

Water Worries

Climatic Consequences: Update #3

- **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. Dam building offers a potential offset to increasingly variable rainfall.
- **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. In Australia, the authorities plan to spend billions on water initiatives, particularly in the drought-stricken eastern part of the continent; desalination is increasingly important.
- **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. In the western U.S., policy makers faced with reduced snowmelt can look to increase water supply (e.g., piping in water from other sources, desalination), and/or reduce demand (e.g., promoting conservation by automated water meters).
- **Pollution rising** — Higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution. A number of developing nations, including China and India, seem most at risk from climate-related water pollution, given that their pollution levels are already relatively high. Municipal wastewater treatment is forecast to experience rapid growth in emerging economies.
- **Supply-demand imbalance growing** — In many regions of the world where the supply of water is increasingly an issue because of climate change factors, there is also growing demand for water. Driven by urbanization and industrialization, water withdrawal in Asia is forecast to grow rapidly. In developed economies, while water demand is not growing particularly rapidly, supply issues (including aging infrastructures) mean that the focus is on efficient water usage.
- **Well-positioned** — We identify 24 companies in agricultural biotechnology, automated water meters, bottled water, desalination, engineering and construction, farm equipment, monitoring equipment, pipes and valves, wastewater treatment, and water services.

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

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Contents

Climate Change and Water	3
The Supply-Demand Balance	4
Climate Change and Water: The Physical Science Basis	8
Precipitation	8
Drought	9
Snow Cover	10
Pollution	11
Precipitation Patterns Changing	13
Australia: More Rainfall but a Changed Distribution	13
India: Dam Building a Potential Offset to Variable Rainfall	14
Drought Increasing	16
Eastern Australia: Looking to Sources Other Than Rainfall	16
Drought-Tolerant Crops	18
Snow Cover Decreasing	19
Water Shortages in the Western U.S.	19
Supply-Increase and Demand-Management Initiatives	20
Pollution Rising	24
Municipal Wastewater Treatment	24
Water Demand: Emerging Market Thirst	27
Infrastructure Development and Wastewater Treatment	31
Desalination	32
Bottled Water	34
Water Demand: Developed Economy Efficiency Initiatives	35
Demand Management	35
Water Recycling and Reuse	36
Public-Private Partnerships	37
Climatic Consequences: An Update	40
Appendix A: Climatic Consequences Companies	41
Appendix B: Climatic Consequences Companies by Sector	42
Appendix C: Climatic Consequences Companies by Country	43
Appendix D: Climatic Consequences Companies Performance	44
Appendix A-1	46
Analyst Certification	46

Figure 1. Industries Well Positioned to Benefit from Water Worries

Industry	Comment
Agricultural Biotechnology	Drought-tolerant genes would reduce crops' reliance on water
Automated Water Meters	Water metering has been shown to reduce water consumption
Bottled Water	Large areas in developing countries often lack safe drinking water
Desalination	In severely stressed areas, desalinizing sea water is often the only available option
Engineering and Construction	Water infrastructure projects include rainwater collection facilities and dam building
Farm Equipment	Drought in Australia has bolstered global wheat prices, boosting incomes of farmers
Monitoring Equipment	Much water is lost due to inefficiency and leakage
Pipes and Valves	Often neglected, 1-2% of global urban pipe networks need upgrading every year
Wastewater Treatment	Treated wastewater can be used for a number of consumer and industrial purposes
Water Services	Private sector involvement is growing; 44% of West Europe is already private

Source: Citi Investment Research

Climate Change and Water

In “Climatic Consequences: Investment Implications of a Changing Climate” (published on January 19, 2007; order no. US01T004), we discussed physical, regulatory, and behavioral implications of climate change issues. Subsequently, we published two updates to that report: “Climatic Consequences: An Update” (published on April 4, 2007; order no. US014956), and “Climatic Consequences: Update #2” (published on June 15, 2007; order no. US023673).

In this third update we further examine the implications of climate change for water. Various water-related issues have been making headlines lately:

Various water-related issues have been making headlines lately.

- In the Mexican state of Tabasco, flooding in early November affected as many as one million of the state's 2.2 million residents, prompting President Felipe Calderón to declare the event one of the worst natural disasters in Mexico's recent history.
- In the U.S. southeast, 32% of the region is currently in “exceptional drought,” the Department of Agriculture's most severe designation.
- In Europe, the most recent data show that mountain glaciers continue to melt, according to an analysis by the Zurich-based World Glacier Monitoring Service. The United Nations Environment Programme (UNEP) report, “Global Outlook for Ice and Snow,” released on World Environment Day 2007 (June 5) also highlighted Europe's shrinking glaciers.

Floods, droughts, and changing snow cover have long been newsworthy events. What's significant now is that climate change is having a significant impact on those variables.

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

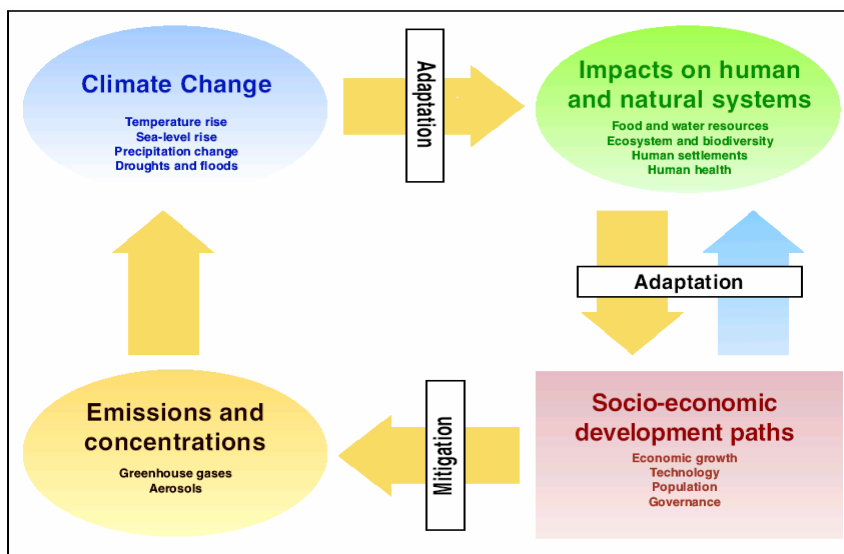
At this point, it's worth distinguishing between *climate* and *climate change*:

- The IPCC has focused¹ on “classical measures of climate...e.g., temperature, precipitation, sea level, plus extreme events including floods, droughts, and storms.”

¹ Climate Change 2001: Synthesis Report

- Climate *change* as defined by the IPCC refers to “statistically significant variations that persist for an extended period, typically decades or longer. It *includes shifts in the frequency and magnitude of sporadic weather events* as well as the slow continuous rise in global mean surface temperature [italics added].” The Panel noted that “an integrated view of climate change considers the dynamics of the complete cycle of interlinked causes and effects across all sectors concerned” — see Figure 2.

Figure 2. Climate Change: An Integrated Framework



Source: Intergovernmental Panel on Climate Change

In February, 2007, the IPCC released its most recent report² on the scientific basis for climate change. A key conclusion:

There have been changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.

- At continental, regional, and ocean basin scales, *numerous long-term changes in climate have been observed*. These include changes in Arctic temperatures and ice, *widespread changes in precipitation amounts*, ocean salinity, wind patterns and *aspects of extreme weather including droughts, heavy precipitation*, heat waves and the intensity of tropical cyclones [italics added].

The Supply-Demand Balance

Importantly, in many regions of the world where the supply of water is increasingly an issue — in large part because of climate change — there is also *growing demand* for water. Among the factors driving water demand:

- A thirsty consumer sector in emerging markets (water withdrawal rises with living standards).
- Water-intensive industrial processes in developed economies.

As we discuss below, climate-related issues *are key swing factors* in the supply-demand balance for this finite resource — see Figure 3.

² Climate Change 2007: The Physical Science Basis

Figure 3. Factors in the Water Supply-Demand Balance

Supply		Demand
Precipitation patterns changing	}	{
Drought increasing		
Snow cover decreasing		
Pollution rising		
		Emerging market consumer sector
		Developed economy industrial sector

Source: Citi Investment Research

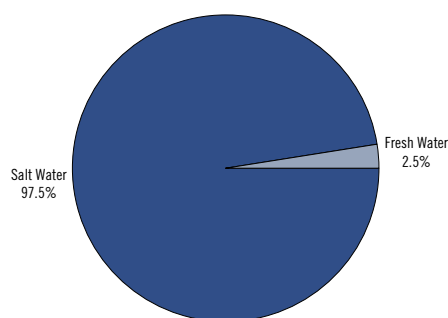
Water Supply: The Basics

By the estimates of the United Nations Educational Scientific and Cultural Organization (UNESCO), the world contains approximately 1,386 million cubic kilometers (km) of water:

- 97.5% of this is salt water.
- 2.5% is fresh water — see Figure 4.
- More than two-thirds of the fresh water is in the shape of ice and permanent snow cover in the Antarctic, the Arctic, and mountainous regions — see Figure 5. About one-third is under the ground, with some of this groundwater accessible for withdrawal — the United Nations has cited³ estimates that groundwater represents about 20% of global water withdrawals.
- Only 0.26% of the total amount of fresh water (about 90,000 cubic km) is potentially available above ground in lakes and river systems.

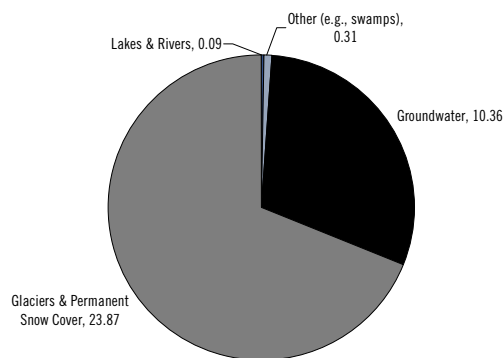
Only 0.26% of the total amount of fresh water is potentially available.

Figure 4. The World's Water



Source: United Nations Educational Scientific and Cultural Organization

Figure 5. Total Global Freshwater by Location (Millions of Cubic Kilometers)



Source: United Nations Educational Scientific and Cultural Organization

The values in Figure 5 characterize *static* water storage. In reality, the values of water storage *vary during water exchange* among the oceans, land, and the atmosphere. (Recall that water exists in three states: liquid, solid, and invisible vapour.) This exchange is called “water turnover.” A measure of *renewable* (versus static) water resources includes water replenished annually in the process of water turnover — the mean value of renewable global water resources is estimated by UNESCO at 42,750 cubic km per year.

³ *Vital Water Graphics*, United Nations Environment Programme

As we discuss below, to facilitate human activities there are two distinct water supply sectors:

- The *drinking water* sector, which focuses on the treatment of raw source water to ingestible (“potable”) standards for distribution to consumers.
- The *wastewater* sector, which focuses on the collection and treatment of liquid waste for re-use in a number of ways, including drinking water.

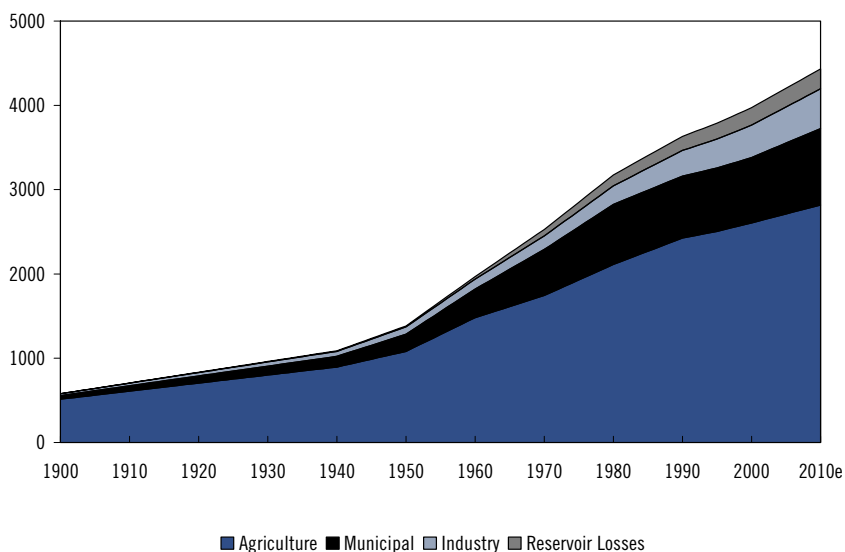
Water Demand: The Long-Term Trend

Figure 6 illustrates that, at a *global* level, there are three main uses of water resources (although, as we discuss below, sector demand *differs by region*):

- *Agricultural* — water is used primarily for irrigation.
- *Municipal* — water use is directly related to withdrawal by the populations of cities and towns. While the absolute amount of water directly *consumed* per capita might not change, water *withdrawal* increases with urbanization, and the construction of offices, schools, shopping malls, etc.
- *Industrial* — water is used for a number of purposes in industry, including cooling. The electricity generation sector is a particularly large consumer.

In addition, note that a not insignificant amount of water has typically been lost to evaporation during reservoir construction.

Figure 6. Water Withdrawal by Sector (in Cubic Kilometers)



Source: United Nations Educational Scientific and Cultural Organization

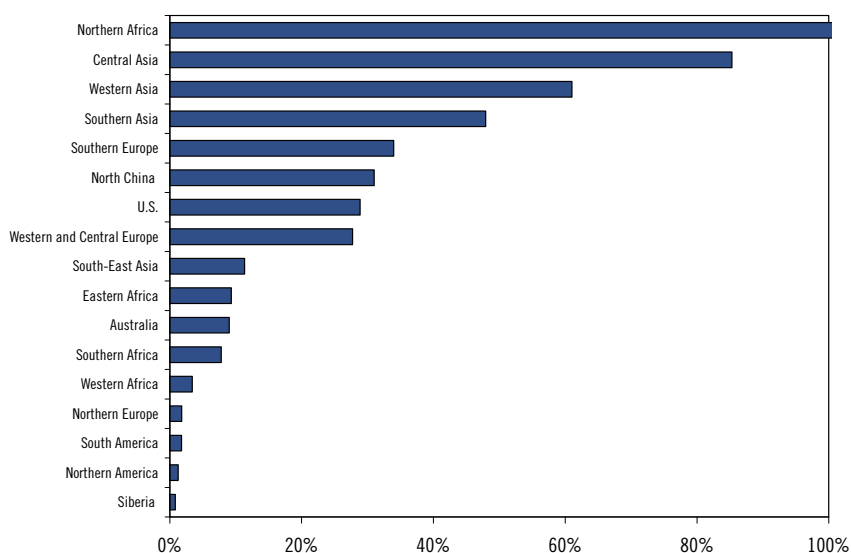
While water withdrawal may seem not that great, amounting to about 10% of renewable global water resources...

Total global water withdrawal in 2010 is estimated at about 4,430 cubic km per year. So, it would seem that water withdrawal is not that great, amounting to about 10% of renewable global water resources.

...water resources are distributed very unevenly. Unpopulated areas of the earth have large water resources, but little water withdrawal.

Importantly, however, *water resources are distributed very unevenly*. As Figure 7 illustrates, unpopulated areas of the earth — including Siberia and the northern part of the American continent — have large water resources, but little water withdrawal. By contrast, densely populated areas — including large parts of Asia, as well as Southern Europe — have high levels of water withdrawal relative to the available resources.

Figure 7. Water Withdrawal as a Percentage of Water Resources



Source: United Nations Educational Scientific and Cultural Organization

This issue of uneven water distribution is also true *within* specific countries:

- As we discuss below, the bulk of the Australian population is concentrated on the eastern side of the continent, which has become progressively drier because of climate-driven precipitation change that is delivering more rain to the sparsely-populated western side.
- The two fastest growing states (in terms of population growth) in the U.S. — Arizona and Nevada — also rank as the driest in terms of annual precipitation.
- China, which has roughly 20% of the world's population, has only about 7% of the world's water resources, with about four-fifths of that water supply concentrated in the south of the vast country.

