," says Eilon Adar, Director of the Zuckerberg Institute for Water Research at Ben-Gurion University of the Negev. Adar says that by measuring all the data streams, agronomists can tell when a plant is most likely to engage in photosynthesis, which is when water is most rapidly absorbed through the roots. "We used to think the ideal time to irrigate was during the night. But with underground drip irrigation, we don't have to worry about evaporation, so we water during photosynthesis, during the day."

Farmers in Israel also “fertigate” their crops, or mix nutrients into the drip irrigation systems to get fertilizer where it is most needed. This process has enabled them to shrink the depth of some crops’ root zones because the roots don’t need to cover as much area to absorb sufficient nutrition. This in turn allows farmers to run a polyethylene sleeve underneath the plants to capture the brackish, or salty, water that does manage to escape the roots and percolate down through the soil. This water can then be used to irrigate salt-tolerant crops like asparagus.

Today Israeli farmers produce

9x

the amount of food they did in 1964.

Since 1964, Israeli farmers increased their water consumption by only

3%

Adar attributes the technological advancement of Israel’s farmers to advanced education and the proper valuation of water in Israel. “There is no free water in Israel, everyone must pay,” says Adar. “This is what happens when you see water as a commodity and give it a value.”

NEXT STEPS

There is still much to be learned about the relationship between food, energy and water. Each change made to one system affects the others. Therefore, data collection and analysis in each field must be shared and coordinated in order to achieve a complete systems-level view. Once the data is consolidated, predictive models can be built to assess the total impact, both short-term and long-term, of changes across the systems.

PERCEPTION IS REALITY

Building global water awareness

As part of the brainstorming process in the Global Innovation Outlook, participants were asked a simple hypothetical question: If you had $10 billion to invest in any water-related startup, what would it be?

The answers ran the gamut. Some wanted to fix leaks. Some wanted to invest in renewable energy. And some wanted to update agricultural technology. But one answer came up time and time again.

"I'd invest in a massive public relations effort," says Lori Armstrong, Global Water Resource Industry manager at Environmental Systems Research Institute, Inc. (ESRI). "We have a perception problem with water. People think it's cheap and abundant. So I would take a page out of the climate change book. We need to pump up the public relations machine and make water a cool cause."

Climate change, terrorism, economic crises. With so many major global challenges to worry about, it's hard to ask the average person to find time in their day to consider one more. But a consistent message backed by easily understood information would gain mindshare, increase urgency and change behavior.

"For those who have the luxury of clean water running from the tap, the signs of water crisis are not apparent enough to change behavior," says Kristin Rechberger, Vice President, Corporate Partnerships, Mission Programs at National Geographic Society. "But if we wait until those signs are apparent to all, it will be too late. That's why we must build awareness to include economic, social, humanitarian and national security indicators—and do it now."

1. Virtual Water

DAILY DOMESTIC USE PER CAPITA

Canada	778
United States	616
Australia	605
Korea	552
Italy	483
Japan	373
Spain	342
Portugal	308
Mexico	300
Turkey	238
France	232
Czech Republic	213
Germany	151
Poland	149
India	139
United Kingdom	139
Denmark	114
China	95

Some amount of water is required to produce nearly everything humans consume. But very few consumers have any idea how much water goes into producing an apple, an automobile or a pair of jeans.

"I think we can borrow a page from the energy folks in the way they think about embodied energy throughout the lifecycle of a product," says Steve Vassallo, Principal at Foundation Capital, a California-based venture capital firm. "We need to start applying that same thinking to water that is embodied in different products. Because when we trade these products, we are essentially moving water around the world."

The concept Vassallo is referring to is called "virtual water." It is a basic measurement of how much water is required to produce various goods, usually used in the context of trade. For example, one kilogram of wheat embodies 1,300 liters of water, while the same amount of beef embodies 15,500 liters of water. A sheet of paper embodies about 10 liters of water, while a pair of jeans embodies more than 10,000 liters (see chart, next page).

