Thematic Investing Focus

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Water Worries: Update #2

The Rising Risk of "Water Bankruptcy"

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- **"Water bankruptcy"** — Global water usage is unsustainable. While the scarcity of freshwater is felt most acutely in Africa and West Asia, water scarcity has become an economic constraint in major growth markets such as China, India and Indonesia, as well as commercial centers in Australia and the western U.S. In addition to burgeoning demand, climate change is another factor that threatens some countries with "water bankruptcy."

- **Depleted aquifers** — Global groundwater withdrawals rose five-fold during the twentieth century, so that half of drinking water is now from groundwater sources. The *greatest* amount of groundwater abstraction occurs in regions with *very low* recharge rates. In some major cities (Bangkok, Buenos Aires, Jakarta), groundwater supplies have fallen considerably as a result of aquifer depletion, saline intrusion, and/or groundwater pollution.

- **Limited options** — In the face of steadily growing demand for the finite resource, there are limited options for increasing water supply:

  Desalination — Even with a five-fold increase in capacity by 2050, desalination would still only account for 1% of the global water supply.

  Wastewater recycling — Although treatment capacity is growing rapidly, it will take time before recycled wastewater volumes are meaningful; a 3% compound annual growth rate implies that recycled wastewater would account for 9% of the global water supply by 2050.

  "Virtual water" — As water scarcity has increased, the savings associated with trade of "virtual water" embedded in agricultural products has become more apparent, e.g., Pakistan exporting food for consumption in water-poor Saudi Arabia. However, most trade is *not* driven by comparative advantage based on water but, rather, by broader economic factors.

  Rainwater harvesting — Reflecting environmental and social issues, there is little scope for the construction of large dams that store water over years, and transfer from areas of high rainfall to dry areas.

- **Curbing agricultural demand** — Given the water-intensive nature of irrigation, agriculture currently accounts for about 70% of total water withdrawals. Cutting the sector's demand for water is possible by (i) more efficient irrigation techniques, and/or (ii) the introduction of drought-resistant crops.

See Appendix A-1 for Analyst Certification and important disclosures.

Contents

"Water Bankruptcy"

Earlier this year, the *World Economic Forum* (WEF) stated[1] that:

- The financial crisis gives us a stark warning of what can happen if known economic risks are left to fester.

The WEF went on to highlight what it perceives to be a key economic risk:

We are living in a water "bubble" as unsustainable and fragile as that which precipitated the collapse in global financial markets.

- *We are living in a water "bubble" as unsustainable and fragile as that which precipitated the collapse in global financial markets.* We use water unsustainably [italics added].

Expanding on that point, the report predicted that:

- Worsening water security will soon tear into various parts of the global economic system. It will start to emerge as a headline geopolitical issue…*We are now on the verge of water bankruptcy* [italics added].

Water shortages are becoming increasingly costly.

A separate report[2] by the *World Wide Fund for Nature* pointed out that water shortages are becoming increasingly costly:

- California's current water crisis management will cost taxpayers an estimated US$1.6 billion per year by 2020. Australia's emergency overhaul of its water supply regime, necessitated by 10 years of over-abstraction but precipitated by the 2007 drought, is expected to cost US$10 billion. China's scheme to channel billions of cubic metres of water from the Yangtze River in support of farmers along the dwindling Yellow River involves untold costs, while Libya's need since 1991 to pump 730 million cubic metres of water a year from underneath the Sahara costs that country US$25 billion a year.

In addition to the *direct cost* of responding to water issues, there is also a toll in terms of *lost output.* On that point, the *World Economic Forum* wrote that:

- The ongoing drought in Australia is expected to shave 1% off the country's GDP in 2006-2007. In the U.S., water shortages are reported to have cost the agricultural sector US$4 billion a year over the past two years…Some estimates conclude that environmental degradation and pollution cost the Chinese economy between 8% and 12% of its GDP annually…The crisis in water and sanitation holds back economic growth in sub-Saharan Africa, losing 5% of GDP annually, far more than the region receives in aid.

Similarly, in its most recent *World Water Development Report,* [3] the United Nations pointed out that:

Water scarcity is already an economic constraint in major growth markets such as China, India and Indonesia.

- While the scarcity of freshwater is felt acutely in Africa and West Asia, *water scarcity is already an economic constraint in major growth markets* such as China, India and Indonesia, as well as commercial centres in Australia and the western United States [italics added].

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[1] *The Bubble Is Close to Bursting,* January 2009

[2] *Understanding water risks,* March 2009

[3] *United Nations World Water Development Report 3,* March 2009

Specifically addressing the issue of water as an economic constraint, the *Pacific Institute* stated[4] that inadequate water infrastructure and water-management capacity:

- Constrain companies' growth, disrupt operations, and necessitate costly investments in equipment and technology.

The *Pacific Institute* report made another important point:

- Countries with poorly developed infrastructure are also *less able to decouple their economy from climatic variability,* which puts not only agricultural and food sectors at risk, but other industries as well [italics added].

In addition to water shortages caused by a supply-demand imbalance and/or pollution, climate change is another factor that threatens some countries with "water bankruptcy."

In other words, in addition to water shortages caused by a supply-demand imbalance and/or pollution, *climate change is another factor that threatens some countries with "water bankruptcy."*

Water Worries: Spreading

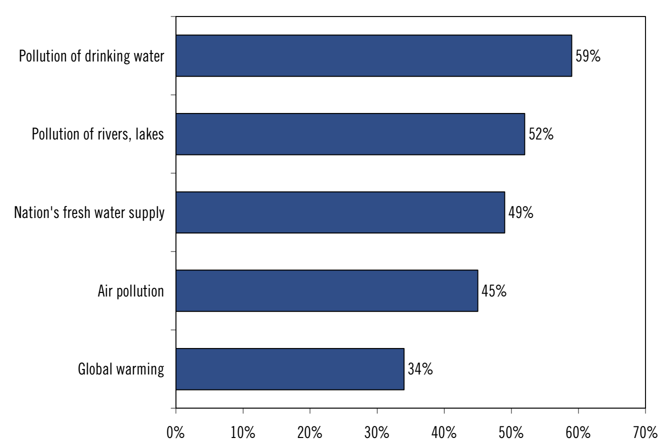
Private citizens are increasingly concerned about water issues.

Reflecting the factors outlined above, it's not surprising that private citizens are increasingly concerned about water issues. That is even the case *among people living in areas that currently have no significant supply problems:*

- A recent Gallup survey revealed that pollution of drinking water is Americans' No.1 environmental concern, with 59% saying they worry "a great deal" about the issue, versus just 34% worried about "global warming" — see Figure 1.

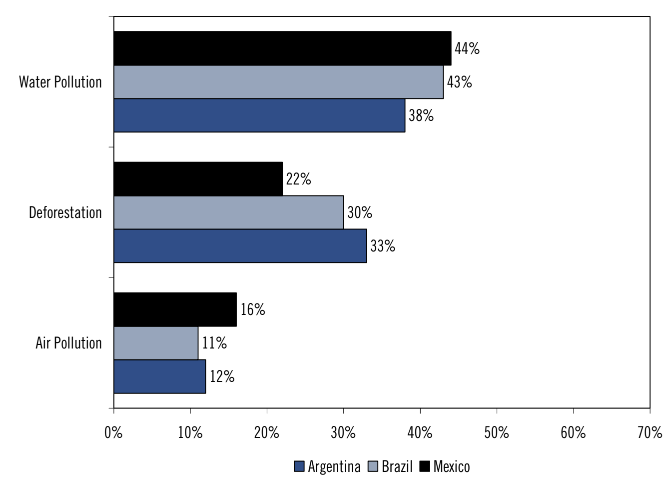
- South of the U.S. border, water pollution is the leading environmental concern in major economies in Latin America (see Figure 2), despite the fact that (apart from the Andes) the region as a whole has little water scarcity.

Figure 1. "I Worry About this Problem a Great Deal"
March 2009 survey of Americans



Source: Gallup

Figure 2. Environmental Problem Most Concerned With
December 2008 survey



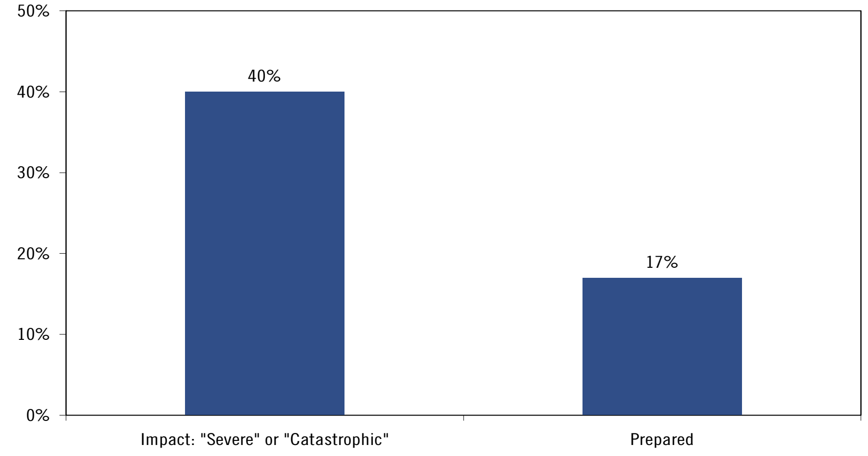
Source: TNS Global

[4] *At the Crest of a Wave: A Proactive Approach to Corporate Water Strategy*, September 2007

40% of *Fortune 1000* companies said the impact of a water shortage on their business would be "severe" or "catastrophic," although only 17% said they have prepared for such a crisis.

It's not only private citizens that express concern about water issues — a survey of *Fortune 1000* companies revealed that 40% said the impact of a water shortage on their business would be "severe" or "catastrophic," *although only 17% said they have prepared for such a crisis* (see Figure 3).

Figure 3. Fortune 1000 companies and a Water Shortage: Impact and Preparedness



Source: Marsh Center for Risk Insights

Climate Change and Water

In a 2008 report ("Water Worries: Climatic Consequences Update #3," January 4, 2008) we wrote that:

- Floods, droughts, and changing snow cover have long been newsworthy events. What's significant now is that…the most recent analysis of the Intergovernmental Panel on Climate Change (IPCC) concluded that *climate change is having a significant impact on those variables.*

In a subsequent report ("Climatic Consequences: Update #4," June 19, 2008) we noted that:

Climate change occurs over an extended period, so that the conditions observed in one season may have little significance in the face of a more powerful long-term trend.

- *Climate change occurs over an extended period,* so that the conditions observed in one season may have little significance in the face of a more powerful long-term trend.