Climate Change and Water: The Physical Science Basis

Below we summarize some of the key findings of the most recent IPCC report (referenced above) that have significance for the issue of water supply.

Precipitation

Precipitation is the general term for rainfall, snowfall and other forms of frozen or liquid water falling from clouds. As climate changes, several direct influences alter precipitation amount, intensity, frequency and type:

- Warming accelerates *land surface drying*, and boosts the potential incidence and severity of droughts.
- The water-holding capacity of the atmosphere increases with rises in temperature. At the same time, a consequence of warming is increased evaporation. Because precipitation comes mainly from weather systems that feed on the water vapour stored in the atmosphere, these trends have generally *increased precipitation intensity* and the risk of heavy rain.
- The warmer climate therefore increases risks of *both drought* — where it is not raining — *and floods* — where it is — but at different times and/or places. For example, in the summer of 2002, Europe experienced widespread floods; that was followed a year later by heat waves and drought.

Changes are occurring in the amount, intensity, frequency and type of precipitation.

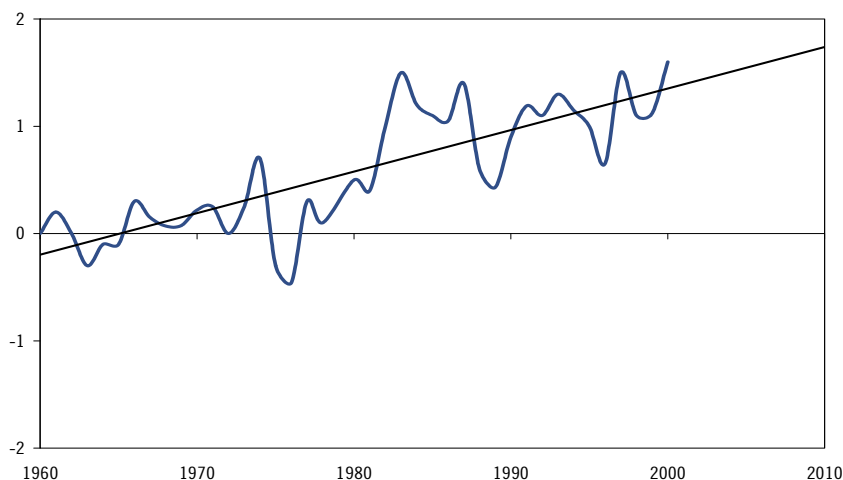
Observations of long-term trends from 1900 to 2005 show that changes are occurring in the amount, intensity, frequency and type of precipitation:

- It has become *significantly wetter* in eastern North and South America, northern Europe, and northern and central Asia.
- It is *drier* in southern Africa, the Mediterranean, and southern Asia.
- More precipitation now *falls as rain rather than snow* in northern regions. (As we discuss below, reduced snow cover is a key issue for water supply in the western U.S.)
- Widespread increases in *heavy precipitation events* have been observed, even in places where total amounts have decreased.

Even as the potential for heavier precipitation results from increased water vapour amounts, the duration and frequency of events may be curtailed.

Overall trends in precipitation are indicated by the Palmer Drought Severity Index, which measures the cumulative deficit (relative to local mean conditions) in surface land moisture — see Figure 8. With regard to the deficit in moisture that has occurred since the 1980s, the IPCC noted that “even as the potential for heavier precipitation results from increased water vapour amounts, the duration and frequency of events may be curtailed, as *it takes longer to recharge the atmosphere with water vapour* [italics added].”

Figure 8. Palmer Drought Severity Index (with Trend Line)
Positive Coefficient Corresponds with Dryness



Source: Intergovernmental Panel on Climate Change

Drought

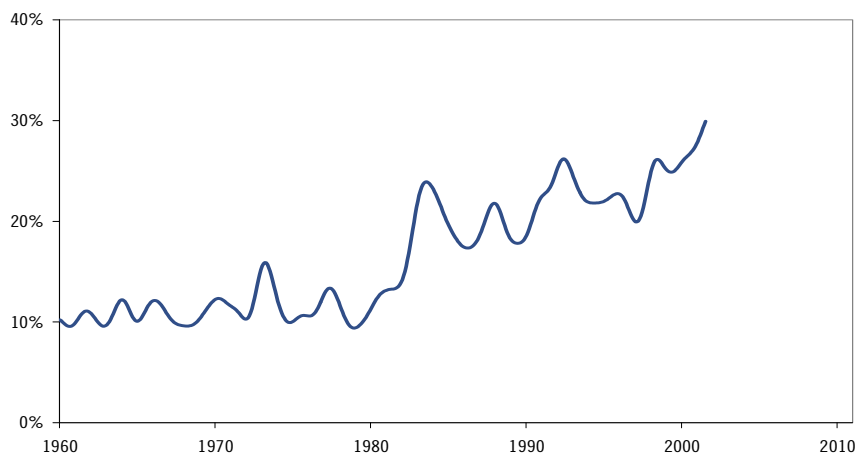
The extent of regions affected by droughts has increased, given that precipitation over land has marginally decreased while evaporation has increased due to warmer conditions.

For the reasons outlined above, the extent of regions affected by droughts has increased, given that precipitation over land has marginally *decreased* while evaporation has *increased* due to warmer conditions. (In simple terms, drought is an imbalance between precipitation and evaporation.)

On that point, a 2004 analysis⁴ by scientists at the National Center for Atmospheric Research found that “the global very dry areas...have more than doubled since the 1970s, with a large jump in the early 1980s” (see Figure 9). In particular, “most parts of Eurasia, Africa, Canada, Alaska, and eastern Australia became drier from 1950 to 2002.”

Global very dry areas have more than doubled since the 1970s.

Figure 9. Percentage of Total Global Land Area in Very Dry Conditions (Land areas within 60°S - 75°N)



Source: National Center for Atmospheric Research

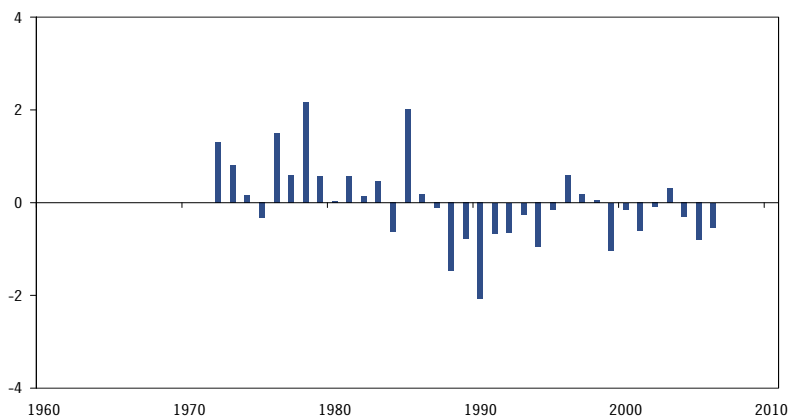
⁴ A Global Dataset of Palmer Drought Severity Index for 1870-2002: Relationship with Soil Moisture and Effects of Surface Warming, Aiguo Dai et al., Journal of Hydrometeorology, December 2004

Snow Cover

Satellite measurements capture most of the earth's seasonal snow cover on land, and reveal that Northern Hemisphere snow cover has declined, especially since 1980 and with an increasing trend during the past decade — see Figure 10. In many places, the snow cover decrease has occurred *despite increases in precipitation*. Of course, ice melts when the local temperature is above the freezing point.

Snow cover decrease has occurred despite increases in precipitation.

Figure 10. Anomaly of Northern Hemisphere Snow Cover Extent
(Departure from the Long-Term Mean in Millions of Square Kilometers)



Source: Rutgers University Global Snow Lab

A decline in the amount of snow and ice on earth has significant implications for many regions of the world:

- As we discuss below, dams and reservoirs were built across the western U.S. to exploit snowmelt in a fast-growing region characterized by low annual rainfall. However, climate change is dramatically reducing snow cover.
- Of the 2,500 square kilometers of glaciers in the four countries of the tropical Andes — Bolivia, Colombia, Ecuador, and Peru — 70% are in Peru, and 20% in Bolivia. That the area covered by glaciers is shrinking is particularly worrying for Peru: after decades of migration down from the Andes, two out of three Peruvians now live on its desert coast, which irrigation projects have made habitable. But the increasingly irregular flow of glacier-fed rivers is threatening the supply of both water and hydro-generated electricity. Similarly, in Bolivia, glacial melting threatens water supplies to La Paz and its satellite city, El Alto.
- The Indus river basin spans parts of four countries — Afghanistan, Pakistan, India and China — in an area that is more than 30% arid. The Indus is particularly critical for Pakistan's 160 million people, as it irrigates 80% of the country's agricultural land. Because of the high portion of its flow derived from glaciers, the river is extremely sensitive to climate change—Himalayan glaciers provide the Indus with 70-80% of its water, the highest proportion of any river in Asia. Climate change aside, the World Wildlife Fund recently pointed out⁵ that "the Indus basin is already suffering from severe water scarcity due to overextraction for agriculture."

In South America, the increasingly irregular flow of glacier-fed rivers is threatening the supply of both water and hydro-generated electricity.

The Indus river basin spans parts of four countries: Afghanistan, Pakistan, India and China. Himalayan glaciers provide the Indus with 70-80% of its water, the highest proportion of any river in Asia.

⁵ World's Top 10 Rivers at Risk, March 20, 2007

Higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution.

Developing nations seem most at risk from climate-related water pollution.

Pollution

As per the IPCC:⁶

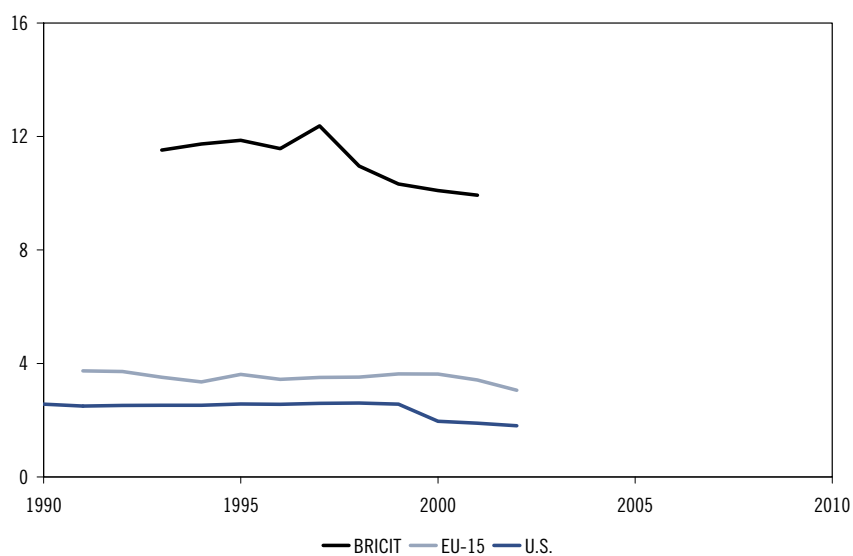
- Higher water temperatures, increased precipitation intensity, and longer periods of low flows *exacerbate many forms of water pollution*, with impacts on ecosystems, human health, water system reliability and operating costs [italics added].

Specifically,

- *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.
- *Increased precipitation intensity*: Increases in intense rainfall result in more nutrients, pathogens, and toxins being washed into water bodies. (Enhanced precipitation has resulted in increased nitrogen loads of up to 50% in rivers in the Chesapeake and Delaware Bay regions.)
- *Longer periods of low flows*: Lower water availability reduces dilution of toxins in water bodies.

As Figure 11 illustrates, developing nations, such as the “BRICIT” countries (Brazil, Russia, India, China, Indonesia, Turkey), seem most at risk from climate-related water pollution, given that their pollution levels are already high, even though their economies, while growing rapidly, are still relatively small. (The U.S. and EU-15 each account for about 28% of global GDP; the six BRICIT countries combined only account for 14%.) In a subsequent section, we discuss measures that some of those BRICIT countries are taking to reduce water pollution levels.

Figure 11. Organic Water Pollutant Emissions (Million Kilograms Per Day)



Source: World Bank

⁶ Climate Change 2007: Impacts, Adaptation and Vulnerability.

Figure 12. 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	Deere	U.S.	Australian drought has bolstered global wheat prices, boosting U.S. farmers' incomes
	Leighton Holdings	Australia	Part of the consortium building a desalination plant in eastern Australia
	Monsanto	U.S.	Drought-tolerant crops are an area of research focus
	United Group	Australia	Currently involved with fifteen Australian water projects
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
Emerging Market Thirst	Veolia Environnement	France	The global leader in water is involved with wastewater treatment in emerging economies
	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
Developed Economy Efficiency	Veolia Environnement	France	#2 desalination company globally is #1 overall in water services
	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

Figure 13. More Climatic Consequences Companies

Company	Sub-Theme	Company	Sub-Theme
BioFuel Energy	Alternative fuels	Nalco Holding	Industrial water treatment
China Everbright International	Municipal wastewater treatment	Nestlé	Bottled water
Danaher Corp	Industrial water treatment	Promotora Ambiental SAB de CV	Mexican water infrastructure
Danone	Bottled water	Roper Industries	Automated water meters
Doosan Heavy Inds & Construction	Desalination	Rotork	Global water infrastructure
Empresas ICA SAB de CV	Mexican water infrastructure	Suez	Global water services
Epure International	Municipal wastewater treatment	Suzlon Energy	Wind turbines
Gammon India	Indian water infrastructure	Thermax	Municipal wastewater treatment
Halma	Leak detection	Veolia Environnement	Global water services
ITT Corp	Water monitoring	VeraSun Energy	Alternative fuels
Jaiprakash	Indian water infrastructure	Wacker Chemie	Solar power
Kurita Water Industries	Industrial water treatment		

Source: Citi Investment Research

Precipitation Patterns Changing

Some of the manifestations of climate change outlined above, including changes in precipitation amounts, are already an issue for the global financial community. That is especially true for Australia — the driest inhabited continent on earth — where climate change issues have been the focus of two dozen reports in the past year by Citi Investment Research analyst Elaine Prior.

Australia: More Rainfall but a Changed Distribution

A February, 2007 Citi report⁷ noted that:

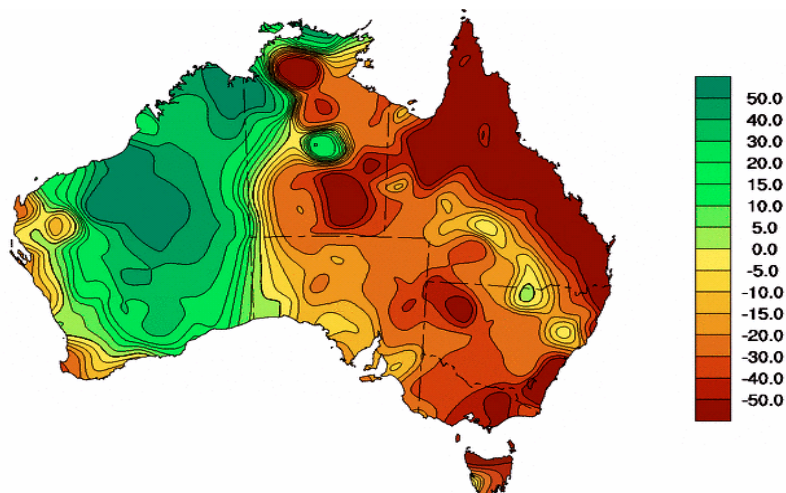
- Climate change has *dramatically influenced rainfall patterns across Australia, but it hasn't brought ubiquitous dryness to the continent* [italics added]. Aggregate rainfall has actually increased since the 1970s. In the past thirty years rainfall has averaged 496mm, while in the previous thirty years it averaged 452mm. Furthermore, the data also shows that droughts in the past thirty years have been less frequent than droughts in the previous 30 year period.

