Written Testimony before the United States Senate Committee on Energy and Natural Resources, Subcommittee on Water and Power

Wednesday, July 25, 2012
2:30 pm
Dirksen Senate Office Building, Room 366
Washington, DC

Presented by:

Daniel W. Bena
Senior Director of Sustainable Development
PepsiCo, Inc.
700 Anderson Hill Road
Purchase, NY 10577

I would like to take this opportunity to thank Chairman Bingaman and Ranking Member Murkowski for their important work on this Committee. I would like to specifically thank Subcommittee Chairwoman Shaheen and Ranking Member Lee for holding this hearing and inviting PepsiCo to talk about its efforts to reduce energy usage and improve water efficiency.

My name is Dan Bena, and I am the Senior Director of Sustainable Development for PepsiCo, the largest food and beverage company in North America and second globally, with net revenues of more than $65 billion and a product portfolio that includes 22 brands that generate more than $1 billion each in annual retail sales. With nearly 300,000 associates worldwide -- over 100,000 of which are employed in the United States -- and serving consumers in more countries and territories than the United Nations has member States, PepsiCo's people are united by what we call Performance with Purpose. Performance with a Purpose is a principle through which PepsiCo is committed to sustainable growth by investing in a healthier future for people and our planet. We believe this means a more successful future for PepsiCo.

In this context, we have made several public commitments around environmental sustainability. Specifically, to:

- help conserve global water supplies, especially in water-stressed areas, and provide access to safe water;
- continue to make our packaging increasingly sustainable, minimizing our impact on the environment;
- work to eliminate solid waste sent to landfills from our production facilities;
- work to achieve an absolute reduction in GHG emissions across our global businesses; and,
- continue to support sustainable agriculture by expanding best practices with our growers and suppliers.

Particularly germane to the focus of this subcommittee is the progress we have made in the area of water conservation. We established a system-wide goal in 2006 to improve our water use efficiency by 20 percent by 2015, and I am proud to advise that by the end of 2011, we exceeded that goal—four years earlier than our target. This progress is being recognized in a number of ways such as PepsiCo's receipt of the US Water Prize this year from the Clean Water America Alliance, and receipt of the Stockholm Industry Water Award.

We have also improved our energy use efficiency by 8.2 percent from a 2006 baseline. This represents an estimated $32 MM savings in 2011, which corresponds to approximately 1.5 million MWH of thermal and electric energy. This is equivalent to the average annual energy consumption for nearly 100,000 US homes.

PepsiCo's vehicle fleet has and will continue to play a critical role in the achievement of our energy reduction targets. For example, in 2008, our Frito-Lay business in the United States set a goal to reduce fossil fuel dependency 50 percent by 2020 and become the most fuel efficient fleet in North America. Over the last four years, with a portfolio of solutions tied to people, process, and technology, Frito-Lay has reduced fuel usage by 14 percent and has built a glide path to the 50 percent reduction. This 14 percent reduction in fuel usage from Frito-Lay North America eliminated 6,600,000 gallons of gasoline, which is equivalent to taking more than 11,000 cars off the road.

One of the ways we continue to achieve these results is through the broad-scale deployment of ReCon (Resource Conservation) - an innovative system used to improve energy and water use efficiency in our manufacturing facilities. Through the ReCon process, we audit our energy and water management practices, compare all energy and water uses and costs, and assign relative values to each in order to zero in on what can be improved. Then we make adjustments based on best practices used throughout PepsiCo.

Since 2008, PepsiCo has executed a strategic engagement program with suppliers in North America, and by the end of 2011 the program involved 50 suppliers representing over 120 facilities. These suppliers leveraged the ReCon program to deliver a single-year 2.5 percent improvement in thermal energy efficiency, 7 percent improvement in electrical energy efficiency and an 18.7 percent reduction in waste-to-landfill. This corresponds to an estimated productivity improvement of nearly $2 million in 2011.