We went on to discuss how the *long-term trends* of changing precipitation patterns, increasing drought, and decreasing snow cover seemed to be having an impact on water supplies in various regions of the world. In that regard, the United Nations, in its aforementioned *World Water Development Report,* included a summary table of climate change impacts on water systems by geography — see Figure 4. As the table illustrates, only three geographies (Southeastern Asia, Northern Europe, and Northern America) are *currently* considered to have *adequate* water supplies, while climate change factors are forecast to have an increasing impact on water systems *globally.*

Figure 4. Climate Change Impact on Water Systems by Geography

Climate System	Region	Geography	Current Status	Climate Change Implications
Snow Melt	Indus	Pakistan	Water scarcity emerging	More rainfall in place of snow
	Ganges-Brahmaputra	India	Water quality problems	
	Northwestern China	China	Extreme water scarcity	
	Red and Mekong Rivers	China	Poor water quality	
	Colorado River	U.S.	Water scarcity	
	Andes	South America	Water scarcity	
Deltas	Ganges-Brahmaputra	India	Water scarcity	Increased flood frequency
	Nile River	Africa	Highly dependent on runoff	
	Yellow River	China	Severe water scarcity	
	Red River	China	Requires expensive irrigation	
	Mekong River	China	Dependent on groundwater	
Semi-Arid / Arid Tropics	Monsoonal: Indian subcontinent	India	Variable rainfall	Increased drought and flooding
	Non-Monsoonal: Sub-Saharan Africa	Africa	Flashy water systems	
	Non-Monsoonal: Southern Australia	Australia	Flashy water systems	
Humid Tropics	Southeastern Asia	Southeastern Asia	Adequate water	Increased rainfall variability
	Southern China	China	Low water output	
	Northern Australia	Australia	Fragile ecology	
Temperate	Northern Europe	Northern Europe	Adequate water	Increased rainfall
	Northern America	Northern America	Adequate water	
Mediterranean	Southern Europe	Southern Europe	Increasing pressure on water	Significantly lower rainfall
	Northern Africa	Northern Africa	High water scarcity	
	West Asia	West Asia	Heavy pressure on water	

Source: Food and Agriculture Organization (FAO), United Nations, and Citi Investment Research and Analysis

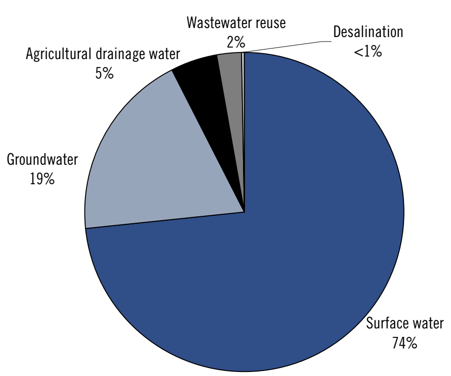
Depleted Aquifers

The UN also pointed out in its *World Water Development Report* that:

- Around 20% of total water used globally is from groundwater sources [see Figure 5]...and this share is rising rapidly, particularly in dry areas. This rise has been stimulated by the development of low-cost pumps and by individual investment for irrigation and urban uses. Private investment in self-supply of groundwater — essentially uncontrolled and unmonitored — has mushroomed in response to inadequate public services.

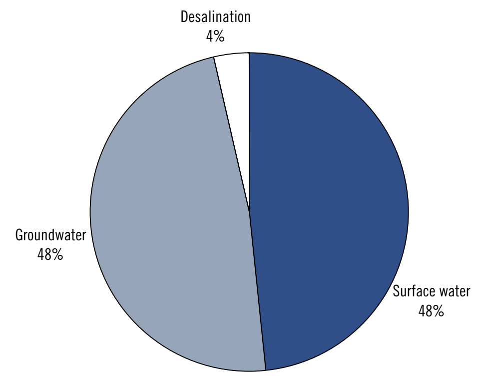
Figure 6 illustrates that groundwater is a particularly important source for drinking water.

Figure 5. Sources of Water Globally: All Uses



Source: FAO-AQUASTAT

Figure 6. Sources of Water Globally: Drinking Water



Source: FAO-AQUASTAT

Groundwater can not be relied upon indefinitely as a source of drinking water.

The UN warned, however, that groundwater can not be relied upon indefinitely as a source of drinking water:

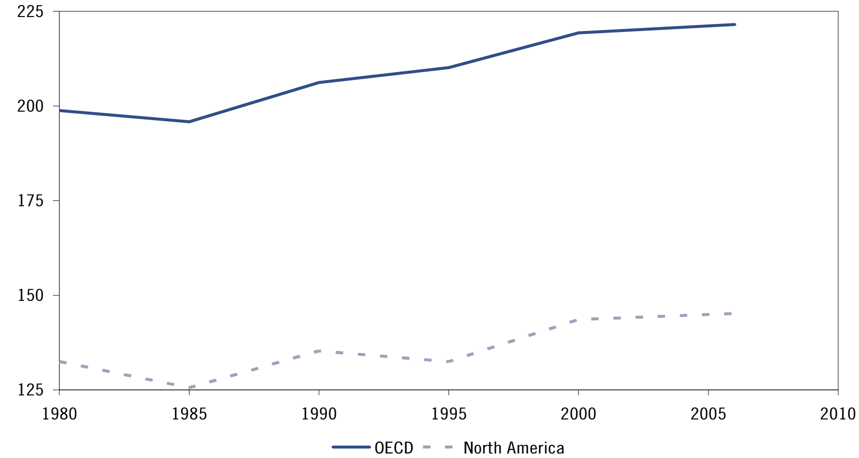
- Groundwater is a major source of urban water supply around the world not just in megacities but also in thousands of medium-size towns. Some cities (for example, Beijing, Dhaka, Lima, Lusaka and Mexico City) are located on or near major aquifers, and urban water utilities have drawn heavily on groundwater for their supply. In other cities (for example, Bangkok, Buenos Aires and Jakarta), *the share of water derived from groundwater has fallen considerably as a result of aquifer depletion, saline intrusion or groundwater pollution* [italics added].

(Excessive pumping of groundwater can lead to saltwater intruding into aquifers, leading to a permanent reduction in freshwater availability. The reason for this is that saltwater is denser than freshwater, which is why freshwater tends to flow above saltwater.)

By way of quantifying the rapid drawdown of aquifers, the report pointed out that:

- Groundwater withdrawals rose five-fold during the 20th century [and by 11% since 1980 in the OECD area — see Figure 7], leading to a rapid drawdown of aquifers in some areas, putting at risk the sustainability of the uses that rely on it.

Figure 7. Groundwater Abstractions (Billion Cubic Kilometres Per Year)



Source: OECD

The rapid drawdown of aquifers is outpacing the natural replacement rate.

The UN highlighted that the rapid drawdown of aquifers is outpacing the natural replacement rate:

- Of total annual precipitation of 577,000 cubic kilometres (km^3) per year (based on long-term averages), 79% falls on the oceans, 2% on lakes and 19% on land. Most of this evaporates or runs off into streams and rivers. *Only 2,200 km^3, or 2% [of the precipitation that falls on land], is infiltrated into groundwater* [italics added].

Moreover, a report[5] by the *International Water Management Institute* pointed out that the *greatest* amount of groundwater abstraction occurs in regions with *very low* recharge rates:

[5] *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture,* 2007

- Groundwater use in agriculture [the sector that consumes the largest volume of water] is *absent or minimal* in regions with *high recharge,* and it is *intensive* where the *recharge is too small to sustain intensive groundwater use* [italics added].

(This reflects the fact that water resources are distributed very unevenly — unpopulated areas of the earth have large water resources, but little water withdrawal.)

At current rates, annual groundwater abstraction will equal the natural replenishment rate by 2020.

Given that global abstraction of groundwater grew at a 4% compound annual rate between 1950 and 2000, continued growth in groundwater withdrawal at the same rate would mean that, *by 2020, annual groundwater abstraction would equal the natural replenishment rate.*

Increasing Supply: Limited Options

As we outline below, there are limited options for increasing the supply of water in the face of steadily growing demand for the finite resource.

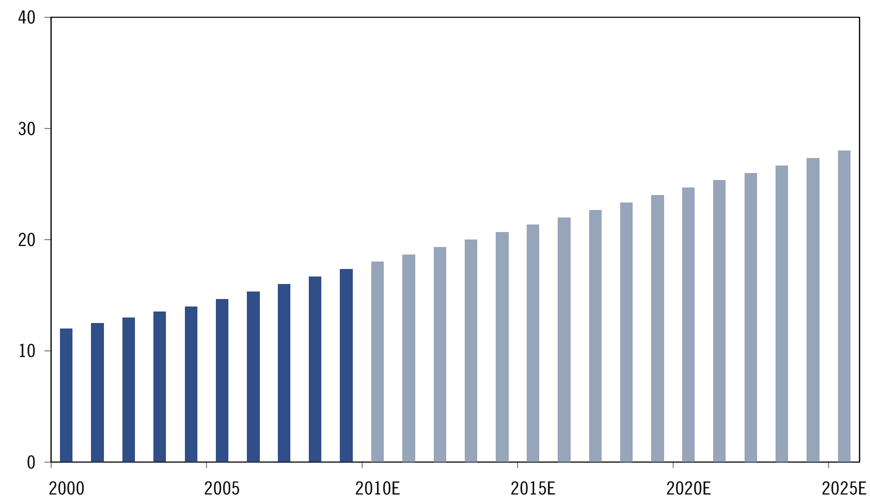
Desalination: Only Ever a Small Portion of the Water Supply

The *World Water Development Report* observed that:

- Desalination based on brackish water sources (48%) and seawater (52%) is increasingly affordable as a result of new membrane technology ($0.60-$0.80 per cubic metre). It is used mostly for drinking water and industrial supplies in countries that have reached the limits of their renewable water resources (such as Cyprus, Israel, Malta and Saudi Arabia). Little is used for agriculture, but its use for high-value crops in greenhouses is gradually increasing. *Desalination accounted for only 0.4% of water use in 2004 (nearly 14 cubic kilometres a year), but production should double by 2025* [italics added] — see Figure 8.

Desalination accounted for only 0.4% of water use in 2004, but production should double by 2025.

Figure 8. Global Water Desalination Capacity (Cubic Kilometers)



Source: United Nations and Citi Investment Research and Analysis

In “Water Worries” we pointed out that companies involved with desalination include **Doosan Heavy Industries and Construction, General Electric,** and **Veolia Environnement.**

With regard to new desalination projects, a news story[6] in August 2008 noted that:

- Plans for the biggest desalination plant in the Western Hemisphere received final California state approval…clearing the way for construction to start [in 2009] and for the plant to open north of San Diego in 2011.

Even still, the California Department of Water Resources Director was quoted as saying:

"Desalination will probably never be a major portion of the water supply, but it's going to be a critical part of a portfolio of a reliable supply."

- Desalination will probably *never be a major portion of the water supply,* but it's going to be a critical part of a portfolio of a reliable supply [italics added].

A key issue is that, despite desalination becoming "increasingly affordable," cost remains a key variable. So, for example, the *World Wide Fund for Nature* recently pointed out[7] that:

- Saudi Arabia has chosen to de-subsidize water use by its citizens and instead use the water of Pakistan embedded in food grown specifically for Saudi Arabian consumption, *as costs to pump and desalinate the huge amounts needed to achieve food security at home reach into the billions of dollars* [italics added].

On the subject of food costs in Saudi Arabia, the *International Water Management Institute* noted in its aforementioned report that:

- Saudi Arabia expanded wheat irrigation during the 1970s, eventually becoming an exporter. In 1992, Saudi Arabia spent $2 billion to subsidize local production of 4 million metric tons of wheat, *which it could have bought at a fifth of the cost in the global wheat market* [italics added].

