Alpheus Water Blog

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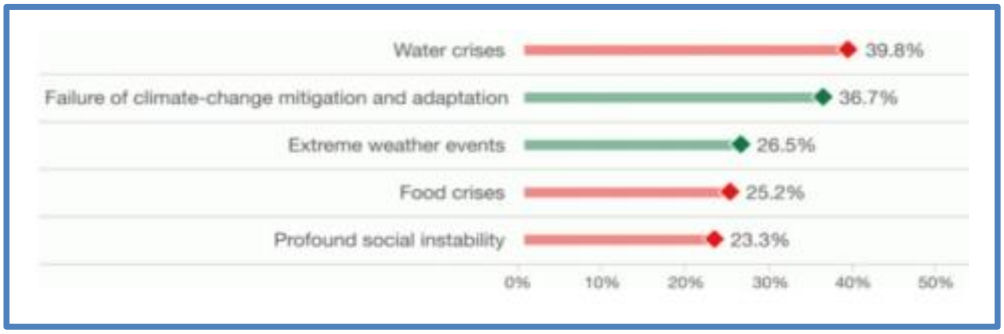
H_2O Will Trump CO_2 in the Coming Decade's ESG

Summary

Water sector investments are inherently ESG-oriented (i.e., incorporating environmental, social and governance analysis) because water is critical to life yet increasingly scarce and polluted. With the recent ratification of COP21 on global air quality, ESG-aware investors will likely shift their prior focus to water's mushrooming challenges. This is not just because U.S. President Donald Trump is skeptical on global warming (i.e., air quality) or that he calls for massive increases in infrastructure spending (which likely includes water infrastructure). Rather, water is a next step, with as much as $2.3 trillion ($1 trillion in the U.S. alone) in deferred investments,[1] leading to a "perfect storm" of rising water shortages, dilapidated infrastructure and pollution. Similar to air, all of these challenges were initially seen as "local." However, water is increasingly seen as a global resource because of growing trade of water-intensive products (such as food, which is increasingly produced by water-benefitted countries), as well as the contamination of downstream rivers and oceans. Many world leaders already recognize this need: The World Economic Forum recently listed "water crisis" as the #1 long term threat to the global economy (see Figure 1[2]).

> **"[CLEAN WATER] MAY BE THE MOST IMPORTANT ISSUE WE FACE AS A NATION FOR THE NEXT GENERATION."**
>
> —U.S. PRESIDENT DONALD TRUMP
>
> ("TRUMP, CLINTON, JOHNSON, AND STEIN'S VIEWS ON AMERICA'S TOP 20 SCIENCE, ENGINEERING, TECH, HEALTH & ENVIRONMENTAL ISSUES IN 2016," SCIENCEDEBATE.ORG/20ANSWERS.)

Figure 1: Greatest Long-Term Global Risk (Potential Impact)



[1] "Meeting the Water Reform Challenge," Organization of Economically Developed Countries, 2009; and "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future," Economic Development Research Group, 2016.

[2] "Global Risks Perception Survey 2016," World Economic Forum.

Environment

Please also refer to our prior report: "Water Quality: Don't Count on It," www.alpheuswaterresearch.com/water-quality.

By some estimates, freshwater scarcity (including malnutrition) is now the #1 reason for environmental fatalities. The estimated annual deaths from all pollution ranges from 14%[3] to 40%[4] of all fatalities globally. The main difference explaining the wide range in these estimates is that the 40% includes deaths from malnutrition. Under this view, not having enough food sustenance is directly related to insufficient water for agribusiness. By including approximately 4mn annual deaths from malnutrition to 1mn from diseases that are directly related to water pollution (Figure 2[5]), the world's annual water-related deaths exceeds that of "outdoor"[6] air pollution. To eradicate hunger, the clean water supply for agribusiness needs to double by 2050 (Figure 3[7]).

Figure 2: Deaths from Environmental Causes (Including Malnutrition)

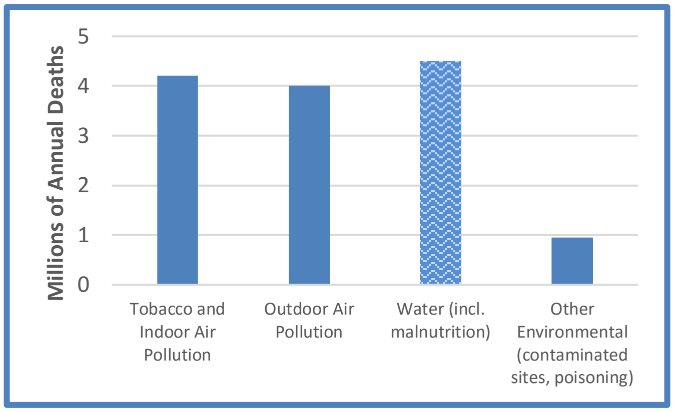
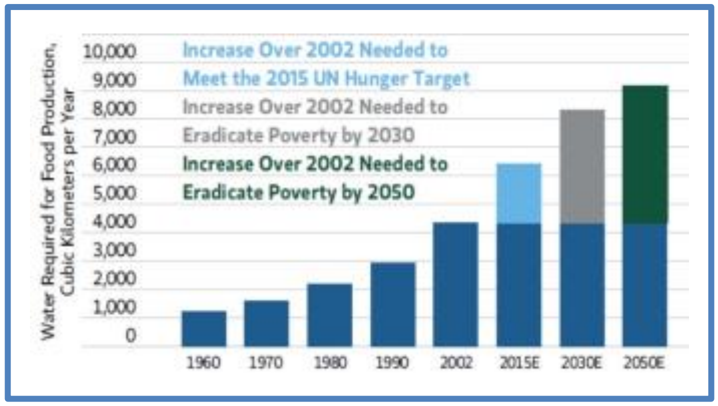


Figure 3: Water Needed to Produce Food



Compared to air, water is also more prone to long-term environmental degradation because it is heavier. Of the 118 basic elements, less than ten[8] are light enough to remain in the air. In addition, the vast majority of the 2,000 new compounds being developed every year are heavier than air. Many of these hormones, pharmaceuticals, and pesticides are designed to be soluble in water or easily absorbed by the body. Several examples of "controlled" toxins that are now showing up in water include:

- **Mercury.** U.S. Mercury Air Toxins legislation was ratified in 1990,[9] drastically reducing mercury emitted into the air by coal-fired electricity generation plants. However, the mercury from prior acid rain will still be in water supplies for decades.[10]

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[3] "The Poisoned Poor: Toxic Chemicals Exposures in Low- and Middle-Income Countries" (Global Alliance on Health and Pollution, 2012), which uses the term "directly caused."

[4] Lang, Susan, "Water, Air, and Soil Pollution Causes 40% of Deaths Worldwide, Cornell Research Survey Finds," *Cornell Chronicle*, 2012, which references David Pimentel, Cornell University professor, who uses the term "contributing to," with the main difference (vs. 14%; see prior footnote) being the inclusion of malnutrition from soil degradation and pollution.

[5] Alpheus Water Research estimates, based on data from World Health Organization, the Global Alliance on Health and Pollution (GAHP), and David Pimentel, "Water, Air and Soil Pollution Causes 40% of Deaths Worldwide" (see prior footnote).

[6] Note on comparability and multicollinearity of data: "Indoor" pollution is excluded since it is highly correlated with second-hand cigarette smoke and wood-burning stoves, neither of which have a direct impact on much broader air pollution. In our view, "outdoor" air can be compared with water, which is generally distributed from a central, common source (and therefore can be regulated). The UN readily concedes that deaths are difficult to correlate to "indoor" or "outdoor" air pollution, and usually both have a negative impact on health. Further, anyone who is impacted by bad air could also be impacted by poor water quality, and vice-versa.

[7] United Nations Environment Program, February 2009.

[8] Including some naturally occurring compounds, such as methane.

[9] i.e., as part of the Clean Air Act. Even though implementation and the legality of the legislation still continues to be debated today, the 2000 legislation effectively made it nearly impossible to build new coal-fired generation plants, and led to many shut-downs of existing plants.

[10] "Mercury: Time to Act", United Nations Environment Program, 2013.

- **Radionuclides.** The air surrounding the nuclear meltdowns of Chernobyl and Fukushima is no longer a health risk, but the soil and water contamination will remain for centuries.
- **Landfill toxins.** Beneath China's unlined and unregulated landfills, the heavier and/or water-soluble toxins didn't show up for decades in underground aquifers. However, rain seepage has now led 90% of China's urban water aquifers to be classified as "not suitable for drinking."[11,12] Similarly, approximately one in every five Bangladeshi deaths are attributed to arsenic from their main underground aquifer.[13]

From a technology standpoint, local water pollution is also not as easily solved. To address its air pollution, China has relocated many of its coal-fired thermoelectric plants to remote areas and has built the world's largest solar and wind sector. However, moving or cleaning up the aquifers is impossible. In most of the world, the dependence on aquifer water is increasing (and the aquifers are depleting,[14] thus magnifying the pollution) as surface water has already been over-tapped.