Throughout the last eight years, PepsiCo's partnership and relationship with the EPA Energy Star program has been very strong. PepsiCo has been an active participant with the Food Processing Focus Team and has spoken at a number of Energy Star events. Our Energy Management Program has been highlighted in the EPA's Public Service Announcements (see Addendum One). The EPA's Guidelines for Energy Management have been used as the foundation of PepsiCo's successful internal and external Energy Management / Sustainability programs. And, as a direct result of PepsiCo's Supplier / Co-Packer Outreach Program, more than 150 additional companies have joined the Energy Star Program.

Since joining the EPA Energy Star program, PepsiCo has been recognized with awards for Partner of the Year in Energy Management in 2007 and Partner of the Year in Sustained Excellence in 2008, 2009, 2010, 2011 and 2012.

Recognition is great, but no single company can alone resolve the magnitude of the global crises we face today, which is why collaboration and partnership are so critical for lasting solutions and impact. In this context, I cite the progress of the Beverage Industry Environmental Roundtable (BIER). The Beverage Industry Environmental Roundtable is a technical coalition of leading global beverage companies working together to advance environmental sustainability within the beverage sector. Formed in 2006, BIER aims to accelerate sector change and create meaningful impact on environmental sustainability, including water efficiency, matters. Through development and sharing of industry-specific analytical methods, best practice sharing, and direct stakeholder engagement, BIER accelerates the process of analysis to sustainable solution development.

Each year, the industry water dataset continues to grow in size, with 2011 representing the most robust report to date, including over 1,600 facilities distributed across six continents. Analyses were conducted to determine industry water use, production, and water use ratio over a three year period from 2008-2010. Over this period, the industry aggregate water use ratio improved by 9 percent, avoiding the use of approximately 39 billion liters of water in 2010. To put this in context, this is enough water to supply the entire population of New York City for eight days (see Addendum Two).

However, water and energy use in our food and beverage facilities is only a small part of the picture. Agriculture represents approximately 70 percent of water use globally, and as high as 90 percent in developing economies; 30 percent of the world's greenhouse gas emissions; and 40 percent of the worldwide employment. To improve resource use in agriculture is to have significant positive impact on the environment.

Improved resource use also makes good business sense. For example, six out of 10 of PepsiCo's top-sourced raw materials are agricultural. We conduct agricultural operations in 30 countries. For PepsiCo, maintaining a sustainable supply chain is paramount to minimizing risks to our business operations.

One of the ways that we are maintaining a sustainable supply chain is by focusing on irrigation. The irrigation methods employed by PepsiCo are constantly evolving to better meet the needs of local communities. Irrigation methods such as flood, pivot, and drip can conserve in excess of 70 percent of farm water use. We are piloting technology such as i-crop, developed in partnership with Cambridge University, and low-cost tensiometers, developed in partnership with the PepsiCo Foundation and the Earth Institute, both of which have the potential to conserve billions of gallons of water in agriculture.

We are also testing innovative approaches to reduce on-farm greenhouse gas emissions. One example is with our US Tropicana business, where the single biggest contributor to Tropicana's carbon footprint wasn't the transport of the juice to stores or the energy required to operate a modern citrus farm. Rather, it was the fertilizer used to grow the orange trees. A great deal of natural gas is used to make nitrogen fertilizer, and a great deal of fertilizer is used on citrus trees — so much that fertilizer accounted for 15 percent of the total carbon footprint for our orange juice. We have partnered with a company called Yara, to pilot an alternative fertilizer. If successful, the greener fertilizers could lower the carbon footprint of PepsiCo's citrus growers by as much as 50 percent and reduce the total carbon footprint of Tropicana orange juice by up to 12 percent. Given how much fertilizer is used throughout the U.S. farming system as a whole — more than 13 million tons of nitrogen in 2007 alone — a greener way to help plants grow could put a serious dent in U.S. carbon emissions (see Addendum Three).

Finally, understanding this subcommittee's interest in the nexus between water and energy, I share two initiatives at PepsiCo of which we are especially proud.