It's estimated that Saudi Arabia, the largest producer of desalinated water in the world, consumes about 24 billion cubic meters of water annually. As noted above, the cost of the *newest* membrane technology is $0.60-$0.80 per cubic meter of desalinated water, but the billions of meters of desalinated water that energy-rich Saudi Arabia produces annually likely cost much more to produce.

Similarly, writing about drought in Spain, *Infrastructure Journal* noted[8] that high energy costs have reduced the appeal of desalination in that country:

- According to the water division of Veolia, desalination costs 0.65-0.80€/m^3 (amortized) which is largely the result of the heavy energy demands included in the process…including pumping water from the sea.

While costs are falling, the capital costs of new desalinization plants are considerable, and operating costs are highly sensitive to energy prices.

The potential for desalination in agriculture is limited by cost.

In summing up the limits of desalinization, the *United Nations Development Programme* wrote[9] that:

- While costs are falling, the capital costs of new [desalinization] plants are considerable and operating costs are highly sensitive to energy prices…The cost of pumping water rises sharply with distance as well, so that inland cities would face higher cost structures. *These factors help to explain why oil-rich states and coastal cities in water-stressed areas will probably remain the main users*…The potential in agriculture is limited by cost. That is especially so for producers of low value-added staple crops that require large volumes of water [italics added].

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[6] *Biggest Desalination Plant in W. Hemisphere Gets OK,* Reuters, August 25, 2008

[7] *Understanding water risks,* March 2009

[8] *After the storm: Water in Catalonia,* July 23, 2008

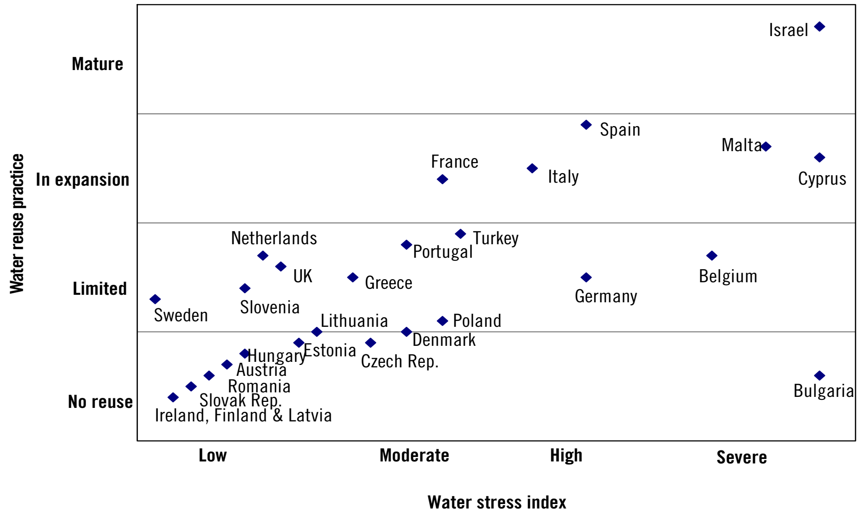
[9] *Human Development Report 2006*

"Toilet-to-Tap" Recycling: Growing Rapidly, But Still Insignificant

Treated wastewater costs about a third less than desalination.

In contrast to the negligible amounts derived from desalination, Figure 5 illustrates that wastewater — treated and untreated — accounts for about 2% of global water sources. An important factor here is that treated wastewater costs about a third less than desalination. Not surprisingly, Figure 9 illustrates that the greatest volume of treated wastewater reuse currently takes place in water-stressed countries.

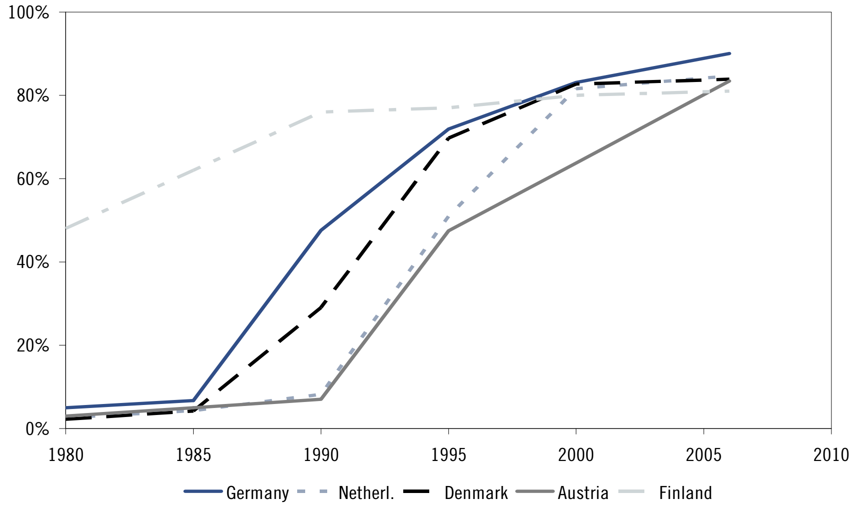
Figure 9. Water Stress and Treated Wastewater Reuse



Source: United Nations

In developed economies, wastewater has, in recent years, been subject to increasingly rigorous treatment prior to its discharge into freshwater or coastal waters. So, for example, Europe's 1991 *Urban Wastewater Treatment Directive* has resulted in significant expansion in treatment capacity over the last 20 years, with advanced wastewater treatment being commonplace across Europe — see Figure 10.

Figure 10. Percentage of Household Wastewater Subject to Treatment by Advanced Technologies



Source: OECD

In "Water Worries" we pointed out that companies involved with wastewater treatment in developed economies include **Danaher, General Electric, Kurita Water Industries,** and **Nalco**. In that report, we also noted that China's central government target is to raise the municipal wastewater treatment rate from 52% in 2005 to 70% by 2010, thereby creating opportunities for companies such as **China Everbright International, Epure International,** and **Veolia Environnement.**

Advanced wastewater treatment means that sewage can be viewed as a resource with a number of possible uses.

Advanced wastewater treatment means that sewage can be viewed as a *resource* with a number of possible uses:

- Agricultural irrigation (wastewater flows are typically more reliable than freshwater sources, and are rich in nutrients for the cultivation of high-value crops).
- Urban landscaping.
- Industrial cooling and processing.
- Indirect potable water production (e.g., through groundwater recharge).

With regard to agricultural irrigation, the *World Water Development Report* observed that "there are no reliable figures on the extent of wastewater use in agriculture at the global level, but it is estimated that some 20 million hectares of agricultural land is irrigated by *untreated, partially treated or wastewater-polluted river water."* (20 million hectares represents an area equal to about two-thirds the land mass of Italy.)

The UN report pointed out that:

- *Restricting the crops that can be grown with wastewater is difficult* because farmers grow crops that have high demand in the local market and that are thus the most profitable to cultivate…Courts in Pakistan have found in favour of farmers, ruling that access to irrigation water is a fundamental right and that *the loss of livelihood overrides potential health risks* [italics added].

Similarly, the *International Water Management Institute* pointed out[10] that:

Wastewater is dependable in quantity but poor in quality.

- Steadily increasing amounts of wastewater generated by cities, often discharged into streams, have given rise to a new water resource that farmers have opted to use as an alternative. *This resource is dependable in quantity but poor in quality* because untreated wastewater from cities in the developing world can contain harmful pathogenic micro-organisms, excessive nutrients, and toxic chemicals. In most places wastewater use is not subject to any control or surveillance, posing health risks to farmers using the water and people eating crops grown with wastewater — and causing environmental impacts such as groundwater contamination and disruption of ecosystems in downstream areas [italics added].

As for *urban* uses of recycled water, the UN report pointed out that:

- In 2008 Sydney Water in Australia began providing homes in the Hoxton Park area with two water supplies — recycled water and drinking water (dual reticulation). Recycled water is to be used for gardens and other outdoor needs, toilet flushing and potentially as cold water in washing machines and for certain non-residential purposes. The recycled water taps, pipes and plumbing are coloured purple to distinguish recycled water from drinking water.

[10] *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture,* 2007

With regard to "indirect potable water production," a recent *Reuters* story[11] pointed out that:

- Cities like Los Angeles and San Diego are revisiting an idea once abandoned in the face of staunch political opposition — recycling purified sewer water for drinking supplies. Disparaged by critics as "toilet-to-tap," such recycling plans have gained new currency from the success of the year-old Groundwater Replenishing System in Orange County near Los Angeles. That system distills wastewater through advanced treatment and pumps it into the ground to recharge the area's aquifer, providing drinking supplies for 500,000 people, including residents of Anaheim, home of Disneyland.

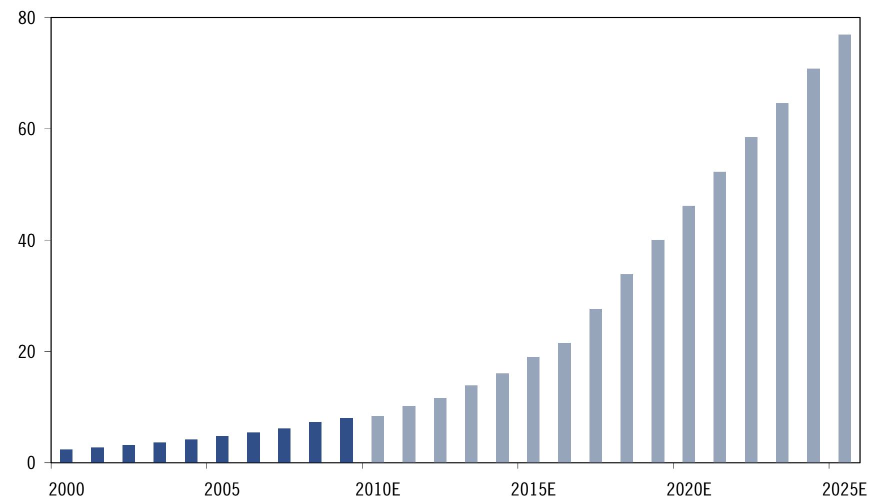
As for the safety of recycled purified sewer water for drinking supplies, the *International Water Management Institute* wrote[12] that:

- Aquifers have been recharged intentionally with treated wastewater for many years in the United States, with no recorded unacceptable impacts. Israel has been recharging an aquifer south of Tel Aviv with reclaimed wastewater for 20 years.

Figure 11 illustrates that wastewater treatment capacity is forecast to grow rapidly although, as we discuss below, recycled wastewater will likely account for only 9% of the global water supply by 2050 (as illustrated in Figure 14).

Although wastewater treatment capacity is forecast to grow rapidly, recycled wastewater will likely account for only 9% of the global water supply by 2050.