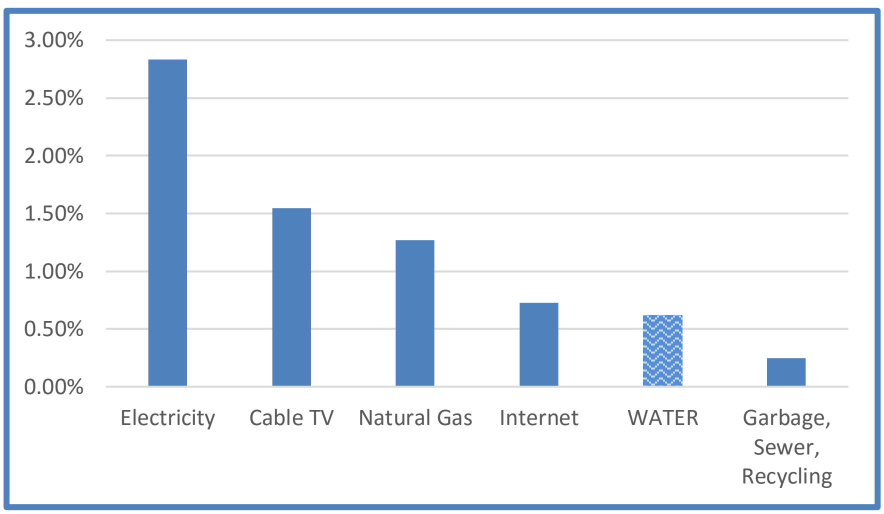
Social

The main social challenge of water is that it is considered a "human right"[15]; thus, clean water should be available—and affordable—to all. However, this dual mandate is difficult at best in view of several factors.

1. Revenues (Including Subsidies) Well Below Marginal Costs

Compared to other utilities, water is highly affordable (Figure 4[16]) especially considering its role as a basic need vs. luxuries such as cable TV, even though prices are increasing at a rate above inflation (Figure 5[17]).

Figure 4: Household Utility Bills as Percent of Income (U.S.)



[11] Belmaker, Genevieve, Cindy Drukier, Tara MacIsaac, Larry Ong, "The Coming Water Crisis," *Epoch Times*, December 2016.

[12] Chen, Trina, "China Environment Sector," Credit Suisse First Boston, August 14, 2014, p. 18.

[13] "Water in Crisis: Spotlight on Bangladesh," by Saima Hedrick as guest author to The Water Project, Inc.

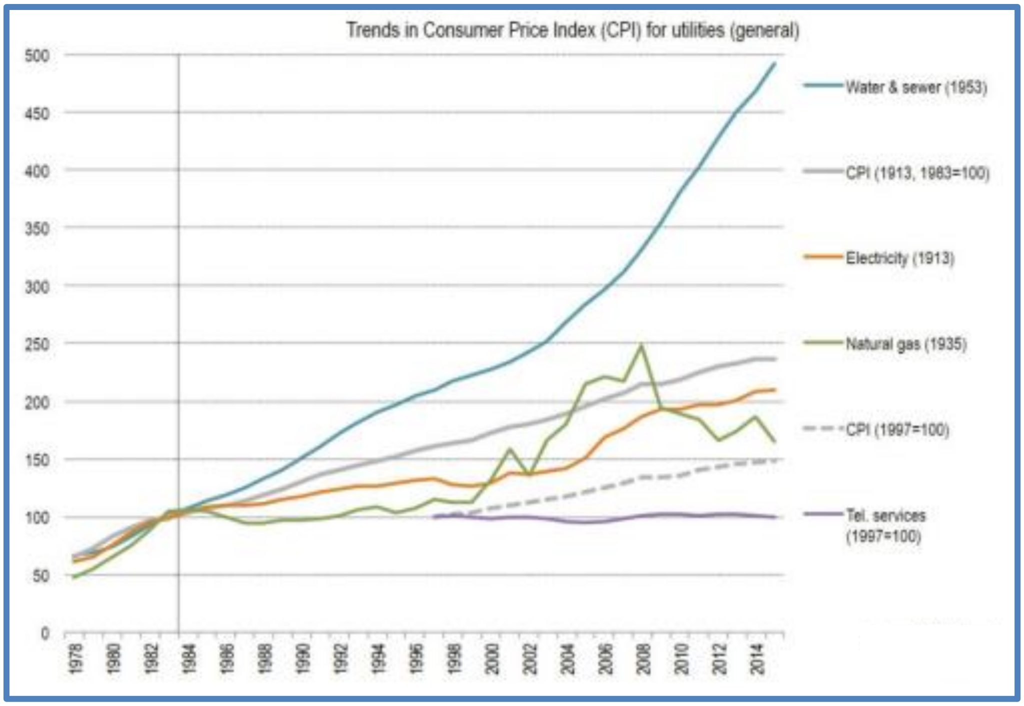
[14] Please also refer to prior report, "Depleting Aquifers: the End Game for Cheap Water": www.alpheuswaterresearch.com/depleting-aquifers.

[15] The United Nations General Assembly explicitly recognized water as a human right through Resolution 64/292 on July 28, 2010.

[16] Conna, Shannon, "Utility Bills 101: Tips, Average Costs, Fees and More," August 20, 2016; and, U.S. Census Bureau Factfinder: factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_15_5YR_DP03&src=pt.

[17] Beecher, Janice A., Ph.D., IPU-MSU, "Trends in Consumer Prices (CPI) for Utilities Through 2014," February 2015. Data from U.S. Department of Labor, Bureau of Labor Statistics.

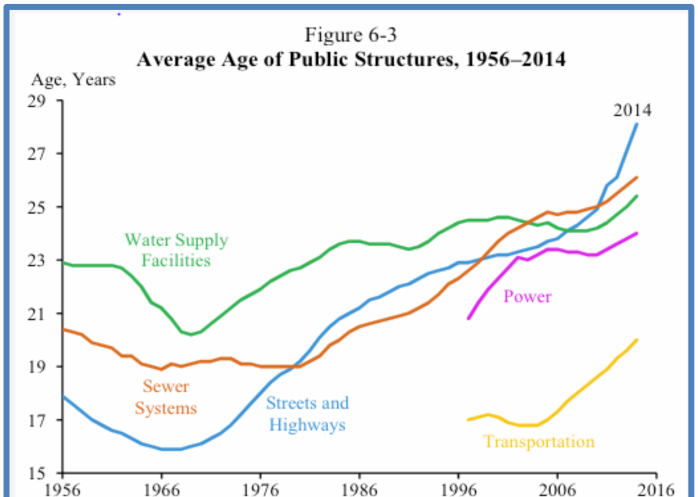
Figure 5: U.S. Utility Bill Inflation



Part of the cost of water is paid via subsidies, including rising issuance of tax-exempt municipal bonds and grants. However, even after including these subsidies, revenues are well below the long run marginal cost of water, including:

- **Maintenance capital expenditures** have been deferred for decades in most developed countries, particularly the replacement of old pipes that are past their depreciated lives. As an arguably "less worse" example in the OECD,[18] the United States has 1.2 million miles of water pipeline[19] with a steady rise in their average age since 1978 (Figure 6[20]). Thus, water leaks, breaks, and contamination are increasing, ultimately leading to the potential for many Flint, Michigan–like problems. The cost of replacing and upgrading an existing system can be higher than when it was first built because the cost of digging up streets is easier when a community is first developed.

Figure 6: Dilapidated Infrastructure in the U.S.



Note: Water supply facilities and sewer systems exclude Federal structures—which account for at most 6 percent of the value of their combined capital stock—because disaggregated Federal data are unavailable. Data for power and transportation fixed assets begin in 1997 because disaggregated data are unavailable for years prior to 1997.
Source: Bureau of Economic Analysis.

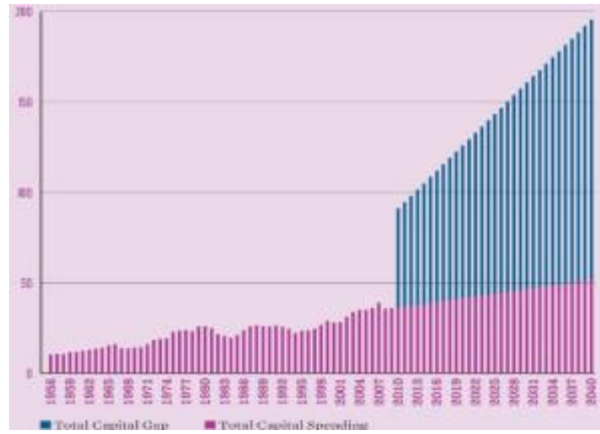
[18] Organization for Economic Development and Cooperation, including 34 member countries that are generally democracies with a relatively high standard of living.

[19] Fishman, Charles, "13 Things You Probably Don't Know About the U.S. Water System (But Should)," voices.nationalgeographic.com, August 12, 2014.

[20] Bureau of Economic Analysis.

