Global Equity Research
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Watching water

A guide to evaluating corporate risks in a thirsty world

Pages 6-19 of this report were prepared in collaboration with Piet Klop of the World Resources Institute, a non-profit, non-partisan research organization based in Washington, D.C., and Fred Wellington, formerly of WRI. JPMorgan gratefully acknowledges their assistance.

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About This Report

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A scarcity of clean, fresh water presents increasing risks to companies in many countries and many economic sectors. These risks are difficult for investors to assess, due both to poor information about the underlying supply conditions and to fragmentary or inadequate reporting by individual companies. As a result, market prices of securities are unlikely to accurately reflect the potential costs of water-related problems.

In this report, JPMorgan Global Environmental, Social, and Governance Research offers investors a framework for evaluating the impact of water scarcity and water pollution on individual sectors and companies. This is the first of a series of reports on transformational issues that we expect to offer investor clients and corporate managements over the course of 2008.

This report draws on the expertise of the World Resources Institute, which has helped us provide an overview of the issues from a global perspective. Then, with both our corporate and investor clients in mind, JPMorgan equity analysts from around the world lay out the water-related risks and opportunities they see facing companies in specific sectors. We provide criteria for examining these issues, which we hope will be of use to companies seeking to improve communication with investors about environmental issues as well as to investors themselves.

Here are the main points:

- **Exposure to water scarcity and pollution is not limited to onsite production processes, and may actually be greater in companies' supply chains than in their own operations.**
- **The power-generation, mining, semiconductor manufacturing, and food and beverage sectors are particularly exposed to water-related risks, in our view.**
- **In our opinion, corporate disclosure of water-related risks is seriously inadequate and is typically included in environmental statements prepared for public relations purposes rather than in the regulatory filings on which most investors rely.**
- **We recommend that investors assess the reliance of their portfolios on water resources and their vulnerability to problems of water availability and pollution.**

We look forward to your comments on this report. We also welcome your ideas about other ways in which we may assist you in addressing environmental risks and opportunities affecting the securities markets.

Introduction

Economic Research

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Water is increasingly scarce due to the confluence of population growth, urbanization, and climate change. Deteriorating water quality exacerbates the supply problems. These factors play out on a local basis, with some regions clearly more affected than others.

Wall Street appears well aware of the investment opportunities in water supply infrastructure, waste water treatment, and demand management technologies. Much less attention has been paid to those sectors that rely on clean water as an input into supply chains or production processes, or have waste water as an output. Water pollution impacts are as important, and diverse, as impacts due to water scarcity.

Importantly, risks differ between sectors and between countries and regions because of climatic conditions, water resources availability, and water use efficiencies. Regionally, areas such Northern California may well encounter more severe water-supply problems as climate reduces the Sierra Nevada snowpack.[1] Other areas, such as Northern Europe, may see more intense rainfall. Sectorally, while steel production everywhere may come under pressure as water supplies tighten, plants in China, which use four to nine times as much water per ton of steel as plants in the US or Japan, may face additional competitive burdens as a result.

The financial impact of water shortages on sectors and companies is unclear, because information on water use data and impacts is spotty and partial. We believe this will change as the consequences of water-supply shortfalls become more apparent.

- Increased publicity surrounding supply shortfalls can lead to increased government intervention, such as the recent restrictions on water use in the Atlanta area and in Australia, altering companies' cost structures.
- In many situations, the risk of business interruption due to water scarcity appears to be on the rise, making contingency planning more important.
- As water becomes more precious, companies' real and perceived behavior with respect to water consumption and discharge is also likely to have greater consequences in the marketplace, with an increased risk of consumer backlash against companies judged to be profligate or irresponsible.

We anticipate that companies will come under increasing pressure to provide detailed disclosure of water-related risks to investors, including potential changes in supply or treatment costs, regulations, and costs arising from supply-chain disruptions. This report represents an initial effort to outline these risks and to understand how they may affect various companies and industries in the coming years.

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1. Earman, S and Dettinger, M. (2007) Climate Influences on Groundwater Recharge: Implications for Western Groundwater and Surface Water Resources in the Face of Climate Change, Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstract H14E-04.

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A World of Water Scarcity

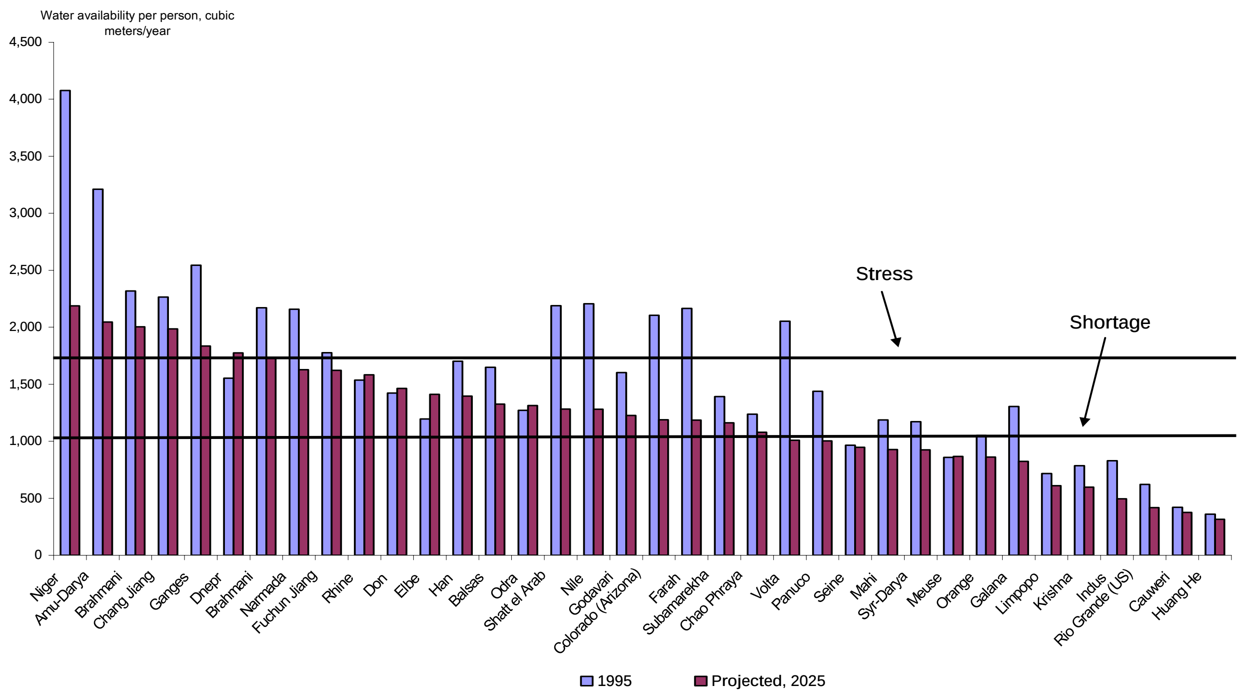
Pages 6-19 of this report were prepared in collaboration with Piet Klop of the World Resources Institute and Fred Wellington, formerly of the World Resources Institute. JPMorgan gratefully acknowledges their assistance.

The world has plenty of water, but 97.5% of it is saltwater. Mankind depends on the remaining 2.5%—of which only a fraction is accessible surface or groundwater—to serve a variety of functions: sustaining life, growing food, supporting various economic processes, and transporting and assimilating waste.

Globally, there are increasing pressures on water supply. In many regions demand for water now outstrips renewable supplies. It is likely this gap will widen. Moreover, water pollution is getting worse in many developing economies, which exacerbates the challenge of delivering sufficient water of the required quality.

As a rule of thumb, a river system drawn upon to provide 1,700 cubic meters of water per person per year can be considered stressed. By this definition, many regions that have rarely lacked for supplies of river water, such as the Colorado in the Southwestern US, the Nile basin in Africa, and the Narmada River in central India, face more frequent supply concerns. Some areas, such as the Volta River basin in West Africa, are expected to move from water surplus to severe shortage within the next two decades (Figure 1).

Figure 1: Half the World Faces Water Stress



Source: World Resources Institute.

Stress on water supplies is occurring around the world. In 2025, on recent trends, river basins important to major economies, including the US, Mexico, Western Europe, and China, will likely experience significant water problems as consumption outpaces supply replenishment. The projected shortfalls in South Africa, northwestern India, and North China are particularly severe.[2]

The worsening of the supply/demand imbalance in many parts of the world is attributable to three principal factors:

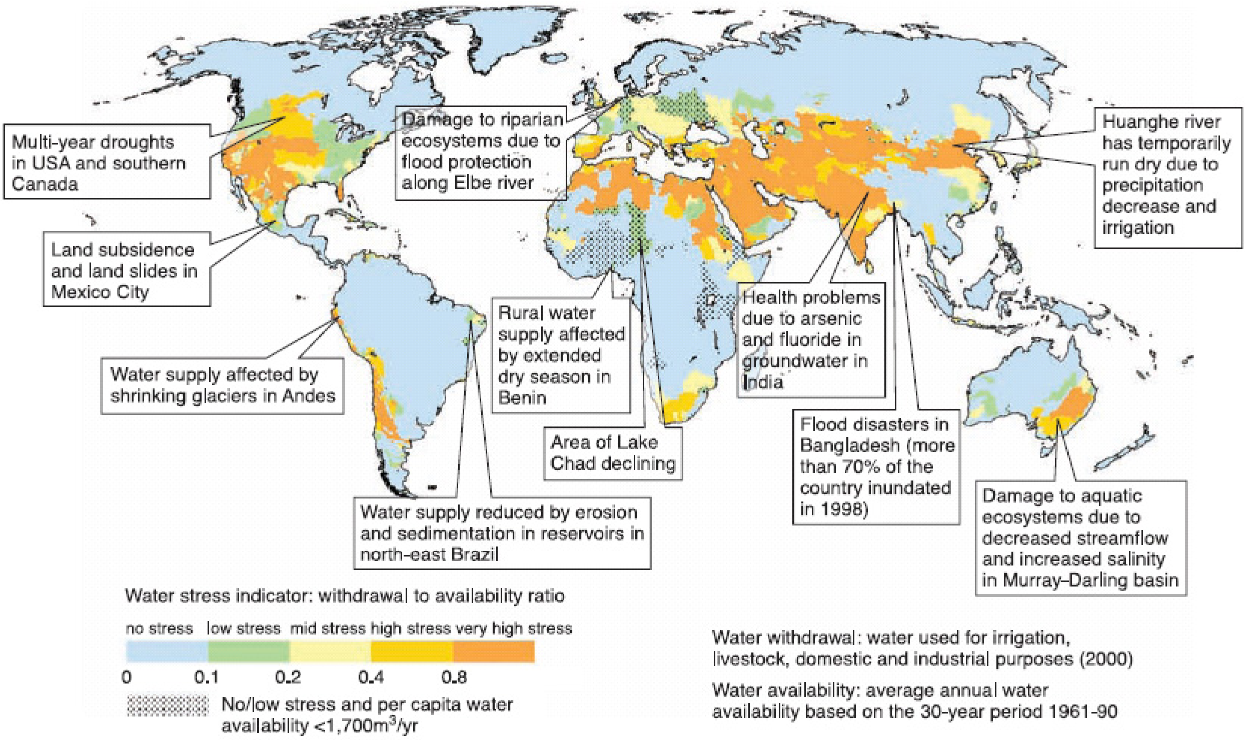
- **Population growth.** Global population is around 6.4 billion and growing at some 70 million people per year. It is projected to reach 8.1 billion by 2030 and 8.9 billion by 2050. Most of this growth is expected to occur in emerging economies, as populations in most OECD countries should remain fairly stable. The notable exception is the US, whose population is projected to grow to 370 million in 2030. The correlation between population growth and water consumption is straightforward. Empirically, global water withdrawals have closely followed the world population curve and are expected to continue to do so.

- **Urbanization and rising incomes.** More than half the world's population now lives in cities. It is not just the growth of cities that accounts for water scarcity; after all, urbanization moves people out of water-intensive agricultural settings. Urbanization tends to be accompanied by industrialization, which has its own water demands. However, we believe it is higher incomes and changing consumption patterns that mostly account for the increase in water use per capita.

- **Climate change.** On the supply side, climate change is increasingly altering hydrologic cycles (leading to increased flooding in some areas, drought in others). Climate change influences freshwater systems in complex ways with respect to both long-term average availability as well as variability of water supplies. Climate change can also affect water quality, as higher water temperatures, increased rainfall intensity, and longer periods of low water levels exacerbate various forms of water pollution. Figure 2 illustrates some of the observed effects on water resources that are likely attributable to climate change.

2. http://earthtrends.wri.org/maps_spatial/maps_detail_static.php?map_select=265&theme=2

Figure 2: Examples of Current Vulnerabilities of Freshwater Resources



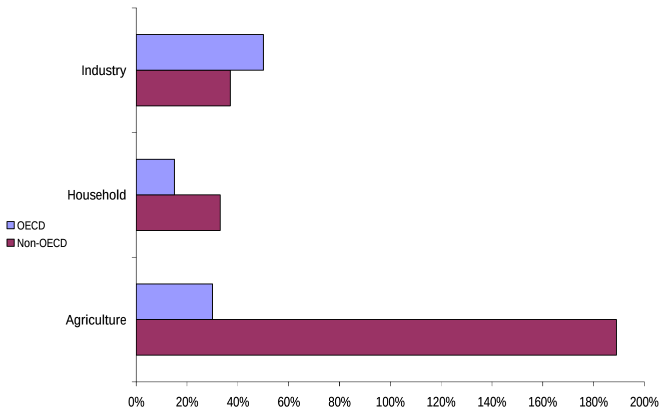
Source: Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, "Freshwater resources and their management. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," 2007.

Even as supply is becoming increasingly precarious, data suggest worsening trends in water quality in certain regions of the world. This is generally not the case in wealthier countries, where industrial and household water pollution has been brought under control. In developing countries, however, water quality is deteriorating. Fast-growing cities and industries are important sources of pollution, as untreated sewage and wastes—organic, chemical, toxic—are dumped into water, making the receiving surface water or groundwater unfit for use or expensive to treat.

Water-quality issues interact with availability concerns. Excessive pumping of groundwater, for example, can lead to saltwater intruding into freshwater aquifers, permanently reducing freshwater availability. Toxic spills or routine discharges of effluent can reduce the availability of clean surface water downstream.

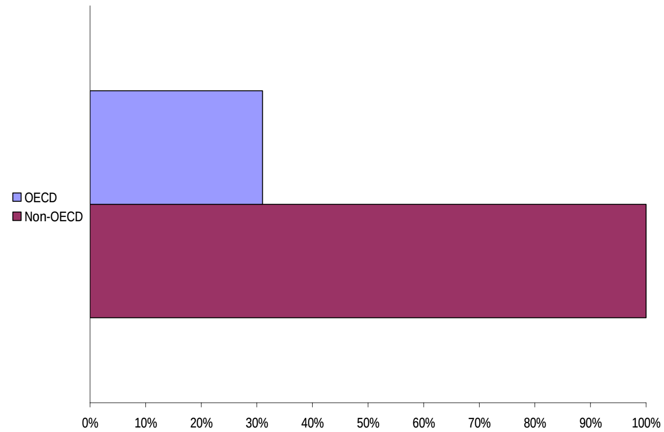
Water-quality data are highly location specific, and the different indicators are impossible to aggregate. One important indicator is biological oxygen demand, which reflects the level of organic pollution from agriculture and untreated sewage. Organic pollution from an "industrializing" agricultural sector in emerging economies is an acute danger to water quality (Figure 3). Nitrogen overloading, due principally to fertilizer runoff, is an acute danger to water quality, causing excess growth of plants and algae, harming fisheries, and significantly raising the cost of purifying drinking water (Figure 4).

Figure 3: Change in Biological Oxygen Demand, 1995-2020E



Source: OECD Environmental Outlook (2001).

Figure 4: Change in Nitrogen Loading from Agriculture, 1995-2020E



Source: OECD Environmental Outlook (2001)

Water Risks in the Value Chain

The trends in water quantity and quality are clearly important from a developmental and societal perspective, and it is this aspect of water issues that receives the greatest attention. More important for business, however, is reliance on water in the production of goods and services. Trends in availability and quality of this resource can have clear implications for businesses and their investors.