Figure 11. Global Wastewater Treatment for Reuse Capacity (Cubic Kilometers)



Source: Global Water Intelligence and Citi Investment Research and Analysis

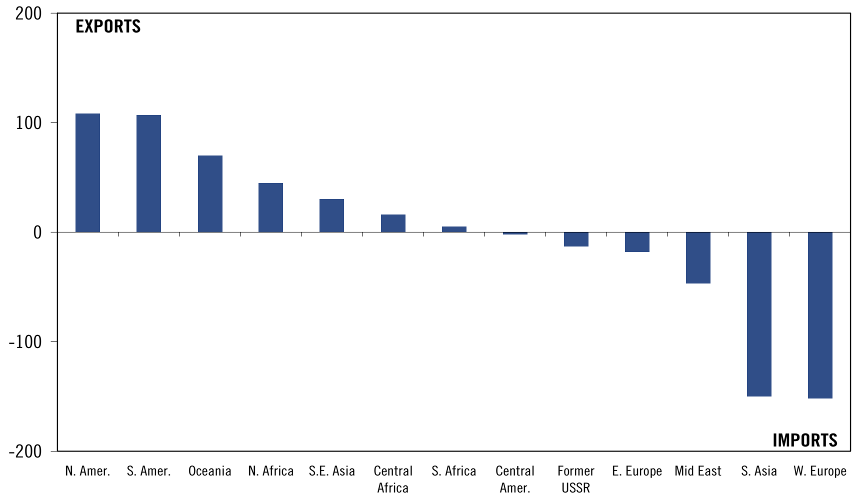
[11] *Fast-Growing Western U.S. Cities Face Water Crisis,* March 12, 2009

[12] *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture,* 2007

"Virtual Water:" Limited Trade Potential

As water scarcity has increased, the savings associated with trade of "virtual water" embedded in various products has become more apparent. In theory, the virtual water trade involves the importation by water-scarce nations (e.g., Saudi Arabia) of their least water-efficient goods (largely agricultural products) from countries that have a lower opportunity cost of water and higher productivity (e.g., Pakistan) — see Figure 12.

Figure 12. Trade in Virtual Water
Net Amount in Cubic Kilometers Per Year



Source: United Nations

Global water savings through international trade of agricultural products is equivalent to 6% of the global volume of water used for agricultural production.

By way of example, Mexico imports wheat, maize and sorghum from the United States, which require 7.1 cubic kilometers (km^3) of water a year in the U.S. to produce. If Mexico produced the imported crops domestically, it would require 15.6 km^3 a year. So, from a global perspective, this trade in cereals saves 8.5 km^3 of water a year. And despite some virtual water exports from countries with low water productivity to countries with high productivity, global water *savings* through international trade of *agricultural products* has been estimated at about 350 km^3 a year, equivalent to 6% of the global volume of water (including rainfall) used for agricultural production.

The *Economist* pointed out[13] that trade in virtual water has recently been having geopolitical implications:

- The overthrow of Madagascar's president in mid-March [2009] was partly caused by water problems — in South Korea. Worried by the difficulties of increasing food supplies in its water-stressed homeland, Daewoo, a South Korean conglomerate, signed a deal to lease no less than half Madagascar's arable land to grow grain for South Koreans. Widespread anger at the terms of the deal (the island's people would have received practically nothing) contributed to the president's unpopularity. One of the new leader's first acts was to scrap the agreement.

[13] *Water: Sin aqua non,* April 8, 2009

The global volume of virtual water trading accounts for about 40% of total water consumption.

In total, the *global volume* of virtual water trading is 1,625 km^3 a year, accounting for about 40% of total water consumption. About 80% of those virtual water flows involve agricultural products, with the remainder being industrial products. The trade in virtual water is rising rapidly — the *World Bank* has pointed[14] to estimates that projected developing-country cereals imports through 2025 will save 147 km^3 of water, equivalent to 12 percent of those countries' irrigation water consumption.

Even still, the *World Wide Fund for Nature* observed[15] that:

Most trade is not based on rational determinations of comparative advantage based on water, but rather on broader political and economic factors.

- Most trade is *not based on rational determinations of comparative advantage based on water,* but rather on broader political and economic factors [italics added].

Rainwater Harvesting: Less Scope for Large Dams

In the aforementioned article, the *Economist* also pointed out that:

- Climate change increases problems of water management. Larger floods overwhelm existing controls. Reservoirs do not store enough to get people or plants through longer droughts. In addition, global warming melts glaciers and causes snow to fall as rain. Since snow and ice are natural regulators, storing water in winter and releasing it in summer, countries are swinging more violently between flood and drought.

  That is one big reason why dams, once a dirty word in development, have been making a comeback, especially in African countries with *plenty of water but no storage capacity* [italics added].

Similarly, in its recent *World Water Development Report,* the United Nations noted that:

Increasingly, it will be impossible to do without some form of water storage.

- Increasingly, *it will be impossible to do without some form of water storage,* either surface (reservoirs or water-harvesting systems) or underground (cisterns and aquifers). Global changes, in particular the impacts of climate change, elevate the need for water storage to a higher priority…The potential for increased storms and extreme rainfall events means that dams and other large-scale infrastructure will need to be built to higher engineering standards, to withstand future risks [italics added].

However, the *World Bank* pointed out[16] that:

There will be less scope for the large dams that store water over years and transfer from areas of high rainfall to dry areas.

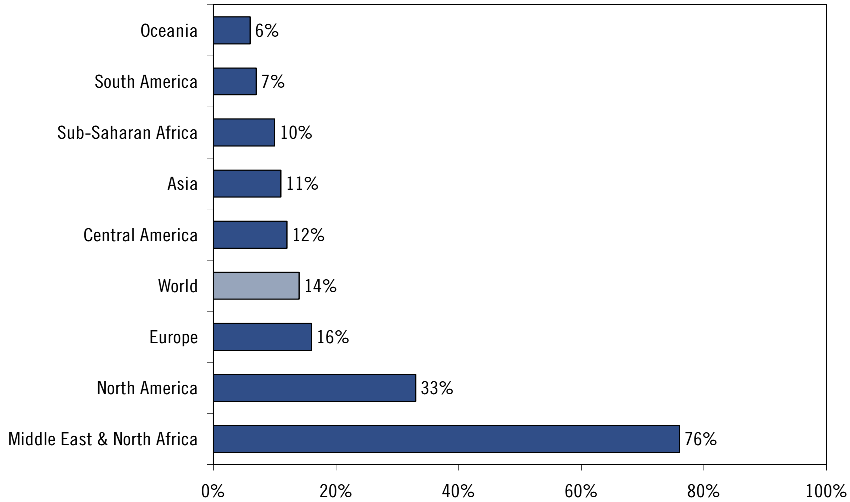
- *There will be less scope for the large dams that store water over years and transfer from areas of high rainfall to dry areas.* The environmental and social consequences of these dams will continue to be contested, and it is likely that nations will construct relatively few of them. *There could be more investment in the construction of small dams* to meet inter-seasonal deficits and harvest runoff locally, provided these dams contribute to basin efficiency. Small dams do not raise social and environmental problems on the same scale as large dams [italics added].

[14] *Reengaging in Agricultural Water Management,* 2006
[15] *Understanding water risks,* March 2009
[16] *Reengaging in Agricultural Water Management,* 2006

Water shortages are putting increasing pressure on irrigated agriculture.

In a section below, we discuss the differences between rain-fed and irrigated agriculture. Water shortages are putting increasing pressure on irrigated agriculture, so that capturing the (increasingly variable) rainfall needed for rain-fed agriculture is becoming more important. There is significant potential to capture more rainfall by building dams — Figure 13 illustrates that, globally, available storage reservoir capacity is just 14% of the volume of annual renewable water resources (i.e., surface water and groundwater recharged by precipitation).

Figure 13. Reservoir Storage as a Percentage of Renewable Water Resources



Source: Foundation for Water Research

In "Water Worries," we highlighted two Indian companies well positioned to benefit from dam building as an offset to increasingly variable rainfall in that country: **Gammon India** and **Jaiprakash.**

One Scenario for Averting Water Bankruptcy

As outlined above, there are limited options for increasing the supply of water in the face of steadily growing demand for the finite resource. Figure 14 illustrates that it is forecast that global water demand will *increase by over one-third* between 2000 and 2050:

- The agricultural sector will remain the largest consumer of water (Figure 16) although its consumption *growth* will be relatively slow — a compound annual rate of just 0.2% between 2000 and 2050. As we discuss in detail below, the reason for this slow demand growth is *more efficient water usage.*
- The greatest *absolute* increase in water demand is forecast to come from the urban sector: +691 cubic kilometers.
- The industrial sector is forecast to have the largest *percentage* increase in water demand — a compound annual growth rate of 1.9%.

Recycling, combined with improved agricultural efficiency, would likely mean that the world would avoid water bankruptcy.

As for supply to meet this demand, Figure 14 outlines one scenario including, most notably, *a significant increase in wastewater treatment and reuse.* Recycling, combined with improved agricultural efficiency, would likely mean that the world would avoid water bankruptcy.

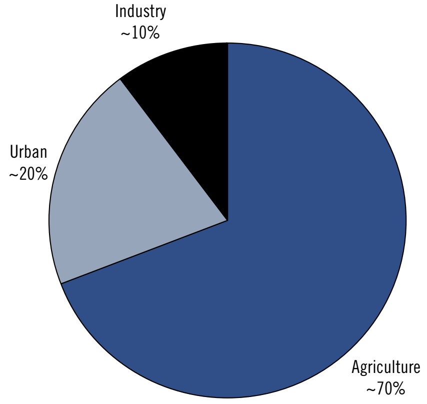
Figure 14. One Scenario for Averting Water Bankruptcy: "The Water Balance Sheet"
Cubic Kilometers

Sector	Demand 2000	Demand 2050		Supply 2000	Supply 2050	CAGR 2000-50
Irrigated Agriculture			Surface water	1902	2137	0.2%
			Groundwater	476	468	0.0%
			Agricultural drainage water*	170	170	0.0%
			Wastewater (untreated and treated)	83	200	1.8%
Sector total	***2630***	***2975***		***2630***	***2975***	***0.2%***
Urban			Surface water	502	875	1.1%
			Groundwater	140	234	1.0%
			Wastewater (treated)	0	173	Nmf
			Desalination	12	62	3.4%
Sector total	***654***	***1345***		***654***	***1345***	***1.5%***
Industrial			Surface water	187	481	1.9%
			Groundwater	56	78	0.7%
			Wastewater (treated)	2	58	6.6%
Sector total	***245***	***617***		***245***	***617***	***1.9%***
World			Surface water	2591	3494	0.6%
			Groundwater	671	780	0.3%
			Agricultural drainage water*	170	170	0.0%
			Wastewater (untreated and treated)	85	431	3.3%
			Desalination	12	62	3.4%
World total	**3529**	**4937**		**3529**	**4937**	**0.7%**

*Includes surface runoff; water is distributed by a system of drains and pipes

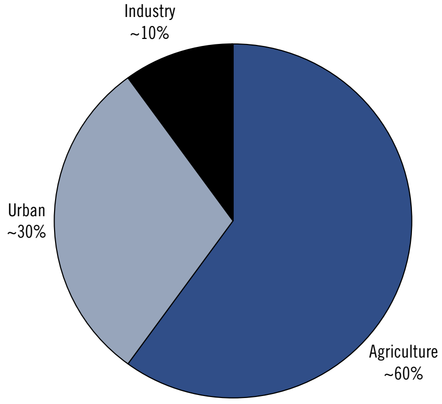
Source: International Water Management Institute, United Nations, International Food Policy Research Institute, Citi Investment Research and Analysis

Figure 15. Consumption of Water Withdrawn by Sector: Current



Source: United Nations

Figure 16. Consumption of Water Withdrawn by Sector: 2050



Source: Comprehensive Assessment of Water Management in Agriculture

Curbing Agricultural Demand

The scenario for averting water bankruptcy outlined in Figure 14 depends, in large part, on using more efficient techniques to slow the growth in consumption of water by the agricultural sector. In that regard, the Food and Agriculture Organization of the United Nations wrote[17] that:

- It is expected that, under pressure from limited water resources and competition with other users, *demand management will play a more important role in improving [agricultural] irrigation efficiency in water scarce regions* [italics added].