- **Growth capital expenditures** are necessary to replace depleting "wholesale" water supplies with sustainable new supplies. (See Figure 7.[21]) The cost of existing supplies is low by any measure, reflecting the cost of rainfall irrigation (close to zero) and from aquifer pumping and legacy aqueducts over shorter, flatter distances (less than 1¢ per gallon). However, these sources are quickly depleting,[22] which ultimately implies a "borrowing" of water at practically no cost. New water will need to come from much deeper aquifers/reservoirs and transported over increasingly longer distances via expensive aqueducts and/or pumped over mountains. In the most stressed areas of the world, sustainable water will need to come from desalination and water reuse, but all of these alternatives are 2–10x the cost of existing water.

Figure 7: Projected vs. Needed Capex (Including Growth, Environmental, Deferred)



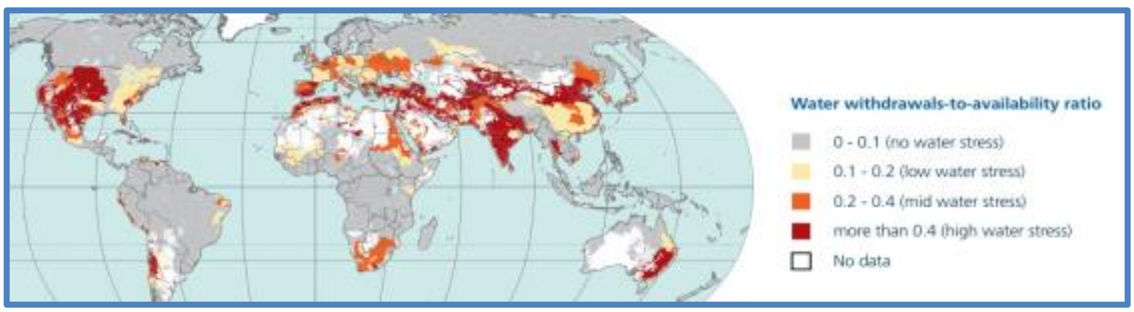
- **Environmental capital expenditures** are increasing. The world has deferred a plethora of environmental costs—both in remediation and in sustainable water treatment—that are increasingly reflected in skyrocketing health care and other "commons" costs.

As with any commodity, the best means to curb demand is to raise prices. However, political-regulators are reluctant to allow tariff increases for voting residential consumers, particularly the poor. Moreover, agricultural and industrial competitiveness often depends on inexpensive water.[23]

2. New Supply Needed

Even with more efficient use, water sector investment needs are expected to grow at 2–3x global GDP in order to address this perfect storm of depleting supply, dilapidated infrastructure, and pollution.[24]

Figure 8: Water Sustainability (Consumption/Withdrawals vs. Natural Replenishment)



We are now at a critical juncture where water constraints are emerging in nearly all of the agricultural and urban centers of the world as the amount of water being consumed (i.e., withdrawn) exceeds the amount that

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[21] "Failure to Act: The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure," American Society of Engineers, 2011. Data from EPA 2001–2010. Spending calculated by CBO (2010). Projections by Downstream Strategies and EDR Group.

[22] Please refer to Alpheus Water Research's prior report: "Virtual Water: Real Price Upside for Benefitted Land" at www.alpheuswaterresearch.com/virtual-water.

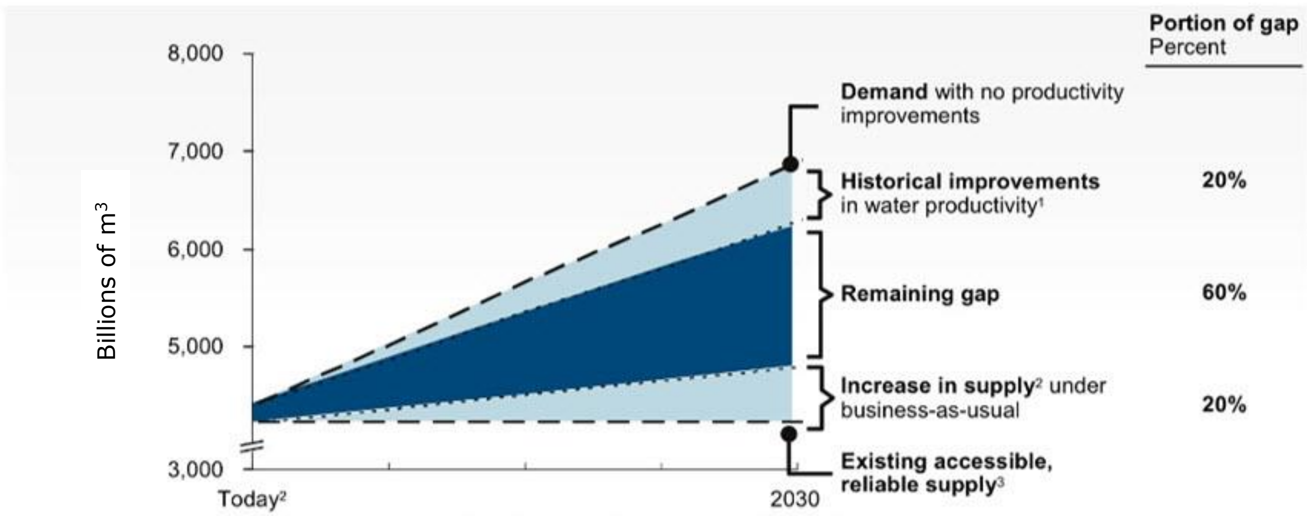
[23] Please also refer to prior Alpheus report, "Depleting Aquifers: the End Game for Cheap Water": www.alpheuswaterresearch.com/depleting-aquifers.

[24] "Charting Our Water Future," McKinsey Global Water Resources Group, 2009.

naturally replenishes. Ultimately, this is reflected in rivers that no longer reach the ocean and in depleting reservoirs, lakes, and aquifers. (See Figure 8.[25])

As is indicated in Figure 9,[26] the "business as usual" practices will not meet demand for water.

Figure 9: Water Demand Growth—"Business as Usual" Scenario



1 Based on historical agricultural yield growth rates from 1990-2004 from FAOSTAT, agricultural and industrial efficiency improvements from IFPRI
2 Total increased capture of raw water through infrastructure buildout, excluding unsustainable extraction
3 Supply shown at 90% reliability and includes infrastructure investments scheduled and funded through 2010. Current 90%-reliable supply does not meet average demand

Traditional Financing Mechanisms Difficult

Without adequate revenue to cover costs, water financing has been increasingly subsidized through municipal debt. Figure 10[27] shows that although the water sector's investment needs are much lower than surface transportation (although other studies would indicate a much higher investment need for water), the proportion that is unfunded is the second highest of any sector.

Figure 10: U.S. Infrastructure Funding Gap (2016–2025)

	Total Investment Need (USbn)	Funded (USbn)	Unfunded (USbn)	*% Unfunded*
Electricity	934.00	757.00	177.00	***18.95%***
Airports	157.00	115.00	42.00	***26.75%***
Ports/Waterways	37.00	22.00	15.00	***40.54%***
Highways/Roads	2042.00	941.00	1101.00	***53.92%***
Water	**150.00**	**45.00**	**105.00**	***70.00%***
Total	**$ 3,320.00**	**$ 1,880.00**	**$ 1,440.00**	***43.37%***

[25] "Water and Jobs," United Nations World Water Development Report, 2016; referencing the Center for Environmental Systems Research, University of Kassel (generated in December 2014 using WaterGAP3 model) based on Alamo, et al. (2007).

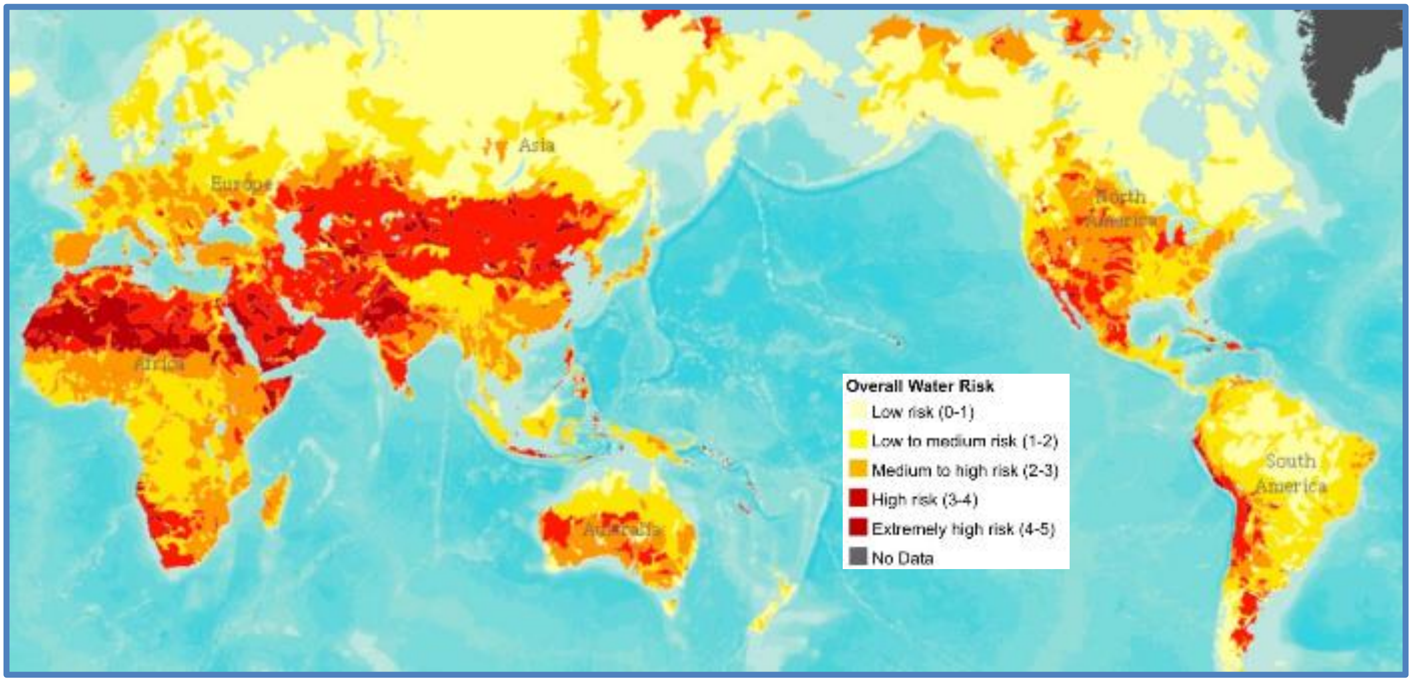
[26] ibid.