The calculation takes into account every drop of water used in the production lifecycle, from irrigation to industrial processes to discharge. And when these products are exported or imported, governments and businesses can use virtual water as a reference point to help in making decisions about trade policy.

Virtual water is a useful tool in understanding embodied water, but it is not perfect. For example, it does not consider the source of the water being used, nor does it take into account whether that water could have been used for other purposes. For example, growing wheat in a rain-fed plain is more responsible than growing irrigated wheat in an arid region.

Still, virtual water is an important new data point that can help inform public policy. And if it were ever extended to consumer labeling, it could significantly increase consumer awareness and change buying behavior.

It takes...

10 liters
of water to make one sheet of **PAPER**

40 liters
of water to make one slice of **BREAD**

70 liters
of water to make one **APPLE**

80 liters
of water per dollar of
INDUSTRIAL PRODUCT

91 liters
of water to make one pound of **PLASTIC**

120 liters
of water to make one glass of **WINE**

140 liters
of water to make one cup of **COFFEE**

1,300 liters
of water to make one kilogram of **WHEAT**

4,800 liters
of water to make one kilogram of **PORK**

10,855 liters
of water to make one pair of **JEANS**

15,500 liters
of water to make one kilogram of **BEEF**

16,600 liters
of water to make one kilogram
of **LEATHER**

REGIONAL VIEW:
Singapore GIO Deep Dive
October 16, 2008
1°22'N 103°48'E
POPULATION: 4,839,400
AREA: 270 SQ MI (707.1 KM²)

Despite the absence of a natural source of water on this island city-state, Singapore is known as a "hydro hub." Though it still imports nearly 50 percent of its water from nearby Malaysia, it uses a combination of storm water catchment, desalination and recycled water to serve its needs.

2. Water Footprints

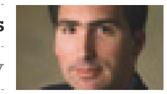
Tightly linked to the concept of virtual water is the practice of "water footprinting." This nascent methodology for determining the total water impact of a nation, business or individual has the potential to increase accountability for responsible water use.

Developed in 2002 by Dr. Arjen Hoekstra, a professor of Multidisciplinary Water Management at the University of Twente in the Netherlands, water footprinting consists of calculating the total amount of water used by an individual, nation or business. It is measured by estimating the direct and indirect water consumed and/or polluted per unit of time. It takes into account blue water (freshwater), green water (evaporated water) and graywater (polluted water) for each footprint.

Proponents of the idea recommend that the footprint consist of the operational water footprint (water consumed during production and manufacturing) as well as the supply-chain water footprint (including water impacts related to disposal of or pollution resulting from the finished product.) It's a comprehensive calculation that would have to be supported by careful measurement of a company's consumption and discharge, including metering and real-time monitoring.

Some GIO participants felt that water footprinting would be a useful tool for reporting corporate water use. But there is as yet no agreed upon standard of measurement, and monitoring remote parts of the supply chain can be nearly impossible. That's why the most important element in the reporting of corporate water use is the need for precise and defensible measurements. Without that, water footprinting is an exercise in estimation.

Q&A



Alex Moen, Vice President, Mission Programs

National Geographic Society

National Geographic Society, a Global Innovation Outlook Partner, has been inspiring people to care for the planet for more than 120 years. But now the nonprofit group best known for its iconic magazines has a new challenge: adding water to the growing list of environmental issues that demand our attention. Alex Moen, Vice President, Mission Programs at National Geographic Society answered our questions on cultural awareness of water scarcity.

Q What are the biggest challenges in raising global awareness of water as a social imperative?

One of the primary challenges in raising global awareness is that water, as an issue, is in certain respects not a *global* problem. It's a series of local and regional challenges complicated by multiple, interdependent issues. It will be very difficult to address these myriad issues without people understanding this global water web.