Importantly, the analysts noted:

While an analysis of aggregate rainfall patterns suggests Australia has had wetter conditions, in the past 30 years the distribution of rainfall has changed dramatically.

- While an analysis of aggregate rainfall patterns suggests Australia has had wetter conditions in the past 30 years the distribution of rainfall has changed dramatically [italics in original]. The eastern side of Australia has become progressively drier, while the western side has become progressively wetter — see Figure 14.

Figure 14. Trend in Annual Total Rainfall in Australia, 1970 – 2006 (Millimeters Per Decade)



Source: Australian Bureau of Meteorology

As a result:

A redistribution of rainfall from Australia's most populated areas to the unpopulated parts of Western Australia.

- This redistribution of rainfall from Australia's most populated areas to the unpopulated parts of Western Australia due to climate change is having significant impacts on both urban water supply and Australia's agricultural industry.

⁷ See Australian Special Research February 7, 2007, report, "Turning on the Tap: Opportunities in Water."

Although the unpopulated parts of Western Australia are now experiencing more rainfall, that has absolutely no significance for the key agricultural and urban areas on the other side of the vast continent. Possible offsets to the drought conditions in eastern Australia are discussed in a subsequent section.

India: Dam Building a Potential Offset to Variable Rainfall

An April 2007 Citi report⁸ pointed out that, for very different reasons, India is also vulnerable to climate-influenced precipitation change, given that “its monsoon systems and flow of Himalayan rivers are all dependent on current climatic patterns.” The vulnerability of the sub-continent was outlined as follows:

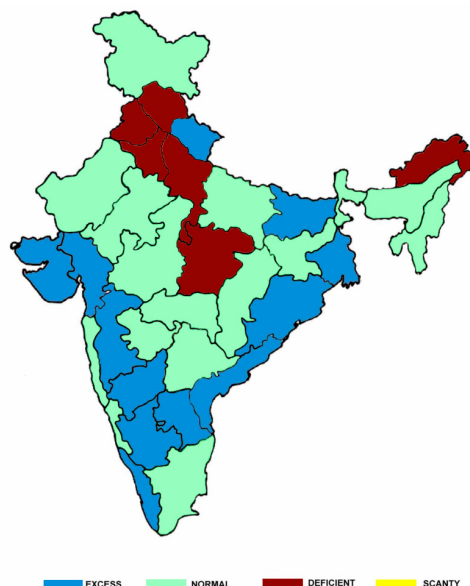
50% of India’s precipitation takes place in 15 days, and 90% of the rivers are filled within four months.

- Though total precipitation in India, including snowfall, amounts to 4000 billion cubic meters across the country, *50% of the precipitation takes place in 15 days and 90% of the rivers are filled within four months* [italics added]. This makes the availability and distribution of water in India uneven across both space and time.

Following the end of the 2007 monsoon season (which runs from June through September), Citi analysts commented⁹ that:

- Rainfall [was] above normal — at 105% of the Long Period Average (LPA of 89cm); higher than the Indian Meteorological Department’s forecast of 93%. *While the quantum of rainfall is encouraging, the distribution and timeliness of monsoons indicate mixed trends* [italics added]...Similar to last year, rainfall for the season as a whole was deficient in Northwest India (-15% departure from normal); while the southern peninsula experienced rainfall that was 26% above normal — see Figure 15.

Figure 15. Rainfall Distribution Over India During 2007 Monsoon Season



Source: India Meteorological Department

⁸ See Rohini Malkani’s April 9, 2007, report, “CitiViews – India Market Watch.”

⁹ See Rohini Malkani’s October 15, 2007, report, “CitiViews – India Market Watch.”

In addition to concerns about the distribution of rainfall in India, the April 2007 Citi report also pointed out that:

- Storage facilities are poor — Indian dams can store only 200 cubic meters per capita, as compared to over 1,000 cubic meters in China and 5,000 in the U.S.

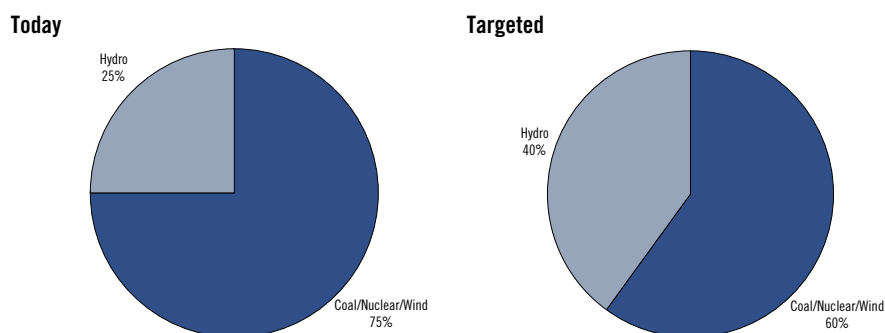
The report suggested that these trends point to “emerging opportunities in irrigation, tube-wells as well as building more dams, as climate change is likely to further increase the variability of rainfall in India.”

The Indian government plans to increase the proportion of the nation’s power generated from hydroelectric sources.

On top of this climate-driven need for dam-building, it is also the case that the Indian government plans to increase the proportion of the nation’s power generated from hydroelectric sources. Today, 64% of India’s electricity is from thermal generation (reflecting a glut of thermal projects in recent decades, driven by a plentiful supply of cheap coal), 25% is hydroelectric, and 11% is from nuclear and wind sources.

Hydroelectric power is a “clean” energy source that is unaffected by fuel supply concerns driven by geopolitical factors, as well as by fuel price volatility. It enhances India’s security (by reducing reliance on external sources) and is ideal for meeting peak electricity demand, in contrast to relatively expensive coal-fired thermal generation, which is best used for meeting base load demand. The goal of the Indian government is to correct the imbalance in generation mix from 75:25 in favor of coal/nuclear over hydroelectric, to 60:40 — see Figure 16.

Figure 16. India’s Hydro/Thermal Mix



Source: Indian Ministry of Power

The above factors suggest that a number of companies with exposure to Indian engineering and construction projects seem well positioned, including:

- **Gammon India**, a construction company with skill-sets in a variety of sectors, including hydroelectric, pipelines, and water supply.
- **Jaiprakash**, a conglomerate with interests in engineering and construction, cement, and hydroelectric projects.

Aggregate Australian rainfall has actually increased since the 1970s. Nevertheless, Australia remains the driest inhabited continent on earth, and the recent change in precipitation patterns has meant that the eastern side of the continent has become progressively drier.

Drought Increasing

We noted above that aggregate Australian rainfall has actually *increased* since the 1970s. Nevertheless, Australia remains the driest inhabited continent on earth, and the recent change in precipitation patterns has meant that the eastern side of the continent has become progressively drier.

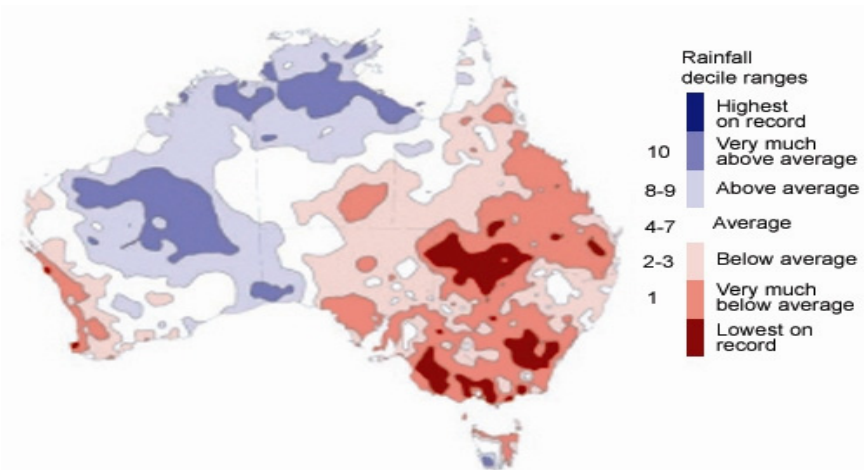
In addition, Australia's annual mean surface air temperature has been increasing, with the warming trend since 1950 nearly double the observed trend over the century as a whole. The combination of reduced precipitation and increased evaporation has, not surprisingly, resulted in drought conditions in the east.

Eastern Australia: Looking to Sources Other Than Rainfall

A recent report¹⁰ by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Australian Bureau of Meteorology observed that:

- The last 5 to 10 years *mark one of the most severe droughts in Australia's history...*[Figure 17] shows the rainfall deciles for March 2002 to December 2006...Over this period very low rainfall was experienced across eastern Australia, with record low rainfall in key catchment areas of the Murray and Darling Rivers and water catchments for Sydney, Canberra and Melbourne [*italics added*].

Figure 17. Australian Rainfall: March 2002 – December 2006
(From Highest on Record to Lowest on Record)



Source: Australian Bureau of Meteorology

As for the response to these trends, the aforementioned February 2007 Citi report noted that:

- Australia has been slow to adjust to the longer term impact of climate change, with both State and Federal Governments only providing a notable lift in water industry capex during the past couple of years. However, the momentum is shifting quickly. [In January 2007] *the Federal Government announced it would spend \$A11bn to improve water use efficiency...in the Murray Darling Basin over ten years* [*italics in original*].

¹⁰ Climate Change in Australia: Technical Report 2007

Australian capital cities are poorly positioned to cope with climate change, and water supply from other sources than rainfall will be necessary.

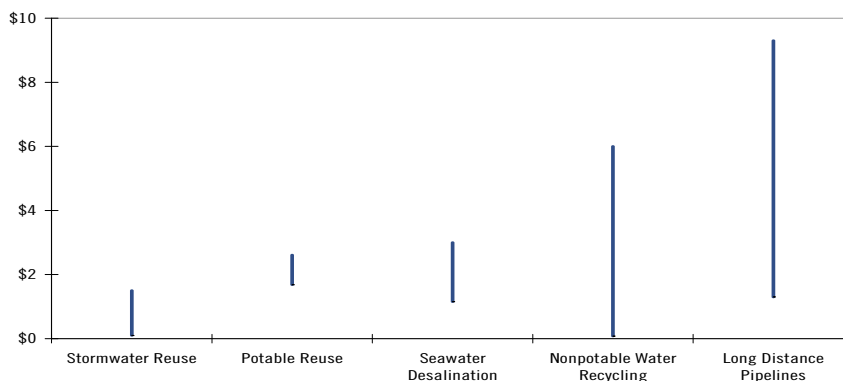
Recycling existing water is one of the most economic solutions in Australia.

Since that report was published, Federal elections were held in Australia, with “climate change [looming] large as an election issue,” as Citi analyst Elaine Prior noted in a September report.¹¹ Significantly, after the victory of the Labor party in those elections, Australia ratified the Kyoto Protocol. (As for a post-Kyoto agreement, following the UN’s climate change conference in Bali last month, Citi Investment Research analysts Meg Brown and Mike Tyrrell reiterated their expectation of a “delay in serious global [climate change] negotiations until after the U.S. presidential election” in 2008.¹²)

The options available to Australian policy makers are somewhat limited given that, as the February 2007 Citi report pointed out, “geographically, Australian capital cities are poorly positioned to cope with climate change, and water supply from other sources than rainfall will be necessary.” (The variable nature of Australian stream flow means that the continent is dependent on capturing rainfall in dams; storage capacity of Australian capital city dams relative to consumption is around 3 times the average in Europe or the U.S.) Three possible options:

- **Piping.** The high cost of carrying water, both in terms of energy expended for pumping and evaporation losses, means that piping over long distances is a very expensive proposition. (Water is heavier than oil; a system to move it long distances — especially if it involves tunneling — can cost billions.)
- **Seawater desalination.** Technological advances have significantly lowered the cost of desalination in recent years. (The two primary methods are thermal desalination, which involves evaporation of seawater, and membrane desalination, an electrically-driven process that uses special membranes through which water is passed under pressure.) *While desalination may be one response to climate-related water shortages, it is very-energy intensive and so is typically not a climate-friendly solution* (except when renewable energy sources are used). That said, as we noted above, the geography of Australia has necessitated the search for a supply of water from sources other than rainfall. Australia currently has one major desalination plant in operation (Perth), one under construction (Tugun in Queensland), and four in the planning stages.
- **Recycling.** Recycling existing water is one of the most economic solutions in Australia (see Figure 18), particularly in areas that are far from the ocean.

Figure 18. Australian Water Adaptation Costs (\$ per Kilolitre)



Source: Commonwealth Scientific and Industrial Research Organization

¹¹ See Elaine Prior’s September 24, 2007, report, “Australian Clean Energy Target Announced.”

¹² See Meg Brown and Mike Tyrrell’s October 3, 2007, report, “Social Securities: October 07.”

Capital expenditure on Australian water infrastructure creates opportunities for a number of companies, including:

- **Leighton Holdings**, Australia's largest diversified heavy engineering contractor. One of its subsidiary companies is part of the consortium that is building a major desalination plant in Tugun, eastern Australia.
- **United Group**, a provider of maintenance, project management, and engineering services to a number of sectors is currently involved in fifteen water projects.

The Australian drought has also had positive implications for some other companies. In a report¹³ on **Deere**, a Citi Investment Research analyst cited that one positive for the company was "wheat price rallies due to foreign competitors' drought," i.e., the Australian drought that has been impacting wheat production by the world's third-largest exporter of the grain. Wheat prices remain close to record highs.

Drought-Tolerant Crops

The biggest use of water worldwide is for irrigation by the agriculture sector.

We noted above that the biggest use of water worldwide is for irrigation by the agriculture sector (see Figure 6). Agricultural biotechnology company **Monsanto** is at the forefront of the latest development in the industry: 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.

As a result of its research, Monsanto has several products under development, including drought-tolerance traits. (In the terminology of the agricultural biotechnology industry, biotech crops can feature "traits," such as resistance to a particular pest.) The benefit of a drought-tolerance gene would come in the reduction of a crop's reliance on water.

¹³ See David Raso's September 13, 2006, industry note, "Nebraska farm show highlights patience needed."

The steady decrease in high-altitude winter snow is particularly worrisome for the U.S., given that the melt of mountain snowpack each spring has provided the western U.S. with most of its water.

Snow Cover Decreasing

We pointed out that (i) more precipitation now falls as rain rather than snow in northern regions and (ii), concomitant with rising temperatures, Northern Hemisphere snow cover has declined. The steady decrease in high-altitude winter snow is particularly worrisome for the U.S., given that the melt of mountain snowpack each spring has provided the western U.S. with most of its water. (Snowmelt is considered the best source of water because it requires little chemical treatment to bring it up to drinking standards.)

Water Shortages in the Western U.S.

Dams and reservoirs were built across the western U.S. in order to exploit snowmelt in a region characterized by low annual rainfall. However, it appears that the supply of fresh water in the region may well have peaked:

- The snowpack in the Sierra Nevada, which provides most of the water for Northern California, was at its lowest level in nearly 20 years (and less than 40% of average) in the spring of 2007.
- The flow of the Colorado River, which largely consists of snowmelt from the Rocky Mountains, was exceptionally low in the five year period 2000-2004.¹⁴
- Lake Powell, the reservoir in Arizona and Utah that was created by the damming of the Colorado River, is at about 50% of capacity.
- Lake Powell feeds Lake Mead, the reservoir in Arizona and Nevada that supplies nearly all the water for Las Vegas. It, too, is also half-empty. Not only are these two reservoirs threatened by reduced snowmelt, but higher temperatures also cause them to lose significant amounts of water to evaporation — the Colorado River basin is two degrees warmer than in 1976.