Businesses face three varieties of water-related risks:

- **Physical risks.** Physical water risks mostly affect sectors in which water is consumed or evaporated in the production process. In these sectors, a lack of water of adequate quality directly reduces production. Agriculture, beverages, and food processing are the most obvious examples, but other industries, such as power generators requiring large amounts of water for cooling also are subject to physical risks.

- **Regulatory risks.** Regulatory water risks have to do not so much with the absolute quantity of water available as with the conditions under which it may be used or discharged. Traditionally, many industries were able to obtain water at little or no cost by drilling their own wells or installing their own intake pipes. Regulatory responses include permits, prices, or both to control consumption and discharge. Regulation has become dramatically more important in the water sector in recent years as water resources have been fully committed and engineering solutions no longer offer easy ways to increase supply. This not only raises costs, but may result in less predictable supply. Regulation is most consequential for sectors that use or discharge relatively large amounts of water in connection with relatively low-value production processes.

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- **Reputation risks.** The increasing competition for clean water among economic, social, and environmental interests has a large potential for damaging the reputation and even growth prospects of companies. This is particularly true in developing countries where multinational companies source inputs, as the associated water use or discharge directly affects the livelihoods of people who may themselves not have sufficient access to clean water. Multinationals may be deemed "guilty by association" and singled out as culprits.

Table 1: Water-Related Risks at the Company Level

Risks	Supply Chain	Production Process	Product Use
Physical	Temporary non-availability of water disrupts supply chain	Temporary non-availability of water disrupts operations	Non-availability or scarcity of water required for using product or service limits growth
	Water scarcity drives up input prices	Increased capital expenditure on water treatment, water extraction, or alternative technologies to circumvent water problems raises costs	
	Intensifying competition for scarce water constrains growth	Intensifying competition for scarce water constrains growth	
Regulatory	Suspension or withdrawal of supplier's water license or discharge permits disrupts supply chain	Reallocation to more urgent needs during drought disrupts operations	Non-issuance of water license or restrictions on use of particular products or services due to water intensity raises costs or checks growth
		Suspension or withdrawal of supplier's water license or discharge permit disrupts operations and/or constrains growth	
Reputation	Competition with household water demand constrains suppliers' growth	Increased capital expenditure on wastewater treatment to meet or exceed standards	Public outcry regarding water intensity of product damages brand, reputation, hinders growth
	Responsibility "by association" for suppliers' water pollution damages brand or reputation, hinders growth	Competition with household demands, or pollution incidents, damages brand or reputation, hinders growth	

Source: World Resources Institute.

These three types of risks often appear in combination. For example, water scarcity (physical) may lead to the revocation of water licenses (regulatory), or to damage to a firm's image and brand (reputation). Physical, regulatory and reputation risks may impact at different points along the value chain and may affect suppliers, production facilities, or users of the product.

Companies may have major exposures to water scarcity and water pollution even in countries where they do not have production operations. Backward linkages (supply chain) and forward linkages (product use) may create water risks that go unnoticed by management and investors.

- **A number of industries require much more water in the supply chain for the production of raw materials than they do for "on-site" production.** For example, the food and beverage sector relies on irrigated agriculture for important inputs. As a result; water scarcity in key production areas could lead to higher prices for grain, meat, and other inputs. Aluminum manufacturers in the US Northwest experienced the supply-chain impact in 2001, when water shortages led to the curtailment of hydroelectric power supplies, forcing the closure of several aluminum plants.

- **Forward linkages can be just as problematic.** The use of many products—washing machines, tourist resorts—requires water. Scarcity may curtail sales of boats and motors, swimming pools, and some types of irrigation equipment. Forward linkages also have reputational implications: in regions where freshwater is in short supply, water-intensive products and services may draw the ire of people who lack basic water services.

There are three principal channels through which risks surrounding water scarcity or water pollution can affect corporate financial performance:

- **Financial losses** in the form of foregone revenue due to disruption of the production process.

- **Higher costs** related to (1) supply chain disruption; (2) changes in production processes; (3) capital expenditures to secure, save, recycle, or treat water; (4) regulatory compliance; and (5) the increased price of consuming or discharging water. In emerging economies, even where a particular company is not a heavy user of freshwater or discharger of polluted water, it may have to absorb the costs associated with improved local water-quality standards driven by higher incomes and increased environmental consciousness.

- **Delayed or suppressed growth** due to intensifying competition for water.

The risks of disruption, "forced" capital expenditures, or constraints to growth may manifest themselves in a higher cost of capital for businesses that rely heavily on fresh water resources. There may also be other avenues of material impact, such as worsening health conditions of workers or prospective customers. Water-related social conflicts that do not directly involve a particular firm may nonetheless interfere with routine operations. The risks of water, then, can take many forms.

Sectoral Impacts

Some sectors of the economy clearly are more at risk from water-supply or water-quality problems than others. In this section, we examine selected sectors that, in our view, merit particular attention from investors with respect to water risks. Agriculture, the sector that is most reliant on water, is excluded from this analysis, as few direct producers of farm products are listed companies. Starting on page 20, JPMorgan equity analysts examine some of these sectors in greater detail.

In our view, the most sensitive sectors are power generation, mining, oil and gas production, manufacturing, food processing, and beverages. These sectors are either highly reliant on water as an input in the production process or have wastewater issues, or both (Table 2). Sectors that rely on water availability for the use of the goods or services they produce also are highly exposed to water problems. As aggregate data on water consumption by particular industries is not readily available, we discuss individual companies for purposes of illustration.

Table 2: Examples of Sectoral Impacts of Water Scarcity

Sector	Principal Impacts
Food and Beverages	Manufacturing disruptions, higher commodity costs, higher power costs, loss of access to sources of bottled water
Manufacturing	Production disruptions, problems with discharge of liquid wastes
Semiconductor Manufacturing	Production disruptions, higher costs for water purification, limits on expansion
Power Generation	Plant shutdowns due to lack of cooling water, high costs to purchase substitute power
Insurance	Positive impact due to demand for new coverages; costs from fire and drought claims
Extractive Industries	Potential restrictions on drilling, mining, use of slurry transport, and waste discharge

Source: World Resources Institute.

Food and Beverages

The food and beverage sectors are heavily dependent on water for production of inputs as well as of final goods. Their water use is so vast that it affects overall water availability in a significant way. We estimate that the combined direct consumption of five food and beverage giants, Nestlé, Unilever, Coca-Cola Co., Anheuser-Busch, and Danone approached 575 billion liters per year, enough to service the daily basic water needs of everyone on the planet. [3]

The real risks of dependence on water play out locally and regionally. It is *effective* water availability that matters, i.e. the right amount of water at the right quality at the right time at the right place. Food and beverage processors appear to have increasing difficulty obtaining the water they require, as other social demands for water are deemed more important. Within the past few years, Coca-Cola Company and Nestlé both have lost access to groundwater at certain locations despite compliance with local laws and regulation in effect at the time the relevant plants were built.

In addition to these local production issues, food and beverage companies have global exposures to water scarcity through their supply chains. Supplies of

3. Data derived from company reports.

agricultural inputs are highly water dependent, not only for irrigation but in some instances for power generation and transportation. Floods and prolonged droughts, notably Australia and South-East Europe, have forced up food and grain prices worldwide. Last year, drought in Ghana severely reduced hydropower production, forcing Unilever Ghana to cut power consumption by 25% and purchase expensive diesel generators to make up for lost power from the grid.[4] A 2001 drought in the US Northwest led to low water levels at hydroelectric dams, driving up the price of the aluminum used to make beer cans while simultaneously reducing production of barley, a critical ingredient for brewers. Both events forced up Anheuser-Busch's production costs.

Manufacturing

The share of total water withdrawn by the manufacturing sector is rising fast in emerging economies. Manufacturing's share of total water consumed is much lower than its share of net withdrawals, as most of the water is used for cooling, waste assimilation, and other process purposes, and subsequently returned to groundwater or surface water bodies. Still, the impact of the manufacturing sector on the availability of clean water elsewhere can be huge: a 2005 toxic benzene spill in northeast China meant that industries could not draw water from the Songhua River for days.

Quantity, quality and timing of water supplies are important; just how important varies from one sub-sector to another. For some industrial processes—cooling, for example—brackish or salt water will do, and at least at the input-side water scarcity risks can be mitigated. Other manufacturing processes, however, require better-quality fresh water.

Apart from supply-side factors, the impact of water scarcity and pollution on sectors largely depends on their water use efficiencies. Efficiency improvements and their investment implications differ greatly across countries, sectors and companies. For example, Indian steel companies consume about 10-80 cubic meters of water to produce a single ton of steel. Producing a ton of steel in the US consumes 5-10 cubic meters.[5]

Semiconductor Production

Semiconductor plants require vast amounts of clean water to create and clean silicon wafers. To make a single 200 millimeter wafer, a typical semiconductor plant requires 7.5 m^3 gallons of ultrapure water, which translates into nearly 13 m^3 of municipal water input. Large facilities can use more than 10,000 m^3 of ultrapure water per day.[6] As wafer sizes increase, the semiconductor industry will demand even more water. In Silicon Valley, chip manufacturing has been estimated to account for a quarter of water withdrawals.[7] The industry is particularly vulnerable

4. Michael Philips, "How Ghana's Economic Turnaround is Threatened" (2007). Available: http://www.source4africa.com/blog/index.php?entry=entry070809-085517

5 Center for Science and the Environment (2004) To use or to misuse *Down to Earth Magazine* Available: http://www.cseindia.org/dte-supplement/industry20040215/misuse.htm

6. Klusewitz and McVeigh, "Reducing water consumption."

7. UNEP-FI and SWI. "Challenges of Water Scarcity – A Business Case for Financial Institutions." 2006. Available: http://www.unepfi.org/fileadmin/documents/challenges_water_scarcity_2005.pdf

to degradation or contamination of source water, which can lead to higher pre-treatment costs for filtration, disinfection, reverse osmosis or other water purification techniques.

The electronics industry's huge water demands may become a reputation risk in countries where people still don't have access to basic water and sanitation services. Indeed, there have been cases of semiconductor manufacturers being denied expansion requests because of the additional water they would need.[8] Companies have been forced to make large capital expenditures to increase water-use efficiency.

Power Generation

The generating industry has a voracious demand for water. At 514 million m^3 of freshwater per year, the thermoelectric power sector accounts for 39% of total freshwater withdrawals in the United States.[9] Power plants fueled by coal and natural gas use 2,800 and 2,300 liters, respectively, to produce one megawatt hour of electricity. Nuclear power plants need more freshwater than gas-fired generators—3,100 liters per megawatt hour—to keep from overheating (Table 3). Water is also required in coal plants in conjunction with sulfur removal. Carbon-capture technologies would further increase power plants' water needs.

Table 3: Water Use in Power Generation

Cubic meters per megawatt hour

		Coal	Natural Gas (Combined Cycle)	Nuclear	Solar	Hydroelectric
Withdrawal	Open loop cooling	76 - 190	28 – 76	95 – 227	2.8 – 3.4	
	Closed loop cooling	1.1 - 2.3	0.8	1.8 – 4.1		
Consumption		1.1 – 2.3	0.4 – 0.6	1.5 – 2.7	2.8 – 3.4	17

Source: U.S. Department of Energy, "Report to Congress on the Interdependency of Energy and Water," 2006.

The scale of water intake by individual plants is quite large. As an example, American Electric Power's 882 megawatt capacity Riverside natural gas power plant in Oklahoma uses 62,000 m^3 per day, or nearly 25 million m^3 per year.[10]. The plant's water use is approximately equal to the annual consumption of a city of 180,000 inhabitants. The big difference with other sectors is that only 2-5% of this intake is lost, due principally to evaporation, with the rest eventually being returned to surface water bodies.

A growing body of anecdotal evidence points to the materiality of water issues to the power sector globally. In 2003, when France experienced low river levels and exceptionally high temperatures, Electricité de France had to shut down a quarter of

8. Donovan, Robert. "CleanRooms: Reducing Water Usage in Semiconductor Manufacturing." June, 2002. Available: http://cr.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=145333

9. US Department of Energy, National Energy Technology Laboratory "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements" (2007). Available: http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/2007WaterNeedsAnalysis-UPDATE-Final_10-10-07b.pdf

10. AEP Corporate Responsibility Report 2006. Available: http://www.aep.com/citizenship/crreport/GRI /EN8.asp

its 58 nuclear power plants, even after water-temperature regulations were softened to “guarantee the provision of electricity to the country.” The average electricity price spiked 1,300%, and EDF lost €300 million as it had to import power. In the summer of 2007, the Tennessee Valley Authority was forced to partially shut down its Browns Ferry nuclear plant due to the high temperature of the cooling water it draws from the Tennessee River even as Memphis and Nashville, both served by TVA, were experiencing record power demands.

The material impact – notably the increase in electricity prices – is exacerbated as the same lack of water that forces shutdowns of thermoelectric plants is likely to coincide with low water levels in hydropower reservoirs. Water-related shutdowns are expected to become more common as climate change intensifies summer heat waves and prolongs droughts in already arid areas. In the US, these include the places experiencing the fastest population growth, including Phoenix, Tucson, and Las Vegas.

Lack of water can also constrain generators’ growth potential. In Idaho, two proposed power plants have faced local opposition because of their need for large amounts of groundwater. Tennessee imposed a moratorium on the installation of new merchant power plants because of cooling constraints,[11] and Dominion Power was forced to invest $1.1 billion in a water recycling facility in Massachusetts to curb the release of hot water from a generating plant.[12]

Shifting to renewable energy sources does not necessarily resolve the problem. The production of one liter of corn ethanol requires a staggering 1,700 liters of water. Concentrated solar—using the sun to evaporate water and drive steam turbines—requires more than 2,600 liters of water per megawatt hour.

Insurance

Many insurance companies see water shortage as an opportunity for growth. As businesses become more concerned about potential water-supply shortfalls, they will likely seek insurance against business interruption, expanding an important market. Many business-interruption policies are tailored to the needs of a specific buyer and thus provide greater profit than standardized policies.

Insurers, however, will be reluctant to tread where losses are unpredictable. Losses from business interruption due to water scarcity may well fall into this category, particularly because the extent to which supply chains or production are interrupted will depend on the specific actions of government officials.

Such unpredictability stemming from public policy has already affected insurers’ willingness to write policies protecting clients against water-pollution claims. Such claims may occur years after the pollution occurred—they have long tails, in insurance parlance—and may cover actions that did not appear problematic at the time, such as injury due to the discharge of a substance that was not regulated as a pollutant at the time it was discharged. Claims related to water scarcity are

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11. Running Dry, EPRI Journal Summer 2007
12. Daley, B. 2007 Plant to Stop Pumping Water into Bay. *The Boston Globe*. Available: http://www.boston.com/news/local/massachusetts/articles/2007/12/18/plant_to_stop_pumping_water_into_bay/

likely to have shorter tails, but may be similarly unpredictable to the extent that public officials' choices determine which companies and facilities are affected by water shortage and which are not.

Extractive Industries

Oil and gas exploration use water for well drilling, completion, and fracturing. Water risks are particularly important in new tar sands developments, which use 4-5 liters of water to separate out each liter of oil. Water also plays an important role in the extraction, downstream processing and conveyance of metals. Often, metals move from the mine to processing points in slurry-suspension form, requiring large quantities of water.

Water use in metals mining ranges between 100 and 8,000 liters of water per ton of ore extracted. In 2000, mines in the US alone withdrew about 518,000 m^3 per day. Water pollution from mines is also a troublesome issue. Mine drainage often contains sulfuric acid and dissolved iron. Acid runoff further dissolves heavy metal such as copper, lead, and mercury into the groundwater. All this presents reputation and regulatory risks to be managed. In the Appalachian region of West Virginia, for example, it is estimated that drainage cleanup costs from years of coal mining will be between $5 billion and $15 billion by the time work is finished.[13]

Assessing Corporate Risks

Most companies that are reliant on water for industrial purposes publish disclosures of water-related information. These disclosures, however, are of limited usefulness to investors. Generally speaking, the information is sparse, overly broad, and not put into an investor-oriented context. Moreover, most information related to companies' reliance on water is disclosed not in securities filings but in corporate social responsibility or sustainability reports, which may not be widely used by investors.

Disclosure generally includes both qualitative discussion around the importance or use of water and quantitative disclosure around company-defined water metrics. Many companies highlight the importance of water issues and their reliance on stable water supply for production purposes, but discussion of the potential for water-related issues to impact operations is far less common. When operational issues are disclosed, the discussions are mostly historical, as in Exelon Corp.'s after-the-fact disclosure that it had to halt a power plant's operations for two weeks after an oil spill in the Delaware River contaminated water supplies.