Another challenge is getting people to think of their own individual attachment to water—and then understand the connections between us through water. We need to better comprehend the personal value of water on a universal level, by transcending simple economic value and understanding the cultural and other special significances that water holds for people. Only then can we begin to address the issue as a social imperative.

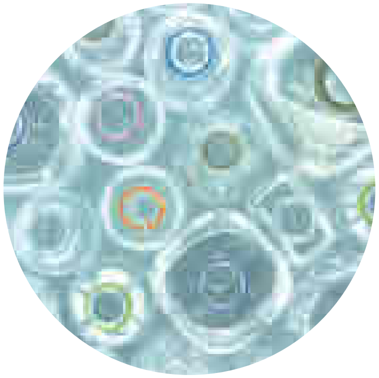
Q What approaches do you think would be most effective in solving this problem?

We rarely think about water until it is in short supply or unsafe, which is too late. We need to be able to personalize the issue and get people to place and maintain a personal value on water to better proactively manage this vital collective resource. Furthermore, in order to mitigate "issue fatigue" with the general public we have to recognize and highlight the interconnectedness of energy, climate, water and food. We need to focus on living smarter and more responsibly on a daily basis rather than focusing on the issue of the day.

Q Is National Geographic Society planning anything in particular to aid in this effort?

As an organization, National Geographic is committed to inspiring people to care about the planet. We continuously look for opportunities to raise public awareness around key environmental and humanitarian issues. Worldwide, access to safe water and sanitation are among the most urgent challenges of our time. There are many groups working on freshwater issues, but the message is perhaps not breaking through yet in the same way the "green" message has.

National Geographic has both a global reach and proven credibility to help spotlight issues. We are interested in engaging and convening people, organizations, institutions and other stakeholders working hard on water issues, to help amplify their voices and create a groundswell of coordinated popular thinking that would lead to a change in attitudes and behavior with regard to our relationship with water.



Case Study: Singapore's NEWater

Singapore rests at the southern tip of the Malay Peninsula. It is a 700 square kilometer island-state that is blessed with a world-class shipping port and an industrious and innovative workforce. However, Singapore lacked natural water resources and suffered from flooding and river pollution in the 1960s and 1970s.

Driven by a vision of water sustainability, PUB, Singapore's national water agency, has been developing a robust and diversified water supply strategy from four different sources known as the Four National Taps (water from local catchment areas, imported water, reclaimed water known as NEWater and desalinated water).

Pioneered by PUB, NEWater is a key pillar of Singapore's sustainable water supply. High-grade reclaimed water, NEWater is produced from treated used water that is purified using advanced membrane technologies, making it ultra-clean and safe to drink. It has also passed more than 30,000 scientific tests and surpasses World Health Organization requirements.

Because it is ultra clean, NEWater is ideal for industries that need highly purified water. Most of the NEWater is supplied to wafer fabrication, electronics and power generation industries as well as commercial and institutional complexes for cooling purposes. This frees up potable water for domestic use. PUB also blends a small percentage of the NEWater with the reservoir water.

"Our challenge is to secure public acceptance and encourage industry to convert to NEWater for nonpotable uses," says Mr. Peng Kah Poh, Director (InfoComm), PUB. "Through intensive public education, the demand for NEWater has grown steadily."

Singapore's NEWater has passed more than

30,000

tests for purity and safety.

Today, NEWater is produced by four plants and meets 15 percent of Singapore's total water needs. With the opening of a new plant in 2010, that number will rise to 30 percent.

But securing an adequate supply is only half of the water equation—managing the demand side is just as crucial. PUB has a wide-ranging water conservation plan that encourages customers to use water wisely. Singapore's per capita domestic water consumption has been brought down from 165 liters per day in 2003 to the current 157 liters. The target is to lower it to 155 liters by 2012.

"For Singaporeans, the educational journey toward water conservation starts at a very young age," says Chee Kiong Goh, Director of Cleantech at The Economic Development Board of Singapore. "Water survival has been inculcated throughout society since the 1960s."