Cutting agricultural demand for water is possible by (i) more efficient irrigation techniques, and/or (ii) the introduction of drought-resistant crops.

As we discuss in detail, cutting agricultural demand for water (70% of world water usage) is possible by (i) more efficient irrigation techniques, such as drip irrigation, and/or (ii) the introduction of drought-resistant crops.

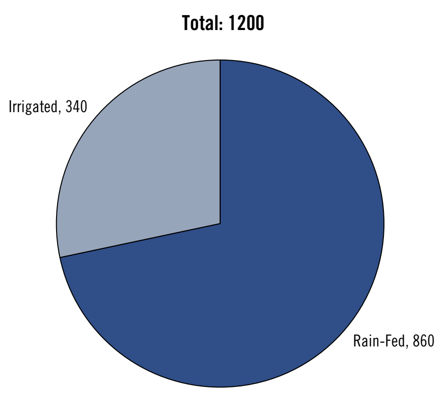
Rain-Fed Agriculture: Vulnerable

Rain-fed agriculture (whereby the soil stores rain and releases it slowly to plants) covers 72% of the world's cultivated land — see Figure 17. Rainwater used in agriculture has, thus far, not been subject to competition from other sectors although, as illustrated in Figure 4, *climate change is resulting in changing rainfall patterns in many regions of the world.* Consequently, a major report[18] about agriculture and water noted that:

Climate change, which is expected to increase the variability and intensity of weather events, exacerbates the risks of rain-fed production.

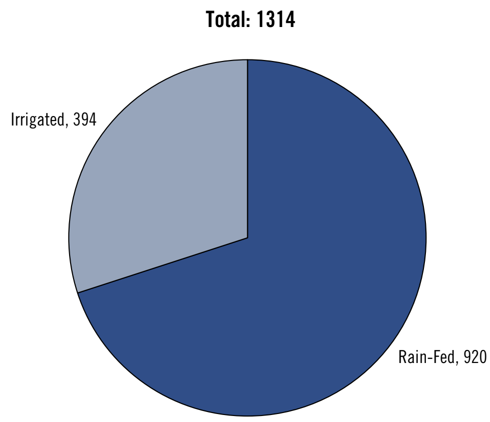
- *Climate change, which is expected to increase the variability and intensity of weather events, exacerbates the risks of rain-fed production,* particularly in semi-arid areas vulnerable to drought. Floods may damage infrastructure (roads, bridges), with negative implications for marketing farm output [italics added].

Figure 17. Cultivated Land, Rain-Fed and Irrigated: Current
(Millions of Hectares)



Source: International Water Management Institute

Figure 18. Cultivated Land, Rain-Fed and Irrigated: 2050
(Millions of Hectares)



Source: International Water Management Institute

[17] *The FAO Irrigated Area Forecast for 2030,* 2002

[18] *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture,* International Water Management Institute, 2007

Irrigated Agriculture: Unsustainable Water Consumption

When rainfall is inadequate, irrigation is required — Figure 18 illustrates that, reflecting growing demand for food as well as the effects of climate change on rain-fed agriculture, the area of irrigated land is forecast to increase 16% by 2050, versus a 7% increase in cultivated land that is rain-fed. (Note that although irrigated agriculture occupies only 28% of the world's cropland, it accounts for almost half [46%] of the *value* of total agricultural output, because multiple cropping made possible by irrigation produces higher yields per acre.)

Irrigation requirements could increase 20% because of climate change factors alone.

Reflecting the fact that higher temperatures will result in greater evaporation, climate change will *materially increase irrigation water requirements.* One study[19] estimated that irrigation requirements could increase 20% because of climate change factors alone:

- Baseline global warming by the 2080s would cause the farmland-weighted averages for annual temperatures to rise by 5.4°C and the corresponding averages for precipitation to fall by 4.3 mm per year. If these changes are applied to [a] simple regression equation, the incidence of irrigation would need to rise by 20.3 percentage points as a consequence of climate change. The increase would be almost entirely from higher temperature; the slight decline in precipitation would have little effect.

Given the water-intensive nature of irrigation, agriculture currently accounts for about 70% of total water withdrawals (see Figure 15), with that amount *rising to over 90% in some developing countries.* (Livestock water demand is just 2-3% of total global water consumption.)

60% of the water withdrawn for agriculture is consumed by crops and evaporation.

Furthermore, unlike in industrial and domestic uses in *developed* economies, where little water is actually consumed and much of it is returned to rivers after use, a large volume of water used in agriculture is lost. It is estimated that 60% of the water withdrawn for agriculture is consumed by crops and evaporation, with just 40% returning to surface water or groundwater. So, in contrast to rain-fed cultivation, *agricultural irrigation competes with other sectors for water.*

As for the sectors that agriculture will increasingly be competing with, Figure 16 illustrated that demand for water by urban areas is forecast to increase significantly in coming decades. Reflecting this trend, it was pointed out[20] that:

- The OECD Environmental Outlook Baseline projects a *decrease in agricultural water consumption* in China to 2030, largely as a result of improved irrigation technology. But this is *expected to be more than offset by a dramatic increase in non-agricultural water uses associated with economic development* [italics added].

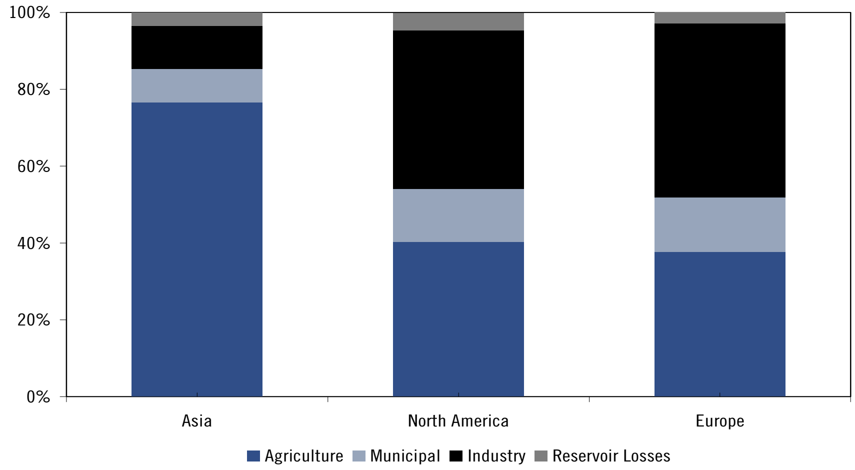
Improving agricultural water efficiency is largely a developing region issue.

Finally, while the agricultural sector *in aggregate* is the largest consumer of water by far, *sector demand differs by region* so that, in the U.S. and Europe, the industrial sector is the largest consumer of water — see Figure 19. In other words, *improving agricultural water efficiency is largely a developing region issue.*

[19] *Global Warming and Agriculture,* Center for Global Development, Peterson Center for International Economics, 2007

[20] *Environmental Outlook to 2030*

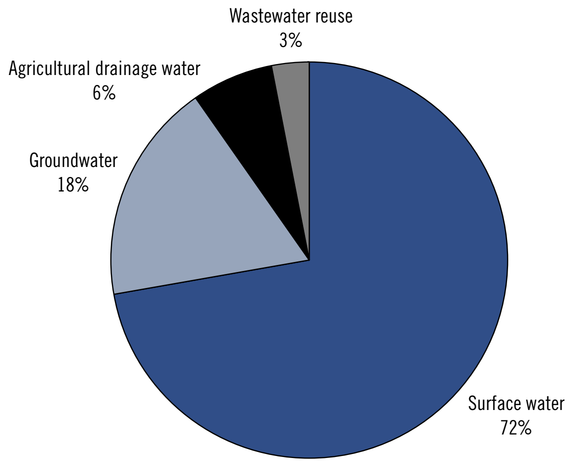
Figure 19. Water Withdrawal by Sector (Current)



Source: United Nations Educational Scientific and Cultural Organization

As for the sources of water used for agricultural irrigation, Figure 20 illustrates that the two most important sources are surface water (e.g., rivers and lakes) and groundwater.

Figure 20. Sources of Water Used for Agricultural Irrigation



Source: FAO-AQUASTAT

Note here that, even when surface water is available, it may not always be suitable for irrigation — so, for example, it was reported[21] that:

One-fourth of the water sampled along China's two largest rivers was found to be too polluted even for farm irrigation.

- One-fourth of the water sampled along China's two largest rivers — the Yangtze and Yellow — was found to be *too polluted even for farm irrigation* [italics added].

Although groundwater only accounts for about one-fifth of the water used in agricultural irrigation, expanded usage of groundwater in the last two decades (see Figure 7) has contributed significantly to growth in global irrigated areas. Specifically, irrigated areas supplied wholly or partly by groundwater are officially reported at 69 million hectares, more than double the approximately 30 million hectares in the 1950s. We noted above that current rates of groundwater withdrawal are unsustainable.

[21] *China Faces a Water Crisis,* BusinessWeek, April 15, 2009

Efficient Irrigation: "More Crops per Drop"

As discussed above, one possible response to competing demands for limited water resources is to expand the use of wastewater — untreated and treated — for agricultural irrigation. But before alternative water *sources* are utilized, a key opportunity is to improve the efficiency of water already currently *used* for agricultural irrigation. On that point, a World Bank expert stated:[22]

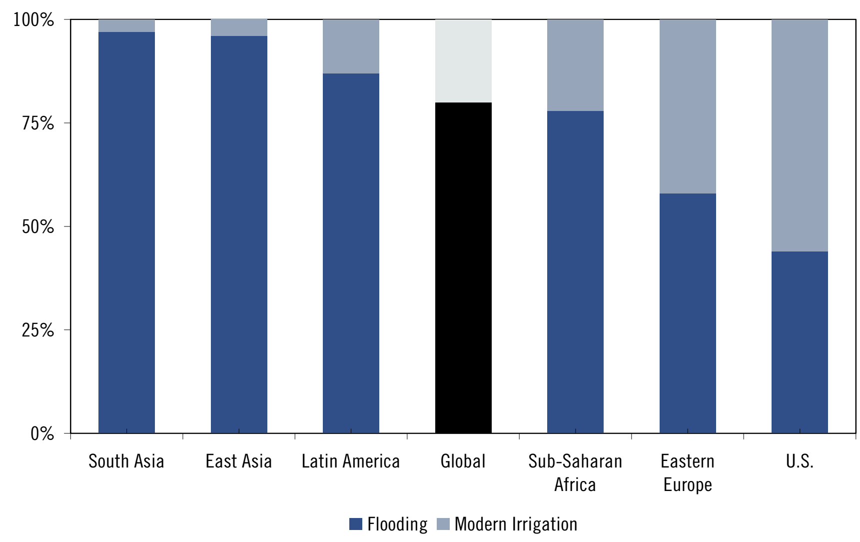
Saving water rather than the development of new sources is often the best "next" source of water.