[27] "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future," Economic Development Research Group, 2016.

Globally a Source of Conflict

On a global geopolitical scale, water will be an increasing source of social conflict and war. On one hand, water is a unique strategic resource as a non-substitutable prerequisite to human health, food, and most forms of energy. On the other hand, the world's 263 transboundary lake and river basins cover nearly half of the world's land surface[28] and provide 40% of our water.[29] Thus, the many countries that are diverting and damming rivers and drawing down shared lakes and aquifers are reducing the water supply of other countries. Exacerbating these factors are the added environmental issues of upstream polluters contaminating the water being used by downstream countries. (See Figure 11.[30])

Figure 11: Global Water Stress



Several examples of worsening international water conflicts follow.

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[28] United Nations, "Transboundary Waters," www.un.org/waterforlifedecade/transboundary_waters.shtml.

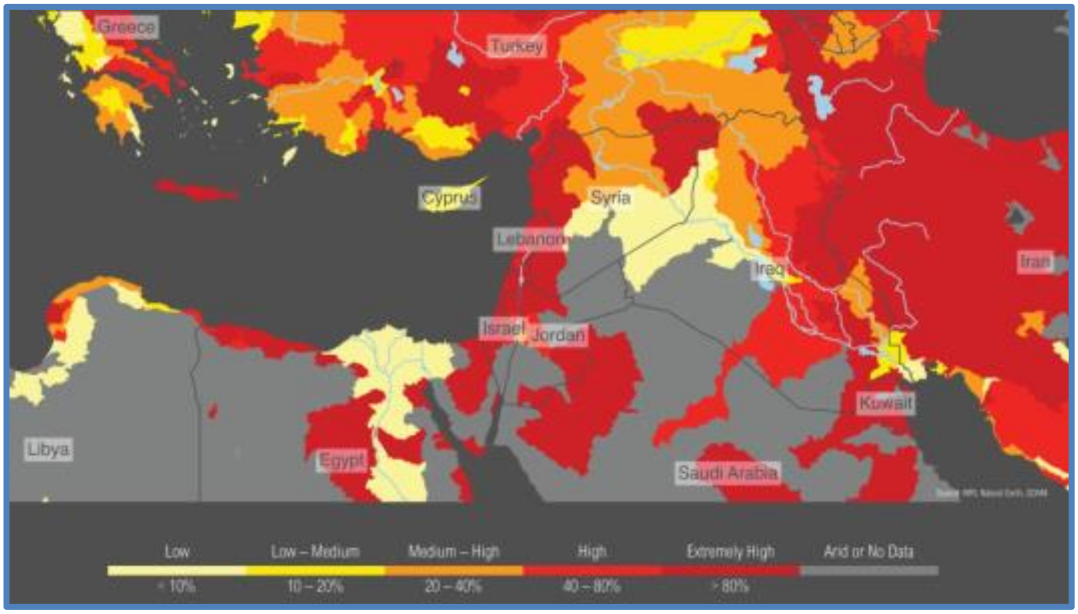
[29] Le Clue, Sophie, "Geopolitico Risks: Transboundary Rivers," *China Water Risk*, February 9, 2012.

[30] Gassert, F., M. Luck, M. Landis, P. Reig, and T. Shiao, "Aqueduct Global Maps 2.0," Working Paper, Washington, DC, World Resources Institute, 2013. wri.org/publication/aqueduct-global-maps-20.

ISIS and the Middle East

The Middle East includes 19 of the 25 most "water stressed" countries in the world.[31] Although perennial conflicts are not expressly about water, most of the region's social instability has its roots in water scarcity. (See Figure 12.[32])

Figure 12: Syria and Middle East Water Stress



Syria is a poster-child example of poor water policy, which has directly led to the current war and refugee crisis. In the mid-1970s, then-President Hafez al-Assad adopted a food self-sufficiency policy leading to unprecedented tapping of the region's aquifers. Then, from 2006–2010, Syria had a "1-in-900–year probability[33]" drought. The lack of rain and empty wells forced 1.5 million farmers to relocate to the cities,[34] leading to unemployment of over 60% and massive food inflation (CPI at 30%)[35] as a common powder keg for social unrest.

On the other extreme, Israel is a prime example of good water policy: All Israelis pay the same cost-based tariff for water, enabling about 55% of the country's water to come from desalination and 86% of distributed water from reuse.[36] Israel is also one of the world leaders in agribusiness water technology, allowing the country to be self-sufficient in food. As a sensitive geopolitical issue, Israel controls the water rights for the region and exports excess water to contiguous countries.[37] In the past summer, the West Bank's 3.8 million residents complained repeatedly about being denied sufficient freshwater following a four-year drought.[38]

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[31] Luo, T., R. Young, P. Reig, "Aqueduct Projected Water Stress Country Rankings," Technical Note, Washington, DC, World Resources Institute, 2015.

[32] Gassert, F., M. Luck, M. Landis, P. Reig, and T. Shiao, "Aqueduct Global Maps 2.0," Working Paper, Washington, DC, World Resources Institute, 2013. wri.org/publication/aqueduct-global-maps-20.

[33] i.e., the severity of the drought would imply an occurrence of once in every 900 years based on meteorological statistical models (but note that the world has seen many improbable record-breaking events in the prior two decades).

[34] Van der Heiden, Kitty, Betsy Otto, and Andrew Maddocks, "Beyond Conflict, Water Stress Contributed to Europe's Migration Crisis," World Resources Institute, November 3, 2015.

[35] World Bank country overview, October 2016. www.worldbank.org/en/country/syria/overview.

[36] "Financial Models for Water Sustainability; Jerusalem Institute, Milken Innovation Center, April 2016.

[37] Elizur, Yuval, "Over and Drought: Why the End of Israel's Water Shortage Is a Secret," *Haaretz News*, January 24, 2014.

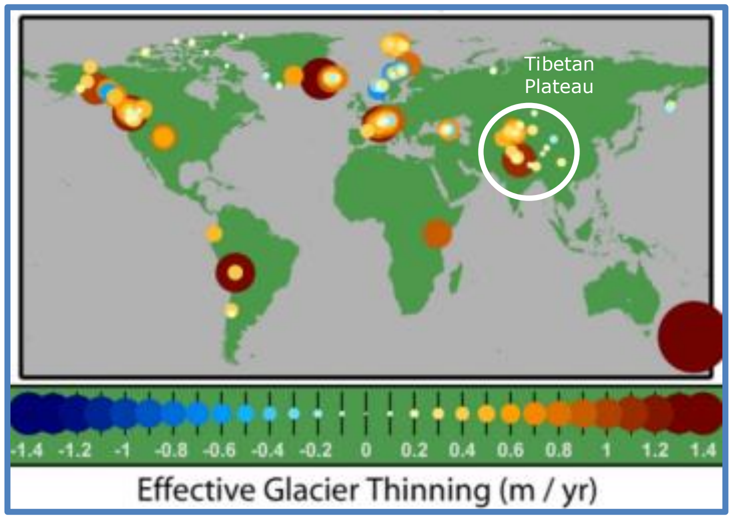
[38] Van der Heiden, Kitty, Betsy Otto, and Andrew Maddocks, "Beyond Conflict, Water Stress Contributed to Europe's Migration Crisis," World Resources Institute, November 3, 2015; and Belmaker, Genevieve, Cindy Drukier, Tara MacIsaac, Larry Ong, "The Coming Water Crisis," *Epoch Times*, December 2016.