Singapore is now recognized as a global hydro hub for its innovative water management, and has managed to turn the country's vulnerability into a key strength.

NEWater will meet

30%

of Singapore's total water demand by 2010.

NEXT STEPS

Water management awareness and accountability starts and ends with education. Consumers can be educated through more explicit labeling of virtual water content in the products they buy and real-time metering of the water they consume at home. Businesses can closely study the true cost of their water use and efficiency-gain potential across their supply chains for more active water management strategies.

A Smarter Planet

The 21st century has brought with it a series of global wake-up calls to accompany our concerns about water—security and terrorism, energy and climate change, housing and finance. But where previous generations might have been overwhelmed by these shocks to the system, we face these challenges today armed with unprecedented capability. We are developing the means to gather information in real time and understand, at a deep level, what is happening in these systems, how they are interrelated and how we can improve them.

At IBM we call this building a smarter planet. While much of the approach relies heavily on advanced information gathering and analysis—such as leveraging massive computer power to model the systems we are trying to understand—its success also depends on a more fundamental change: as this GIO report has consistently asserted, we need a greater level of cooperation across traditional boundaries.

In essence, we will have to pioneer and perfect a new way of making decisions. We will have to balance our understanding of complex problems with the intricacy of their connections—understanding water, for instance, in the context of energy needs, transportation systems, environmental change and societal demands. We will have to consider local, national and regional needs while monitoring the global implications of our actions, drawing on improved modeling techniques to allow us to test solutions before we unleash them. And we will have to continue to drive cooperation between governments, private businesses, universities and citizens across the world to find optimal answers that work for everyone.

No easy task, for sure. But we believe this vision is achievable, and we invite you to work with us and the Global Innovation Outlook community around the world to help lay the foundation for a smarter planet.

GIO contributors include representatives from the following companies and organizations:

ABB
African Water Association (AfWA)
Albourne Partners
AMR Research
Amsterdam Topstad
Aquaya Institute
ARCADIS, Netherlands
Asia Pulp & Paper
Bermuda Institute of Ocean Sciences
Brandix Lanka
Brown University
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Institute of Meteorology and Water Management Scientific Council
Instituto Argentino de Responsabilidad Social Empresaria (IARSE)
International Water Association (IWA)
ITT Water & Wastewater
Katzenbach Partners
King Abdulaziz City for Science & Technology (KACST)
Lab-Ferrer
Lloyd's
LXG Core
Manila Water
Marathwada Sheti Sahaya Mandal
Marine Institute
Masdar, Abu Dhabi Future Energy Company (ADFEC)
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Ministry of Environment and Water, UAE
Ministry of Natural Resources and Environment, Vietnam
Ministry of Science and Technology, Brazil
National Disaster Management, Ministry of Home Affairs, Government of India
National Geographic Society
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Siemens
Siemens Water Technologies
Singapore Economic Development Board
Singapore Press Holdings
Siruthuli
South African National Bottled Water Association
Southern Peru Copper Corporation (SPCC)
Suez Environnement
Swiss Fresh Water
Te Rūnanga o Ngāi Tahu
Thai Meteorological Department
The Artemis Project
The Beacon Institute for Rivers and Estuaries
The Coca-Cola Company
The Dow Chemical Company
The Nature Conservancy
TNO Science and Industry
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UNESCO-IHE Institute for Water Education
Unie van Waterschappen
United Nations Department of Economic and Social Affairs (UNDESA)
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University of Melbourne
University of Newcastle
University of Pecs, Institute of Environmental Sciences
University of Rhode Island
University of the Philippines, Visayas
WaterAid
WHEB Venture Partners
Woodrow Wilson International Center for Scholars
Woods Hole Oceanographic Institution
Zuckerberg Institute for Water Research