- Saving water rather than the development of new sources is often the best "next" source of water both from an economic and from an environmental point of view.

Water usage, and dependence on rain-fed or irrigated agriculture, varies across regions, for the most part following climate patterns. The arid countries that withdraw the most groundwater for irrigation purposes are India, the U.S., and China. (Approximately 70% of the world's irrigated land is in Asia; China and India together account for more than half of irrigated land in Asia.) As we pointed out above, irrigated agriculture accounts for almost half of the *value* of the world's agricultural output.

Much of that irrigation is highly inefficient — Figure 21 illustrates that over 80% of global irrigation is still done by simply flooding fields, but *with less than 40% of that water actually reaching the intended crops.*

Figure 21. Irrigation Methods by Region



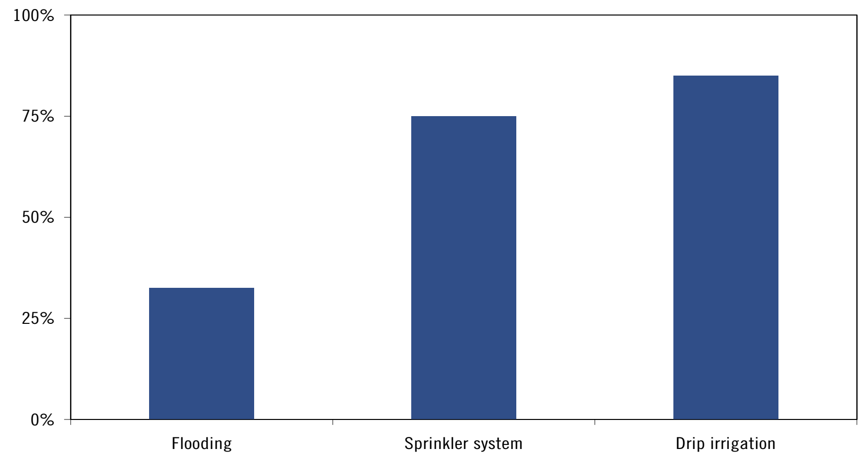
Source: World Bank

In terms of modern irrigation systems, two methods that offer high levels of water efficiency are (i) sprinklers and (ii) drip irrigation — see Figure 22. ("Irrigation efficiency" compares water withdrawal to water beneficially used by plant roots.) Although introducing new irrigation technology typically increases costs, it also increases water use efficiency, resulting in overall savings.

[22] Manuel Schiffler, *Perspectives and challenges for desalination in the 21st century,* 2004

Figure 22. Irrigation Efficiency by Method

Water Beneficially Used by Plant Roots as a Percentage of Water Withdrawal



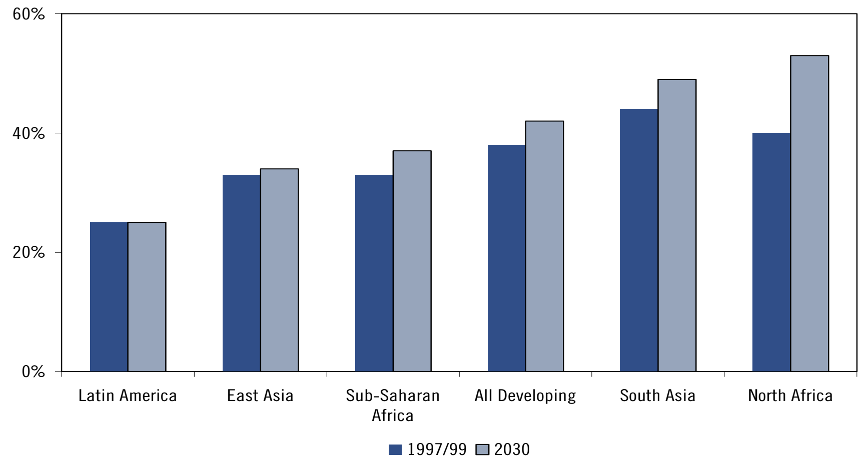
Source: World Bank

- *Sprinkler irrigation* involves piping water to a central location within a field, and then distributing it by a network of overhead high-pressure sprinklers. This technology is utilized in less than 20% irrigated areas globally.
- *Drip irrigation* delivers water (and fertilizer) at or near the root zone of plants, rather than spraying an entire field. This technology is currently utilized in only about 1% of all irrigated land.

In many developed countries, crop yields and water productivity are already quite high, thereby limiting the scope for further improvements.

It's important to acknowledge here that, in many *developed* countries, crop yields and water productivity are already quite high, thereby limiting the scope for further improvements. With regard to *developing* regions, Figure 23 illustrates that water efficiency is forecast to increase by 4 percentage points by 2030, with the increase being more pronounced in water scarce regions (e.g., North Africa) than in regions with abundant water resources (e.g., Latin America).

Figure 23. Irrigation Efficiency in Developing Regions: 1997/99 and 2030



Source: FAO

In terms of companies well positioned to benefit from these trends, **Lindsay** and **Valmont Industries** are the leaders in the global mechanized irrigation equipment market, with a combined market share of 73%.

Drought-Tolerant Crops

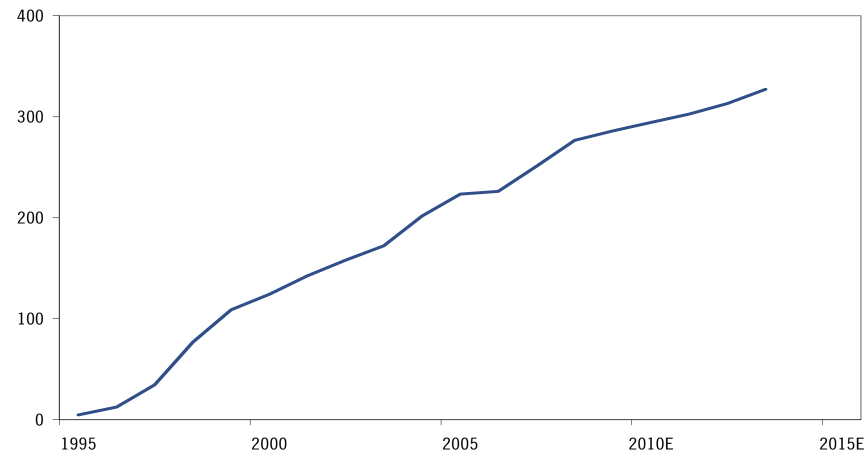
Another way to cut agricultural demand for water is by using agricultural biotechnology. The industry leader in ag biotech product development is **Monsanto** — in 1981, the company established a molecular biology group, and biotechnology was firmly established as its strategic research focus.

It was not until 1996 that Monsanto commercialized its first biotech crops: *Roundup Ready* soybeans (resistant to the company's popular *Roundup* herbicide), and *Bollgard* cotton (resistant to a common pest). A pest-proof corn (*YieldGard* corn) soon followed. The modified cotton and corn allowed farmers to forgo dousing their crops with chemicals, while the modified soybeans allowed farmers to spray more *Roundup* without killing the crop. In the industry terminology, these products featured single "traits," such as resistance to a particular pest.

Global agricultural biotech acreage is forecast to double this decade.

Figure 24 illustrates that global agricultural biotech acreage is forecast to double this decade, as farmers adopt agricultural biotech products for their higher yield potential. Because Monsanto was a first mover, it has enjoyed a strong lead in agricultural biotech over competitors such as **Syngenta**, although that company has been working hard to catch up.

Figure 24. Global Agricultural Biotech Acreage (Millions)



Source: Company reports, U.S. Department of Agriculture, and Citi Investment Research and Analysis

Monsanto is also at the forefront of another development in agricultural biotechnology: marker-assisted breeding. This process involves the mapping of particular genes, which control certain desirable properties such as yield, moisture retention, and plant height. Marker-assisted breeding increases the probability of these favorable genes appearing in the hybrid seed during the breeding process.

In particular, marker-assisted breeding can help address two limiting factors for crop yields — the availability of (i) water and (ii) nitrogen (either in the topsoil or via fertilizer).

- Monsanto, in a joint venture with **BASF,** is addressing *water consumption* by using marker-assisted breeding to develop drought-tolerant corn and soy varieties. Commercialization of drought-tolerant crops is expected by 2012.
- Separately, crops that use *nitrogen* efficiently also lead to less downstream water pollution, reflecting reduced fertilizer consumption. Syngenta is targeting a launch of nitrogen-efficient crops for 2015.

Water Worries: An Update

In "Water Worries" we summarized the climate change factors impacting water supplies:

- *Precipitation patterns changing:* The water-holding capacity of the atmosphere increases with rises in temperature. Even as the potential for heavier precipitation has increased, the duration and frequency of downpours may be curtailed, as it takes longer to recharge the atmosphere with water vapour.
- *Drought increasing:* Precipitation over land has marginally decreased, while evaporation has increased due to warmer conditions. As a result, global "very dry" areas have more than doubled since the 1970s.
- *Snow cover decreasing:* Shrinking glaciers are an issue from the South American Andes to Asia's Indus river basin. Northern Hemisphere snow cover has declined, especially since 1980, and with an increasing trend during the past decade.
- *Pollution rising:* Higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution.

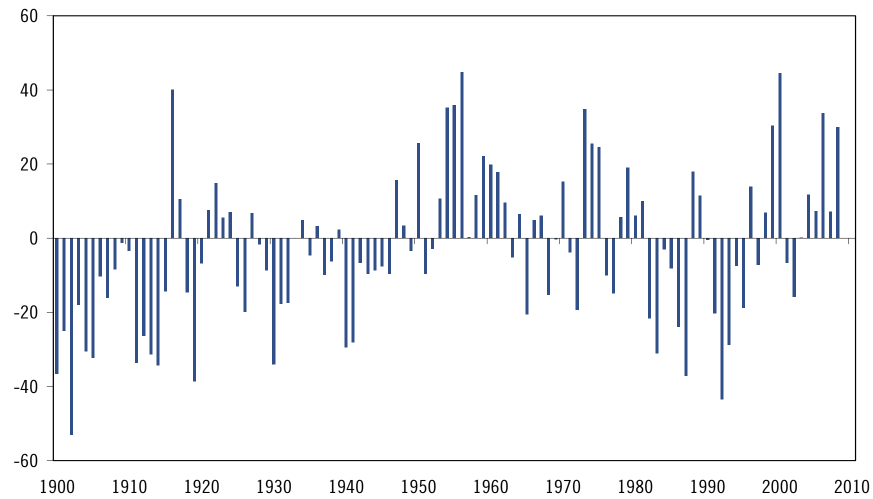
Below we update our analysis of how those climate change factors are impacting water supplies.