China/India and the Tibetan Plateau

Several books have predicted the next war in South East Asia will be over water.[39] Such a conflict would most likely occur when the next Himalayan drought further diminishes already stretched supplies and particularly the region's agribusiness food chain.

The Himalayan mountains' water resource supplies the world's largest population of around 2.4 billion, or 40% of the world total. However, nearly all of these reserves—including rivers, lakes, and aquifers—are depleting rapidly and glaciers are disappearing due to global warming. (See Figure 13.[40]) Most of the main glacier-fed rivers pass through China, then through other SE Asian countries, before reaching the sea (Figure 14[41]).

Figure 13: Map of Global Glacial Melt 1970–2014



However, China has over-tapped and even diverted many of these rivers to support its 1.2 billion populace and centrally planned growth mandate. As a result, there is less water for downstream consumption, and many of the rivers are no longer navigable by the barges and fishing boats that have been there for generations. China has also erected 80,000 dams,[42] which allow for upstream water storage but that radically alter downstream ecology, particularly for fish reproduction (as the main source of protein in the region). Finally, some of these rivers are also the most polluted in the world. Already, there have been many cases of gunboat confrontations and local protests where these rivers cross from China to the other countries.

Figure 14: Map of Tibetan Plateau Aquifer in SE Asia

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[39] Examples: Working, Robert G., David C. Stole, and Christopher Jasparro, *International Conflict over Water Resources in Asia,* Palgrave Macmillan, St. Maarten's Press, 2013; and Chellaney, Brahma, *Water: Asia's New Battleground*, Washington, D.C., Georgetown University Press, 2011, ISBN 978-1-58901-771-9.

[40] "Spotlight on Glacial Melt," Earth Education Project, Expedition 6; University of Minnesota, 2014. lt.umn.edu/earthducation/expedition6/glacial-melt/.

[41] Michael Buckley, "Meltdown in Tibet," www.MeltdowninTibet.com; map based on www.youangdu.com.

[42] "What Country Boasts the Most Dams?," *Ask the Editors*, Infoplease, copyright 2000–2014 Sandbox Networks, Inc., publishing as infoplease, 10 Jan 2017, www.infoplease.com/askeds3-26-99askeds.html.

NAFTA Water—U.S., Canada, Mexico

President Trump's calls for "fair trade" for NAFTA[43] water will be challenged by huge differences in "water blessed" Canada and "water stressed" Mexico, with the unevenly blessed United States (also technically classified as "water stressed") in the middle.

Canada is near the top of the global water blessed list,[44] having 21% of the world's freshwater, but only 0.5% of the population. To the extent that global warming continues (extending Canadian farmers' growing season) and U.S. and Mexican aquifers deplete, NAFTA water issues are likely to become more center-stage. Although water is difficult to export directly (due to its high weight/transportation cost), some expect big new water pipelines to be constructed. In the 1970s, U.S. legislators proposed a mammoth $100 billion "Parson's" infrastructure project. The network's pipes, aqueducts, and use of pre-existing rivers would span from Alaska to Mexico, stabilizing the Ogallala reservoir and replenishing the Mississippi and Colorado Rivers along the way.[45] The project was shelved due to its enormous cost, as well as political and environmental opposition. However, with greatly worsening water stress over the past four decades, various portions of the project and other lower cost transnational water projects are being revisited.

> "FUTURE (U.S.–CANADA) WATER DISPUTES WILL MAKE THE DEBATE OVER THE KEYSTONE PIPELINE 'LOOK SILLY.'"
>
> GARY DOER
> CANADIAN AMBASSADOR TO THE U.S.
>
> (FROM LLOYD ALTER'S "WILL THE NEXT WAR WITH CANADA BE A FIGHT OVER WATER," *TREEHUGGER MAGAZINE*, AUGUST 25, 2014.)

Nonetheless, a more likely and economic outcome for NAFTA water will be increased trade of "virtual water"—mainly via Canadian exports of crops, electricity,[46] and other water-intensive goods.[47] More water-intensive industries are also likely to relocate to Canada.

The main U.S. water challenge is high consumption: The U.S. uses double the water per capita vs. Europe and 6x as much as China.[48] The states that are closest to Canada (particularly near the bordering Great Lakes, which hold 84% of North American surface water) generally have sufficient water supply. However, the vast majority of water reserves further south are depleting. The high consumption of the U.S. reflects the legacy of being a newer, wealthier, and initially "water-blessed" country, thereby leading to legacy luxuries, such as:

- Inexpensive "water-intense" foods (particularly beef, which consumes more water than any other protein and, including feedstock, occupies over 90% of U.S. farmland);
- American affinity for golf courses, lawns, and gardens; and
- Americans' bias against water re-use.

Compared to the U.S., Mexico's water stress is far worse still, with extreme water scarcity compounded by poor water quality. The management of two of the largest U.S./Mexico "shared" rivers—the Colorado and Rio Grande—underscores the delicate south NAFTA water scarcity issue. By the time the Colorado River reaches Mexico, it is mostly tapped out, one of an increasing number of large rivers in the world that often no longer reach the ocean. Similarly, the Rio Grande, the second longest river in the U.S. and bordering the two countries, now rarely reaches the ocean.[49]

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[43] North American Free Trade Agreement.

[44] i.e., counting from the bottom-up of the World Resources Institute Technical Report, "Aqueduct Projected Water Stress Country Rankings," Washington, DC (Luo, T., R. Young, P. Reig, 2015).

[45] i.e., via the Colorado River, which now barely reaches Mexico and often does not reach the ocean in the Sea of Cortez.

[46] i.e., from hydropower through transmission lines.

[47] Please also refer to Alpheus's prior report, "Virtual Water: Real Price Upside for Water Benefitted Land," December 2016. www.alpheuswaterresearch.com/virtual-water.

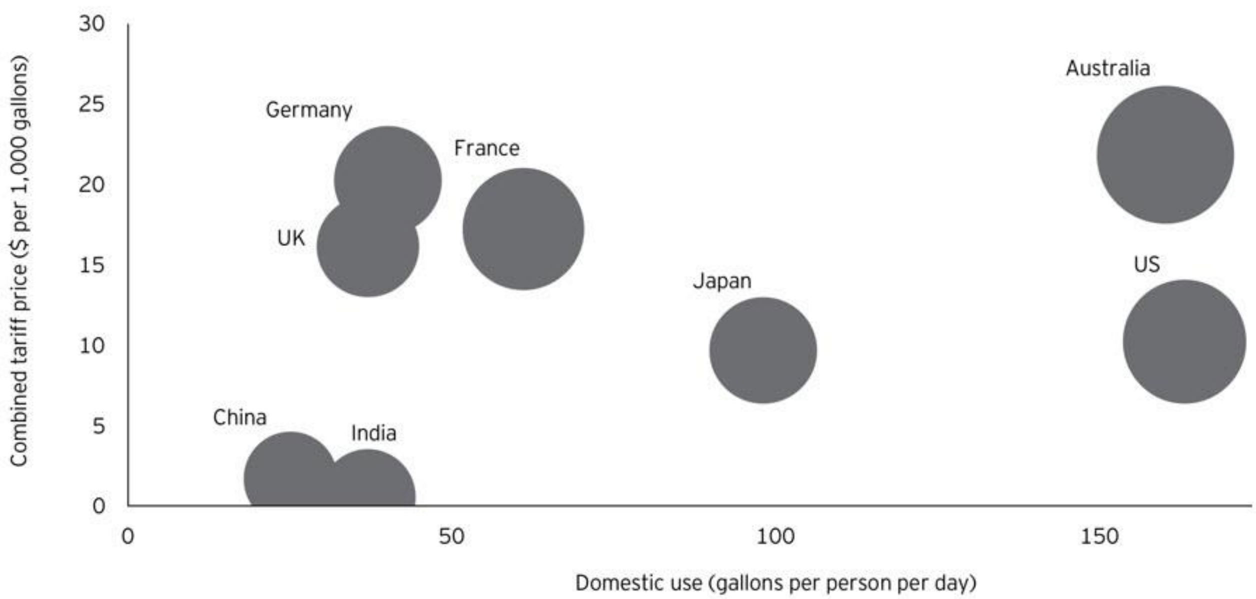
[48] "UNDP Human Development Report," 2006.

[49] "The Flow of the Rio Grande," National Park Service. www.nps.gov/bibe/learn/nature/waterflow.htm.

Governance

International water scarcity conflicts will need to be addressed with negotiations over transnational water rights and fair trade. As global nationalism and calls for fair trade increase, governments are likely to expand their traditional complaints about subsidies (i.e., from low-cost financing, currency manipulation, tariffs/quotas, fuels, etc.) to include input of artificially inexpensive the water and the trade of "virtual water." Figure 15[50] depicts some of the world's largest water consumers; note the low tariff and outsized consumption of the U.S. vs. other developed countries. Note also that except for Australia (which has a huge water-intensive mining and agribusiness sectors vs. a small population), all of the countries that have low water tariffs are under moderate-to-severe water stress (Japan, U.S., China, India). The reverse is also true; high tariffs are associated with lower water stress. Another fair trade issue will be water cross-subsidies, which commonly occur when residential/commercial users (10% of demand) pay more than their fair share of water revenues vs. agribusiness (70%) or industry (20%).