In total, the Colorado River serves the needs of 30 million people in seven western states: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. Somewhat ominously then, a recent quantitative analysis¹⁵ by scientists at the National Oceanic and Atmospheric Administration concluded that:

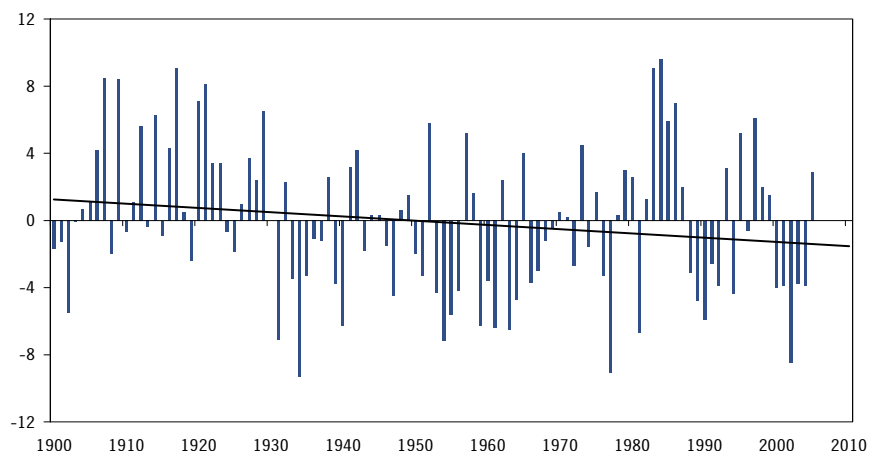
- The Southwest is likely past the peak water experienced in the 20th century...A decline in Lees Ferry flow will reduce water availability below current consumptive demands within a mere 20 years — see Figure 19.

A reduction in water availability below current consumptive demands within a mere 20 years.

¹⁴ A point near Lees Ferry in northern Arizona is where the annual flow of the Colorado River is measured. Measurement units are “acre-feet,” which is the volume of water necessary to cover one acre of surface area to a depth of one foot.

¹⁵ M. Hoerling and J. Eischeid, “Past Peak Water in the Southwest,” *Southwest Hydrology*, January / February 2007

Figure 19. Flow at Lees Ferry Minus 108 Year Average with Trend Line (Million Acre Feet)



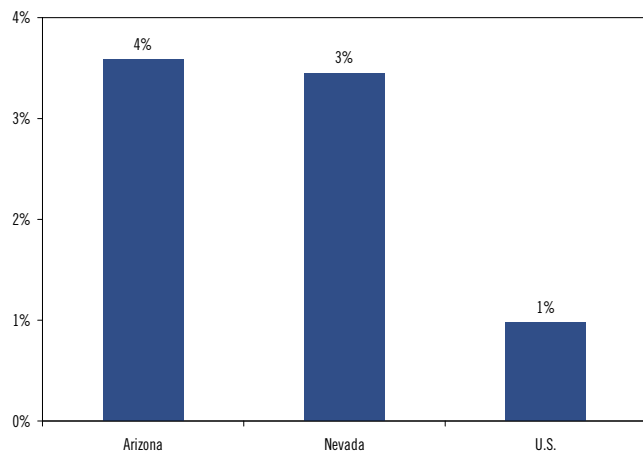
Source: Upper Colorado River Commission

Supply-Increase and Demand-Management Initiatives

The two fastest-growing states (in terms of population growth) in the U.S. also rank as the driest in terms of annual precipitation.

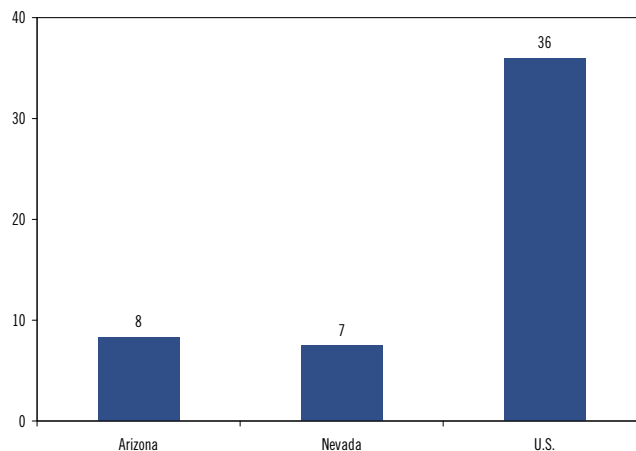
Not only are key regions of the U.S. faced with a reduced water supply, it is also the case that many of those regions are experiencing burgeoning water demand spurred by rapid population growth. Indeed, the two fastest-growing states (in terms of population growth) in the U.S. — Arizona and Nevada (see Figure 20) — also rank as the driest in terms of annual precipitation (see Figure 21).

Figure 20. Population Growth, 2005 - 2006



Source: U.S. Census Bureau

Figure 21. Average Annual Precipitation (Inches)



Source: U.S. National Oceanic and Atmospheric Administration

In terms of responding to these challenges, U.S. policy makers can look to increase supply (by, for example, piping in water from other sources, desalinating seawater, or recycling), and/or reduce demand (e.g., promoting conservation by automated water meters).

Pipelines

Of all the metropolitan areas in the U.S., Las Vegas is likely the most vulnerable to water shortages. That is partly a result of the city's explosive growth. More importantly, however, is that the state of Nevada receives a smaller share of Colorado River water than any of the other six states with which it signed a water-sharing compact in the 1920s. Furthermore, Nevada's share of that water, along with water destined for Southern California, Arizona and northern Mexico, is stored in Lake Mead, which, as noted above, is currently half-empty.

While water may be an issue for Las Vegas, cash is much less of a problem. On that point, the Southern Nevada Water Authority has filed an application with the federal Bureau of Land Management to build a multi-billion dollar water pipeline. The 285-mile conduit would run from the east-central part of the state, where the Authority has identified groundwater (i.e., water deep underground) that can be extracted and transported to metro Las Vegas. A hearing is scheduled for February, 2008. (Note here that, in contrast to some other projects such as dam construction, laying pipelines is generally quite straightforward, and does not require specialized engineering skills. In addition, piping water a few hundred miles across the southern U.S. is much more feasible than piping water thousands of miles across the Australian outback.)

Desalination

Another possibility that has been raised is that Las Vegas might pay for a desalination plant on the Pacific Coast that would transform seawater into potable water for use in California and Mexico; in exchange, Nevada would get a portion of their Colorado River water in Lake Mead.

In many countries, the cost of converting seawater into drinking water is now roughly in line with the price already paid by consumers.

The concept of processing seawater is nothing new; Saudi Arabia, Kuwait and other Middle Eastern states have been using desalination for more than half a century, and desalination meets 70% of Saudi Arabia's drinking water requirement. Until recently, however, desalination had been too expensive for use in the U.S. Advances in technology have significantly lowered the cost of desalination in recent years, so that Citi analysts have pointed out¹⁶ that, in many countries, "the cost of converting seawater into drinking water is now roughly in line with the price already paid by consumers" (although, as noted above, desalination is still very energy-intensive and, consequently, not particularly climate-friendly.)

With costs falling rapidly, more coastal water systems in the U.S. are implementing desalination facilities. On that point, the Pacific Institute has pointed out¹⁷ that, as of 2006, more than 20 proposals had been put forward for large desalination facilities along the California coast — see Figure 22. The Institute observed that "if all of the proposed facilities were built, the state's seawater desalination capacity would increase by a factor of 70, and seawater desalination would supply 6% of California's year 2000 urban water demand." Upon its completion in 2010, a plant in Carlsbad will be the largest desalination facility in the Western hemisphere, producing 50 million gallons of water each day, or as much as 10% of the surrounding region's drinking water.

¹⁶ See Australian Special Research February 7, 2007, report, "Turning on the Tap: Opportunities in Water."

¹⁷ *Desalination, With A Grain of Salt*, June 2006

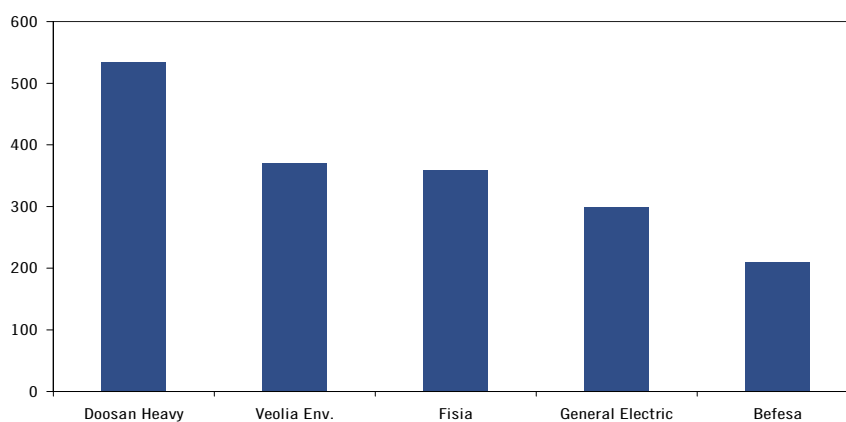
Figure 22. Proposed Desalination Plants in California



Source: Pacific Institute

In terms of companies well positioned for this opportunity, Figure 23 illustrates that **General Electric** is the largest U.S. player in the global desalination industry. (We discuss Doosan Heavy Industries and Veolia Environnement below. Fisia is a unit of Italy's Impregilo Group. Befesa is a unit of Spain's Abengoa.) A number of acquisitions facilitated GE's emergence as a global leader in the water sector, including BetzDearborn and Osmonics in 2002, Ionics in 2004, and Zenon Environmental in 2006.

Figure 23. Desalination Bids Won, 2000 – 2006 (Millions of Gallons per Day)



Source: Global Water Intelligence

GE's involvement in water extends beyond desalination; the company is expanding rapidly in other areas, including water treatment, particularly in developing markets. On that point, a Citi report¹⁸ pointed out that:

- To highlight the revenue growth potential of the water market, GE recently projected that it would see growth of ~5% per annum between 2003 and 2009, *while the developing markets would see growth of 35% per annum* [italics added].

¹⁸ See Mark Heslop's August 9, 2007, report, "Rotork PLC: Turning on the Taps."

Automated Water Meters

In “Climatic Consequences” we noted that:

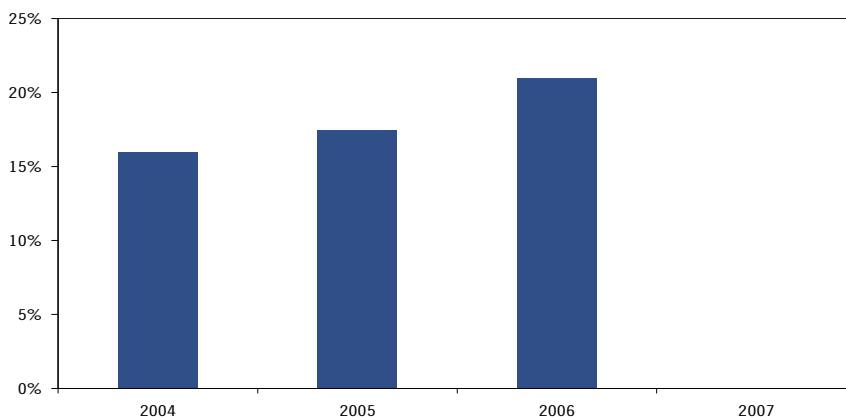
- The U.S. Energy Policy Act of 2005 requires states to investigate the use of advanced utility metering. At the local level, California and Texas...are pioneering programs to promote use of automated meter reading (AMR).

AMR technologies take traditional meter reading systems to the next level by removing the costly and error-prone process of having a human “meter reader” interact directly with the meter to retrieve and record data. Typically, AMR systems transmit data (often via radio frequency) to an electronic device, with those data then being recorded by either a “walk-by” or “drive-by” reader. AMR systems can also be taken to the next level, with data transmitted directly to utility headquarters in order to enable near real-time data analysis and dissemination.

Just over 20% of water meters in the U.S. are now automated.

While electric utilities have led the way in the adoption of AMR, penetration of AMR systems within the U.S. water industry has gained considerable traction over the last few years. Although water remains markedly cheaper than electricity, increasing awareness of water scarcity issues are driving a tendency to view water as a valuable resource that must be priced according to its true value, a key driver of increased penetration of water AMR systems. As Figure 24 illustrates, just over 20% of water meters in the U.S. are now automated.

Figure 24. U.S. Water Utilities' Automated Meter Reading Penetration Rates



Source: The Scott Report on AMR Deployments

AMRs offer utilities a number of ways to influence water usage, including pricing that discourages waste, and monitoring of consumption trends in order to enforce restrictions.

AMRs offer utilities a number of ways to influence water usage, including:

- Graduated pricing structures that increase per-gallon pricing for heavier users, discouraging waste.
- Monitoring of consumption trends in order to enforce restrictions on certain types of usage, such as lawn irrigation, in times of drought.

(An analysis of 8,000 households in the U.K. calculated that metering resulted in an average 9% reduction in water consumption.)

Roper Industries is the number two player in the North American automated water meter market (after Itron), with a 17% share. In 2006, Roper's water business accounted for approximately 16% of sales.

Pollution Rising

We noted above that a number of developing nations, including China and India, seem most at risk from climate-related water pollution, given that their pollution levels are already relatively high (see Figure 11).

Municipal Wastewater Treatment

In China, rapid economic expansion has led to water fundamentals being pressured at both ends: not only is demand surging from agriculture, industry, and an increasingly urbanized population, but supplies are shrinking, in part because of unchecked pollution. On that point, the Asian Development Bank recently noted¹⁹ that:

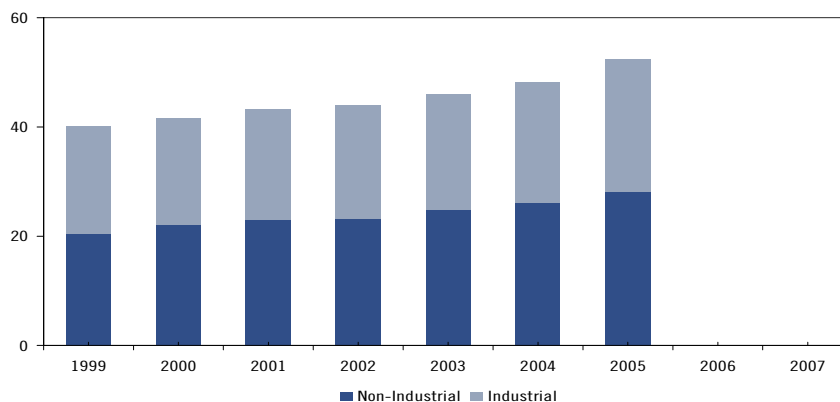
The water in most of the length of China's five major rivers is unsafe for direct human contact, about half of China's lakes are polluted, and nearly two-thirds of China's large cities are experiencing serious wastewater pollution.

- The water in most of the length of China's five major rivers is unsafe for direct human contact, about half of China's lakes are polluted and nearly two-thirds of China's large cities are experiencing serious wastewater pollution... Water shortages are also a growing concern. Water availability is declining, in particular in northern [China], where 40% of the country's total population has access to only 20% of the country's water resources. Of a total of over 30 provinces and regions, 10 are water-short, and eight of these are in the north. Nationwide, about 60% of [China's] 669 cities are experiencing water shortages, and 114 cities are facing severe shortages.

Similarly, a recent Citi Investment Research report²⁰ pointed out that:

- On the water front...freshwater resources are increasingly becoming polluted in China, reducing the availability of water of suitable quality and increasing the costs of treatment. Little access to sanitation [i.e., a poor sewage infrastructure] and high rates of urbanization in China, together with limited or declining treatment of wastewater, have added to the load of organic pollutants emitted...While industrial wastewater was a main pollutant in the 1990s, the situation has been worsened by domestic sewage. According to the U.N., from 1998 to 2002, the volume of wastewater discharged from domestic sources increased by almost 20% — see Figure 25.