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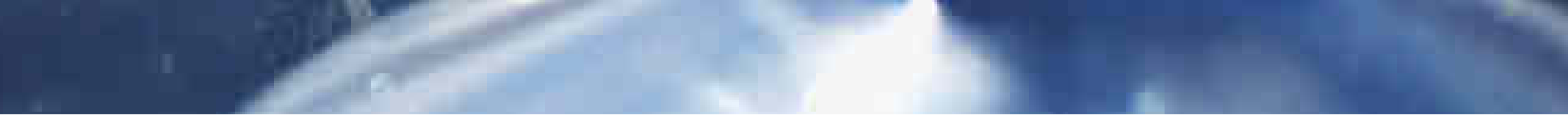
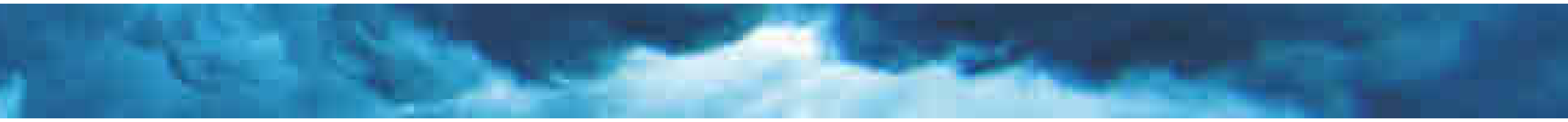
About the GIO

In early 2004, IBM took an unprecedented step: We opened up our annual technology and business forecasting processes to the world with the first Global Innovation Outlook.

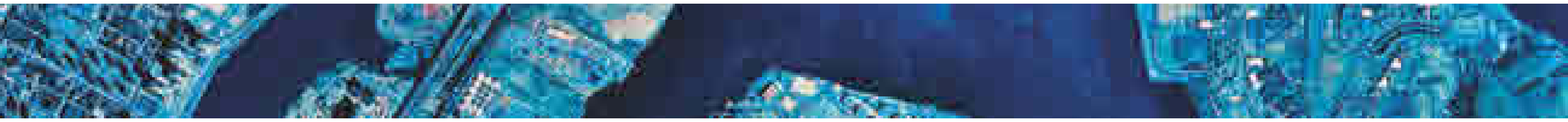
The GIO is rooted in the belief that the very nature of innovation has changed. Today, the greatest innovations come from multiple sources, working together, solving common problems. And that means the truly revolutionary innovations of our time—those that will create new markets, redefine old ones and maybe even change the world for the better—will require collaboration on a global scale. With that in mind, the GIO challenges some of the brightest minds on the planet—from the worlds of business, politics, academia and nonprofits—to collaboratively address some of the most vexing issues on Earth, and identify opportunities for business and societal innovation.

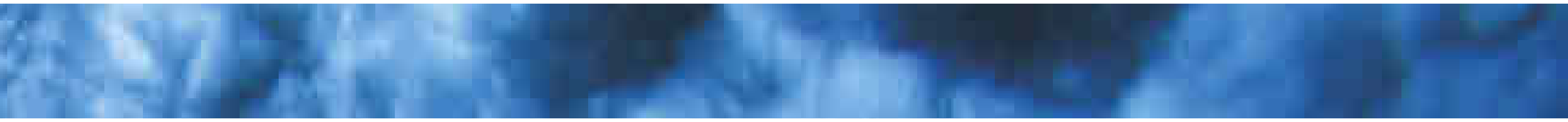
This collaboration begins with a series of open, dynamic conversations called "deep dives." To date, more than 55 GIO deep dives on five continents have brought together more than 750 influencers from dozens of countries. These free-form conversations, fueled by a diverse mix of expertise and perspectives, are inevitably candid and spirited. Collectively, they result in an explosion of ideas that spark new relationships, policy initiatives and market opportunities for all involved. Previous topic areas have included the environment, health care and transportation. To order copies of reports from previous GIOs at no charge, please visit www.ibm.com/gio/order.





Water





A GLOBAL INNOVATION OUTLOOK REPORT