The first is our snacks manufacturing facility in Casa Grande, Arizona. A few years ago, Frito-Lay set out on an ambitious mission to transform an existing facility so that it would run primarily on renewable energy sources and recycled water while producing nearly zero waste. We called this effort "near net zero." We chose the Casa Grande, Arizona facility because of its location, where sunlight is plentiful and water conservation is important, and its size – big enough to be effective, yet small enough to be manageable. Frito-Lay invested in and implemented a combination of technologies to enable Casa Grande to significantly reduce the use of key natural resources and reduce the site's overall environmental footprint. Using innovative technologies, our Casa Grande facility is generating two-thirds of all energy used from renewable sources and is working towards significant reductions. Specifically, 75 percent of the water is recycled, 50 percent reduction in greenhouse gas emissions, and an 80 percent reduction in the use of natural gas (see Addendum Four).

Finally, we understand the importance of lasting change being within reach only when large-scale policies are enacted. In Gujarat, India, PepsiCo Foundation partnered with the Columbia University Water Center to test a new approach to positively impact food security, water security, and climate security—all in one model. The details are supplied in a white paper as Addendum Five, but, in short this paper presents the results of the Columbia Water Center's study of the severe groundwater crisis in the Mehsana region of Northern Gujarat, India. The study concludes that the current pattern of groundwater exploitation is both costly for the state and unsustainable for farmers, and could lead to the complete failure of agriculture in the area within a few years if left unchecked. The study was conducted as the first phase of a multi-phased project designed to help conserve water and energy while improving farmer incomes in North Gujarat. Future papers will outline the initial outcomes of the area pilot project along with resulting recommendations for policymakers in the area.

Again, I would like to thank Chairwoman Shaheen and Ranking Member Lee for giving PepsiCo this opportunity to share its perspectives.

Addenda:

Addendum One: Public Service Announcement from the US EPA Energy Star Program Featuring Frito-Lay Green Team Progress

Addendum Two: Water Efficiency Benchmarking Report from the Beverage Industry Environmental Roundtable (BIER)

Addendum Three: Time Magazine Coverage of Tropicana's Alternative Fertilizer Pilot

Addendum Four: Summary of Casa Grande "Near Net Zero" Plant Progress

Addendum Five: Columbia University Earth Institute Gujarat White Paper

Addendum One: Public Service Announcement from the US EPA Energy Star Program Featuring Frito-Lay Green Team Progress

JOIN PEPSICO IN THE FIGHT AGAINST GLOBAL WARMING. PepsiCo is one of thousands of organizations saving energy with help from EPA's ENERGY STAR® Program. That means lower energy bills for PepsiCo and a cleaner environment for all of us. Learn how your organization can be a part of the solution at **energystar.gov.**