Figure 15: Global Water Tariff vs. Per Capita Consumption



Note: Size of the bubble represents the total annual amount of fresh water used to produce the goods and services consumed.

Similar to COP21 on air, increasing water pollution will need to be addressed with regional and global agreements to address "tragedy of the commons"[51] issues. Contaminated water not only leads to "cancer villages" for local communities, but also increasingly to downstream river and ocean degradation. Many recent studies show deteriorating metrics for depleted global fishing, oceanic "dead zones," reef destruction, warmer waters, and huge oceanic garbage patches.[52]

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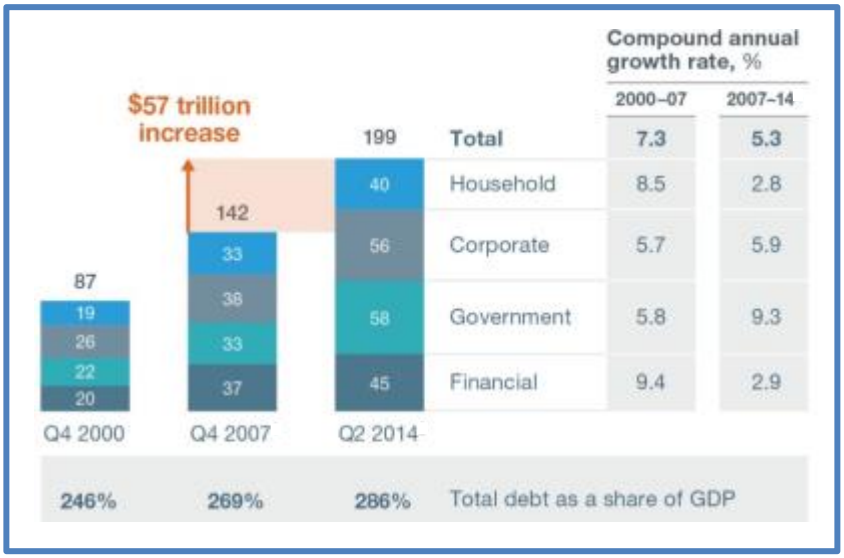
[50] "The U.S. Water Sector on the Verge of Transformation," Ernst and Young. Data from Standard and Poor's Credit Week, "Special Report on Water," 7 March 2012, and Global Water Footprint Network.

[51] "Tragedy of the commons": an economic problem in which every individual tries to reap the greatest benefit from a given resource. As the demand for the resource overwhelms the supply, every individual who consumes an additional unit directly harms others who can no longer enjoy the benefits. Investopedia.

[52] Please refer to Alpheus's prior report: "Water Quality: Don't Count on It," www.alpheuswaterresearch.com/water-quality.

Water sector governance will also inevitably include much more private sector participation, both as a source of innovation and of financing. Globally, government debt is at an all-time high and has increased faster than GDP since the 2008 financial crisis (Figure 16[53]).

Figure 16: Global Debt (US$tn)



U.S. municipal debt is also near an all-time high (Figure 17[54]). More importantly, most local governments find it politically untenable to finance deferred investments to replace dilapidated infrastructure with higher water prices. Finally, to the extent that some utilities are no longer able to access sufficient wholesale water supply, they are implementing conservation programs, thus leading the revenue base (without real tariff increases) to decline.

Figure 17: U.S. Municipal Debt Increase 2002–2010

[53] "Debt and (not much) deleveraging," McKinsey Global Institute. Data from Bank for International Settlements, Haver Analytics, International Monetary Fund "World Economic Outlook," national sources.

[54] "America's Water: Developing a Road Map for the Future of our Nation's Infrastructure," Columbia Water Center, Colombia University Earth Institute, March 2016.

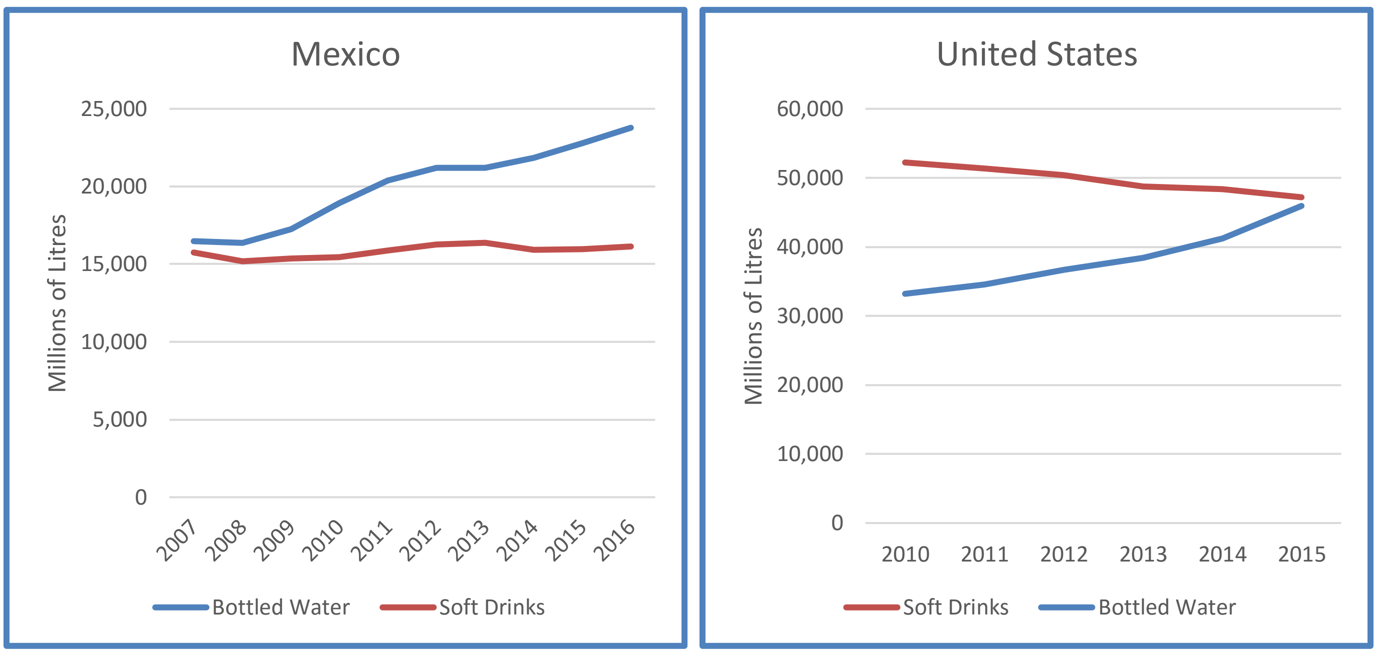
A more local aspect of water governance is the need for companies' managements to become more efficient and environmentally conscious. Several of the most water-intensive sectors are already undergoing radical change, including adoption of water ESG metrics and goals.

Beverages

The beverage sector is now facing its most significant strategic and governance challenges ever due the trifecta of:

1. **Water Security.** About 40% of global bottling companies are located in areas of "severe" to "extreme" water stress.[55] As one of the most water-intensive sectors, these bottling plants are dramatically reducing their water consumption, and many are being forced to relocate or shut-down.
2. **Bottled Water Competition.** Using Mexico (with the highest per capita soft drink consumption in the world) and the U.S. (highest aggregate consumption) as examples, Figure 18[56] shows the health-driven trend from soft-drinks to bottled water.

Figure 18: Bottled Water vs. Soft Drink Market Share (Mexico, U.S.)



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[55] Water Use Benchmarking in the Beverage Industry – Trends and Observations, Beverage Industry Environmental Roundtable, 2012.

[56] HSBC, Euromonitor, Bloomberg, Forbes.

3. **Bottled Water Costs and Environmental Challenges.** Even as soft-drink companies enter bottled-water to maintain market share, consumers may revert to tap water. Many studies there is no significant health benefit to bottled water, at least in developed countries. Tap water is also much less expensive (Figure 19[57]). However, perhaps the greatest challenge for bottled water will come from environmental opposition. Bottled water has a huge water footprint, requiring a 9.2 gallons of water per gallon after including the water needed to make the bottle (Figure 20[58]).

Figure 19: Cost of Tap Water vs. Soft Drinks (U.S.)