Precipitation Patterns Changing

In its "statement on the status of the global climate in 2008" the *World Meteorological Association* (WMO) observed that global precipitation over land was "above the 1961–1990 average" last year — see Figure 25. However, as we noted above, heavier precipitation is not surprising; it is the *variability* of that precipitation that is significant.

Heavier precipitation is not surprising; it is the variability of that precipitation that is significant.

Figure 25. Annual Global Precipitation Anomalies (Millimeters)
Anomaly to the 1961-1990 average



Source: National Climate Data Center

Precipitation throughout the year was variable in many areas in 2008.

Looking behind the global average for 2008, the WMO wrote that:

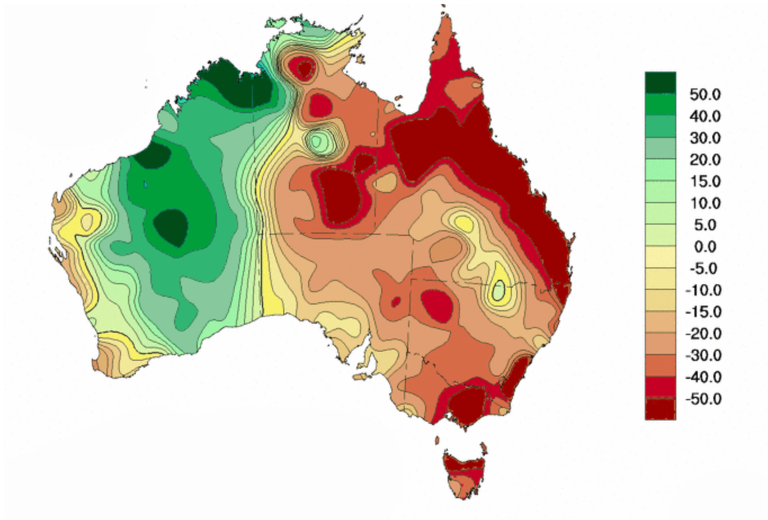
- *Precipitation throughout the year was variable in many areas. Less than average conditions* were observed across the western and south-central contiguous United States; southwestern Alaska and the Hawaiian Islands; south-eastern Africa; southern Europe; northern India; and parts of Argentina, Uruguay, eastern Asia and southern Australia. Most of Europe, western Africa, the north-eastern and central contiguous United States, parts of northern South America, south-eastern Asia and northern Australia *experienced wetter than average conditions* [italics added].

Similarly, scientists at the *National Climate Data Center* wrote[23] that precipitation patterns in 2008 involved:

- Large areas of *wet anomalies* over the central and northeast U.S., Southeast Asia, Amazon Basin, and parts of Western Europe and northern Australia. *Dry anomalies* dominated much of the Mediterranean Sea, Australia, Hawaii, the western U.S., and parts of southern Africa, South America, and East Asia.

Figure 26 illustrates that, as outlined above, sparsely-populated Western Australia has become progressively wetter, while the developed eastern side of the continent has become progressively drier.

Figure 26. Trend in Annual Total Rainfall in Australia, 1970 – 2008
Millimeters Per Decade



Source: Australian Bureau of Meteorology

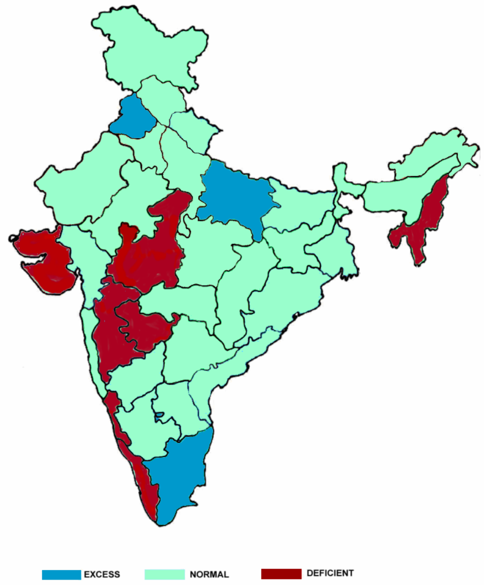
And following the end of the 2008 monsoon season in India (which runs from June through September), Citi analysts commented[24] that:

- Trends in monsoons remained disappointing, with rainfall during the week ended 3rd September 27% below normal. On a cumulative basis, from 1 June – 3rd Sept, the rainfall was 3% below normal — see Figure 27.

[23] The Climate of 2008 in Historical Perspective

[24] See Rohini Malkani's September 5, 2008, report, "India Econ Views"

Figure 27. Rainfall Distribution Over India During 2008 Monsoon Season



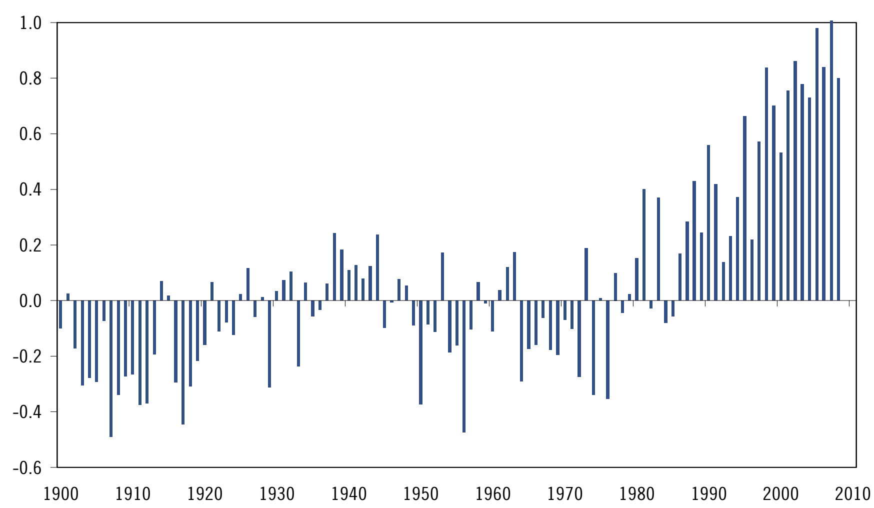
Source: India Meteorological Department

Drought Increasing

We pointed out in "Water Worries" that, in simple terms, drought is an imbalance between precipitation and evaporation. Obviously, warming trends accelerate land surface drying, and boost the potential incidence and severity of droughts. In that regard, Figure 28 illustrates that, since the beginning of modern measurements in 1850, the ten warmest years on record have occurred in the last two decades.

Since the beginning of modern measurements in 1850, the ten warmest years on record have occurred in the last two decades.

Figure 28. Annual Global Temperature Anomalies (degrees C)
Anomaly to the 1961-1990 average



Source: National Climate Data Center

Reflecting this combination of increasingly variable precipitation and steadily rising temperatures, the WMO pointed out that:

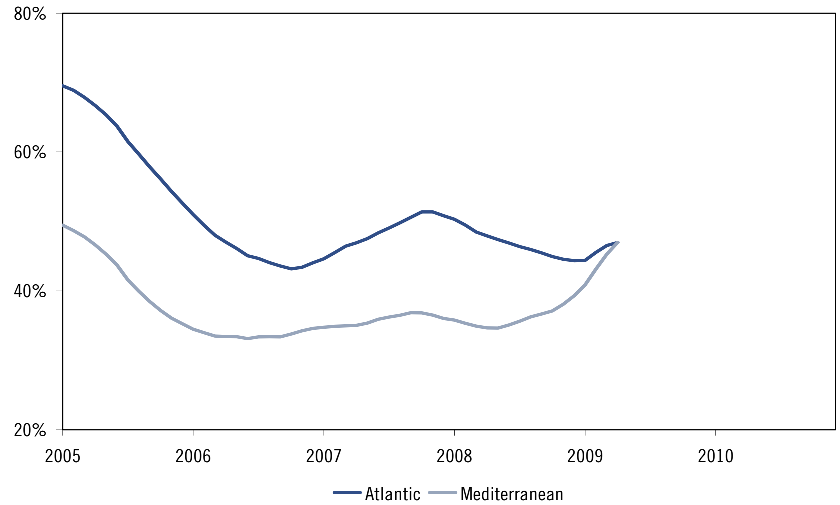
- At the end of July [2008], most parts of the southeast of North America were classified as having moderate to exceptional drought conditions…The continuous dry conditions across northern and central California resulted in numerous large wildfires. In Canada, southern British Columbia experienced its fifth driest period in 61 years. In Europe, Portugal and Spain experienced their worst winter drought in decades. South America, including the centre-east and north-east of Argentina, and a large part of Uruguay, Paraguay and southern Brazil, was particularly hit by a severe and prolonged drought, which started in the latter half of 2007…In southeastern Australia, dry conditions reinforced long-term drought over much of that region.

Figure 29 illustrates that, reflecting Spain's worst winter drought in decades, reservoir levels in that country fell to very low levels early in 2008, before recovering after what the WMO labeled as "intense rainfall" during the September–November period:

- In Valencia, Spain, a total rainfall of 390 mm was recorded in 24 hours, of which *144 mm was recorded in less than 1 hour*[25] [italics added].

Reflecting Spain's worst winter drought in decades, reservoir levels in that country fell to very low levels early in 2008.

Figure 29. Water Levels of Spanish Reservoirs as a % of Capacity
Twelve-Month Moving Average



Source: Ministerio de Medio Ambiente

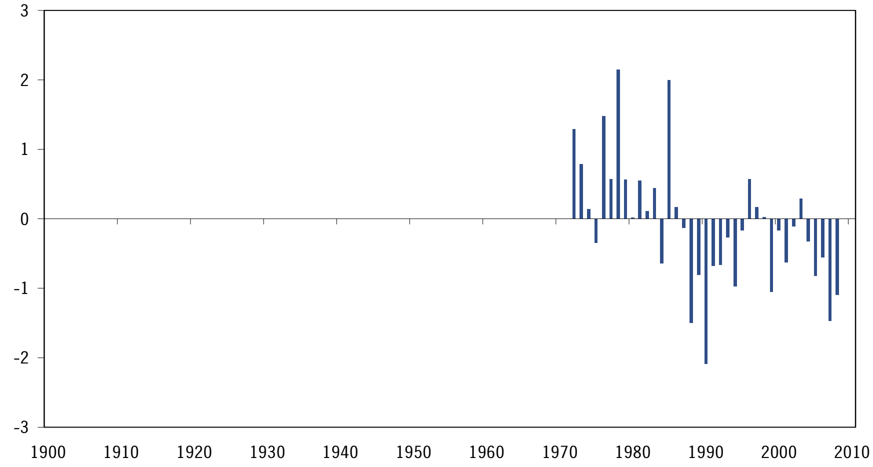
Snow Cover Decreasing

The 2008 Annual Report of the *Rutgers University Global Snow Lab* stated that:

- Annual snow cover extent (SCE) over Northern Hemisphere lands averaged 24.4 million square kilometers in 2008. This is 1.1 million sq. km. less than the 39-year average and ranks 2008 as having *the 4th least extensive cover on record* — see Figure 30 [italics added].