Quantitatively, many companies disclose the amount of water consumed for industrial processes in corporate sustainability reports. The most common metric is total water use, stated in cubic meters. Reports typically do not provide any method for evaluating this number or relate it to financial variables. Disclosures related to consumption or wastewater discharge in the supply chain are far less common.

13. US Geological Survey, 2005. Available: http://ga.water.usgs.gov/edu/wumi.html

The analyst's task is complicated by the fact that there is no standardized format for corporate disclosure of water-related risks. Definitions are inconsistent, complicating comparisons across companies. Different companies even apply wildly different definitions of what they mean by "water use."

Issues and risks related to compliance with water-quality regulations such as the Clean Water Act are commonly reported in securities filings and annual reports. However, these disclosures often are insufficient to help investors understand the risks. For example, a company is extremely unlikely to disclose the fact that regulators are raising concerns about effluent from a plant that is the sole production location of a key component.

Evaluating Water Risks: An Example

In this section, we consider the water risks facing the food and beverage sectors to illustrate the sorts of issues we think investors need to evaluate. These risks are significant, in our view, and may affect the industry in many different ways over both short and long time horizons (Table 4). Our assessment is qualitative in nature, and the actual financial exposure to each of these potential risks is unique to individual companies. Nonetheless, we believe a matrix such as this, applied to the entire sector, presents a starting point for focused discussion with management and subsequent analysis of exposure to water risks.

Table 4: Water-Related Risk Evaluation for Food and Beverage Sectors

	Near-term			Longer-term		
Potential Risks	Supply chain	Production process	Product use	Supply chain	Production process	Product use
Physical						
Regional water stress	●●	●		●●●	●●	
Regulatory						
Plant siting / permit		●●		●	●●●	
Water right (license)	●	●●		●●	●●●	
Water price		●			●●	●
Reputation						
Pollution	●	●		●●	●●	
Community relations		●	●		●	●

Key: ●●● = priority area for investor attention; ●● = moderate risk; ● = potential risk.

Source: World Resources Institute.

In our view, there are four main water-related factors that should affect securities valuations in the food and beverage sectors:

- First, obtaining plant siting permits could become more difficult. Companies thus may face significant obstacles to their expansion plans.

- Second, the cost of obtaining and treating water may rise as a function of new or more strictly enforced water policies, because of supply/demand imbalances, or simply because of public pressure.

- Third, the risk of business interruption may increase due to water availability concerns at plants or in the supply chain.

- Fourth, a company's water consumption, or the water pollution it causes, can raise key reputational concerns, especially where the competition with local economic, social, or environmental demands is intense.

This framework brings forth a host of issues into which investors may wish to probe:

Security of water rights, both for the production plants and further up the supply chain. Irrigated agriculture is the big water consumer in many countries and, for that reason, a prime target for water re-allocation towards higher value-added uses.

Water stress through over-appropriation of surface water resources or overdraft of groundwater resources. Acute water shortages may lead to the disruption of on-site operations and increased production costs because of investments in securing access to water resources (longer pipes, deeper wells, water treatment). Ultimately, water shortages can be an effective check on further growth, as when water use licenses are not renewed. Water stress can worsen due to external factors, such as population growth, even if there has been no change in a plant's operation or water consumption.

Investments in water efficiency through measures to reduce water demand or recycle waste water. Many companies have adopted water efficiency targets at the plant or company level. However, it is important to focus on those places along the supply chain where water efficiency matters most.

The price-cost differential between the price of water and its full social cost neatly captures the level of long-term sustainability of the water demands by food and beverage production plants and their agricultural suppliers. Admittedly, that full social cost is difficult to establish. But unless the price of water starts to approximate its value, we believe long-term sustainability is doubtful.

Ability to pass on increased costs in water supply or treatment to customers. An alternative to increased investments in securing water may in some cases lie in sourcing different inputs (e.g., artificial sugar).

Compliance with regulations and water-quality standards as well as the investments to meet or exceed the relevant standards (and again, the ability to pass the increased costs on to customers). The relevant standards can be locally or internationally defined, or by competitors aiming to exceed those standards.

Restrictions on growth, plant siting, and other business decisions. Spatial planning that incorporates drought or flooding risks may constrain companies' siting decisions. Water withdrawal caps or allocation rules may limit growth prospects and, unlike water-quality constraints, are difficult to overcome with investment.

Equity of access to water resources, as evidenced by the health of communities and the local environment as well as local economic growth to the extent that these are harmed by limited access to clean water. This may be one of the important reputational concerns facing the food and beverage industry. And, again, it relates to suppliers as well as production plants.

Disputes and disruptions are how poor community relations may manifest themselves. If they affect a company's license to operate, they may have a real impact on continuity of operations. The frequency of disputes or social disruptions is of interest, too, as a sign of whether "water relations" are improving or deteriorating.

Pollution spills obviously pose reputation risks for the food and beverage industry. A particular risk arises with suppliers, such as farmers whose pesticides contaminate surface water or groundwater, for which a multinational company may be deemed guilty by association. The incidence of pollution events over time, as well as the timeliness of companies' responses when disaster strikes, are key indicators of an investor's vulnerability to this particular type of risk.

Water Risks: Six Case Studies

The pages above offer a framework for investors to assess water-related risks at the sectoral and corporate levels. We have asked selected JPMorgan equity analysts around the world to apply this framework to the sectors and geographic regions they cover, in hopes of providing deeper understanding of how water-related risks will affect securities valuations in sectors that are especially exposed to these risks.

These evaluations are intended as tools for risk analysis, not as guides to near-term securities valuations. No analyst evaluates the water risks of every company under his or her coverage, nor does any analyst upgrade or downgrade a particular stock due to water-related concerns. Rather, our purpose is illustrative, to show how, in our view, companies' water-related risks can be factored into the evaluation of equity investments

Power Generation: Asia Plans for Water Shortage

Asian Power Generators Equity Research

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Water shortage is a growing concern in Asia. As many as 660 million people in the region are without water access altogether. Although major projects are underway, such as the vast south-to-north diversion project in China, it is expected that supply will remain tight in the long run.

So far, water shortage has had minimal financial impact on Asian power producers. As water-related expenses remain a relatively minimal part of Asian power utilities' cost bases, a majority of the listed power generators do not have any specific near-term programs to cut down on water consumption. Most of the companies we cover provide little detail about their water usage, making it difficult for investors to conduct meaningful financial analysis.

Nonetheless, we believe water shortage will become a more pressing problem in Asia, with consequences for generating stations that require large amounts of water. Our examination of three companies in the region, Electricity Generating Public Company and Glow Energy in Thailand and also China Resources Power in China, suggests differences in the seriousness companies attach to incipient water shortage and in the responses.

Where Water Is Scarce

Of the 1.1 billion people around the world who have no water access, 60% reside in Asia (Figure 6). China has approximately 300 million people still without water, and India approximately 140 million. Given the two countries' rising economic growth, there will likely be increasing pressure on water supplies for industry and agriculture and to sustain greater household consumption.

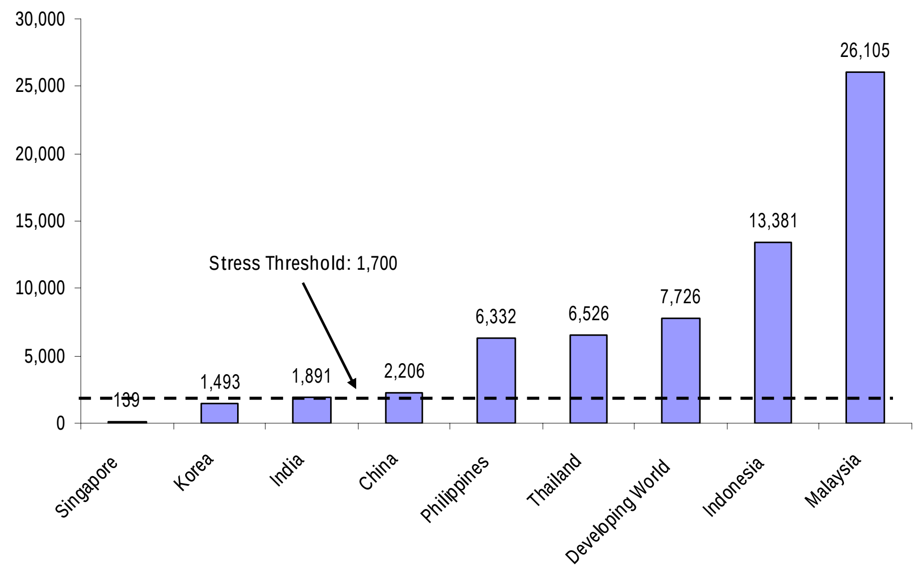
We use three key indicators to assess water availability across the region. These include:

Water barrier index: This index measures the extent to which currently available water resources are sufficient to cater to the existing population. Availability of less than 1,700 cubic meters per person annually indicates stress, with supply below

1,000 cubic meters per person deemed scarcity. The water barrier index shows that wealthier economies, notably Singapore and Korea, face the greatest water stress (Figure 5). India and China are likely to fall into the stress zone as economic growth induces greater water demand. Although China's overall supply is adequate, uneven availability has brought scarcity in the north and northeast, which have only 15% of the country's water resources but 40% of the population.

Figure 5: Water Barrier Index by Country in 2000

Cubic meters per capita

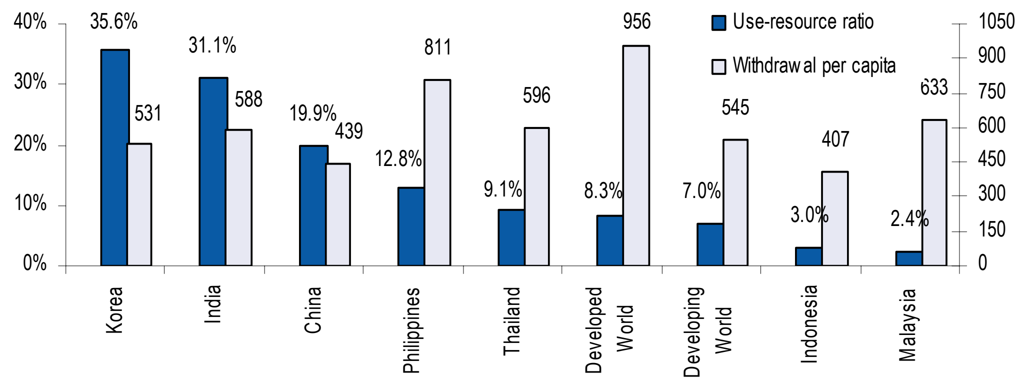


Source: FAO, United Nations, JPMorgan.

Use-to-resources ratio: This measure is a ratio comparing the amount of water required with the amount available. Interestingly, some of the wealthier countries, notably Korea, use less water per capita than some far poorer economies, such as India and Thailand (Figure 6). The high water use in the Philippines is due to large losses in the supply system; usage per person is actually around the same level as in Indonesia. Some of the more tropical countries, such as Indonesia, Malaysia, and Thailand, have much greater water resources in relation to demand.

Figure 6: Use-to-Resource Ratio in 2000 in Select Countries

%, cubic meters per capita

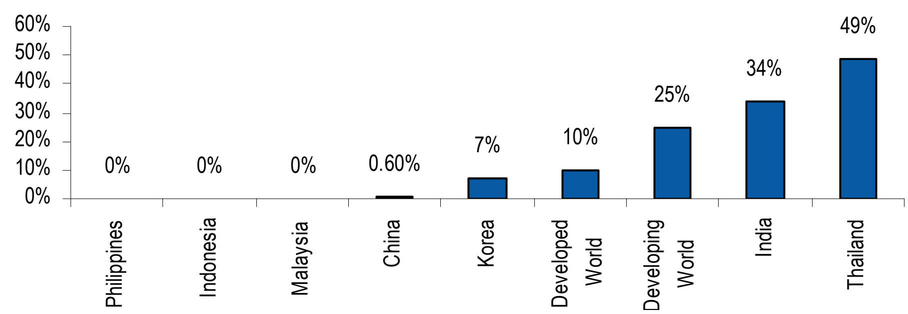


Source: FAO, United Nations, JPMorgan.

Import dependence ratio: The third useful water sustainability indicator measures how dependent a country is on water resources in other countries. Here, Thailand and India rank highest on import dependence (Figure 8).

Figure 7: Dependency Ratio in 2000

%



Source: FAO, United Nations, JPMorgan.

Scarcity is anticipated to become a much more severe problem across the entire continent over the next two decades. Several countries that had ample supplies a few years ago, notably Pakistan, Afghanistan, India, Korea, and Iran, are likely to experience more frequent signs of water stress (Table 5).

Table 5: Current and Projected Water Resources by Country

Cubic meters

	Avg Annual Renewable Water Resources (1000 m³)	Renewable Water Per Capita 1975	Renewable Water Per Capita 2000	Renewable Water Per Capita 2005	Renewable Water Per Capita 2025 - Low Projection	Renewable Water Per Capita 2025 - Medium Projection	Renewable Water Per Capita 2025 - High Projection
Kuwait	0	20	9	7	5	5	5
UAE	0	283	0	33	23	22	21
Qatar	0	310	0	65	50	48	46
Saudi Arabia	2	331	90	98	68	65	61
Jordan	1	454	199	154	115	108	102
Singapore	1	265	249	139	123	117	111
Bahrain	0	426	x	160	127	120	114
Israel	2	497	331	248	202	191	182
Oman	1	1074	383	384	276	261	247
Absolute Scarcity						500	
Pakistan	223	3260	1563	1410	1023	971	924
Water Scarcity						1000	
Afghanistan	65	4539	3039	2177	1218	1172	1119
India	1897	3056	1865	1719	1443	1359	1285
Korea, Rep (South)	70	1976	1495	1458	1490	1409	1337
Iran	138	4124	2077	1978	1654	1544	1448
Iraq	75	6300	3229	2618	1782	1689	1604
Water Stress						1700	
China	2829	3034	2259	2138	2062	1951	1851
Sri Lanka	50	3561	2689	2410	2274	2141	2022
North Korea	77	4816	3458	3430	3398	3198	3021
Japan	430	3856	3385	3357	3608	3445	3299
Philippines	479	11400	6327	5767	4673	4391	4141
Nepal	210	15515	8929	7747	5794	5446	5135
Thailand	410	9928	6730	6382	5990	5644	5334
Bangladesh	1211	16544	8778	8536	6645	6248	5894
Kazakhstan	110	7754	7033	7394	7915	7419	6986
Vietnam	891	18577	11403	10580	9118	8541	8033
Indonesia	2838	21117	13415	12739	11461	10760	10147
Malaysia	580	47316	25216	22882	18520	17458	16539
Bhutan	95	81826	46055	43920	31168	29604	28207
Fiji	29	49566	35643	33667	32370	30405	28693

Source: Population Action International.

Corporate Responses

Asian power producers appear to be addressing the possibility of water shortages principally through choice of technology. Coal-fired power is expected to remain the dominant source of power in major markets such as China, India, South Korea and Indonesia. Coal plants are heavy water users, and in areas where water supply is relatively scarce, the trend is towards adoption of coal-fired generating units with close-loop cooling systems, to allow water reuse, or air-cooled generating units to cut down on water usage (and in some cases to meet local regulatory requirements). Thailand and Malaysia have a larger presence of gas-fired power plants, which tend to be more water-efficient than coal plants.

Electricity Generating Public Company (EGCO)

Thai power producers heard a warning call about water shortage in 2005, when a severe drought struck Thailand's eastern seaboard. EGCO's key power plant, Rayong, is located in this heavily industrialized area, which benefits from easy access to gas from the Gulf of Thailand but receives little rainfall. Water supply on the eastern seaboard is secured by the Nongplalai and Dokkrai reservoirs. During the dry season in 2005, the water levels in the two reservoirs fell to only 9% of capacity. The entire region, including EGCO's operations, came close to a crisis that was averted only when the monsoon rains came early, enabling the reservoirs to be replenished.

Following the close call in 2005, the government sector has undertaken several major water projects. These include an additional reservoir, Prasae, along with a system of pipelines connecting the key reservoirs with one another as well as with major rivers. We note that government policy is focused much more on supply than on demand-side management.