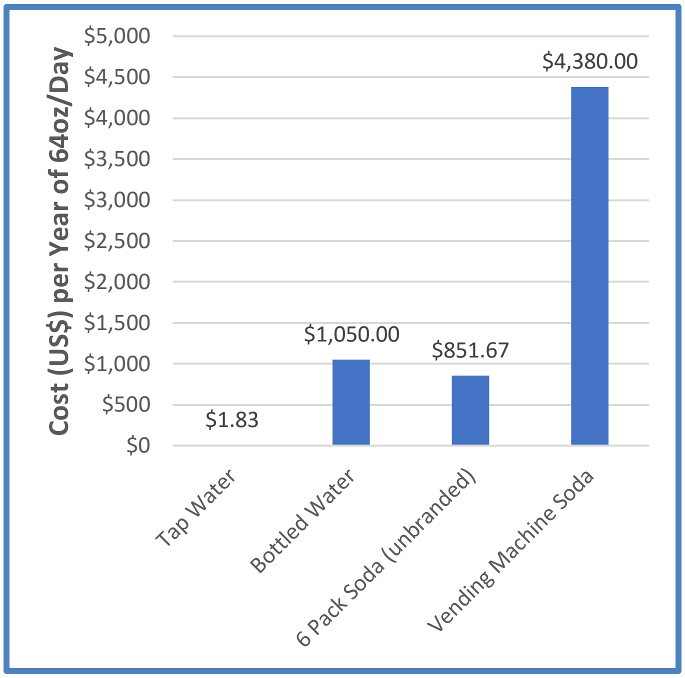
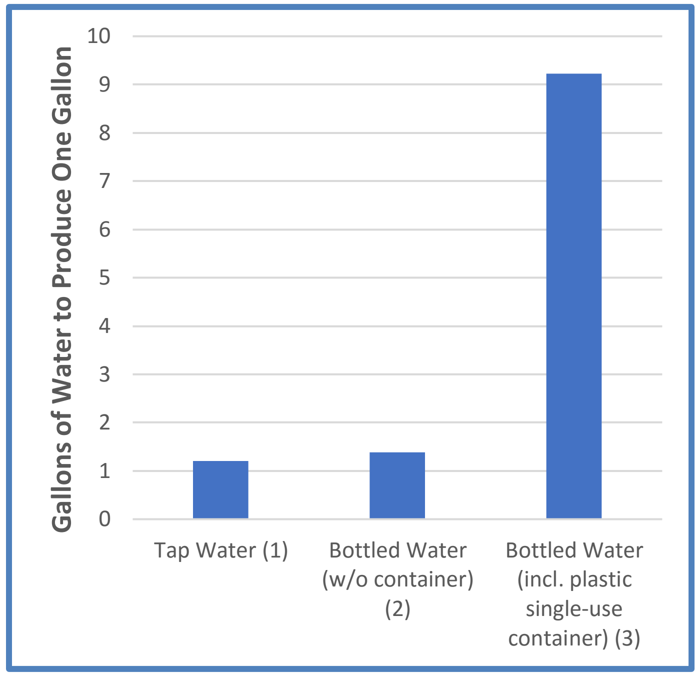


Figure 20: Water "Footprint" of Drinking Water



In addition, only about 22% of bottled water containers are recycled. The remaining ends up in dumps or oceanic garbage patches (Figure 21[59]). New studies[60] indicate that plastics can last hundreds to thousands of years after being broken down into micro-plastics. As they break down in the ocean, they look like food (i.e., initially small fish, then plankton) for much of ocean life, ultimately clogging or filling marine animals' digestive systems to the point that they starve to death.

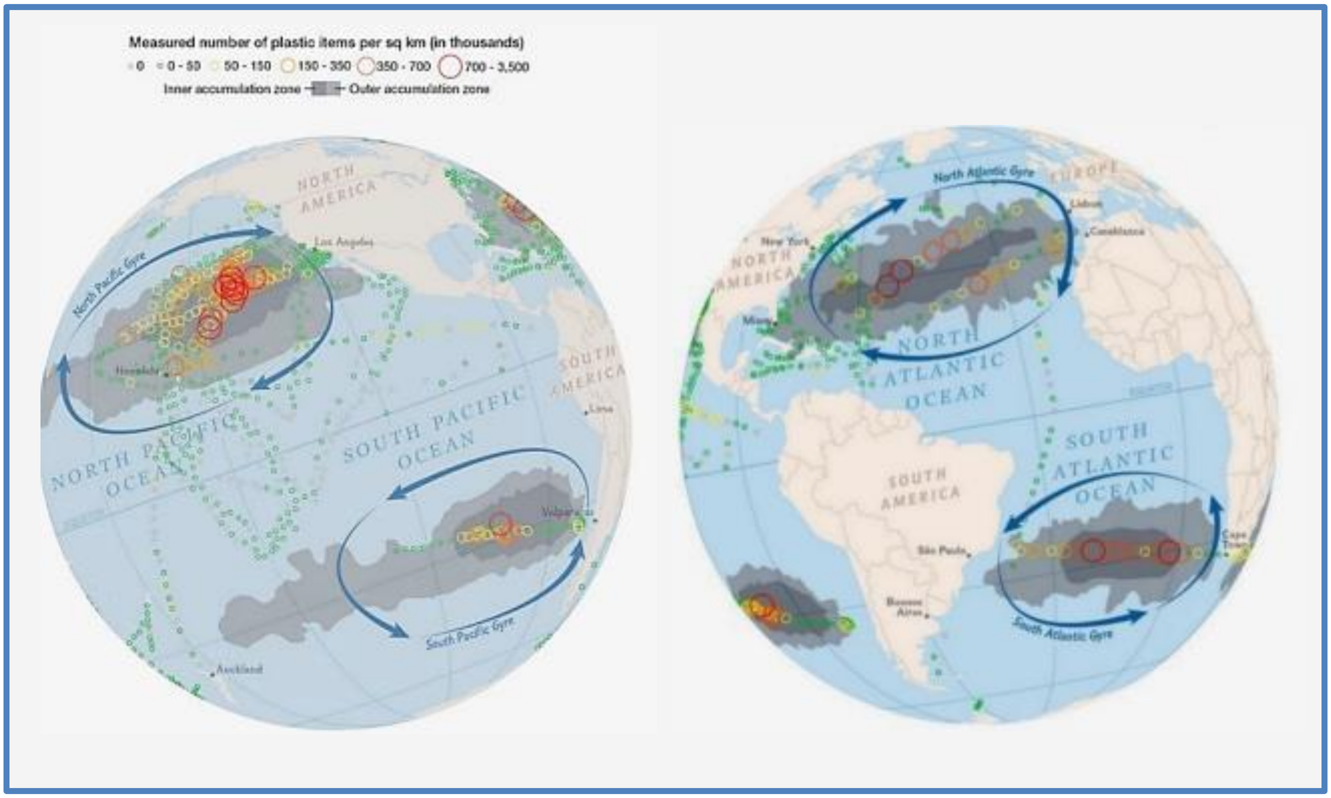
[57] Alpheus Water Research LLC estimates.

[58] Sources: 1. Alpheus Water Research LLC assumes a 15% leakage and 4% evaporation rate; 2. International Bottled Water Association; 3. diNocolantonio, Lisa, Emma Hansen-Smith, Sloan Rice, "Analysis of Water Use for Bottled Water Production," Water and Science Management, 2013.

[59] *National Geographic*, news.nationalgeographic.com/news/2015/01/150109-oceans-plastic-sea-trash-science-marine-debris/?source=maps.

[60] Cozar, A., F. Echevarria, J.I. Gonzalez-Gordillo, X. Irigoien, B. Bedazzled, S. Hernandez-Leon, A. Palma, S. Navarro, J. Garcia-de-Lomas, A. Ruiz, M. L. Fernandez-de-Puelles, and C. M. Duarte, "Plastics Debris in the Open Ocean," *Proceedings of the National Academy of Sciences*, vol. 111, no. 28, July 15, 2014.

Figure 21: Global Trash Patches



Landscaping

The grass for lawns and golf courses does not grow naturally in arid areas such as the Southwest U.S. Hence, many lawns and sports fields are being replaced with artificial turf, summer-time spray-painted lawns, and gardens that are "drought resistant" (i.e., full of succulents, gravel, or rocks). Even though developed market residential gardens consume a large amount of water (Figure 22[61]), the cost-benefit of these investments usually isn't compelling without subsidies. In addition, declining residential water demand (Figure 23[62]) will only have a small effect as it is only around 6% of total demand.

Figure 22: U.S. Residential Water Consumption

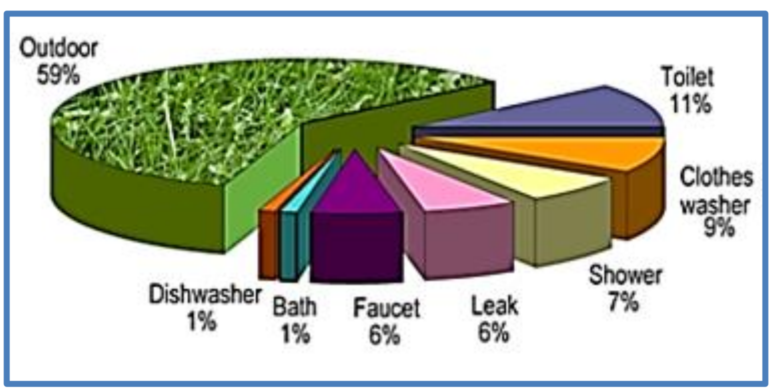
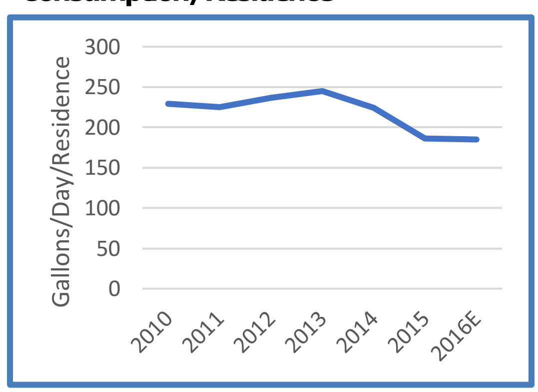


Figure 23: Southern California Water Consumption/Residence



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[61] American Water Works Association Research Foundation, "End Uses of Water," 2013.