Figure 25. Discharge of Wastewater in China (Billions of Tons)



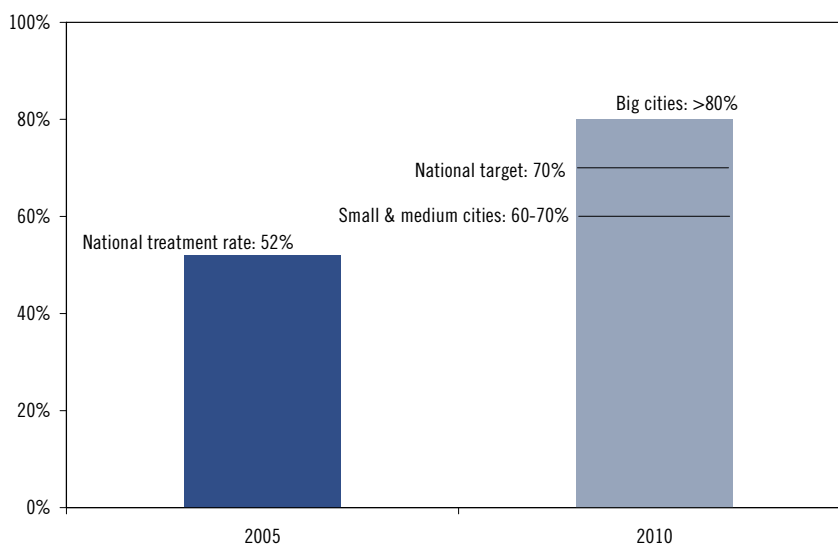
Source: State Statistical Bureau

¹⁹ Environmental Protection in China: Challenges and Solutions, March 18, 2007

²⁰ See Clement Wong's May 15, 2007, report, "China Environmental Services."

The Chinese government has realized the scale of the problem, and started a major policy push under the Eleventh Five-Year Plan 2006-2010 (passed in 2005) to improve management of the country's natural resources. A key focus here is wastewater treatment — of 661 cities in China at year-end 2005, 40% (278) had no wastewater treatment facilities. The central government's target is to raise the municipal wastewater treatment rate from 52% in 2005 to 70% by 2010. The treatment rate in big cities is targeted at greater than 80%, while that for small and medium cities is targeted at 60-70% — see Figure 26.

Figure 26. China's Municipal Wastewater Treatment Rates: 2005 and Targeted 2010



Source: Citi Investment Research

To achieve a treatment rate of 70%, Citi analysts project that China's municipal wastewater treatment capacity will have to increase to 156 million tons per day by 2010, from 81 million tons per day in 2005. To achieve this, China will need to build more than 1,000 wastewater treatment plants between 2006 and 2010, while old treatment plants will require a significant upgrade in capacity.

Operating municipal wastewater treatment plants will become a big business: 26% compound annual growth between 2005 and 2008.

Not surprisingly then, the Citi analysts believe that operating municipal wastewater treatment plants will become a big business, and they are forecasting 26% compound annual growth in the sector between 2005 and 2008.

Veolia Environnement is the world's largest water services company. (We discuss Veolia in subsequent sections on desalination and public-private partnerships.) To learn how to manage wastewater treatment projects, **China Everbright International** (CEI) formed a joint venture (JV) with Veolia in 2003. The JV involved the construction and operation of a wastewater treatment plant in Qingdao, a city in Shandong, the second most populous province of China.

In 2005, CEI won a wastewater treatment project in Zibo, the third largest city in Shandong. In 2006, CEI won another wastewater treatment project in Jinan, another city in Shandong. CEI's strategy is continuous acquisition of wastewater management projects, city-by-city within a province, and then expanding to another province. CEI's revenue contribution from environmental protection activities reached 62% in fiscal 2006 (with its property and infrastructure businesses accounting for a declining portion of total revenues).

In India, there is a huge potential for wastewater treatment as a growing population, urbanization and industrialization have intensified water pollution.

With a track record that goes back more than 10 years, **Epure International** is another company focused on China's wastewater treatment market. (Municipal wastewater revenue represented more than 85% of Epure's total turnover in fiscal 2006.) The company is one of the few players capable of handling very large projects (i.e., daily capacity of more than 100,000 tons). In the past 14 years, Epure has completed more than 400 projects, including the first municipal wastewater plant in Beijing. In the next 3-5 years, the company targets 5-10 large municipal wastewater treatment projects annually

In India, too, there is a huge potential for wastewater treatment as a growing population, urbanization and industrialization have intensified water pollution:

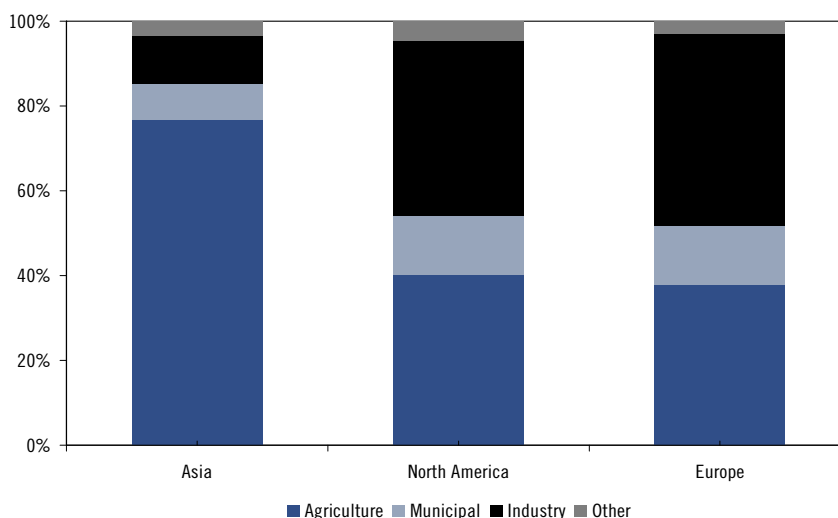
- *Domestic sewage* refers to waste water that is discarded from households. Only about 25% of domestic wastewater in India is treated.
- *Industrial waste water* is generated by manufacturing and chemical processes. About 57,000 polluting industries in India generate about 13 billion liters of wastewater per day, of which roughly 60% is treated.

Thermax, an engineering company, is a leading player in the Indian industrial water and wastewater management sector. The company's Water and Waste Solutions division is involved in a number of areas, including municipal sewage treatment. The division constitutes approximately 7% of total company sales.

Water Demand: Emerging Market Thirst

We noted above that, at a global level, the largest consumer of water by far is the agricultural sector (see Figure 6). However, as Figure 27 illustrates, *sector demand differs by region* so that, in the U.S. and Europe, the industrial sector is the largest consumer of water.

Figure 27. Water Withdrawal by Sector (2010e)

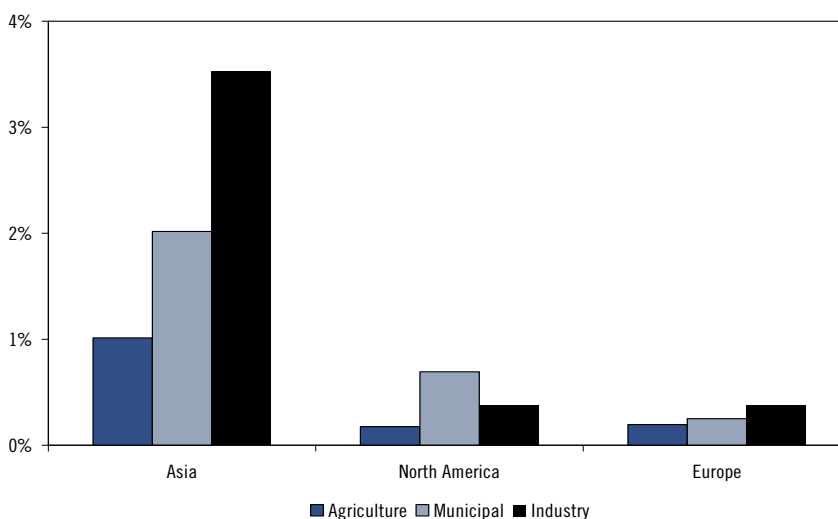


Source: United Nations Educational Scientific and Cultural Organization

While the agricultural sector is currently the largest consumer of water in Asia, the water withdrawal of the municipal and industrial sectors is forecast to grow rapidly.

Moreover, while the agricultural sector is currently the largest consumer of water in Asia, the water withdrawal of the municipal and industrial sectors is forecast to grow rapidly — see Figure 28.

Figure 28. Water Withdrawal by Sector: Forecast Compound Annual Growth, 2010 - 2025



Source: United Nations Educational Scientific and Cultural Organization

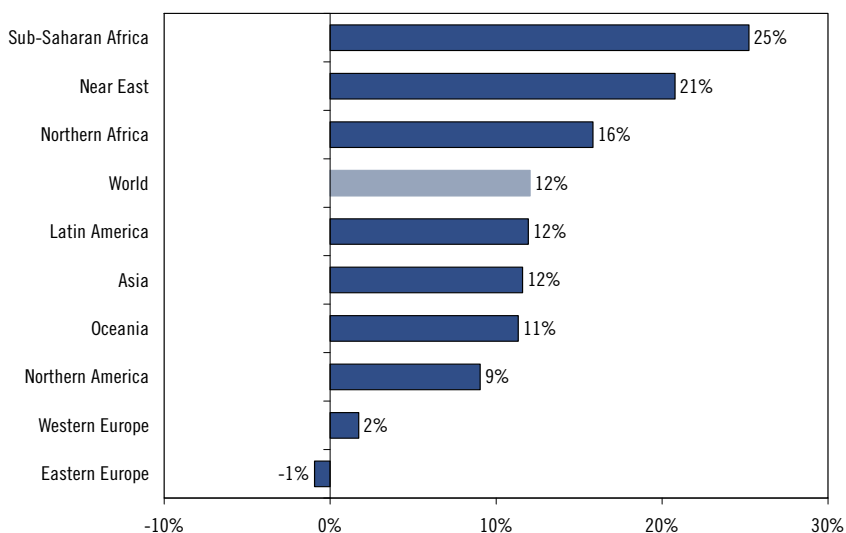
Driving increasing water withdrawal by municipal and industrial sectors in Asia will be a number of factors, including:

- Population growth.
- Quality of life aspirations and changing diets
- Urbanization and industrialization.

Population Growth

As Figure 29 illustrates, the world's population is forecast to expand by 12% over the next decade, with relatively fast growth in developing regions, and relatively slow growth in developed areas.

Figure 29. Forecast Population Growth, 2005 - 2015



Source: U.S. Census Bureau, International Data Base

Obviously, more mouths means increased demand for water, both for drinking *and to grow food*. While the daily drinking water needs of the average adult are between 3 and 9 liters, depending on climatic conditions, the production of foodstuffs involves much greater consumption of water — scientists estimate²¹ that, for an average vegetarian diet, 360 cubic meters of water per capita per year is needed. So, with one cubic meter equaling one thousand liters, the annual drinking water consumption of even the thirstiest vegetarian would still represent just 1% of the water required for food cultivation.

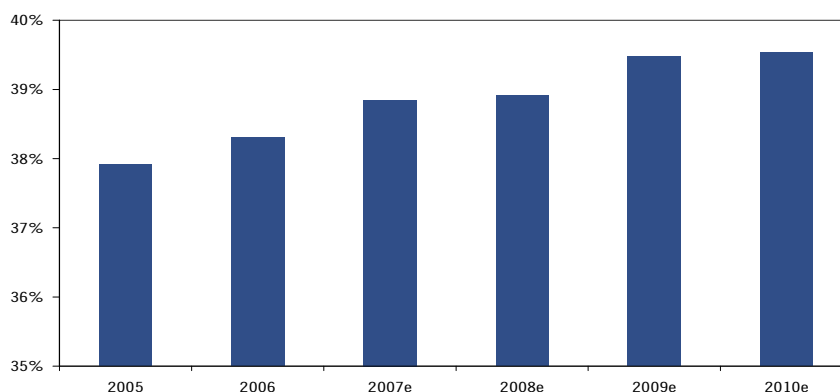
Quality of Life Aspirations and Changing Diets

Drinking water and food are basic human requirements. Other needs include personal hygiene, which requires water, as does cooking and cleaning. In that regard, the World Health Organization considers that a minimum of 30–50 liters per day is necessary for keeping up basic personal hygiene, for cooking, and for cleaning. This amount (which does not include water for flushing toilets), plus the amount consumed as drinking water, has been labeled the “basic water requirement.”

²¹ Alexander Zehnder et al., *Water issues: the need for action at different levels*, Aquatic Sciences, 2003

Of course, most humans aspire to more than just the basics, especially when it comes to the food they eat. On that point, although per capita meat consumption in developing countries is still less than half the levels of developed countries, concomitant with rising living standards, that gap is forecast to continue narrowing — see Figure 30.

Figure 30. Per Capita Meat Consumption of Non-OECD Countries as a % of OECD Consumption



Source: OECD-FAO Agricultural Outlook

Compared to a vegetarian diet, a diet containing 20% meat doubles water consumption.

We noted that, for an average vegetarian diet, 360 cubic meters of water per capita per year is needed; a diet containing 20% meat *doubles* that consumption, to roughly 1,000-1,300 cubic meters (reflecting water consumed directly by animals, and water used in the production of food for livestock).

Urbanization and Industrialization

By 2010, there will be 21 urban agglomerations with populations of 10+ million, up from just 10 in 1990. Seventeen will be in developing economies.

In part reflecting population growth, the United Nations estimates that, by 2010, there will be 21 urban agglomerations with populations of ten million or more, up from just 10 such agglomerations in 1990. Seventeen of those cities will be in developing economies — see Figure 31.

Figure 31. 2010 Urban Agglomerations with Inhabitants of Ten Million or more

Rank	Urban Agglomeration	Country	2010 Inhabitants (000s)
1	Tokyo	Japan	35,467
2	Mexico City	Mexico	20,688
3	Mumbai	India	20,036
4	Sao Paulo	Brazil	19,582
5	New York	U.S.	19,388
6	Delhi	India	16,983
7	Shanghai	China	15,790
8	Kolkata	India	15,548
9	Jakarta	Indonesia	15,206
10	Dhaka	Bangladesh	14,625
11	Lagos	Nigeria	13,717
12	Karachi	Pakistan	13,252
13	Buenos Aires	Argentina	13,067
14	Los Angeles	U.S.	12,738
15	Rio de Janeiro	Brazil	12,170
16	Cairo	Egypt	12,041
17	Manila	Philippines	11,799
18	Beijing	China	11,741
19	Osaka	Japan	11,305
20	Moscow	Russia	10,967
21	Istanbul	Turkey	10,546

Source: United Nations

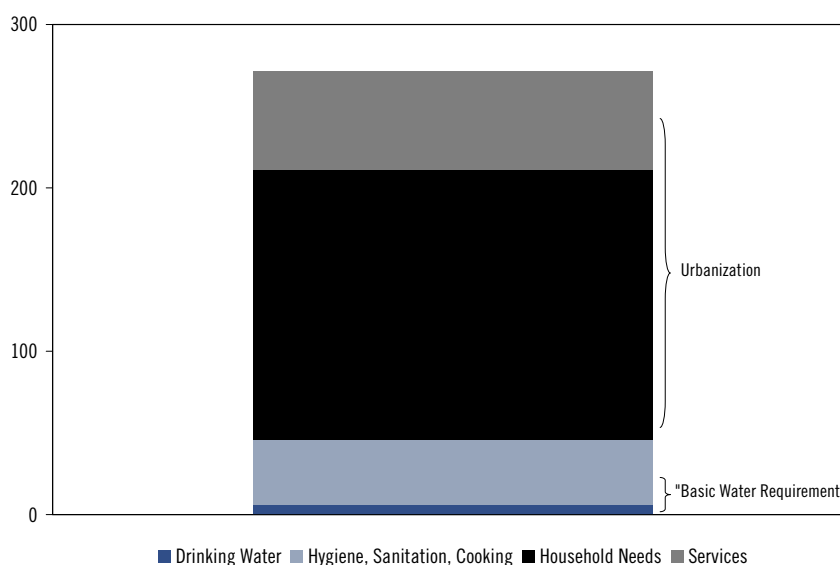
Urbanization can cause the demand for water to increase five-fold beyond the "basic water requirement."