EGCO management appears to believe that the government's measures will be adequate to ensure water supply to the Rayong power station for the foreseeable future. In our opinion, since EGCO did not actually face a water crisis in 2005, the company remains comfortable that this will not occur in the future.

Nonetheless, EGCO appears to be addressing water risks as it diversifies its supply sources and technologies. Its Thai plants are gas-fired combined-cycle units that require water mainly for the production of high-pressure steam to drive turbines. By late next year, EGCO plans to commission its first hydro-electricity project, the 1,070 megawatt Nam Theun II plant in Laos. This is to be a large plant, in hydro terms, and will require substantial water supply to ensure consistent power generation. EGCO management believes the project has been well planned and has a large enough water catchment area (4,000km^2) to ensure adequate upstream supply.

Glow Energy

Glow is perhaps even more exposed to water risk than EGCO, which operates in the same geographic territory. Just like EGCO's, Glow's combined-cycle units require water to drive the steam turbines to produce the electricity. In addition, glow has an important business selling steam to the petrochemical industry. Steam sales account for 13% of Glow's total revenue and are totally dependent upon the availability of water as a raw material.

Glow Energy, which generates all of its power in the eastern seaboard area, is particularly exposed to conflicts between agricultural and industrial water needs. As water becomes a greater issue in this area, farmers are voicing concerns that new pipelines linking the eastern seaboard reservoirs with the Bangpakong River and the Prasae Reservoir to the eastern seaboard could compromise their water supply. The Prasae Reservoir was originally developed with the intention of providing water to the agricultural sector, but these pipelines, built following the near water crisis of 2005, would enable the industrial sector to receive a greater share of the water during a drought. Glow faces regulatory risk as the government considers the farmers' demands to protect agricultural water allocations.

Glow Energy's management appears to be less confident than EGCO's about the adequacy of the government's plans to ensure greater water-supply security. Following the 2005 drought, Glow initiated its own plans to complement the state program. The company's initiatives are principally contingency plans to ensure continuous water supply should reservoir water be inadequate. These include contracting barges to transport water from the Chao Phraya River in Bangkok, renting reverse osmosis machines, and transporting water by truck. Trucks would be the very last resort, given that they are extremely expensive.

China Resources Power

Water scarcity is already an issue for China Resources Power. Over 60% of its power plants are located in provinces where per capita water resources are less than 700 cubic meters per year (Table 6).

Table 6: Location Breakdown of CRP's Operating Plants and Related Water Resources

>60% of CRP's generation capacity is located in areas where water resources are scarce at <700 cubic meters per capita

Provinces	Attributable capacity (MW)	%	Province per capita water resources (cubic meters / yr)
Beijing	77	1%	143
Hebei	820	7%	227
Jiangsu	2,976	25%	275
Henan	2,133	18%	418
Liaoning	1,200	10%	677
Anhui	704	6%	775
Guangdong	1,057	9%	1,430
Zhejiang	240	2%	1,432
Hubei	600	5%	1,540
Hunan	1,738	15%	2,450
Yunnan	147	1%	4,771
Total	11,692	100%	1,856 (National average)

Source: Company data.

The company does not disclose details about its generation units. However, we understand that most of the generation units located in these regions use closed-loop cooling systems and do not encounter major problems of water supply or water-discharge expenses. We believe the major reason China Resources had avoided water-related problems is that these units are located in East China, close to the coast, and may be able to use sea water as part of their water supply.

Some new power plants in China use air-cooling systems instead of water cooling. One of the key advantages of air-cooling systems is their low water consumption rate. This is particularly important in North China, where water resources are scarce but coal resources are abundant. The disadvantage of air-cooling systems is that they consume more electricity.

China Resources could reduce its exposure to water risks by using air cooling, but the current combination of surging coal costs and the low water tariffs makes this investment difficult to justify. Taking the case of a 2x600 megawatt direct air-cooling unit, we estimate the water tariff would have to be as high as Rmb 3.7 per cubic meter at a standard coal cost of Rmb 300 per ton and a construction cost of Rmb 380 million in order to justify the investment (Table 7). These economics make it unprofitable for independent power producers to adopt these new cooling systems, despite the savings on water, unless the government provides subsidies.

Table 7: Breakeven Analysis on a 2x600MW Direct Air-cooling Unit in China

Coal price	-10%	-5%	-3%	Base case	3%	5%	10%
Breakeven water tariff (Rmb / cubic meter)	3.51	3.6	3.64	3.7	3.76	3.8	3.9
Construction cost	-10%	-5%	-3%	Base case	3%	5%	10%
Breakeven water tariff (Rmb / cubic meter)	3.53	3.61	3.65	3.7	3.75	3.79	3.88

Source: China Power.

Note: The base case assumed for coal price in the analysis is Rmb 300 per ton, while the base case construction cost is Rmb 380MM.

Investment Implications

Water supply remains a minor risk factor for the listed power generators, in our view. That said, we recommend that those investors looking for sustainable return and hence total return over time focus on companies with geographically diverse sources. We believe this would favor EGCO over Glow, and perhaps Chinese power producers over Thai power producers.

We do believe generators face a risk that charges on water usage may go up significantly. To address this risk, we would tend to prefer (A) generators with plans to install more direct air-cooling units (e.g., Datang International), which would be largely unaffected by costlier water, and (B) those companies whose investments are essentially "locked in" under long-term power-purchase agreements and are thus able to pass on any cost increases to their off-takers. In this respect, power producers in Thailand, Malaysia, Philippines, and India (except for merchant power plants without long-term power-purchase agreements) should be more defensive than the China power generators.

Manufacturing: Groundwater Risks in Taiwan

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Taiwan ranks high globally for risk of water shortage, despite its abundant rainfall. This may seem surprising, as Taiwan has average annual rainfall of 2.5 meters, 250% of the global average. However, due to the unpredictable rainfall cycle and the island's geography, only 15% of rainwater can be captured and used.

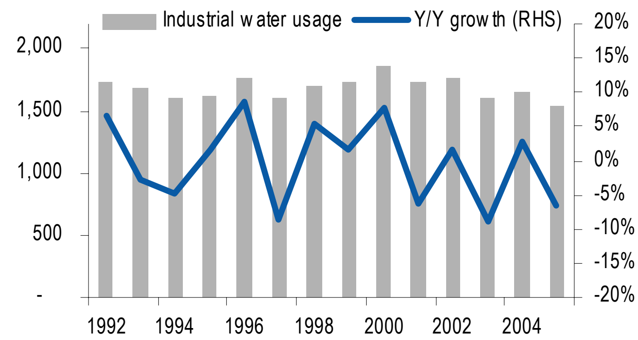
On average, Taiwan experiences a major drought every 10 years and a minor drought every 2-3 years. Seasonal water-supply problems are frequent. Typically, more than 80% of a year's rainfall occurs between May and October, especially after typhoons. The remaining six months of the year bring little rain. Much of the limited rainfall between November and April occurs in Southern Taiwan, leaving industrial and household users in the northern part of the island short of water.

The available water resources in Taiwan appear to be diminishing due to global warming. Average annual rainfall decreased 0.9% from 1991 to 2000. Some estimates indicate that fall-winter rainfall, already scarce, will decrease 5-10% by 2050 even as spring-summer rainfall increases 5-10%. If this change occurs, it could bring more frequent seasonal water shortages.

Agriculture still accounts for the vast majority of water usage in Taiwan, despite the island's heavy industrialization. Industry is responsible for only 9% of total consumption, and industrial consumption has been trending down (Figure 8). This situation, however, may be changing. The Taiwan Ministry of Economic Affairs (MOEA) projects that industrial water use will grow at a 2% compound annual rate through 2021, reaching 15% of total consumption (Figure 9).

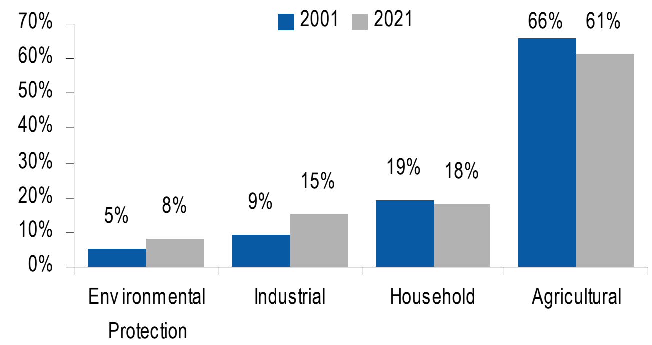
Figure 8: Taiwan Historical Industrial Water Usage

billion tons/year



Source: Taiwan MOEA Water Resources Agency

Figure 9: Industrial Water Usage in 2001 and 2021E



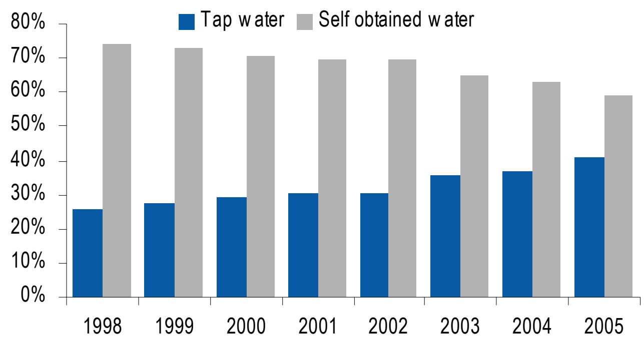
Source: Taiwan MOEA Water Resources Agency, MOEA projections

Taiwanese manufacturers' principal source of supply is ground water. Groundwater, along with a limited amount of surface water, supplies 59% of industrial water consumption. Most of this comes from manufacturers' own wells. But as reliability and water-quality problems have increased, manufacturers have increasingly turned to public water supplies (Figure 10). Industrial consumption of tap water has been increasing at a 7% annual rate.

Taiwan regulations require companies to apply for permits to drill for groundwater. However, specific regulations vary from district to district. To apply for groundwater use, the company must take into consideration the possibility of land subsidence from ground water pumping, changes in the ground water source, land quality, and other related issues. Taipei City no longer allows ground water use due to land subsidence from pumping. Once issued, groundwater rights are valid for five years upon payment of a one-time fixed fee.

The top four manufacturing industries accounted for 59% of total industrial water usage in 2005, with the petrochemical industry by far the largest user. Chemical plants account for 20% of Taiwan's total industrial water usage (Figure 11). The paper industry ranked second, followed by the food and textile industries. Water consumption at petrochemical plants has been increasing (Figure 12), while consumption in most other industries has been declining gradually (Figure 13).

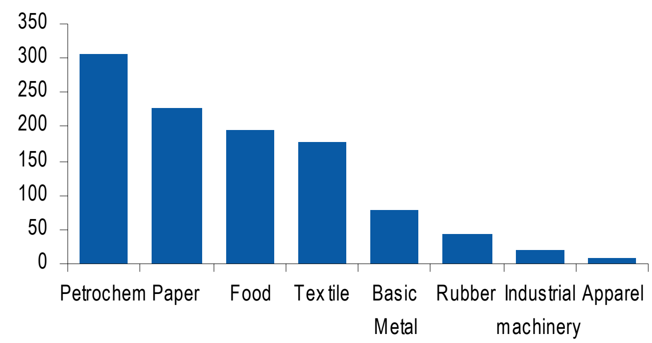
Figure 10: Taiwan industrial water sources



Source: Taiwan MOEA Water Resource Agency.

Figure 11: Taiwan industrial water usage by industry in 2005

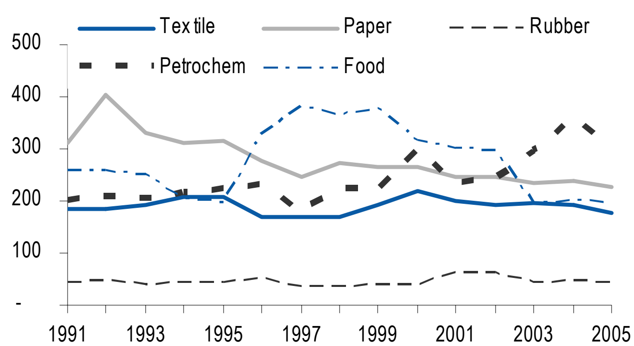
million tons of waters/year



Source: Taiwan MOEA Water Resources Agency.

Figure 12: Taiwan industrial water usage by industry

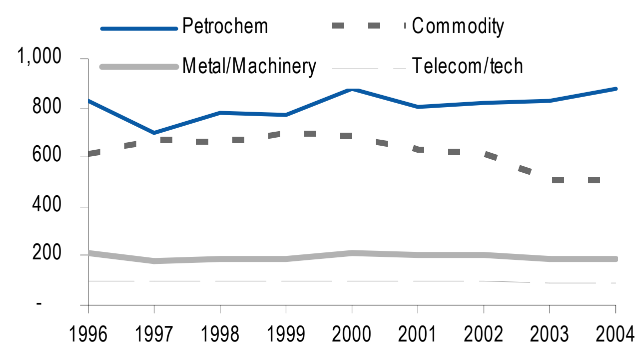
Million tons of water/year



Source: Taiwan MOEA Water Resources Agency.

Figure 13: Industrial water usage by major sectors

Million tons of water/year



Source: MOEA Water Resources Agency.

Note: 4 Major sectors summed up by MOEA, represent all 24 industry groupings

Water pollution has become a more important issue in Taiwan. The Taiwan Water Pollution Control Act was first implemented in 1987 and has been amended 10 times since then. The government monitors industrial wastewater by issuing permits, supervising operations, controlling emissions, and holding unscheduled inspections. The standards with respect to Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Suspended Solids (SS), and True Color vary by industry (Table 8). The Environmental Protection Administration takes samples at least once a year, but many factories face much more frequent monitoring.

Table 8: Taiwan Effluent Standards by Industry

Mg/l

	Paper	Pulp	Textile	Rubber	Food	Petrochem
COD	100-160*	150	100	100	100	100
BOD	30	NA	30	30	30	NA
Suspended solids	30	50	30	30	30	30
True color	550	550	550	NA	NA	550

Source: Taiwan Environmental Protection Administration.

Note: COD limitations for Paper Manufacturing depend on waste paper used. Process that uses (1) no waste paper as raw material, COD limitation at 100 mg/l; (2) uses +60% waste paper as raw material, COD limitation at 180 mg/l; and (3) uses -60% waste paper as raw material, COD limitation at 160 mg/l.

Taiwan's manufacturing sector is extremely diversified, with respect both to industry and geographic scope. Some Taiwanese companies manufacture exclusively on Taiwan, while others have operations in mainland China, Southeast Asia, and other parts of the world. These factors lead to widely different risks among companies.

Unfortunately, Taiwanese manufacturers generally provide little disclosure about water-supply risks. Industries that consume large amounts of water rely principally on ground water, largely because it is cheaper than drawing water from public supplies. All of the companies with which we have spoken have provisions for back-up water supplies. The companies that use relatively little water in their production processes appear to have contingency plans, such as water towers or truck transport, which should sustain them for some time. Industries that rely heavily on water, on the other hand, indicate that access to recycling water and on-site storage will be insufficient to allow them to continue operating in the event of supply shortfalls.

Slightly more information is available about wastewater, due largely to government regulation. All manufacturing industries seem to be aware of wastewater regulations, as they generally all have wastewater treatment systems which effectively lower COD levels for disposal. Most companies keep well documented data on their water usage and are able to provide effluent measures before and after wastewater treatment, although some were unable to provide detailed information.

Pulp and Paper: Cheng Loong, Chung Hwa Pulp

Taiwan's pulp and paper sector has above-average exposure to water-supply risk, because the industry is a heavy consumer of water. The largest company in this sector is Cheng Loong Corporation, which has four Taiwanese mills with total capacity of 1.3 million tons per year. Cheng Loong has 35% Taiwan market share in container board and 25% of the market for paper containers. Its Tayuan plant is its largest industrial paper mill, although its Houli plant, which also produces other products, is larger overall (Table 9).

Table 9: Cheng Loong Taiwan Industrial Paper Operations and Water Usage

Plant location	Annual Capacity ('000 tons/year)	Water Used/Ton Paper Produced	Annual Water Usage ('000 tons/year)
Tayuan	510	6	3,060
Chubei	100	20	2,000
Shinchu	70	10	700
Houli	650	15	9,425
Total	1,330	13	15,185

Source: Company.

Management indicates that the main source of water for its plants is groundwater. Cheng Loong's most water-efficient plant, Tayuan, uses far less water per ton of production than older plants. This greater water efficiency is due in good part to product mix. The Tayuan plant can operate with a single, modern water recycling system because the plant produces only industrial paper. The Houli plant's diverse mix of products makes water recycling more complicated and leads to less efficient water use.