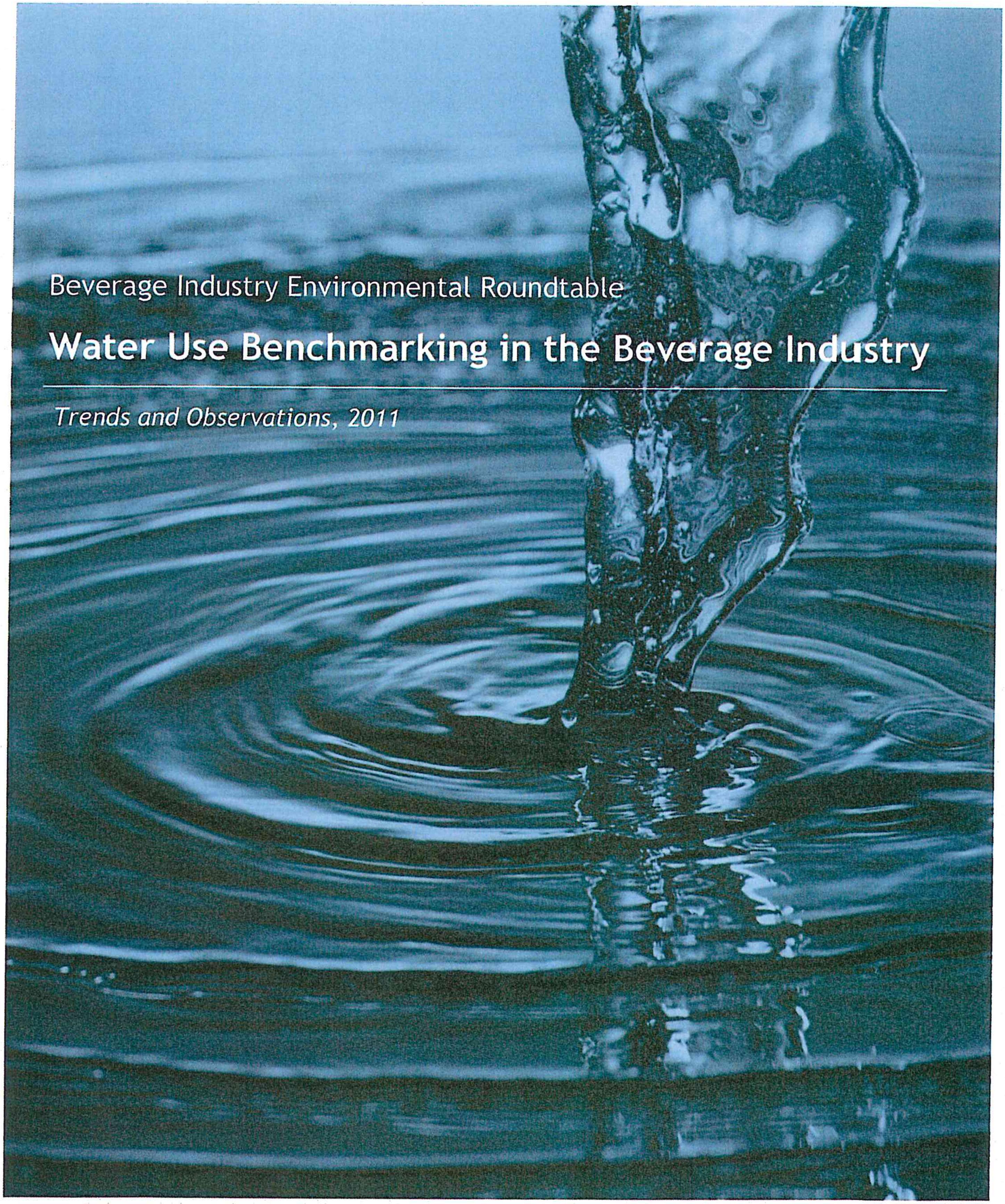
ENERGY STAR

Addendum Two: Water Efficiency Benchmarking Report from the Beverage Industry Environmental Roundtable (BIER)

Beverage Industry Environmental Roundtable

Water Use Benchmarking in the Beverage Industry

Trends and Observations, 2011



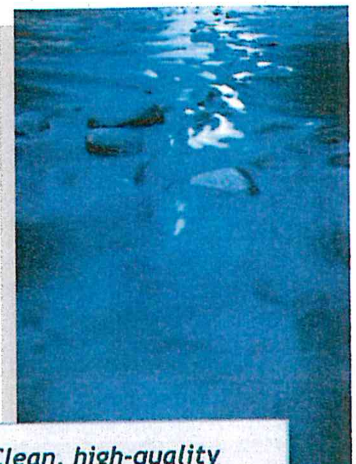
Beverage Industry
Environmental Roundtable

anteagroup

Water Use Benchmarking in the Beverage Industry

Trends and Observations, 2011

Clean, high-quality water is the essential ingredient for all products of the beverage industry. For years, beverage companies have focused on water use avoidance and conservation to demonstrate one aspect of environmental stewardship. Since 2007, the Beverage Industry Environmental Roundtable (BIER) has completed an annual quantitative benchmark to evaluate water use in the beverage industry. This article shares some of the key water use and performance information collected as part of this study, including an evaluation of facility performance in water scarce regions. Further, the article presents important steps BIER members are taking to expand water stewardship studies beyond the four walls of the facility, by accounting for water use in the supply chain and assessing water risks and opportunities.