Urbanization leads to increased water demand:

- *Water for household needs.* Activities such as flushing a toilet, watering flowers, or washing a car increase daily per capita water needs by 80 to 250 liters.
- *Water for services.* Hospitals, restaurants, hotels, and other institutions use considerable amounts of water. The actual numbers vary from 20 liters per capita per day in Africa, to 100 liters in Europe, and 400 liters in North America.

So, as Figure 32 illustrates, *urbanization can cause the demand for water to increase five-fold beyond the "basic water requirement."* (Note that these figures do *not* include water used in power generation or other industrial activities that typically accompany urbanization.)

Figure 32. Daily Water Requirements in Liters Per Person



Source: Alexander Zehnder et al., *Water issues : the need for action at different levels*, Aquatic Sciences, 2003

Sources of Supply

In order to meet this rising emerging market demand, water supply can come from a number of sources, including:

- Infrastructure development and wastewater treatment.
- Desalination.
- Bottled water.

Infrastructure Development and Wastewater Treatment

In the section above on pollution, we discussed how **China Everbright International** and **Epure International** are potential beneficiaries of increased spending on wastewater treatment in China.

Separately, another Citi Investment Research report²² pointed out that:

In China 21% of the world's population is supported by just 7% of the world's water supply.

- [Water] demand [outside the U.S.] is likely to remain strong with a significant proportion of the world currently relying on unsatisfactory levels of water supply or quality. For example in China 21% of the world's population is supported by just 7% of the world's water supply, while 55% of its industrial water effluent goes untreated back in to the environment. As China and other emerging markets, e.g. Middle East, Eastern Europe, continue to benefit from the current economic cycle, *investment in water infrastructure is likely to grow strongly* [italics added].

The report highlighted that **Rotork** is the global leader in heavy duty actuators for the water industry, with an approximate 30% market share. In simple terms, actuators are devices used to turn (open/close) valves. The water segment accounts for 18% of Rotork's actuator revenues.

Mexican Water Infrastructure

Mexico City seems particularly vulnerable to both water shortages and floods.

In other sections, we noted that (i) a warmer global climate increases risks of both drought, where it is not raining, and floods, where it is, but at different times and/or places; and (ii) flooding in the Mexican state of Tabasco in early November affected as many as one million of the state's 2.2 million residents. For the reasons outlined below, Mexico City seems particularly vulnerable to *both* water shortages and floods:

- Mexico City was founded by the Spanish on a lake that has now dried out. The city, which is forecast to be the world's second most populous by 2010 (see Figure 31), is rapidly using up its underground water supplies. And because of poor collection facilities, the 700 millimeters of rain the city gets every year are completely lost. The city's mountainous inland location means that desalination is not an option.
- At the same time, the city is also vulnerable to flooding. Mexico's federal water commission, Conagua, recently pointed out that a shortfall in rainfall drainage and sewerage capacity means that a large area of Mexico City could be under five meters of water in the event of heavy rains. The city is sinking by up to 40 centimeters a year, and the capital is now 10 meters lower than its 1910 level when the city's main sewage canals were built.

As a result of these issues, Conagua put forward a \$3.5 billion five-year plan for Mexico City involving six new water treatment plants, improved rainwater collection facilities, and systems to allow for water reuse. President Felipe Calderon approved the plan on November 8.

Concomitant with that plan for the country's capital, a recent Citi Investment Research report²³ analyzed a *national* infrastructure plan:

²² See Mark Heslop's August 9, 2007, report, "Rotork PLC: Turning on the Taps."

²³ See Geoffrey Dennis' July 19, 2007, report, "Mexico Infrastructure Boom."

- On July 18, President Felipe Calderón of Mexico announced a more detailed plan of the government's infrastructure spending objectives for the new sexenio (2006-2012). The government proposes to spend P\$2.53trn (US\$234bn) on infrastructure programs, or P\$422bn (US\$39bn) annually. The total proposed six-year program amounts to 28% of Mexico's 2006 GDP, or 4% per annum.

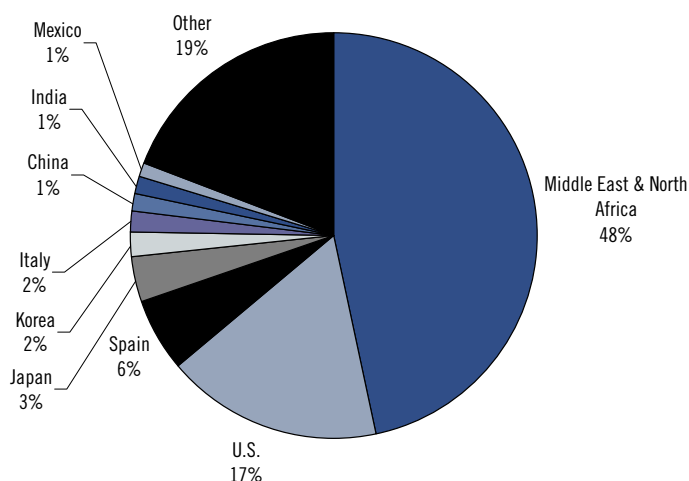
The report noted that, of the total \$234 billion amount, \$14 billion is earmarked for "water & plumbing." As for potential beneficiaries:

- The Citi report observed that "waste management company Pasa [**Promotora Ambiental SAB de CV**] may benefit from the infrastructure plan...The company would benefit directly with long-term (10- to 30-year) contracts with municipalities to distribute and manage water systems."
- Another company interested in participating in water infrastructure projects is **Empresas ICA SAB de CV** (ICA). ICA already manages a water treatment plant in the northern state of Coahuila, and recently won a project to construct and operate an aqueduct in Queretaro, a state in central Mexico.

Desalination

Half of the world's desalination capacity is in the Middle East/Persian Gulf/North Africa regions; as Figure 7 illustrated, Middle Eastern countries, which are located in "Western Asia," have high levels of water withdrawal relative to the available resources. Figure 33 shows other countries with more than 1% of global desalination capacity.

Figure 33. Installed Global Desalination Capacity (2005)



Source: Global Water Intelligence

In the discussion of the outlook for desalination in the U.S., we noted that **General Electric** is the largest U.S. player in the desalination industry. However, Figure 23 revealed that, as measured by bids won between 2000 and 2006, a Korean company, **Doosan Heavy Industries & Construction** is the biggest desalination company globally. In addition, Figure 33 illustrates that South Korea has a relatively large amount of installed desalination capacity.

A key reason for Korea's involvement with desalination: In terms of available domestic water resources, Korea is one of the water-scarce countries as determined by the UN.

A key reason for Korea's involvement with desalination is that, as per the Water Environment Partnership in Asia:²⁴

- Korea's annual precipitation is estimated at 1,283 mm, which is 1.3 times higher than the world's average precipitation (973 mm). However, annual precipitation per capita is estimated at...just one tenth of the world's average. Also...in terms of available domestic water resources, [Korea is] one of the water-scarce countries as determined by the UN.

A recent Citi Investment Research report²⁵ that analyzed the outlook for Korean engineering and construction companies noted that:

- 1H07 overseas new orders were \$17.7bn up by 94.1% yoy. 1H07 overseas new orders exceeded '06 annual new orders of \$16.5bn thanks to *skyrocketing industrial plant new orders from the Middle East*. [The Middle East] represented 65% of total new orders received in 1H07, bolstered by consecutive expansion plans of hydrocarbon plants in the region given strong oil prices. Furthermore, *the region is heavily investing in utility infrastructure such as...water purification plants* [italics added].

As for possible beneficiaries of this Middle East spending:

- Doosan Heavy [has] the strongest overseas new order momentum in 2H07. In our view, Doosan Heavy has a strong chance of winning \$4bn worth of power plant and desalination new orders...

Citi analysts estimate that Doosan Heavy has a 65% share in desalination plants in the Middle East, and a 35% global market share. In addition to opportunities for Doosan Heavy in the Middle East region, Citi analysts have pointed out²⁶ that desalination "will be a future growth driver given water scarcity issues in...Southeast Asia" (e.g., China and India). 18% of Doosan Heavy's revenues are derived from the industrial division, which includes its desalination plant business.

Figure 23 illustrated that the world's second largest desalination company is **Veolia Environnement**. The company has built and/or operates 1,600 plants globally, representing approximately 13% of global desalination capacity. Some recent desalination projects won by Veolia include:

- A plant in Saudi Arabia, which will be one of the world's largest, providing 800,000 cubic meters per day of desalinated water
- A plant in the United Arab Emirates, which will produce 590,000 cubic meters per day of desalinated water.

²⁴ Accessible at http://www.wepa-db.net/policies/measures/currentsystem/southkorea_wss.htm

²⁵ See Brian Cho's, July 9, 2007, report, "Korea Engineering & Construction."

²⁶ See Brian Cho's, September 26, 2007, report, "Doosan Heavy Industries & Construction."

Bottled Water

Desalination removes the salty taste from seawater. Taste aside, a key water supply issue is the availability of drinking water *at ingestible standards*. On that point, a Citi report²⁷ pointed out that:

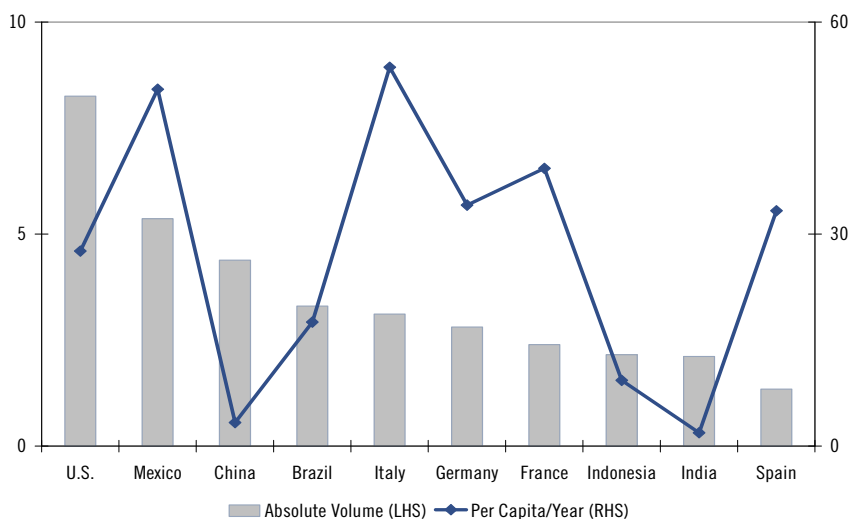
- The UN estimates that 1.1 billion people do not have access to an improved source of drinking water, which is a major cause of child mortality. Child mortality rates in India are still high at 65 per 1000, versus 30 in China and 6.4 in the U.S.

As these statistics highlight, clean drinking water is a particular issue in India; indeed the Citi report pointed out that the country's Prime Minister, Manmohan Singh, recently observed that "un-cleaned dirty water is a major cause of child mortality."

Developing countries already occupy half of the world's 10 largest water markets by volume, although in most of these countries per capita consumption remains relatively low.

Reflecting, in large part, that many countries lack safe drinking water, sales of bottled water in emerging markets have been growing rapidly. Developing countries already occupy half of the world's 10 largest water markets by volume, although in most of these countries per capita consumption remains relatively low (see Figure 34). So, for example, if China's annual per capita consumption doubled from 3 gallons to 6 gallons, it would become the second largest market in absolute size.

Figure 34. Bottled Water Sales (Billions of Gallons) and Per Capita Consumption (Gallons) in 2006



Source: Beverage Marketing Corporation

- **Nestlé** is the global market leader in water measured by the *value* of market share, with brands such as Purelife (purified water accounts for two-thirds of the total water consumed in Latin America and Asia). Water represents around 10% of Nestlé's revenues.
- **Danone** owns four of the largest brands in the world: Aqua (Indonesia), Evian (global), Aga (Mexico), and Wahaha (China). The company is the clear global market leader by *volume*, with an estimated market share of 18%. Water represents around 25% of Danone's revenues.

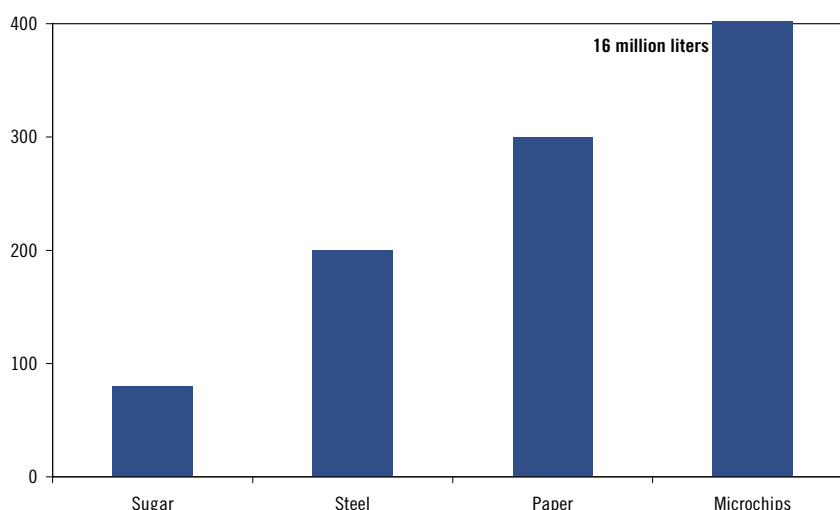
²⁷ See Rohini Malkani's April 9, 2007, report, "CitiViews – India Market Watch."

Many industrial processes are water intensive.

Water Demand: Developed Economy Efficiency Initiatives

As Figure 27 above illustrates, water demand differs by region so that, in the U.S. and Europe, the industrial sector is the largest consumer of water. A key reason for this is that many industrial processes are water intensive — as Figure 35 illustrates, while it takes about 80,000 liters of water to produce one ton of sugar, it requires more than twice as much (200,000 liters) to produce one ton of steel, and two hundred times as much (16 million liters) to produce one ton of semiconductors.

Figure 35. Water Required per Ton Produced (Thousands of Liters)



Source: Citi Investment Research estimates

So, with water supply increasingly an issue, it's likely that there will be greater focus on the efficient use of water in developed economies, involving:

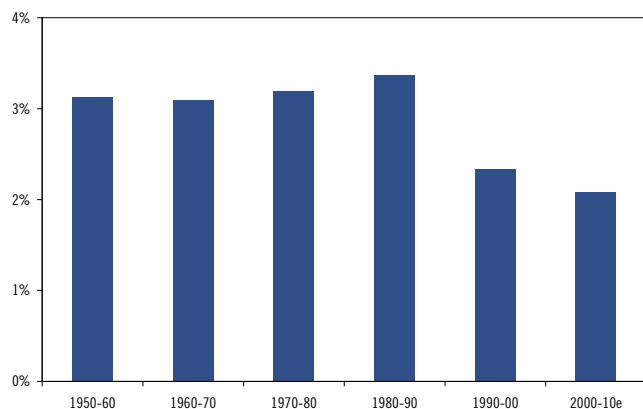
- Demand management.
- Water recycling and reuse.
- Public-private partnerships that facilitate the upgrade of aging infrastructures.

Demand Management

It appears that the overall water intensity of the global industrial sector has been increasing.