Paper manufacturers face environmental trade-offs when it comes to water consumption. First, plants that use wastepaper as raw material require more water per ton of paper produced to remove ink, dirt, plastic, and other contaminants from the pulp slurry. Second, reuse of water raises chemical oxygen demand levels in effluent, making wastewater harder to dispose of. The wastewater includes large amounts of bark particles, fiber debris, filler and coating materials. The Tayuan plant's wastewater has higher COD levels than other plants because it reuses the water through more phases. Treatment is necessary to lower COD levels by 90-95% before the water can be released (Table 10).

Table 10: Potential Water Pollutants from Pulp and Paper Processes

Source	Effluent characteristics
Water used in wood handling/debanking and chip washing	Solids, BOD, color
Chip digester and liquor evaporator condensate	Concentrated BOD, reduced sulfur compounds
"White waters" from pulp screening, thickening, and cleaning	Large volume of water with suspended solids, can have significant BOD
Bleach plant washer filtrates	BOD, color, chlorinated organic compounds
Paper machine water flows	Solids
Fiber and liquor spills	Solids, BOD, color

Source: Smook, 1992

Cheng Loong's plants have on-site water towers, but in the event of water shortage, stored water will maintain production for only a couple of hours due to the plants' heavy water use. In general, however, the company's Taiwan paper mills are located close to abundant water sources. The Houli plant is positioned close to the Tachia River, one of the major rivers in Taiwan, and can rely on it as an alternative water source if necessary. In the event water restrictions force the company to limit production in Taiwan, the company could continue to produce paper at several mills in China.

Chung Hwa Pulp is the largest pulp producer in Taiwan, with 20% market share. The company produces leaf bleached kraft paper (LBKP) and culture paper. In addition to its plants in Hualien (Taiwan), Chung Hwa has a pulp mill in Guangdong (China) with annual capacity of 110,000 tonnes of LBKP.

Water plays a very important role in pulp production, as it is needed in cleaning, pulping, and bleaching processes. Chung Hwa management estimates that it uses 55 metric tons of water for every ton of pulp produced. All of the company's industrial water is filtered through water deionization systems before use. Water for the Hualien plant comes from a nearby river, supplemented by groundwater. In the 38 years of operations, the company has never experienced water shortage; this is mainly because of the abundant supply from the river located close to its Hualien plant.

Textiles and Apparel: Far Eastern Textile, Makalot

Far Eastern Textile is the fourth-largest polyester maker in Asia and the largest textile company listed in Taiwan. The company produces upstream polyester chips (PET chips and bottles) and fibers (polyester staple fibers, POY, DTY), and downstream fabrics and garment products. The company has production bases in Taiwan and China.

Far Eastern Textile uses an average of 5 million metric tons of water per year, with the sources varying by location. Its polyester plants are more water intensive than its textile plants. Within its textile business, fabric dyeing is the most water-intensive process.

The majority of wastewater from textile manufacturing is generated during production at the preparation, dyeing, and finishing stages (Table 11). The Taiwan Environmental Protection Agency estimates that the dyeing and rinsing processes generate 45-64 liters of wastewater per pound of product, with the average plant producing 3.8-7.6 million liters of effluent per day. Far Eastern Textile does not disclose data revealing whether its plants produce more or less wastewater than the average. Information on COD wastewater levels before and after wastewater treatment also is not disclosed.

Table 11: Water Pollution from Textile Manufacturing Processes

Process	Wastewater
Fiber preparation	Little/No
Yarn spinning	Little/No
Slashing/sizing	BOD, COD, metals, cleaning waste, size
Weaving	Little/No
Knitting	Little/No
Tufting	Little/No
Desizing	BOD from water-soluble sizes, synthetic size, lubricants, biocides, antistatic compounds
Scouring	Disinfectants and insecticide residues, NaOHm detergents, fats, oils, pectin, wax, knitting lubricants, spin finishes, spent solvents
Bleaching	Hydrogen peroxide, sodium silicate or organic stabilizer, high pH
Singeing	Little/No
Mercerizing	High pH, NaOH
Heatsetting	Little/No
Dyeing	Metals, salt, surfactants, toxics, organic processing assistants, cationic materials, color, BOD, COD, sulfide, acidity/alkalinity, spent solvents
Printing	Suspended solids, urea, solvents, color, metals, heat, BOD, foam
Finishing	BOD, COD, suspended solids, toxics, spent solvents
Product Fabrication	Little/No

Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA.

By operating in garment manufacturing, rather than textile manufacturing, Makalot manages to avoid most water-related risks. Makalot is the largest original design manufacturer of apparel listed in Taiwan. Its major customers include apparel specialty stores (Gap, Old Navy, Express), mass merchants (Wal-Mart, Target, K-Mart), and department stores (Kohl's, May). Major products include sleepwear (22% of sales), pants (25%), and blouse/shirt (20%).

On average, 76% of shipments are cut and sewn in by Makalot's plants in Indonesia, Philippines, Salvador, and Cambodia. The rest are outsourced to partners in China, Vietnam, Sri Lanka, and other Southeast Asian countries. Makalot thus has negligible exposure to water risks in Taiwan.

The garment manufacturing process itself requires little water. The company does face water risk with respect to fabric dyeing, all of which is outsourced. As of 4Q07, 27% of total production value requires a fabric wash. Of the outsourced fabric wash, 29% is to Cambodia, 10% to China, 21% to Indonesia, 39% to Philippines, and 1% to Vietnam, reducing corporate risks from water shortage in any particular location.

Diversified Manufacturing: Chen Shin Rubber, Giant, Globe Union, Basso

Cheng Shin Rubber is the largest Taiwanese tire maker, manufacturing its "Maxxis" and "Chen Shin" brands in Taiwan, China, Thailand, and Vietnam. Cheng Shin's Taiwan plant has the capacity to make 16,600 radial tires, 22,000 motorcycle tires, and 42,000 bicycle tires per day.

Rubber and tire manufacturing require relatively little water. Water is used to cool machinery, a closed-loop process in which the water is kept from contamination and reused. In the production process, water is required to produce steam that heats the rubber so it can be molded.

Management indicates that the water used in its Taiwan plant is groundwater. The company has implemented a recycling program using a closed water cooling and heating system. Most of the water is reused and, as such, does not account for much of the company's production cost.

While Cheng Shin relies entirely on groundwater, Giant, the largest Taiwanese bicycle maker, obtains its water almost entirely from public supplies. Giant, which makes 5.4 million bicycles annually, has six production plants, with locations in Taiwan, China, and The Netherlands. Its Kunshan plant in China produces mid-level mountain bikes and city bikes, and has the largest capacity in the group, manufacturing 2.5 million units/year.

Giant requires water mainly in the process of coating bicycle frames, but the company is unable to provide further information on its water consumption. Giant says it has a water tower at each plant to provide a backup source of water in the event the public water supply is interrupted.

Globe Union, the largest faucet and bathroom accessories manufacturer in Asia, also relies principally on the local public supplies serving its plants, all of which are located in China. Globe Union uses 300,000 tons of water per year, mainly in the coating process. In the event of shortage or supply interruption, the company's contingency plan is to arrange delivery via tanker truck to its plants.

Basso, which manufactures 20% of the world's pneumatic staplers and nailers as well as automotive power tools, has all of its production in Taiwan. Public water is Basso's main source of supply, with groundwater as a back-up source. Management indicates that water consumption is small, and occurs principally in the coating process. The company believes its access to groundwater supplies secures its operations from interruption in the event of water scarcity.

Investment Implications

Taiwanese manufactures differ substantially in their exposure to water-scarcity risks. Some of the manufacturers we have examined, notably Cheng Loong paper and Far Eastern Textile, appear exposed to the risks of water shortage because their production processes inherently require large amounts of freshwater (Table 12). Cheng Loong may have protected itself somewhat against shortage by locating one of its plants near a major river and by having Chinese plants that can supply product in the event of production interruptions in Taiwan. Chung Hwa Pulp, while also water intensive, appears to be in a better position with respect to potential shortage because of its access to abundant backup supplies.

The fabricated metal producers, Giant, Globe Union, and Basso, use relatively less water to make their products. This would appear to minimize their exposure to risk of water-supply interruption, at least with respect to their own operations. However, it is unclear whether Giant's use of on-site water towers and Globe Union's contingency plan to bring in water via truck at it plants would be sufficient to maintain operations in the event of severe local water shortages. None of these companies is able to evaluate the risk that water issues will interrupt the operations of key suppliers.

Table 12: Water Supply of Selected Taiwan Manufacturers

Industry	Company	Importance of Water	Primary Water Source	Avg Water Usage/Year	Principal Uses of Water	Provisions in Event of Shortage
Paper	Cheng Loong	High	Groundwater	14 million MT	Screen pulp slurry	Recycle wastewater, water tower will last few hours
Pulp	Chung Hwa Pulp	High	Groundwater, river	NA	Cleaning, pulping, bleaching	Plant located close to abundant water source
Textile	Far Eastern Textile	High	Ground water	5 million MT	Prep, dyeing, finishing	Water tower
Apparel	Makalot	Low	NA	NA	Fabric wash outsourced	NA
Rubber	Cheng Shin Rubber	Medium	Ground water	NA	Shaping/molding, cooling	Able to recycle/reuse water
Fab. Metal Products	Giant	Low	Tap water	NA	Coating	Water tower
Fab. Metal Products	Globe Union	Low	Tap water	300,000 MT	Coating, cooling	Water transported through water trucks
Fab. Metal Products	Basso	Low	Tap water	300,000 MT	Coating, cooling	Recycle wastewater, ground water as back-up

Source: Company information and JPMorgan.

Insurance: Shortage Means Opportunity

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For insurers, risk usually means opportunity, and the apparent increase in the risk of water shortage appears to be no exception. Insuring, pricing, underwriting, and settling risks related to an *excess* of water is an old business; the German floods in 2002, for example, cost Allianz €800 million, and frequent summer flood claims in Switzerland cost the industry €150 million or more annually. Insuring against a *lack* of water, on the other hand, lends itself to tailor-made contracts that some insurers expect to find extremely profitable.

There are three main categories of risk related to lack of water and drought:

- **Insured risk.** Crop insurance is increasingly a focus of insurers as the value of commodities rises. Allianz focuses on this in the US via its FireFund unit, and crop insurance in emerging markets, such as Brazil, is a big area of growth. Fire is another big risk covered by traditional policies. The 21-24 October 2007 California brushfire called Witch Fire cost $1.1 billion and destroyed 3,000 homes, but was only the third-largest insured wildfire loss in the US (Table 13). The trend in these losses is upward, and greater numbers of houses are built in fire-prone areas. The Risk and Insurance Management Society estimates that the average annual insured loss from wildfires has doubled in the past ten years to $490 million.

Table 13: Costly Wildfires are Recent Problems in US

Rank	Date	Location	Name	Cost $ bn	Cost in 2007 $bn
1	Oct. 20-21, 1991	California	Oakland Fire	$1.70	$2.59
2	Oct. 25-Nov. 4, 2003	California	Cedar Fire	$1.06	$1.19
3	Oct. 21-24, 2007	California	Witch Fire	$1.10	$1.10
4	Oct. 25-Nov. 3, 2003	California	Old Fire	$0.98	$1.10
5	Nov. 2-3, 1993	California	Los Angeles County Fire	$0.38	$0.54
6	Oct. 27-28, 1993	California	Orange County Fire	$0.35	$0.50
7	Jun. 27-Jul. 2, 1990	California	Santa Barbara Fire	$0.27	$0.42
8	May 10-16, 2000	New Mexico	Cerro Grande Fire	$0.14	$0.17
9	Jun. 23-28, 2002	Arizona	Rodeo Chediski Complex Fire	$0.12	$0.14
10	Sept. 22-30, 1970	California	Oakland & Beverly Hills Fire	$0.02	$0.13

(1) Property coverage only. Effective January 1, 1997, Property Claim Services (PCS) defines catastrophes as events that cause more than $25 million in insured property damage and that affect a significant number of insureds and insurers. From 1982 to 1996, PCS used a $5 million threshold in defining catastrophes. Before 1982, PCS used a $1 million threshold.
(2) Adjusted to 2007 dollars by the Insurance Information Institute.

Source: ISO Property Claim Services Unit, Insurance Information Institute.

- **Indirect risk.** Power curtailment due to lack of water cooling can lead to business interruption. Business interruption insurance is normally written on the basis of tailor-made contracts, covering losses due to power cuts and interrupted supplies for 30-60 days after the event. Smaller coverages of this sort may be issued for supermarkets, restaurants, and household refrigerator/freezer contents. Insurers generally do not cover power stations, so are usually not called upon to cover a generator's foregone sales if generation must be curtailed due to lack of water.

- **Unusual events.** The September 2001 explosion at the AZF fertilizer factory in Toulouse, France, was initially blamed on water leakage following a long dry spell. A judicial inquiry eventually assigned blame to incorrect storage of chemicals, and insurers paid €1.4 billion in settlement. Subsidence also is related to water shortage, with a long period of drought leading to shrinking of foundations in clay soils, as London's, where houses are sometimes built with foundations as shallow as 1-2 feet. UK household insurers were hit hard by subsidence claims in 1992-93. Subsidence often brings follow-on problems by causing drainage pipes to crack, increasing flood risk in homes that already have had subsidence losses.

All of the companies under our coverage insure such risks to a greater or lesser degree. However, we note that Allianz and Munich Re appear to have the broadest exposures, and thus may have the greatest opportunity if demand for coverages related to water shortage should increase.

Nonetheless, most major property and casualty insurers now write extremely broad books of business. Losses are correspondingly diverse (Table 14). Claims attributable to lack of water account for only a very small share of total losses from natural catastrophes and for an extremely small share of property and casualty losses from all causes.

Table 14: Worldwide Property and Casualty Losses, 2006

	Insured loss, $million	Number of events	Share of Insured Losses	Share of events
Floods	$984	58	6.2%	16.6%
Storms	$8,265	47	52.0%	13.5%
Earthquakes	$80	8	0.5%	2.3%
Drought, bush fires, heat waves	$120	5	0.8%	1.4%
Cold, frost	$1,360	12	8.6%	3.4%
Hail	$1,028	5	6.5%	1.4%
Tsunami	$1	1	0.0%	0.3%
Total Natural Catastrophes	$11,838	136	74.5%	39.0%
Total Man-Made Catastrophes	$4,043	213	25.5%	61.0%
Grand Total	$15,881	349	100.0%	100.0%

Source: Swiss Re Sigma.

Climate Change and Insurance

The warming of the earth's climate is expected to lead to increased insurance risks related to water. Records show that the average temperature on earth has increased some 0.7°C since 1900, with the ten warmest years ever recorded all occurring since 1995.

One of the expected effects of global warming is an increase in extreme weather in Europe. A survey done by Munich Re, a reinsurer, reveals a massive increase in weather related natural catastrophes over the period 1950-2005 (Table 15). In inflation-adjusted terms, insured losses have increased 25 times from the average of the 1960s. Between 1980 and 2005, in Europe over 90% of all natural catastrophes were related to extreme weather such as windstorms, hailstorms, severe storms, floods and extreme temperatures.

Table 15: Comparison of Catastrophic Insurance Losses in Recent Decades

	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	Last 10 years	Comparison last 10 : 1960s
Number of losses	21	27	47	63	91	57	2.1x
Overall Losses	48.1	87.5	151.7	247	728.8	575.2	6.6x
Insured losses	1.6	7.1	14.7	29.9	137.7	176	24.8x

Source: Munich Re.

The link between weather catastrophes and climate change cannot be proven conclusively. Insurers, however, are operating on the assumption that a warmer global climate will lead to increased losses. Estimates by the Association of British Insurers, for example, indicate that the predicted increase in storm activity in Britain could lead to average claims several times what is normal today (Table 16). In other locations, climate change is likely to lead to reduced rainfall and could bring more frequent claims related to drought and water shortage.

Table 16: Estimated Future Costs of Weather Claims in UK

£ billion

	Present		2050	
	Annual Average	Extreme Year	Annual Average	Extreme Year
Subsidence	300	600	600	1,200
Storm	400	2,500	800	7,500
Inland Flood	400	1,500	800	4,500
Coastal Flood	0	5,000	0	40,000

Source: Association of British Insurers.