[25] 390 millimeters equals about 15 inches; 144 millimeters equals about 6 inches

Figure 30. Anomaly of Northern Hemisphere Snow Cover Extent
Departure from the Long-Term Mean in Millions of Square Kilometers



Source: Rutgers University Global Snow Lab

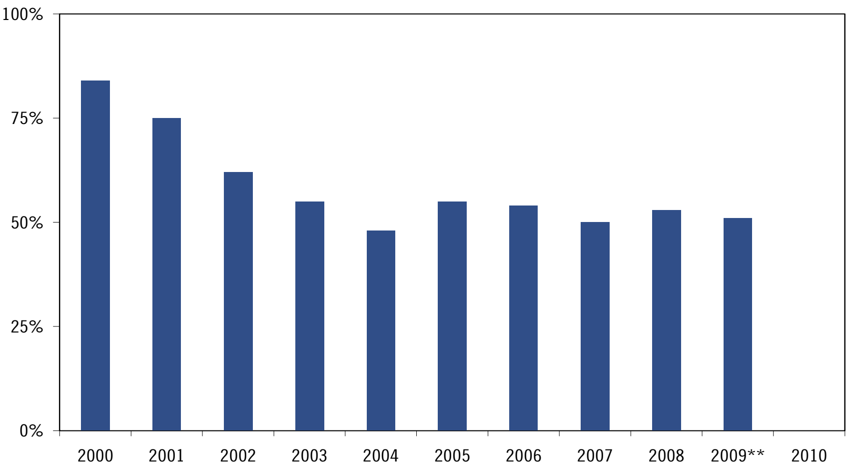
We noted in "Water Worries" that reduced snowmelt has been impacting the Colorado River, which serves the needs of 30 million people in seven western states: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. We referenced a quantitative analysis[26] by scientists at the National Oceanic and Atmospheric Administration, which concluded that:

The Southwestern U.S. is likely past the peak water experienced in the 20th century. A decline in Colorado River flow will reduce water availability below current consumptive demands within a mere 20 years.

- The Southwest is likely past the peak water experienced in the 20th century…A decline in Lees Ferry[27] flow will reduce water availability below current consumptive demands within a mere 20 years.

Figure 31 illustrates that the reservoir capacity of four major reservoirs along the Colorado River in Arizona is currently 51%, down from 84% in 2000.

Figure 31. Reservoir Capacity of Four Major Reservoirs* in Northwestern Arizona



* Lakes Havasu, Mohave, Mead, and Powell **April 2009
Source: National Water and Climate Center

[26] M. Hoerling and J. Eischeid, "Past Peak Water in the Southwest," *Southwest Hydrology,* January / February 2007

[27] A point near Lees Ferry in northern Arizona is where the annual flow of the Colorado River is measured.

Pollution Rising

In "Water Worries" we pointed out that higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution:

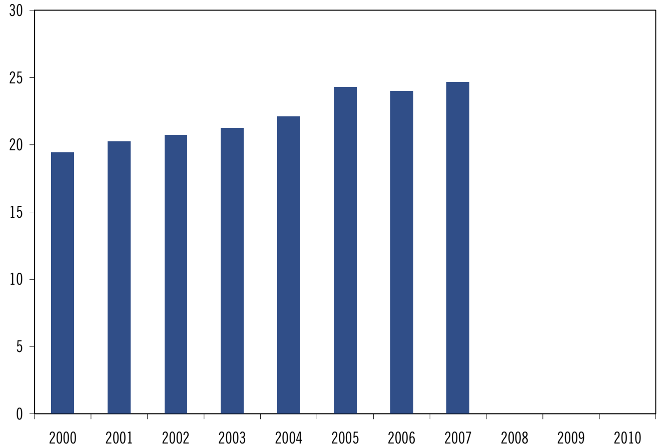
- *Higher water temperatures:* Increasing water temperature affects the self-purification capacity of rivers by reducing the amount of oxygen that can be dissolved and used for biodegradation. We noted above that 2008 was among the ten warmest years on record (see Figure 28).
- *Increased precipitation intensity:* Increases in intense rainfall result in more nutrients, pathogens, and toxins being washed into water bodies. In 2008, global precipitation over land was well above the 1961–1990 average (see Figure 25).
- *Longer periods of low flows:* Lower water availability reduces dilution of toxins in water bodies. Water levels in many of the world's most important rivers — including the Colorado River in the U.S. — have been steadily declining (see Figure 31).

There are growing volumes of wastewater, both from industrial and non-industrial sources.

At the same time that these climate change factors are impacting the quality of water supplies, there are growing volumes of wastewater, both from industrial and non-industrial sources. However, we pointed out above that wastewater in developed economies is subject to rigorous treatment, with that trend spreading to developing economies too.

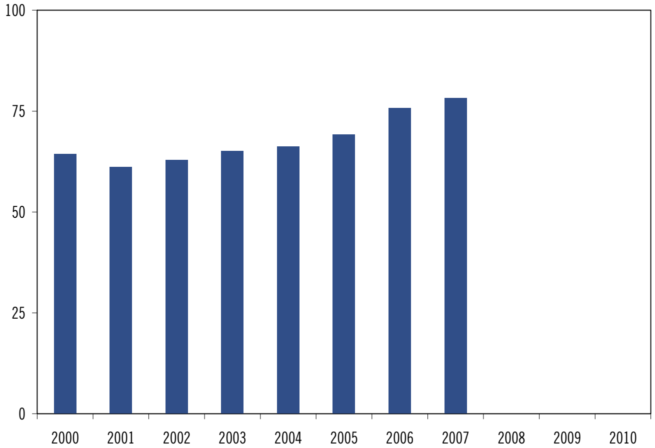
So, for example, China's central government target is to raise the *municipal* wastewater treatment rate from 52% in 2005 to 70% by 2010. Growing volumes of *industrial* wastewater in China (see Figure 32) are also being subject to increasing amounts of treatment (see Figure 33).

Figure 32. Discharge of Industrial Wastewater in China
Billions of Tons



Source: China Statistical Yearbook

Figure 33. Facilities in China for Treatment of Industrial Wastewater
Thousands



Source: China Statistical Yearbook

Well-Positioned Companies

Figure 34 lists 28 companies referenced in the text above, and in the two aforementioned reports discussing "Water Worries," which seem well-positioned to benefit from the various water-related trends.

Figure 34. Select Companies with Water Exposure

Sub-Theme	Company	Country	Comment
Precipitation Patterns Changing			
	Gammon India	India	Expertise in numerous water-related construction activities
	Jaiprakash	India	Dam building by E&C companies offers a potential offset to increasingly variable rainfall
Drought Increasing			
	BASF	Germany	Drought-tolerant crops are an area of research focus
	Crane Group	Australia	A leading Australian supplier of drainage and irrigation products
	Leighton Holdings	Australia	A beneficiary of desalination plant construction in eastern Australia
	Lindsay	U.S.	A leader in the global mechanized irrigation equipment market
	Monsanto	U.S.	Drought-tolerant crops are an area of research focus
	Syngenta	Switzerland	Nitrogen-efficient crops (which reduce water pollution) are an area of research focus
	United Group	Australia	Currently involved with a large number of Australian water projects
	Valmont Industries	U.S.	A leader in the global mechanized irrigation equipment market
Snow Cover Decreasing			
	General Electric	U.S.	Desalination is one potential response to reduced snowmelt; GE is the largest U.S. player
	Roper Industries	U.S.	Automated water meters can reduce demand; Roper is a leading player in North America
Pollution Rising			
	China Everbright International	Hong Kong	A builder and operator of municipal wastewater treatment plants in China
	Epure International	Singapore	Involved with the construction of large municipal wastewater plants across China
	Thermax	India	A leading player in the Indian wastewater management sector
	Veolia Environnement	France	The global leader in water is involved with wastewater treatment in emerging economies
Emerging Market Thirst			
	Danone	France	The global market leader by volume in bottled water
	Doosan Heavy Inds & Construction	S. Korea	#1 desalination company globally benefits from strong demand in Middle East and Asia
	Empresas ICA SAB de CV	Mexico	The E&C company is a potential beneficiary of Mexican water infrastructure spending
	Nestlé	Switzerland	The global market leader in bottled water by the value of market share
	Promotora Ambiental SAB de CV	Mexico	Would benefit from contracts with Mexican municipalities to manage water systems
	Rotork	U.K.	The global leader in heavy duty actuators for the water industry
	Veolia Environnement	France	#2 desalination company globally is #1 overall in water services
Developed Economy Efficiency			
	Danaher Corp.	U.S.	The recycling and reuse of industrial water necessitates water treatment products
	Halma	U.K.	The global leader in leak detection technology
	ITT Corp	U.S.	The company's equipment monitors and regulates the flow of water
	Kurita Water Industries	Japan	Leading player in the markets for water-treatment chemicals and systems in Japan & Asia
	Nalco Holding	U.S.	The largest global player in the industrial water treatment industry
	Suez	France	#2 globally in water services benefits from public-private partnerships
	Veolia Environnement	France	The global leader in water services benefits from public-private partnerships

Source: Citi Investment Research and Analysis

COMPANIES REFERENCED:

BASF(BASF.DE; €30.24; 3M), CHINA EVERBRIGHT INTERNATIONAL (0257.HK; HK$2.35; 1L), CRANE GROUP (CRG.AX; A$9.40; 2H), DANAHER (DHR.N; US$59.96; 2M), DANONE (DANO.PA; €39.33; 2M), DOOSAN HEAVY INDS & CONSTRUCTION (034020.KS; W81,300; 2H), EMPRESAS ICA SAB DE CV (ICA.MX; P$26.84; 1S), EPURE INTERNATIONAL (EPIL.SI; S$0.45; 1M), GAMMON INDIA (GAMM.BO; Rs147.00; 3H), GENERAL ELECTRIC (GE.N; US$13.70; 2M), HALMA (HLMA.L; £1.79; Not Rated), ITT CORP (ITT.N; US$41.55; 2M), JAIPRAKASH (JAIA.BO; Rs173.30; 1M), KURITA WATER INDUSTRIES (6370.T; ¥2,640; 1M), LEIGHTON HOLDINGS (LEI.AX; A$22.30; 3H), LINDSAY (LNN.N; US$36.69; Not Rated), MONSANTO (MON.N; US$89.60; 1M), NALCO HOLDING (NLC.N; US$17.54; 1H), NESTLE SA (NESN.VX; SFr40.40; 1L), PROMOTORA AMBIENTAL SAB DE CV (PASAB.MX; P$12.50; 1S), ROPER INDUSTRIES (ROP.N; US$44.92; 2M), ROTORK (ROR.L; £8.91; Not Rated), SUEZ SA (LYOE.PA; €27.00; Not Rated), SYNGENTA (SYNN.VX; SFr272.00; 1L), THERMAX (THMX.BO; Rs390.05; 1M), UNITED GROUP (UGL.AX; A$9.88; 3H), VALMONT INDUSTRIES (VMI.N; US$66.19; Not Rated), VEOLIA ENVIRONNEMENT (VIE.PA; €21.88; 3M)

Appendix A-1

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