[62] Source: Stephen St. Marie, "Declining Water Deliveries—How Rates and Bills Will Be Impacted," California Public Utilities Commission, Policy and Planning Division, Sept. 2016. Note sample includes 9 of the larger "Class A" urban utilities.

Agribusiness and Food

Most of the world's most prolific agricultural basins are drawing down river, lake, and aquifer water at unsustainable rates. Thus, while water is generally too heavy and low-priced to trade, the trade of "virtual water" of water-intensive agribusiness products is increasing. Please also refer to the Alpheus prior report: *Virtual Water: Real Price Upside for Water Benefitted Land.*[63]

Conclusion:
ESG Investing and Attractive Water Returns Go Hand-in-Hand

ESG-conscious investing in the water sector will lead to higher risk-adjusted returns, not lower.

Investors face several challenges in water investing: 1. Sweeping regulatory change, as the "business as usual model" is clearly unsustainable; 2. "Fair" tariffs and returns are complicated by the view that water is a human right and because water distribution is a natural monopoly; and 3. Increased environmental costs are difficult to incentivize. Nevertheless, profit-minded investors should understand that the best investment opportunities come with strong growth, innovation, and a shortage of capital. More than any other sector, water checks all of these boxes, and applying ESG sustainability metrics will further increase alpha.

A comprehensive analysis found that 90% of 2,000 empirical studies showed a non-negative correlation between ESG and corporate financial performance.[64] While an ESG overlay may appear to limit opportunities, the goal is to screen for only those companies that are sustainable (Figure 24[65]). Following the path of clean air, new water investments that are not "ESG sustainable" will either run out of clean water or otherwise be regulated away as "stranded assets."

Figure 24: ESG Investing vs. Other "Public Good" Mandates

Investment Style/Mandate					
ESG Investing	**Traditional Active Management**	**Passive Investing**	**Socially Responsible Investing**	**Impact Investing**	**Charitable Foundation**
Primary Objectives, Philosophy, Process					
Considers ESG as a longer-term risk to sustainability that may be reflected in fines, penalties, employee lawsuits, boycotts, etc. ESG analysis implies a more robust analysis of risk.	Alpha generation through security analysis; bias is short term; generally does not focus on ESG issues as too qualitative, "known-unknown," or long term.	Match market, or segment of market, reduce fees, provide liquidity.	Excludes certain "sin" investments per se that are inconsistent with investors core values: i.e., tobacco, alcohol, pornography, etc.	Attempts to stimulate investment and lower the cost of capital in areas that are socially "good."	Funds investments with primary emphasis on improving quality of life with less regard to financial returns.
Expected Return					
Long-term positive alpha from enhanced ESG-cognizant risk assessment.	A majority of active fund managers underperform on net basis.	Same as market or sector.	Depends on performance of excluded sectors, companies.	Depends on performance of included sectors, companies.	Below market; less relevant.

[63] www.alpheuswaterresearch.com/virtual-water.

[64] Friede, Gunnar, Timothy Busch, Alexander Bassein, "ESG and Financial Performance: Aggregated Evidence from More Than 2,000 Empirical Studies," *Journal of Sustainable Finance and Investments*, 2015, Volume 5, No. 4, pages 210–233.

[65] Alpheus Water Research LLC; Legg Mason, UBS, HSBC.

The size and return of water sector investment opportunities should increase to the extent that rising needs outstrip traditional funding (i.e., tariffs and government bonds). Using the U.S. as an example, the projected "funding gap" for the water sector is nearly 70%, or $152 billion for 2016–2025. By comparing this to the "cost to GDP of not doing funding gap" investments, the implied return for this incremental investment is nearly 5x. Admittedly, this analysis is crude and apples-to-oranges,[66] but would still imply the potential for strong returns. (See Figure 25.[67])

Figure 25: U.S. Water Funding Gap vs. GDP

All figures in constant 2015 US$s

Total Investment Need	Total Funded	**Total Funding Gap**	**Cost to GDP of Investment Gap**	**Ratio GDP Benefit to Funding Gap**
$150.00	$45.00	$105.00	$508.00	**4.84x**

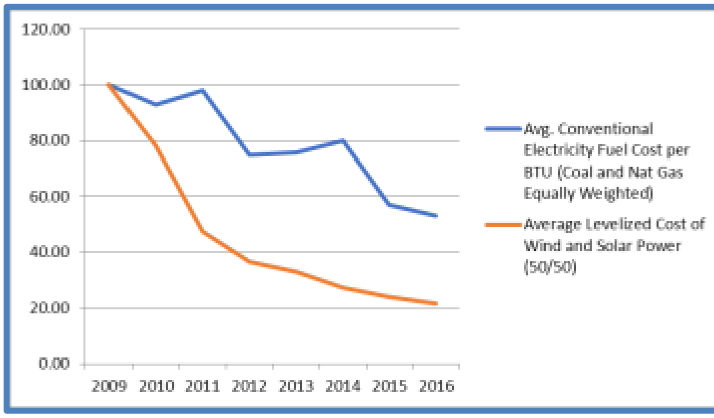
Finally, the poor track record of clean-tech "air quality" investments should not be extrapolated to water, which should continue to provide stronger returns (see Figure 26[68]). Although similar in ESG, investments in the clean air and water sectors are driven by differing starting points, goals, and competitive forces.

Figure 26: Comparison of Air and Water ESG Investing

	AIR	**WATER**
Public Equities 10-Year Return (to 12/31/2016)	**Powershares Clean Energy: -13.10% <ticker: PBW>**	**Powershares Water: +3.56% <ticker: PHO>**
Anecdotal Investment ROIC Including Socioeconomic Benefits	• "Air Pollution Seen Costing Billions to Save Trillions"	• $5-$46 for every $1 spent (globally) • $23 for every $1 spent (U.S.)

- The goal of air quality investments was never to provide "product" (i.e., air), but rather to eliminate polluting emissions. From the beginning, clean energy investments such as solar and wind generation had an uphill climb competing with combustion engines that used the highest BTU-concentrated fuels in the world. Hence, the viability of clean-tech investments initially depended both on regulatory "carrots" (i.e., subsidies for "clean") and "sticks" (taxes on the "dirty"). However, energy clean tech is now reaching "grid parity" in most of the world, with unsubsidized solar and wind competing directly with conventional fuel-based (i.e., oil, gas, coal) generation. In contrast to water, the new clean-energy investments are usually adding to excess supply, with little change in demand. Hence, expected further reductions in solar and wind costs[69] should lead to more excess capacity and downward pricing pressure (Figure 27[70]). With excess capacity, both clean-tech and fossil-based fuels (particularly coal and natural gas) should have limited returns.

Figure 27: Comparison of Conventional Power Fuel Prices (Coal, Gas) vs. Cost of Renewables



[66] i.e., as it compares the cost of investment to the overall GDP benefit to society, implying that the economic return could include increased jobs, reduced healthcare, and other items that would not normally accrue to the water infrastructure investor. In addition, the analysis doesn't factor in tax differences and other adjustments that would impact cash flows and income of a corporation.

[67] "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future," Economic Development Research Group, 2016.

[68] Center for Disease Control (water data); Anna Hirtenstein, *Bloomberg News*, June 2016 (air data); returns: Bloomberg.

[69] i.e., the levelized cost of energy, or that tariff that is required to make a market return over costs.

[70] Thompson Reuters, Lazard Frere, JISEA, U.S. DOE, InvestmentMine.

- By contrast, water investments are mainly focused on providing the commodity,[71] with only a portion of supply coming from cleaning up contaminated water. In contrast to the many technologies and fuels (i.e., hydrocarbons, nuclear, solar, wind, geothermal, etc.) to produce energy, water is non-substitutable at any price. Nevertheless, the marginal cost of providing more water is expected to be much higher than current tariffs; all of the supply-side alternatives (such as longer aqueducts, desalination, and water reuse) are at least 2–10x the cost of existing sources. More importantly, the two most scalable sources have significant drawbacks: 1. Water reuse is politically difficult in developed countries; and 2. Desalination is primarily used near coastal areas due to the up-gravity pumping costs from sea-level.

Chemically speaking (and tongue-in-cheek), the combination of H_20 and ESG will continue to trump CO_2 for investors.

[71] i.e., from the many uses of water (i.e., irrigation/food, direct consumption, sewage, cooling, and various industrial and chemical processes).