The federation of European insurers and reinsurers, CEA, is promoting the notion of public-private partnerships to control risk and loss as average temperatures rise. The federation holds out Spain's public-private system of crop insurance as a potential model. Greece, Italy, and the Netherlands all have adopted various private-public partnership measures in insurance to mitigate losses related to climate change.

Similar moves have occurred in Britain, where the government joined with the Association of British Insurers to address water risks in 2000, following the wettest autumn in 300 years. ABI members agreed to meet the increased demand for flood cover if the government would increase investment in flood management, use planning mechanisms to prevent additional construction in flood plains, and improve flood warnings and emergency preparedness. The association claims that in 2004, 15,000 households were able to obtain flood coverage as new customers as a result of these changes.

Munich Re and Swiss Re have both stated their expectations that the share of losses from natural catastrophes attributable to weather will increase further due to climate change. Munich Re is now promoting "climate friendly" insurance products, such as favorable rates for vehicles with low greenhouse-gas emissions, and has set a policy of conducting environmental audits in conjunction with liability insurance. The company says it will base rates on "prospective underwriting," taking into account the probably weather changes from global warming, which would not affect current rates under the normal "lagged underwriting" approach.

Investment Implications

Three points stand out from our review of risks related to the consequences of water shortage for insurers and reinsurers.

- We see this risk for insurers and reinsurers mainly in business interruption contracts. The covers are not uniform and are in part tailor made, which means the margins on this business are on trend more attractive than the more commodized risks such as motor.

- There is one relatively common risk associated with water shortage but also climate change: wildfires. The California wildfires in October 2007 caused total insured loss of $1.9 billion, Hannover Re estimates. If public concern about water availability and fire risk increases, this could lead property owners to seek greater coverage, with positive implications for insurers.

- The immediate consequences of water shortage on power stations—plant shutdowns—are not generally insured. But the impact of electricity supply interruption on businesses (business interruption cover) and households (freezer content cover) is mostly insured and can be significant, posing some risk of unanticipated loss for insurers.

We also note that as water availability in a given geographic area changes, there may be benefits in increased business for insurers. For example, climate change is thought to be moving the tropical weather pattern in North Africa to the north. This may be benefiting Morocco, aiding economic growth and stimulating demand for insurance. The same weather shift is thought to be causing increasing water shortages in Spain. To the extent that this causes economic hardship, it may be associated with a spike in insurance claims, but may also lead to increased demand for coverage.

Semiconductors: Water Is Material

Semiconductor Manufacturing Equity Research

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Water is an important resource for the semiconductor industry. Chip makers use large amounts of purified water in fabrication plants, for washing the silicon wafers at several different stages in the fabrication process as well for cooling various tools. During 2007 the two largest semiconductor companies in our universe, Intel and Texas Instruments, used over 11 billion gallons of water in the production of chips. We estimate that water usage by Intel and Texas Instruments increased 4% in 2007.

The importance of water makes it a material cost in semiconductor manufacturing. We estimate that water accounts for 20 to 30 basis points of the cost of goods sold for Intel and Texas Instruments. We estimate that a shortage that increased water costs by a factor of 2x would reduce Texas Instruments' earnings per share by $0.02 and Intel's earnings per share by $0.01 in 2008.

The cost and availability of water are important considerations for semiconductor companies when choosing sites for manufacturing facilities and operations. Semiconductor companies must also consider the availability of water when planning to expand existing facilities. Both Texas Instruments and Intel have invested in water reuse systems to assure supply while reducing reliance on public water systems.

Intel Corp., the largest semiconductor company in the world based on revenues of $38.3 billion in 2007, consumes 8.1 billion gallons of water per year—as much as a city the size of Rochester, NY. Intel located some of its 15 fabs in places that suffer from severe water shortages, such as Haifa, Israel, Albuquerque, NM, and Chandler, AZ. As a result, the company has made water conservation a priority. Management estimates that it spent $100 million for this purpose between 1996 and 2006. Intel recently announced a goal of lowering water usage per unit produced to below 2004 levels by 2010. This is not an insignificant goal, because until now each new generation of microprocessors usually has involved a production process requiring greater amounts of water per unit than earlier technology.

Reuse is the most important technique for reducing water consumption in the semiconductor industry. Intel's Hudson, MA plant doubled its output without increasing water intake by reusing 75% of the fresh water consumed at the fab. At Fab 22 in Chandler, AZ, where 4 million gallons per day are recycled, a reverse osmosis treatment plant returns large amounts of drinking-quality water to the local aquifer. Intel estimates that these measures, plus conservation efforts, have reduced its intake from Chandler's public water supplies by 80%.

Intel's ability to conserve water in these ways has reduced the importance of water availability in plant site selection. Two additional fabs are expected to be built at the Chandler location, and Intel recently opened a new fab in Israel, which is also in a region affected by water shortages. This would imply that Intel is comfortable with its ability to reuse water effectively to offset shortages.

Texas Instruments, with 2007 revenues of roughly $13.8 billion, faces challenges similar to Intel's with respect to water availability. TI has a stated goal of zero wasted resources, which requires reducing water use through conservation, reclamation, recycling, and reuse.

TI produces semiconductors in the United States, Germany, and Japan, with the US accounting for 88% of total water consumption. Approximately 73% of the company's water use occurs in fabs, and it is here that its conservation efforts have focused. Two of TI's manufacturing facilities in Japan use integrated water treatment systems that enable zero discharge of industrial wastewater. In 2006, TI's water consumption per unit remained relatively flat at assembly/test sites and decreased by almost 13% from the previous year at manufacturing facilities.

Recycling is a major part of TI's conservation effort. The company recycles almost 4 million gallons of water every day—an amount equal to nearly 40% of its freshwater consumption—at manufacturing sites globally. Recycled water is often used in air-pollution abatement systems, which "scrub" manufacturing exhaust, and in cooling towers, which feed heating and air conditioning systems. TI's Friesing, Germany, site has an indoor climate control system that takes cold water pumped from aquifers, cycles it through a heating/cooling system that keeps the aquifer water separate from all other plant water, and returns the uncontaminated cooling water to the aquifer.

According to the company, water quality and availability are key criteria considered when identifying new plant locations. Its newest plant, in Richardson, TX, is the first semiconductor manufacturing facility with LEED (Leadership in Energy and Environmental Design) certification. Although LEED is most commonly associated with energy efficiency, the plant is expected to use 35% less water than a traditional facility of comparable size. TI is currently exploring the retrofit of large, existing facilities with environmentally responsible design features globally.

Investment Implications

Intel is exposed to water, but risks appear to be minimal. Intel needs water as a vital resource in manufacturing, but when compared to the enormous cost of building a new fab, the cost of assuring water supply is relatively small. Intel's newest fab in Israel is expected to cost nearly $5 billion. If Intel were to double its company-wide expenditures on water to date solely to implement a water reuse and conservation system in that new fab, the construction cost would rise by only 2%.

TI's business risks due to potential water shortages appear to be minimal. Like Intel, TI is also exposed to water as a vital resource in its manufacturing operations, and water is one of many criteria in its site selection process. However, once a site has been selected based on adequate availability of water among other factors, the costs associated with water consumption, reuse and conservation are less than 1% of total cost of goods sold. Further, as TI moves towards its "fab-lite" model wherein an increasing percentage of its manufacturing operations are outsourced, potential water shortages pose less direct risk to TI's overall business.

We believe the main risk to Intel and Texas Instruments in regard to water is the potential shut-down of a fab or delay in building a facility due to water unavailability. Although such events have not happened in the past, a shutdown due to water unavailability or contamination could negatively impact Intel's or Texas Instruments' ability to meet customer demand during a given quarter. We believe a fab shut-down could result in roughly $100-$200 million in missed revenue during a quarter, or roughly $0.02-$0.04 per share, depending on which products are delayed.

While water supply is only one of many factors in the choice of location for a fab, the reliability of water supply during manufacturing is a critical aspect of Intel's and TI's risk profiles. Intel's manufacturing cycle for a microprocessor is 11-13 weeks. If a plant is forced to stop production, all material in process will be lost, effectively wiping out a full quarter's output from that facility. Water is not unique in this regard, as other sources of interruption to the manufacturing process also could cause significant harm to Intel and TI's businesses. Previously, a power outage at Intel's Fab 11X in New Mexico shut down production for four days and cost the company millions of dollars in lost material. It is conceivable that a loss of water supply or malfunction in the water delivery systems could cause a similar impact.

Leisure: The Las Vegas Gamble

Leisure and Gaming Equity Research

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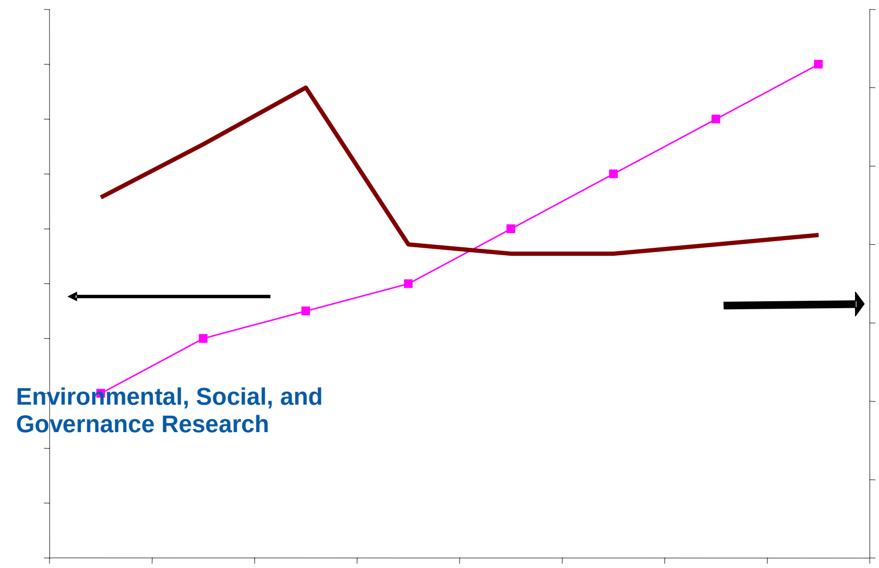
Water is of critical importance to the gaming industry for one very simple reason: its largest American venue, Las Vegas, sits in the middle of the desert. Water scarcity has been a longstanding concern among gaming companies concerned about their ability to continue expanding in Las Vegas.

The industry first engaged with water conservation in a major way in the early 90s, when the Las Vegas Valley Water District began working with every major gaming company to aggressively promote water conservation techniques. Steve Wynn, then of Mirage Resorts, responded by building a water recycling plant underneath the Mirage Volcano and Treasure Island Pirate Lagoon. Since that time, many companies have undertaken such measures as replacing landscaped area with artificial grass and installing low-flow showers and toilets.

The industry's water-scarcity problems have not abated, due largely to the region's headlong growth. Las Vegas has added approximately half a million residents in this decade. With supplies failing to keep pace, Southern Nevada enacted rigorous conservation mandates in 2002, such as limits on lawn watering and bans on use of grass in the yards of new homes. These measures led to a sharp drop in water consumption in 2003, which has been sustained in subsequent years (Figure 14).

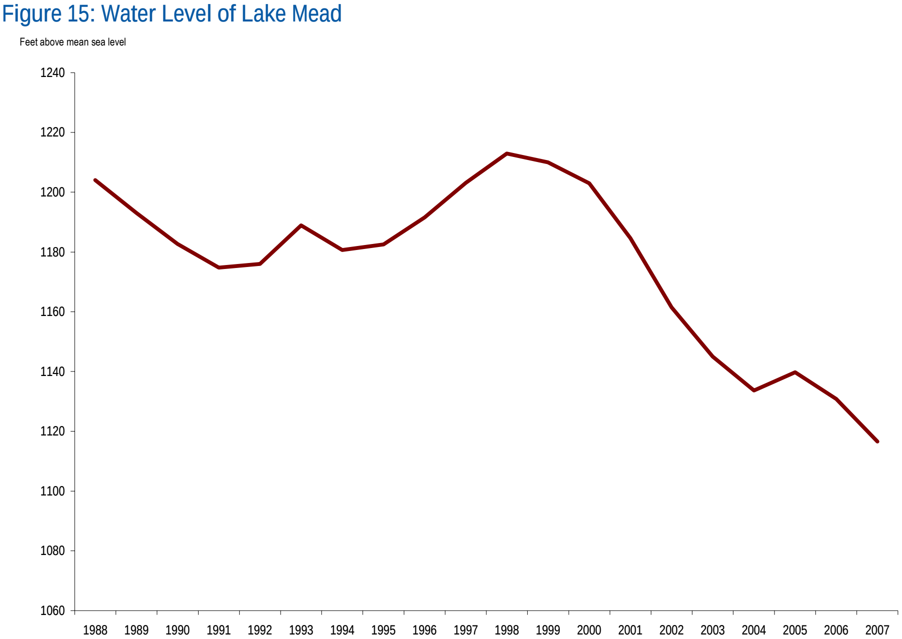
Figure 14: Mandatory Measures Sharply Curtailed Southern Nevada Water Consumption



Source: Southern Nevada Water Authority.

Las Vegas's primary source of water is Lake Mead, located on the Colorado River approximately 30 miles southeast of the city. Lake Mead is the largest man-made lake in the United States. Since 2000, water levels have decreased dramatically due to less than average snowfall (Figure 15). As of February 2008, the lake was at 50% of its water-storage capacity. Some reports predict a 50% chance the lake will dry up completely if water usage continues at current levels.

Figure 15: Water Level of Lake Mead

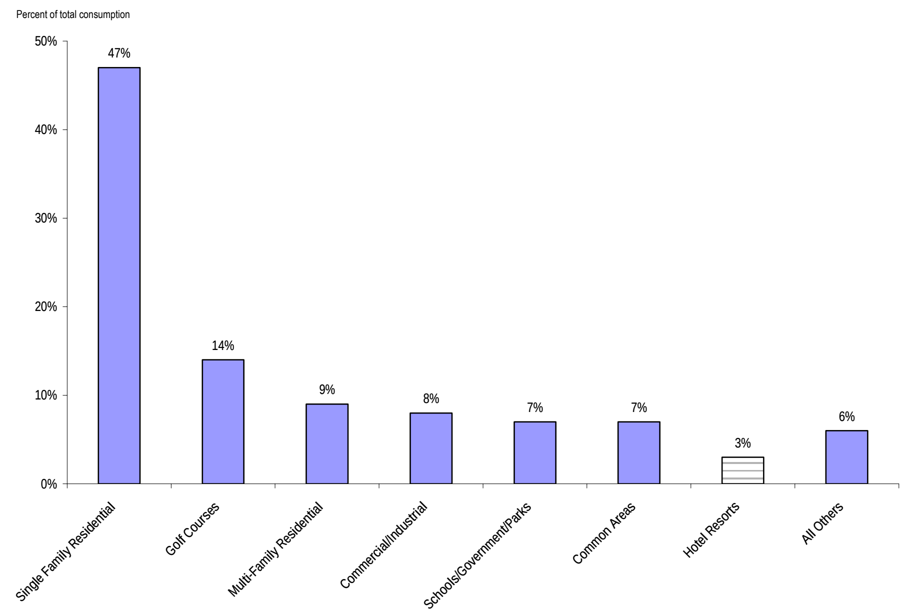


Source: US Bureau of Reclamation.

With 90% of the city's water derived from Lake Mead, a population that has more than doubled since 1991, and an additional 40 million annual visitors, the need to diversify water sources is of primary importance. In response to the prospect of diminished supply from Lake Mead, local authorities are building a 300-mile pipeline, to be completed by 2015, that is planned to draw 65 billion gallons of water a year from remote areas of the state. The gaming industry has strongly supported this effort. Most gaming companies also have donated funds to improve water treatment to prevent a repeat of the 1994 outbreak of cryptosporidiosis, an intestinal disease caused by a microscopic parasite which spread through the city's water supply. The incident resulted in a large number of hotel-room cancellations.

The gaming industry is by no means the major consumer of water in Southern Nevada. In fact, all of the Las Vegas casinos combined use only one-fifth as much water as the area's golf courses (Figure 16).

Figure 16: Water Consumption in Southern Nevada, 2006



Source: Southern Nevada Water Authority

Nonetheless, the industry has an image problem when it comes to water. Amenities such as the "dancing fountains" at Bellagio and the canals at the Venetian play a prominent role in marketing, but visitors increasingly are questioning the desirability of such water-based extravagance amid the area's drought-like conditions.