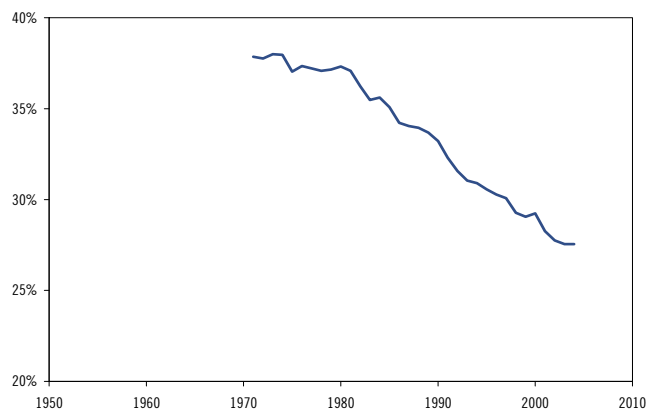
As Figure 6 above illustrates, the industrial sector currently accounts for about 10% of global water withdrawal. However, following steadily rising demand in the four decades 1950-1980, the *growth* in global water withdrawal for industrial use has *stabilized* at around 2% per annum (see Figure 36). This is despite a *decline* in the industrial sector's share of global GDP (see Figure 37). Combined, the two statistics suggest that the overall water intensity of the global industrial sector has been increasing.

Figure 36. Industrial Sector's Water Withdrawal: CAGR by Decade



Source: United Nations Educational Scientific and Cultural Organization

Figure 37. Industry Value Added as a Percentage of GDP



Source: World Bank

That the industrial sector could use water more efficiently was highlighted in a recent United Nations report, which noted that:²⁸

- Given proper incentives, it is generally found that industry can cut its water demand by 40 to 90 percent, even with existing techniques and practices.

Water efficiency is a particular issue for Europe given that, as Figure 7 illustrated, densely-populated Southern Europe has high levels of water withdrawal relative to the available resources. That situation is only likely to worsen because, as European Union environment commissioner, Stavros Dimas, commented²⁹ recently:

- The major impacts of water scarcity and droughts are expected to be made worse by climate change.

Stressing the need for water efficiency in the region, a 2007 European Commission report³⁰ on water issues noted that:

- There is huge potential for water saving across Europe. Europe continues to waste at least 20% of its water due to inefficiency. Water saving must become the priority and all possibilities to improve water efficiency must therefore be explored.

Europe continues to waste at least 20% of its water due to inefficiency.

ITT Corp is well positioned to help the developed world's industrial sector use water more efficiently; the company provides flow equipment to monitor and regulate the flow of water, and minimize its use in industrial processes. ITT generates more than half of its sales from fluid technology (water/wastewater filtration & treatment, pumps, valves) and motion and flow control products.

Water Recycling and Reuse

Once water is used by industry (for a variety of purposes, including cleaning, heating, and cooling), the resulting liquid wastes require specialized treatment, in contrast to the relatively straightforward treatment of wastewater from residential sources — see Figure 38.

²⁸ 2nd UN World Water Development Report, 2006

²⁹ <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1121&format=HTML&>

³⁰ Addressing the challenge of water scarcity and droughts in the European Union, July 18, 2007.

Figure 38. The Residential Water and Industrial Water Value Chains

	Residential	Industrial
<i>Input</i>	Untreated water	Untreated water
<i>Enabling technology</i>	Treatment (i.e., disinfectant)	Pre-treatment (to a very high quality)
<i>Primary product</i>	Drinking water	Process water
<i>Distribution</i>	Pipes, bottles	Pipes
<i>Service</i>	Health, hygiene	Cleaning, heating, cooling, etc.
<i>Treatment</i>	Wastewater treatment	Industrial treatment

Source: Citi Investment Research

In an environment where the supply of water is increasingly an issue, a greater emphasis will likely be placed on water recycling and reuse:

- Water *recycling* normally involves only one user, with the effluent from the user being captured and redirected back into the activity.
- Water *reuse* is the use of treated wastewater for beneficial purposes, such as agricultural irrigation and industrial cooling.

Among the companies involved with industrial water treatment:

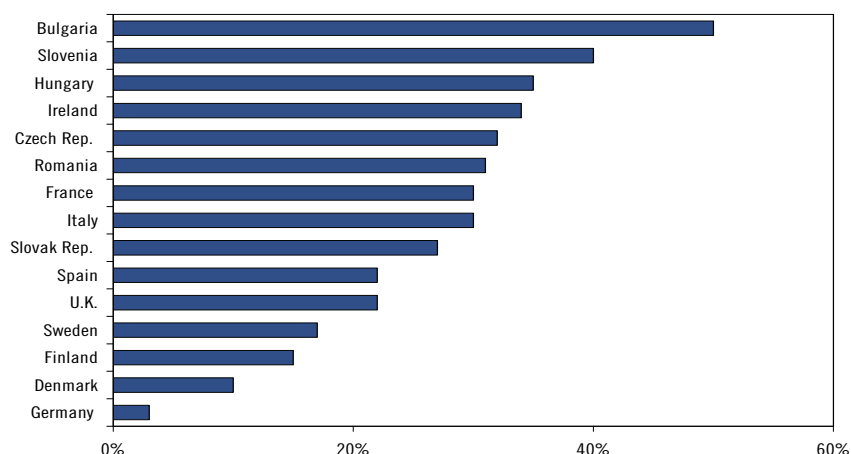
- **Danaher** increased the size of its addressable water market by 50%+ with its 2007 acquisition of ChemTreat International, a privately held provider of industrial water treatment products and services. Danaher's Water Quality segment accounts for about 11% of total sales.
- **Kurita Water Industries** is focused almost exclusively on water-treatment chemicals and systems, with a strong position in markets in Japan and Asia.
- **Nalco** is a global leader in the industrial water treatment industry, with approximately 45% of revenues coming from water treatment.

Public-Private Partnerships

A significant percentage of distributed water never reaches the final user because of leakage.

Even if water is consumed efficiently and wastewater is recycled, it is still the case that, in many parts of the world, a significant percentage of distributed water never reaches the final user because of leakage — see Figure 39.

Figure 39. Estimated Losses from Urban Water Networks

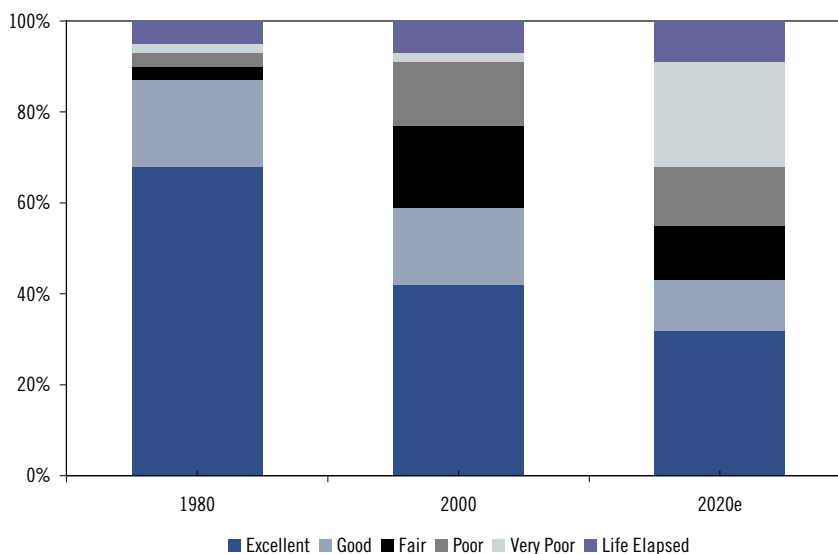


Source: European Environment Agency

Drinking water pipes can be expected to last between 50 and 100 years, which means that 1% to 2% of the network must be replaced every year.

Such problems are most acute in long-established urban areas with aging infrastructures. Drinking water pipes can be expected to last between 50 and 100 years (depending on their quality, the type of ground they are laid in, and climate conditions), which means that 1% to 2% of the network must be replaced every year. In developed countries, including the U.S., most urban pipe networks were laid at the beginning of the twentieth century, but replacement work has often been neglected — see Figure 40.

Figure 40. U.S. Drinking Water Pipe by Classification

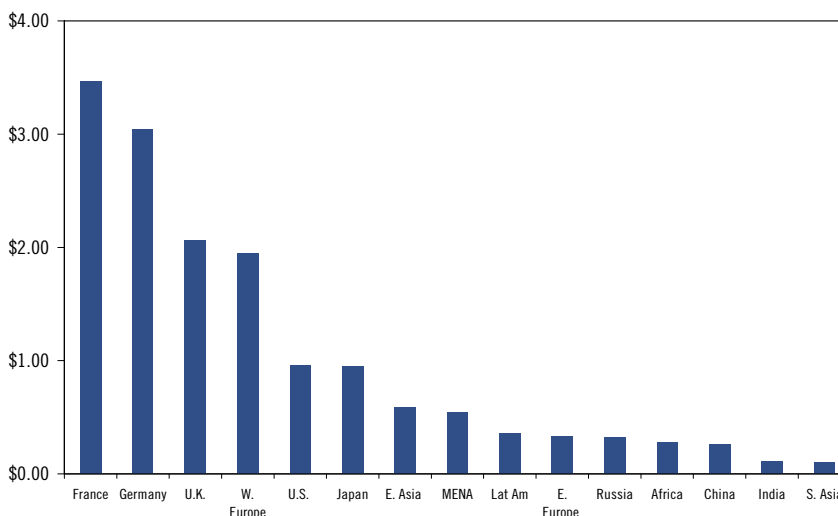


Source: U.S. Environmental Protection Agency

A key issue is financing given that many municipalities have charged only nominal amounts for water.

While significant capital expenditures on water infrastructures are now required in many countries, a key issue is financing given that many municipalities have charged only nominal amounts for water — see Figure 41.

Figure 41. Global Water Tariffs (per Cubic Meter)

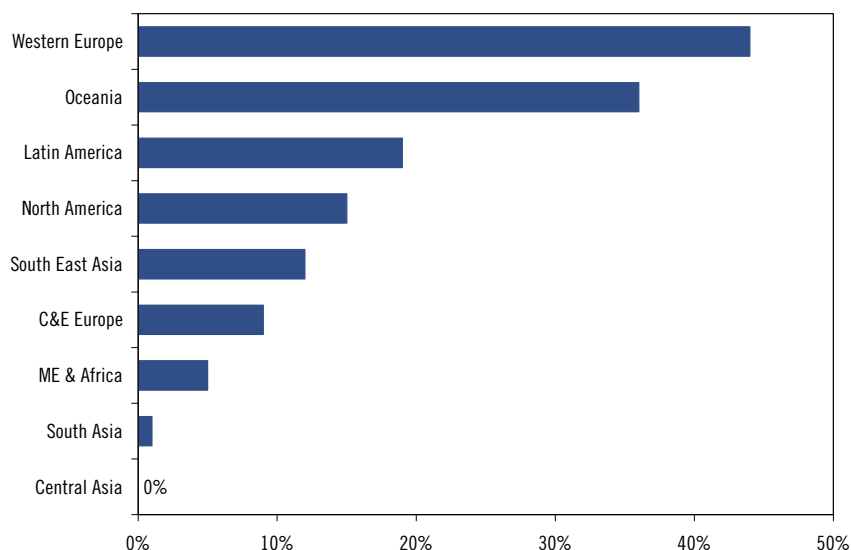


Source: Global Water Intelligence/OECD Global Water Tariff Survey 2007

One response to the financing issue has been private sector involvement, a strategy that has been actively pursued in Europe.

One response to the financing issue has been private sector involvement, a strategy that has been actively pursued in Europe (see Figure 42), a region that has relatively high water prices (see Figure 41).

Figure 42. Percentage of People Served by Private Water



Source: Global Water Intelligence

Instead of full privatization of a water system, one popular option is public-private partnerships. In some of these arrangements, a private operator signs a contract with a government agency to supply services, and a regulator sets the standard for price and quality. Among the advantages of such an arrangement is that the private company has the resources to maintain the water infrastructure, and also has the technical expertise to manage the network efficiently.

It's no coincidence that the world's two largest private water companies — **Veolia Environnement** and **Suez** — are both French. In 1853, during the reign of Napoleon III, Compagnie Générale des Eaux was created, and France's municipal water supply was put in the hands of private management.

- Veolia is the global leader in water services, largely because of its significant operations in France. Even still, the company has material international operations; we noted above that the company has a significant presence in desalination, and is active in the Asian municipal wastewater market.
- Suez is the second biggest player in the global water sector, serving 68 million drinking water customers around the world. Suez is in the process of merging with Gaz de France; as part of that merger, it is planned that Suez Environment will be spun off some time in 2008.

Finally, note that, a British firm, **Halma**, is the global leader in water leak detection technology. The company recently launched the next generation water leak detection product (Permalog +) which, for the first time, will enable water utilities to have leak data delivered directly from underground sensors to their computers. 10% of Halma's revenues are related to water.

Climatic Consequences: An Update

Since our last update in June, Citi analysts have published a number of reports with “climatic consequences.”

Alternative Fuels

In July, Citi Investment Research initiated coverage³¹ of the pure play ethanol companies **BioFuel Energy** and **VeraSun Energy**. BioFuel is a Denver, Colorado-based ethanol producer. VeraSun is a South Dakota-based producer; the company recently announced a merger with U.S. BioEnergy to create the world's largest pure play ethanol company.

President Bush recently signed into law the 2007 Energy Bill which contains an elevated Renewable Fuel Standard requiring the consumption of 9 billion gallons of renewable fuels (i.e. ethanol) in 2008 with progressive increases occurring each year until a total of 36 billion gallons of renewable fuels are consumed in 2022. Citi analysts believe this is a significant event, and should serve as a catalyst for the ethanol industry.

Renewable Energy: Wind

In June, Citi analysts resumed coverage³² on **Suzlon Energy** with an upgrade to Buy from Sell. (The analysts had been unable to publish on the company since January for legal compliance reasons.) The prior Sell rating had been driven, in large part, by concerns about margin contraction.

Suzlon is the largest wind turbine manufacturer in Asia. Following its recent acquisitions of REPower, a German wind turbine company, and Hansen Transmissions, a Belgian company specializing in gearboxes, Suzlon now has the fifth largest share (10%) of the global wind market. Importantly, the REPower acquisition provided Suzlon with access to Europe, which is forecast to be the largest wind turbine market over the next five years.

As for the prior concerns about margin contraction, the Citi analysts now believe that EBITDA margins appear close to a trough, and that fiscal 2007-10 compound annual volume growth of 45% should drive strong earnings gains.

Renewable Energy: Solar

In September, Citi Investment Research initiated coverage³³ on **Wacker Chemie**, a silicon chemistry company — nearly 80% of sales are based on conversion of silicon into various end products. In particular, polysilicon, which is the base for solar wafers, will be a key driver of Wacker's near-term growth.

The main constraint currently facing the global solar power industry is the availability of polysilicon. While silicon is made from sand, which is abundant, there are not enough refineries to turn it into solar-grade polysilicon. And although solar power will likely still account for less than 1% of global electricity supply by 2012, that should still mean an almost four-fold increase in polysilicon demand. To meet this demand, Wacker is aggressively expanding capacity, at a cost of almost €1 billion. Citi analysts believe this is a shrewd strategy, with the company's polysilicon division forecast to generate 50% of group EBITDA growth over the next five years.

³¹ See David Driscoll's July 25, 2007, report, “Ethanol Sector at Inflection Point for Positive Margin Changes.”

³² See Venkatesh Balasubramaniam's June 14, 2007, report, “Suzlon Energy: Upgrading to Buy.”

³³ See Andrew Benson's September 10, 2007, report, “Wacker Chemie: Meet the Wackers.”