Perhaps the most important measure the gaming companies have undertaken to limit water use is one that might seem counterintuitive to customers: build new properties. All planned casino hotels must go through rigorous water screenings and submit water plans to various governmental regulatory agencies, a facet of construction that was previously unheard of in Las Vegas. The largest single usage of water by the gaming industry is evaporative coolers, and the coolers at new properties must conform to state-of-the-art water conservation standards.

In addition, the average Las Vegas hotel room is remodeled every five years. Remodeling gives the owner an opportunity to assesses current water consumption and invest in technology aimed at greater water conservation. To take one example, MGM Mirage recently installed an electronic faucet system that automatically turns off if the water runs too long.

Investment Implications

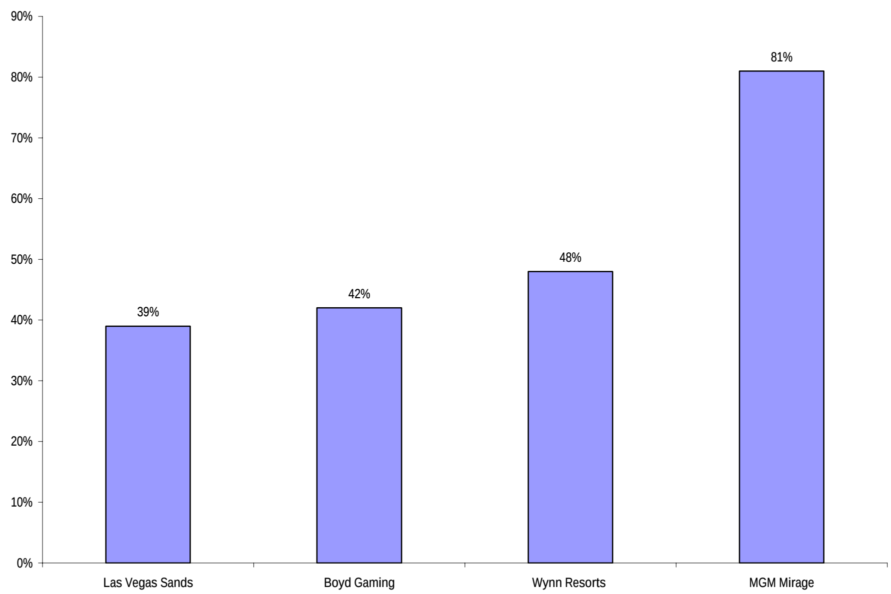
In our view, water-related risks in the gaming companies' financial disclosures have been minimal at best. We believe this is due to two principal factors.

First, the authorities in Las Vegas have responded strongly to the challenges of drought and water shortage. Local governments have both mandated conservation and invested in additional supplies. Water consumption is now lower than it was six years ago and is rising at a very slow pace. Lack of water availability is arguably a lower risk to casinos and hotels in the area than was the case a few years ago.

Second, casinos are the main economic drivers and largest employers in Nevada. We believe in the event of a long-term water shortage, increased pressure for conservation will fall primarily on the agricultural sector in Northern Nevada rather than the Las Vegas-based gaming companies. The state government recognizes the economic importance of the gaming companies and will sooner impose restrictions on the local population rather than risk potential layoffs from casinos, in our opinion.

Nonetheless, from a risk-analysis perspective, we believe several major gaming companies face potential challenges should water-supply problems in Las Vegas become more acute. We estimate MGM will generate approximately 81% of its 2008 EBITDA from Las Vegas, and is therefore the most exposed to any water-related risks there (Figure 17). Las Vegas Sands, Boyd Gaming and Wynn Resorts also have significant exposure to Las Vegas and would likely be significantly affected if lack of water were to curtail their operations in the city.

Figure 17: Share of Gaming Companies' EBITDA from Las Vegas, 2007



Source: JPMorgan and company reports.

Food Processing: Big Risks, Little Disclosure

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An inadequate supply of water presents several serious risks to all food companies. Water scarcity is a key factor in the commodity cost inflation of the last year—over 70% of water used globally is for agriculture—and water is also important to many food manufacturing processes. In addition, consumers are becoming increasingly conscious of the social and environmental costs associated with water, as evidenced by increasing reluctance to purchase bottled mineral water and increasing concern about greenhouse-gas emissions from food transportation.

We believe these risks make water availability a significant issue for investors in the food sector. Unfortunately, food and beverage companies do not provide adequate information for investors to use in assessing these risks, in our view.

Many companies in this sector now highlight their efforts to control water consumption in the context of sustainable development. Some companies have started to measure the environmental impact of their water usage and to look at ways to increase water efficiency throughout their supply chains.

However, the companies we cover do not measure the financial impact of water-related risks. They do not specifically quantify the risk of water shortages on their operations and its potential financial impact. What is the risk of a water source which is being exploited by a water bottler running dry? By how much could the water bill of a company increase in the event of water shortage in a given region? . More generally, what would be the impact of water scarcity on a company's profitability?

The majority of food and beverages companies are conscious of water-related risks, notably water scarcity and water pollution. A number of companies have already experienced business disruptions due to a lack of water, and all seem to know that the threat is becoming very real—the uninterrupted delivery of water can simply no longer be taken for granted. When contemplating an investment decision, an investor needs to have a sense of the impact water scarcity could have on a company's operations and how likely this risk is to materialize. Food and beverage companies, in our opinion, still have far to go in making these risks clear to investors.

Thirsty Business

Water plays a key part in the food and beverage manufacturing. It is directly bottled or used as the main ingredient in soft drinks, and it is used to process raw materials such as fruit and vegetables, to cook or extract products, to cool production lines, and to clean equipment and factories.

We estimate that the total annual water use of five of the biggest food and beverage companies (Coca-Cola, Nestle, Unilever, Kraft, and Danone) represents around 600 billion liters (Table 17). This represents close to 0.1% of total industrial water use, or 0.014% of global water use in 2006. To put it in a different way, the combined water use of these five companies in 2006 came to 95 litres for every person.

Table 17: Food and Beverage Water Consumption Metrics, 2006

billion liters

Company	Water Used (bn liters)	Ratio, liters of water per kg or litee of end product
Coca-Cola	288	2.4
Nestlé	155	4.1
Unilever	66	3.3
Kraft	54	6.0
Danone	51	2.8
Total	613	

Source: Company reports, company environmental/ sustainability reports.

This direct consumption is only a fraction of the total water footprint of these companies. For the food processors, in particular, use in the supply chain is far larger than direct consumption. Unilever reports that the water it uses in manufacturing operations represents only 5% of its total water footprint, with the bulk coming from the water used to grow its raw materials.

All these companies have sought to reduce water consumption in their manufacturing operations. The companies generally identify this as one of a series of sustainability efforts, along with reduced energy consumption and reduced packaging use. There appears to be a common framework that food companies use to minimize their water consumption:

- Measuring current water usage.
- Drawing internal water policies with goals and targets, usually set in terms of water consumed per unit of end product rather than in absolute terms.
- Implementing water use efficiency and recycling technology.
- Reporting performance through independent audits.

This framework generally is leading to activity on three main fronts.

First, most food companies are trying to recycle the water they use in their processes. For instance, PepsiCo's Tropicana orange juice plants capture and recirculate water used during fruit processing to reuse in washing and cleanup operations. Nestlé reuses water extracted from milk in the production of milk powder to reuse as cooling water for its production lines. Danone recycles water used in production or cleaning processes to irrigate agricultural land outside its factories.

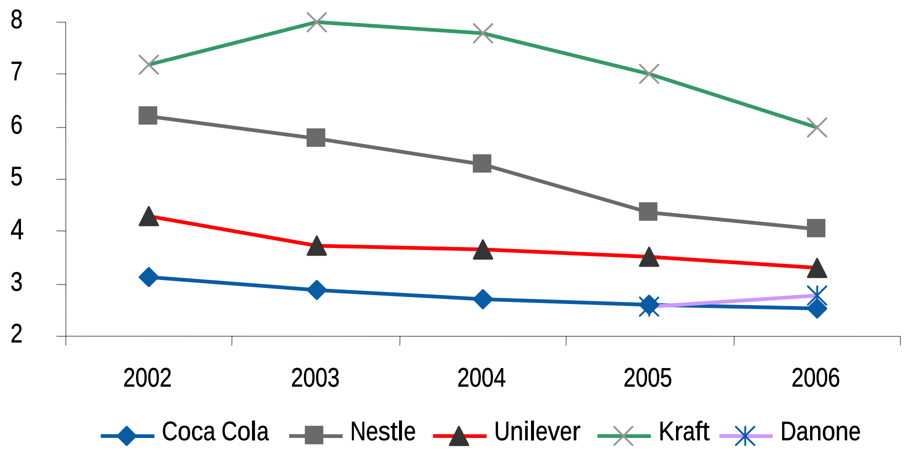
Second, these companies are adopting more water-efficient techniques in their operations. Often this involves technological innovations, such as low-water cookers or advanced air rinsing techniques on bottling lines.

Thirdly, many companies are educating factory workers to be more efficient in their water usage. In many cases, the firms even set water-reduction targets for factory managers.

These initiatives have led to an average 20% increase in water efficiency since 2002 (Figure 18). It is important to note, however, that this measured increase is confined to the areas with each company's immediate control, namely its production facilities, rather than its supply or delivery operations. Further, reduced water consumption per unit does not necessarily translate into reduced consumption overall. As companies expand production around the world, some are seeing their total direct water consumption rise even as consumption per unit of output declines (Figure 19).

Figure 18: Food and Beverage Water Consumption per Unit of End Product

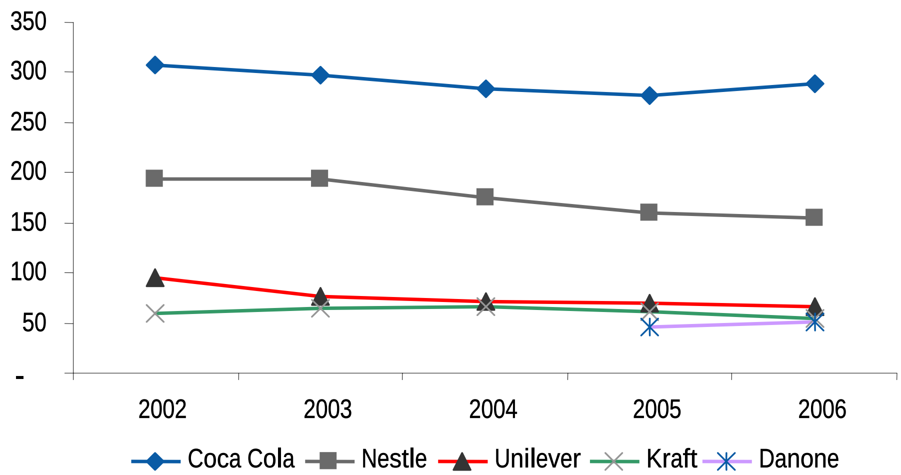
Liters per liter or kg of product



Source: Company reports.

Figure 19: Water Consumption of Food and Beverage Companies

Billion liters



Source: Company reports.

Irrelevant Disclosures

We regard food companies' reported data on water consumption as problematic for several reasons. Definitions of water consumption are not always clear or are sometimes even lacking in reports. The data may not be comparable due to differences in product mix; companies that bottle water directly from a source appear to consume less water than those that purify water (Danone's bottling operations consume 1.3 liters of water for every liter produced vs. Nestlé's 1.9), but we are unable to judge whether, say, Nestlé's milk-powder production is water efficient when compared to Kraft's biscuit production.

Published targets may also not have great relevance. Coca-Cola Co. aims to be the most water-efficient producer among its peers, and it seems from the numbers it already is, but this would be no great achievement, in our view. But unlike its peers, Coca-Cola does not produce water-intensive food products. Nestlé aims to reduce its *water consumption ratio* by 3% and Unilever by 2% annually, but our analysis indicates that neither company's *water consumption* is likely to decrease due to higher production volumes (Table 18).

Table 18: Anticipated Water Consumption by Nestlé and Unilever

Nestlé	2002	2003	2004	2005	2006	2007E	2008E	2009E	2010E	2011E
Vol growth	3.40%	1.90%	2.90%	4.20%	4.70%	4.40%	2.40%	3.40%	3.40%	3.40%
water used (bn liters)	194	193	175	159	155	157	156	156	157	157
% growth		-0.4%	-9.0%	-9.5%	-2.5%	1.3%	-0.7%	0.3%	0.3%	0.3%
products (bn kg/liters)	31	33	33	36	38	39.9	40.9	42.3	43.7	45.2
% growth		6.9%	-0.2%	9.2%	5.2%	4.4%	2.4%	3.4%	3.4%	3.4%
Ratio	6.2	5.8	5.3	4.4	4.1	3.9	3.8	3.7	3.6	3.5
% growth		-6.8%	-8.8%	-17.1%	-7.3%	-3%	-3%	-3%	-3%	-3%
Unilever	2002	2003	2004	2005	2006	2007E	2008E	2009E	2010E	2011E
LFL growth			0.50%	3.40%	2.80%	3.70%	1.50%	3.90%	3.90%	3.90%
water used (bn liters)	94.9	77.1	70.8	69.1	65.8	66.9	66.5	67.7	69.0	70.2
% growth		-18.8%	-8.2%	-2.4%	-4.8%	1.6%	-0.5%	1.8%	1.8%	1.8%
Products (bn kg/liters)	22	21	19	20	20	20.7	21.1	21.9	22.7	23.6
% growth		-6.6%	-6.7%	1.8%	1.9%	3.7%	1.5%	3.9%	3.9%	3.9%
Ratio	4.3	3.7	3.7	3.5	3.3	3.2	3.2	3.1	3.0	3.0
% growth		-13.1%	-1.6%	-4.1%	-6.5%	-2%	-2%	-2%	-2%	-2%

Source: JPMorgan, based on companies' past disclosed consumption and announced targets.

In the end, we believe the data disclosed by the companies we have analyzed are not very useful for the investor. Water-related risks are identified in only a very general way, and this risk is neither qualified nor quantified. In other words, we know neither the potential financial impact of water scarcity on a company's manufacturing operations nor the likelihood of such a risk materializing.

This lack of disclosure with respect to water stands in contrast to more apples-to-apples disclosures related to other inputs. In general, companies disclose their raw materials bills, and the investor can work out the approximate potential impact of input-cost fluctuations on gross margins. This is not the case with water. An investor in a mining company has a sense of the company's proven reserves, which play an important part in the valuation of the company; no corresponding data are available on the water reserves available to companies that draw water from the ground. Valuing the risk that a water source is rendered unusable, or that the company loses its right to exploit it, is all but impossible.

The food and beverage companies we have analyzed treat water risk as a global issue, whereas water scarcity is a local or regional phenomenon first and foremost. Nestlé is the only company that reports the number of its factories (49 out of 481) that are located in water-stressed countries. Nestlé highlights this as a potential risk, stating that it puts more emphasis on water efficiency in these factories. None of the companies we have analyzed provides sufficient information to evaluate the financial impact of potential supply cuts in certain areas or of the need to supply water by truck in the event of disruption. We have no way of knowing if these are tangible risks for the companies.

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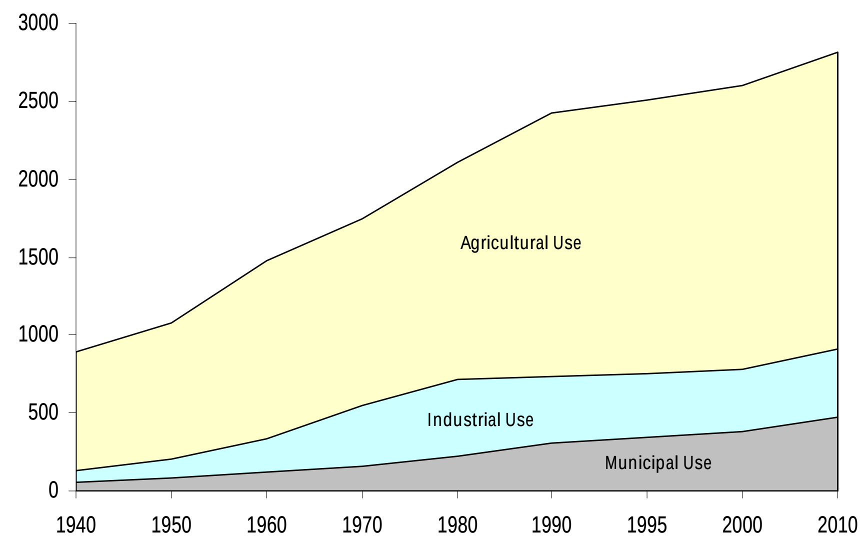
Water Risks in the Supply Chain

The most important water-related risk exposures affecting the food and beverage industry do not occur at manufacturing plants. Water consumption in manufacturing and packaging is minor compared to the massive water content in raw materials. Approximately 200 liters of water are needed to produce the contents of a 200ml glass of milk. The grain in a 30g slice of bread requires 200 liters of water to grow. Agriculture accounts for an estimated 70% of water use worldwide (Figure 20).

Figure 20: Water Withdrawals by Use

Km³ per year



Source: IWMI Water Assessment Report.

Note: Figures for 2010 represent forecasts.

We think water scarcity is an underestimated risk factor for the food and beverage industry. The large food and beverage companies are directly involved in agriculture only to a very small extent. However, their businesses are critically dependent upon agricultural commodities, and the threat of supply disruptions due to a shortage of fresh water resources is not well defined.

In our opinion, water scarcity may be an underestimated driver of agricultural commodity prices in general. Of equal significance to food processors, water scarcity may affect availability of commodities in particular locations. As many food plants are situated to take advantage of meats, fruits, or vegetables produced nearby, local water shortages may unfavorably affect the profitability of individual facilities.

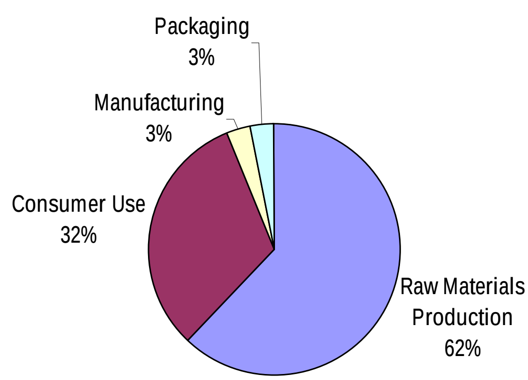
Water scarcity problems may be magnified by the growing demand for water-intensive commodities. Farmers appear to be using water more efficiently; on a per-capita basis, per capita water needs for food fell by half between 1961 and 2000, according to an FAO study. Nonetheless, annual water use in agriculture increased by over 800 billion cubic meters during that period. The growing consumer appetite for meat and water-intensive cereals will likely put even greater stress on water resources in the future.

Agricultural commodities are key drivers of the food and beverage industry's profits, and it is clear that water-related disruptions in the agricultural supply chain may have a dramatic impact on the industry's economic performance. For the industry's large producers of highly branded, highly processed products, such as Nestlé, Unilever, Danone, and Kraft, the costs of raw materials and ingredients account for around 20% of sales. For smaller companies operating at a lower level of the value chain, such as dairies or canned-vegetable producers, the costs of raw materials and ingredients can account for up to 50-60% of sales.

We therefore think it is crucial to assess the exposure of individual companies to water scarcity risk in the context of their total water footprints, and not simply by looking at their direct water bills. The water footprint is the total annual volume of water required to produce a company's goods or services, regardless of whether the water is used by the company itself, in the production of its inputs, in transportation services, or by its distributors.

To our knowledge, only one food and beverage company, Unilever, has ever reported its water footprint. According to the company's estimates, the water it uses in manufacturing operations represents only 3% of its total water footprint. The amount of water used to produce the crops Unilever processes is estimated to be 20 times as high as the amount used in its factories, while consumers use 10 times more water to prepare Unilever products than the company itself uses to manufacture them (Figure 21).

Figure 21: Estimated Water Consumption in Unilever Product Cycle



Source: Unilever

There is no basis for comparing Unilever with other companies, due both to lack of data and to the lack of a clear and universally accepted methodology. Some companies have worked with the World Business Council for Sustainable Development to develop the Global Water Tool, which is intended to enable companies to map their on-site water use and assess risks but does not establish the total water footprint of an organization.

We have attempted to develop a water footprint for Nestlé, using company disclosures and Unesco estimates of the water used in crop production. Using Nestlé data on sourced volumes of milk, coffee and cocoa, which account for 63% of the tonnage of raw materials and ingredients purchased by the group, we estimate that the water footprint of these three commodities purchased by Nestlé represents 35 billion cubic meters. If we assume that the remaining 37% of raw materials and ingredients purchased by Nestlé have a similar footprint, we calculate the water footprint of raw materials and ingredients purchased by Nestlé to be around 55 billion cubic meters (Table 19).

Table 19: JPMorgan Estimate of Water Footprint of Raw Materials and Ingredient Purchased by Nestlé, 2006

	Milk	Coffee	Cocoa	Top 3	Others	Total
Raw materials and ingredients sourced by Nestlé (million tonnes)	11.85	0.75	0.37	12.97	7.51	20.48
Virtual water content m3/ton	990	17,373	27,218	2,686	2,686	2,686
Water footprint million m3	11,732	13,030	10,071	34,832	20,169	55,001

Source: Nestle data, UNESCO.

This volume of water represents 0.9% of annual global water usage by agriculture, which seems to make sense given the global market share of Nestle in food production. Our estimate of Nestlé's water footprint is 350 times the total water withdrawal reported by the company and 982 times its reported water usage (withdrawal minus discharge). On that basis the water footprint of Nestlé would appear to be closer to 4% vs. reported freshwater withdrawal accounting for only 0.004% of global freshwater withdrawal. As our calculations do not include the water footprint of packaging materials, energy, and other goods and services purchased by the group, the total global water footprint of Nestlé is likely to be significantly larger than our estimate. Unfortunately, we do not have the data needed to estimate the company's total footprint.

In principle, it should be possible to calculate water footprints for other food and beverage companies that offer similar disclosures about purchases of raw materials and other inputs. However, we note that the water consumption for a given crop varies considerably among countries, dependent upon local growing conditions and the varieties used (Table 20). The assumptions we have used with respect to Nestlé, which operates and obtains raw materials worldwide, may be particularly inaccurate with respect to a food processor that operates in a single country or region.

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Table 20: Average Virtual Water Content of Selected Agricultural Products in Various Countries

Cubic meters per metric ton

	US	China	India	Russia	Indonesia	Australia	Brazil	Japan	Mexico	Italy	World Average
Rice (paddy)	1,275	1,321	2,850	2,401	2,150	1,022	3,082	1,221	2,182	1,679	2,291
Rice (husked)	1,656	1,716	3,702	3,118	2,793	1,327	4,003	1,586	2,834	2,180	2,975
Rice (broken)	1,903	1,972	4,254	3,584	3,209	1,525	4,600	1,822	3,257	2,506	3,419
Wheat	849	690	1,654	2,375		1,588	1,616	734	1,066	2,421	1,334
Maize	489	801	1,937	1,397	1,285	744	1,180	1,493	1,744	530	909
Soybeans	1,869	2,617	4,124	3,933	2,030	2,106	1,076	2,326	3,177	1,506	1,789
Sugar cane	103	117	159		164	141	155	120	171		175
Cotton seed	2,535	1,419	8,264		4,453	1,887	2,777		2,127		3,644
Cotton lint	5,733	3,210	18,694		10,072	4,268	6,281		4,812		8,242
Barley	702	848	1,966	2,356		1,425	1,373	697	2,120	1,822	1,388
Sorghum	782	863	4,053	2,382		1,081	1,609		1,212	582	2,853
Coconuts		749	2,255		2,071		1,590		1,954		2,545
Millet	2,143	1,863	3,269	2,892		1,951		3,100	4,534		4,596
Coffee (green)	4,864	6,290	12,180		17,665		13,972		28,119		17,373
Coffee (roasted)	5,790	7,488	14,500		21,030		16,633		33,475		20,682
Tea (made)		11,110	7,002	3,002	9,474		6,592	4,940			9,205
Beef	13,193	12,560	16,482	21,028	14,818	17,112	16,961	11,019	37,762	21,167	15,497
Pork	3,946	2,211	4,397	6,947	3,938	5,909	4,818	4,962	6,559	6,377	4,856
Goat meat	3,082	3,994	5,187	5,290	4,543	3,839	4,175	2,560	10,252	4,180	4,043
Sheep meat	5,977	5,202	6,692	7,621	5,956	6,947	6,267	3,571	16,878	7,572	6,143
Chicken meat	2,389	3,652	7,736	5,763	5,549	2,914	3,913	2,977	5,013	2,198	3,918
Eggs	1,510	3,550	7,531	4,919	5,400	1,844	3,337	1,884	4,277	1,389	3,340
Milk	695	1,000	1,369	1,345	1,143	915	1,001	812	2,382	861	990
Milk powder	3,234	4,648	6,368	6,253	6,317	4,255	4,654	3,774	11,077	4,005	4,602
Cheese	3,457	4,963	6,793	6,671	5,675	4,544	4,969	4,032	11,805	4,278	4,914
Leather	14,190	13,513	17,710	22,575	15,929	18,384	18,222	11,864	40,482	22,724	16,656

Source: Chapagain, A.K. and Hoekstra, A.Y.," Water footprints of nations," Value of Water Research Report Series No. 16, UNESCO-IHE, Delft, the Netherlands, 2004.

Water Shortage and Soft-Commodity Price Inflation

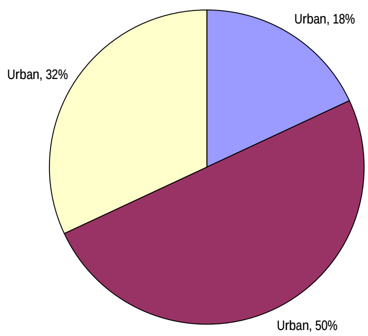
The prices of all soft commodities have been steadily increasing for over a year. We believe a part of this increase is due to water shortages in major crop-exporting regions. Severe droughts in the Murray-Darling basin in Australia, northern China, and parts of the US reduced yields of major crops such as rice, wheat, and corn. These crops are also among the most water intensive of all soft commodities.

- The Murray-Darling Basin, commonly known as Australia's "food bowl," produces all of the country's rice, 66% of its oilseeds, and 31% of its milk. Amid water shortage, farmers shifted to less water-intensive crops. As result, there was a 94% decrease in planted area for rice in 2007/08 (compared to the five-year average) and a 4.5% decrease in milk production in 2006/07. Wheat supply was almost halved in 2007.
- The drought in south-central China in 2006 destroyed 1.64 million acres and left 6.7 million hectares "affected," according to the official press agency. The drought was felt in provinces that produce 10% of the country's corn output, as well the major rice and livestock producing provinces.

Research into the impact of climate change on precipitation, weather patterns and land changes also suggests that the frequency and length of droughts will increase, as extreme weather becomes more common. Desertification will also likely become more widespread. These trends, along with increasing urbanisation and industrialisation in many developing countries, suggest that the amount of land devoted to agriculture could be severely reduced.

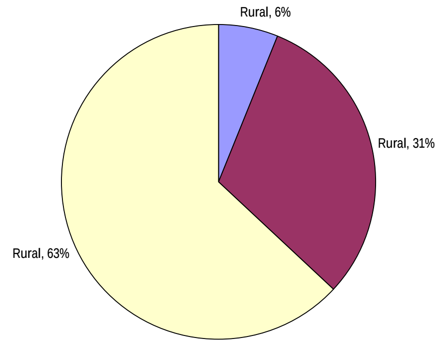
Given the powerful demand drivers, we think water-supply shortages may exacerbate the inflation in commodity prices. At the same time, the world faces growing demand for water-intensive commodities, including grains to produce biofuels as well as products whose consumption tends to rise with income, notably meat. In a country such as China, meat accounts for only 6% of food consumption in rural areas, but three times that share in urban centers, which are far wealthier (Figures 22 and 23).

Figure 22: China Urban Food Consumption, 2004



Source: National Bureau of Statistics.

Figure 23: China Rural Food Consumption, 2004

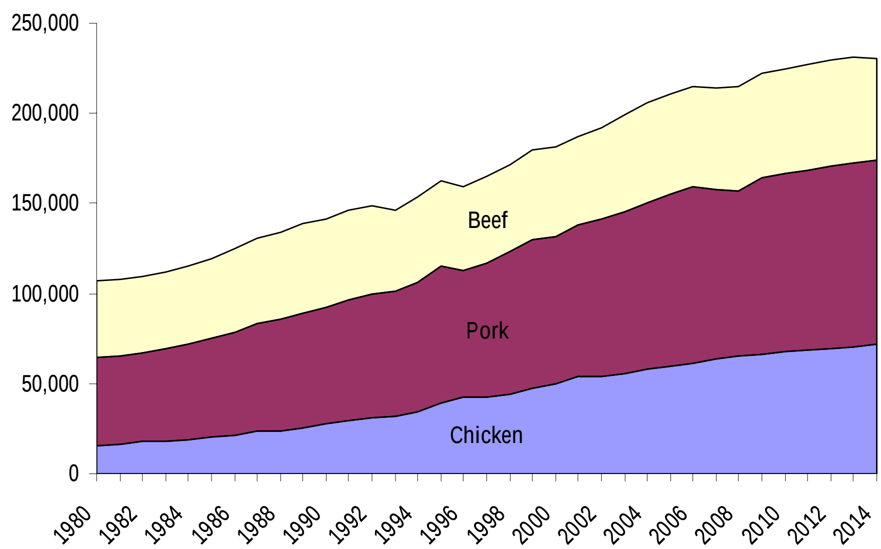


Source: National Bureau of Statistics.

Global meat consumption is predicted to grow sharply over the next 5-10 years, and perhaps even beyond that. According to the US Department of Agriculture's baseline projections (Figure 24), meat consumption worldwide is expected to increase 25% by 2013 and 56% by 2025. The growth is mostly driven by increased demand in East Asia.

Figure 24: Historical and Forecast Global Meat Consumption

Million metric tons



Source: US Department of Agriculture, Economic Research Service. Figures for 2006-2014 represent USDA forecasts.

The problem is that meat is an extremely water intensive commodity. Throughout its life, an animal not only consumes large quantities of water, but is also fed with grains and grain-based feeds that are grown with large quantities of water.

On average globally, 15,000 liters of water are needed to produce one kilogram of beef, 6,000 liters per kilo of pork, and 2,800 liters per kilo of chicken.

The demand for grain to produce biofuel should continue to accelerate in the years to come, given US and European policy objectives. In 2006, about 20% of US corn was used for fuel production—a 300% rise since 2000. In Europe and the US, the vast majority of ethanol is derived from wheat and corn, respectively, which are among the most water-intensive agricultural commodities (Table 21).

Table 21: Virtual Water Content of Crops for Biofuels in the US and Europe

M^3 /Ton

	USA	France	UK	Germany	Global average
Wheat	849	895	501	757	1,334
Maize	489	482	-	442	909
Green Corn (Maize)	337	236	-	-	509
Sugar Cane	103	-	-	-	175
Sugar Beets	84	67	56	77	113

Source: Chapagain, A.K. and Hoekstra, A.Y., "Water footprints of nations," 2004.

Investment Implications

From our research, it clearly appears that most food and beverage companies recognize water scarcity as a genuine operational risk and as such communicate on the matter rather openly and pro-actively. However, we do not think companies go into enough detail to discuss what we see as the two most critical and potentially material issues from a financial perspective:

First, water scarcity may affect the availability and prices of agricultural commodities. In our view, the exposure of individual companies to water scarcity risk must be assessed in the context of their total water footprints, and not simply by looking at their direct water bills. Going through this exercise, one realizes how dependent food companies are on water resources, with water used directly in the production process being quite marginal to a company's overall water reliance.

The large food and beverage companies have little direct involvement in agriculture, but their purchasing power gives them an opportunity (and probably creates a financial and moral obligation) to influence agricultural practices. Although most firms have cut off the capitalistic ties they may have had with agriculture, developing close relationships and creating new models of cooperation with growers may prove a competitive advantage in a world in which commodities may not be taken for granted.

Second, important production facilities may be located in water-stressed areas. Nestlé is the only company that reports on that point. Others may have done the analysis, but this was not clear based on their external disclosures. Investors need to be updated on that subject to be able to understand how companies prepare themselves to address potential disruption in their supply chain short-term and long-term. History shows that disruption to the supply chain in the fast-moving consumer-goods industry, even on a short-term basis, may have material negative long-term consequences in terms of market share and profitability.

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