Appendix A: Climatic Consequences Companies

Acciona (ANA.MC - €210.95; 1M)	Iberdrola (IBE.MC - €10.24; 2M)
Ace Limited (ACE.N - US\$61.04; 1H)	IJM Plantations (JMP.KL - RM3.34; 1L)
Aguas de Barcelona (AGS.MC - €27.56; 2M)	IOI Corp (IOIB.KL - RM7.75; 1L)
Allegheny Technologies (ATI.N - US\$84.25; 1H)	Itron (ITRI.O - US\$95.96; Not Rated)
Alstom (ALSO.PA - €142.89; 2M)	ITT Corp (ITT.N - US\$63.88; 2M)
American Intl Group (AIG.N - US\$56.30; 2H)	Jaiprakash (JAIA.BO - Rs473.35; 1L)
Arch Capital Group (ACGL.O - US\$68.48; 1M)	Johnson Controls (JCI.N - US\$34.59; 2M)
Archer Daniels Midland (ADM.N - US\$45.26; 1M)	KL Kepong (KLKK.KL - RM17.80; 1L)
Babcock & Brown Wind Partners (BBW.AX - A\$1.69; 1M)	Kurita Water Industries (6370.T - ¥3,390; 2M)
Bajaj Hindusthan (BJHN.BO - Rs286.15; 3M)	L'Air Liquide SA (AIRP.PA - €103.29; 2L)
Balrampur Chini (BACH.BO - Rs113.45; 3M)	Leighton Holdings (LEI.AX - A\$60.99; 2H)
BG Group PLC (BG.L - £11.55; 3M)	Magna International (MGA.N - US\$78.07; 1M)
BioFuel Energy (BIOF.O - US\$6.98; 1S)	Makhteshim Agan Industries (MAIN.TA - NIS36.25; 1H)
BorgWarner (BWA.N - US\$46.67; 1M)	Monsanto (MON.N - US\$111.47; 1M)
Brasil Ecodiesel SA (ECOD3.SA - R\$6.95; 2S)	Motech Industries (G244.TWO - NT\$286.00; 1M)
Bunge Limited (BG.N - US\$122.10; 2M)	Nalco Holding (NLC.N - US\$23.90; 2H)
Centrica PLC (CNA.L - £3.53; 1M)	Neste Oil Corporation (NES1V.HE - €24.83; 1L)
Chesapeake Energy Corp (CHK.N - US\$40.01; 1H)	Nestlé (NESN.VX - Sfr514.00; 1L)
Chicago Mercantile Exchange (CME.N - US\$673.99; 2M)	Noble Group (NOBG.SI - S\$2.28; 1H)
China Everbright International (0257.HK - HK\$3.99; 1L)	Ormat (ORA.N - US\$54.46; 2H)
Clipper Windpower (CWPR.L - £7.04; 2H)	Peugeot SA (PEUP.PA - €49.90; 1H)
Compagnie de St Gobain (SGOB.PA - €62.09; 1M)	Philips Electronics (PHG.AS - €28.35; 1M)
Conergy AG (CGYG.DE - €23.36; 3S)	Potash Corp of Sask (POT.N - US\$146.20; 2M)
Constellation Energy (CEG.N - US\$101.47; 1M)	Promotora Ambiental SAB de CV (PASAB.MX - P\$33.50; 2S)
Contact Energy (CEN.NZ - NZ\$8.42; 2M)	Q-Cells (QCEG.DE - €96.90; 2M)
Cosan SA (CSAN3.SA - R\$21.25; 1S)	Rhodia SA (RHA.PA - €26.19; 1H)
CropEnergies (CE2G.DE - €4.20; 3H)	Roper Industries (ROP.N - US\$61.01; 1M)
Danaher Corp (DHR.N - US\$86.17; 2M)	Rotork (ROR.L - £9.70; 1L)
Danone (DANO.PA - €61.04; 2M)	RPS Group PLC (RPS.L - £3.05; 3M)
Deere (DE.N - US\$90.20; 1M)	RWE AG (RWE.G.DE - €98.17; 1M)
Doosan Heavy Inds & Construction (034020.KS - W125,500; 1M)	Schneider Electric (SCHN.PA - €89.95; 2M)
DSM NV (DSMN.AS - €32.47; 2M)	Sharp (6753.T - ¥2,010; 2H)
DuPont (DD.N - US\$43.74; 2M)	Shaw Group (SGR.N - US\$62.31; 2S)
Ebro Puleva (EVA.MC - €12.53; 1M)	Siemens AG (SIEGn.DE - €106.11; 1M)
Electricité de France (EDF.PA - €81.50; 1M)	SIG PLC (SHI.L - £7.40; 2M)
Emerson (EMR.N - US\$55.17; 1M)	SolarWorld (SWVG.DE - €40.84; 2H)
Empresas ICA SAB de CV (ICA.MX - P\$71.01; 1H)	Southwestern Energy Co (SWN.N - US\$58.61; 1H)
Ence (ENC.MC - €7.42; 3M)	Suez (LYOE.PA - €47.94; 1M)
Energy Developments (ENE.AX - A\$3.86; 2H)	SunPower Corp (SPWR.O - US\$127.72; Not Rated)
Entergy Corp (ETR.N - US\$117.04; 2M)	Suntech Power (STP.N - US\$85.96; Not Rated)
Epure International (EPIL.SI - S\$2.06; 1M)	Suzlon Energy (SUZL.BO - Rs2,010.60; 1L)
ERG SpA (ERG.MI - €13.05; 1H)	Swiss Reinsurance (RUKN.VX - Sfr79.05; 1H)
Esco Technologies (ESE.N - US\$38.51; Not Rated)	Syngenta AG (SYNN.VX - Sfr302.25; 3L)
Evergreen Solar (ESLR.O - US\$17.44; Not Rated)	Tenneco (TEN.N - US\$25.88; 3H)
Exelon Corp (EXC.N - US\$80.18; 2M)	Terra Industries (TRA.N - US\$47.21; 1H)
Fluor Corp (FLR.N - US\$144.40; 2H)	Thermax (THMX.BO - Rs834.25; 1L)
Fortum Oyj (FUM1V.HE - €32.65; 1M)	Toyota Motor (7203.T - ¥6,040; 1M)
FPL Group (FPL.N - US\$66.35; 2M)	Umicore NV (UMI.BR - €164.83; 2M)
Gamesa (GAM.MC - €30.54; 2M)	United Group (UGL.AX - A\$19.01; 3H)
Gammon India (GAMM.BO - Rs706.45; 1M)	Veolia Environment (VIE.PA - €63.27; 2M)
Gaz de France (GAZ.PA - €41.49; 1M)	VeraSun Energy (VSE.N - US\$15.20; 1H)
Gazprom RTS (GAZP.RTS - US\$14.09; 1L)	Verbund AG (VERB.VI - €49.36; 2M)
General Electric (GE.N - US\$36.76; 1L)	Vestas Wind System (VWS.CO - Dkr550.00; 2H)
GFI Group (GFIG.O - US\$94.50; 2H)	Wacker Chemie (WCHG.DE - €192.43; 1H)
Halma (HLMA.L - £2.19; 2M)	XTO Energy Inc (XTO.N - US\$52.14; 2H)
Honda (7267.T - ¥3,750; 1M)	Yara International (YAR.OL - Nkr250.00; 2H)

Source: Citi Investment Research

Appendix B: Climatic Consequences Companies by Sector

Sector	Company Name	Sector	Company Name
Consumer Discretionary	BorgWarner	Industrials (cont'd)	General Electric
	Honda		Halma
	Johnson Controls		Ittron
	Magna International		ITT Corp
	Peugeot SA		Jaiprakash
	Tenneco		Kurita Water Industries
Consumer Staples	Toyota Motor		Leighton Holdings
	Archer Daniels Midland		Motech Industries
	Bajaj Hindusthan		Philips Electronics
	Balrampur Chini		Promotora Ambiental SAB de CV
	Bunge Limited		Q-Cells
	Cosan SA		Roper Industries
	Danone		Rotork
	Ebro Puleva		RPS Group PLC
	IJM Plantations		Schneider Electric
	IOI Corp		Sharp
	KL Kepong		Shaw Group
	Nestle		Siemens AG
Energy	Noble Group		SIG PLC
	BG Group PLC		SolarWorld
	BioFuel Energy		Suez
	Brasil Ecodiesel SA		SunPower Corp
	Chesapeake Energy Corp		Suntech Power
	CropEnergies		Suzlon Energy
	Energy Developments		Thermax
	ERG SpA		United Group
	Gazprom RTS		Veolia Environment
	Neste Oil Corporation		Vestas Wind System
	Ormat	Materials	Allegheny Technologies
	Southwestern Energy Co		DSM NV
	VeraSun Energy		DuPont
	XTO Energy Inc		Ence
Financials	Ace Limited		L'Air Liquide SA
	American Intl Group		Makhteshim Agan Industries
	Arch Capital Group		Monsanto
	Babcock & Brown Wind Partners		Nalco Holding
	Chicago Mercantile Exchange		Potash Corp of Sask
	GFI Group		Rhodia SA
Industrials	Swiss Reinsurance		Syngenta AG
	Acciona		Terra Industries
	Alstom		Umicore NV
	China Everbright International		Wacker Chemie
	Clipper Windpower		Yara International
	Compagnie de St Gobain	Utilities	Aguas de Barcelona
	Conergy AG		Centrica PLC
	Danaher Corp		Constellation Energy
	Deere		Contact Energy
	Doosan Heavy Inds & Construction		Electricité de France
	Emerson		Entergy Corp
	Empresas ICA SAB de CV		Exelon Corp
	Epure International		Fortum Oyj
	Esco Technologies		FPL Group
	Evergreen Solar		Gaz de France
	Fluor Corp		Iberdrola
	Gamesa		RWE AG
	Gammon India		Verbund AG

Source: Citi Investment Research

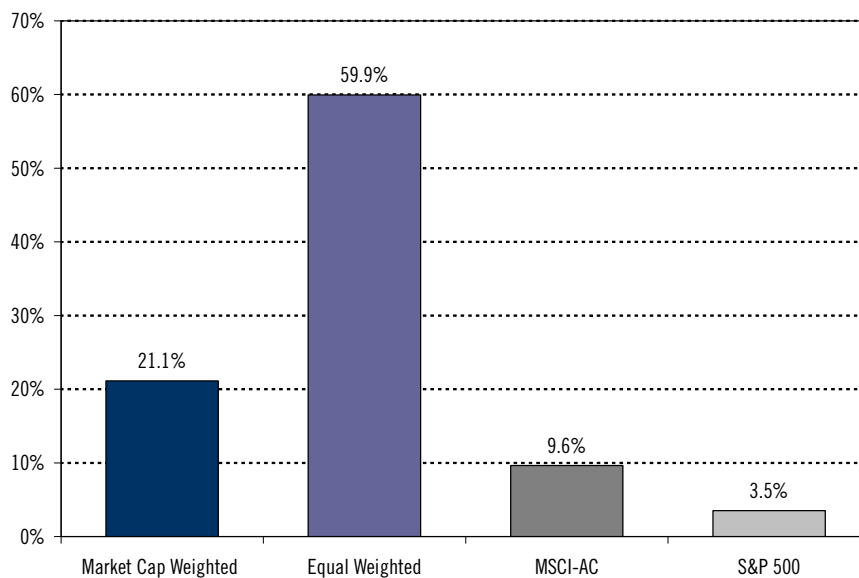
Appendix C: Climatic Consequences Companies by Country

Company Name	Country	Company Name	Country
Australia	Babcock & Brown Wind Partners Energy Developments Leighton Holdings United Group	Singapore	Epure International
Austria	Verbund AG	South Korea	Doosan Heavy Inds & Construction
Belgium	Umicore NV	Spain	Acciona Aguas de Barcelona Ebro Puleva Ence Gamesa Iberdrola
Brazil	Brasil Ecodiesel SA Cosan SA	Switzerland	Nestle Swiss Reinsurance Syngenta AG
Canada	Magna International Potash Corp of Sask	Taiwan	Motech Industries
China	Suntech Power	United Kingdom	BG Group PLC Centrica PLC Clipper Windpower Halma Rotork RPS Group PLC SIG PLC
Denmark	Vestas Wind System	United States	Ace Limited Allegheny Technologies American Intl Group Arch Capital Group Archer Daniels Midland BioFuel Energy BorgWarner Bunge Limited Chesapeake Energy Corp Chicago Mercantile Exchange Constellation Energy Danaher Corp Deere DuPont Emerson Entergy Corp Esco Technologies Evergreen Solar Exelon Corp Fluor Corp FPL Group General Electric GFI Group Itron ITT Corp Johnson Controls Monsanto Nalco Holding Ormat Roper Industries Shaw Group Southwestern Energy Co SunPower Corp Tenneco Terra Industries VeraSun Energy XTO Energy Inc
Finland	Fortum Oyj Neste Oil Corporation		
France	Alstom Compagnie de St Gobain Danone Electricité de France Gaz de France L'Air Liquide SA Peugeot SA Rhodia SA Schneider Electric Suez Veolia Environment		
Germany	Conergy AG CropEnergies Q-Cells RWE AG Siemens AG SolarWorld Wacker Chemie		
Hong Kong	China Everbright International Noble Group		
India	Bajaj Hindusthan Balrampur Chini Gammon India Jaiprakash Suzlon Energy Thermax		
Israel	Makhteshim Agan Industries		
Italy	ERG SpA		
Japan	Honda Kurita Water Industries Sharp Toyota Motor		
Malaysia	IJM Plantations IOI Corp KL Kepong		
Mexico	Empresas ICA SAB de CV Promotora Ambiental SAB de CV		
Netherlands	DSM NV Philips Electronics		
New Zealand	Contact Energy		
Norway	Yara International		
Russia	Gazprom RTS		

Source: Citi Investment Research

Appendix D: Climatic Consequences Companies Performance

Figure 43. Stock Price Performance of 90 Climatic Consequences Companies: 12/31/06 – 12/31/07



Source: Citi Investment Research

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Appendix A-1

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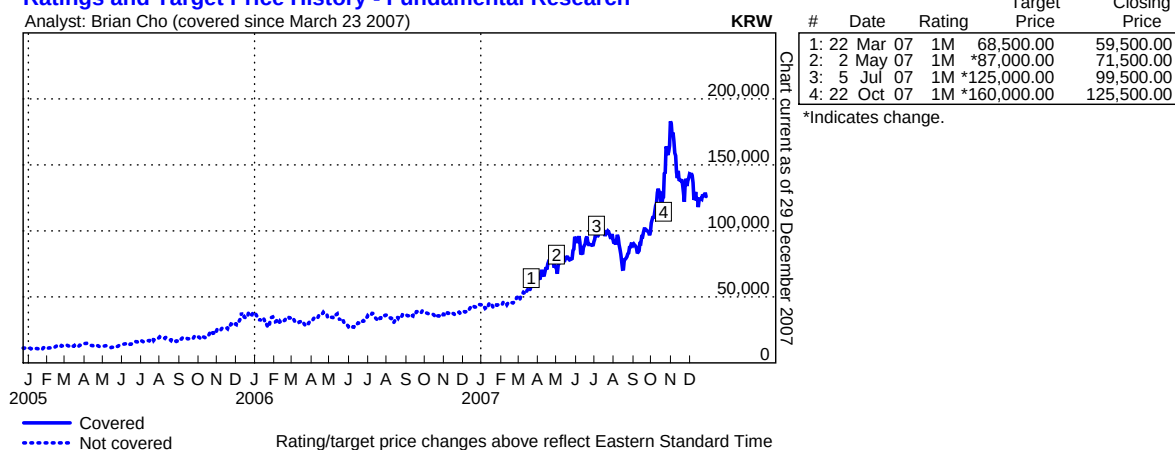
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Doosan Heavy Industries & Construction (034020.KS)

Ratings and Target Price History - Fundamental Research

Analyst: Brian Cho (covered since March 23 2007)



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