Clean, high-quality water is the essential ingredient for all products of the beverage industry.

Benchmarking Process

In 2011, BIER successfully completed its fifth annual water benchmarking study. The study evaluated the performance of more than 1,600 beverage manufacturing locations representing 16 different beverage companies. As in previous years, BIER members continued to fine-tune the benchmarking process by refining the benchmarking metrics (ref. Table 1), determining the most critical data to collect, and adjusting the data analysis process for an ever-expanding data set. For the second year in a row, BIER membership elected to share select results of this annual study with external stakeholders, in support of the Transparency Principle espoused in *World Class Water Stewardship in the Beverage Industry 2010: Water Efficiency and Beyond.*[1]

To establish the data set, each of the 16 member companies submitted three years (2008, 2009, 2010) of facility-specific data, as described in Table 1. For consistent comparison purposes, all companies provided facility-specific data for total water use, total beverage production, facility type and location. The basis for analysis, then, is the water use ratio, which describes how efficiently a facility uses water for beverage production. The annual study, including data collection, analysis, verification, and reporting, has been managed by the Global Corporate Consultancy of Antea™Group, a third-party consultant, since the study's inception.

[1] *World Class Water Stewardship in the Beverage Industry 2010: Water Efficiency and Beyond*, Beverage Industry Environmental Roundtable, November 2010.

For the purposes of this study, four types of beverage production facilities were identified: bottling, brewery, distillery and winery. While all water uses at these facility types (including water used for employee services, on-site landscaping, etc.) were included, non-manufacturing facilities, such as office buildings and warehouses, were excluded from the study. Facility type was then determined by the primary process conducted at each facility. Further, bottling facilities were broken down into additional sub-categories based on product mix, to account for the various product types processed at bottling facilities. All facilities reported a beverage product mix, or a percentage breakdown of the different beverage types produced at each facility (ref. Table 1).

Particular characteristics of each facility and beverage type are further explained in the following sections.

Table 1: Quantitative Facility-Level Data Set

- **Total Water Usage (kL):** all water used by the facility (including bottling and industrial water) from all sources used for activities as identified below:

Includes water used for:

- Facility-level beverage production and packaging (accounts for water contained in product)
- Cleaning/sanitizing processes
- Cooling waters
- Heating waters
- Sanitation
- Landscaping
- Stormwater captured for aforementioned activities

Excludes water used for:

- Return water (underground water returned to the aquifer, recharge area, or natural drainage basin without significant modification).[2]
- Concentrate, syrup or flavor production
- Agriculture
- Production of raw materials (plastic, glass, etc.)
- Shipment of raw materials
- Distribution of finished product
- User consumption purposes (e.g. addition of ice cubes, spirits dilution, etc.)

- **Total Beverage Production (kL):** the volume of finished product generated at a facility or by a company. For facilities that produced alcoholic beverages, the actual volume of product (not scaled for alcohol content) was represented in the beverage production total.

- **Water Use Ratio (L/L):** a calculated ratio of the total water usage to total beverage production at each facility.

- **Facility Type:** designated as brewery, distillery, winery, or bottling based on primary process enacted at each facility.

- **Beverage Product Mix (%):** percentage breakdown of the different beverage types produced at each facility. For purposes of this study, nine beverage types were identified: beer, bottled water, carbonated soft drinks, distilled spirits (high-proof), distilled spirits (low proof), 100% juice, non-carbonated beverages, wine and other.

- **Facility location:** continent, nation, latitude and longitude.

---

[2] Return water use is most frequently associated with the bottled water industry. A constant flow is maintained for microbiological purposes; displaced water which does not enter the facility is returned to the watershed as defined above. Other industries with a similar arrangement for private water resources may also exclude return water from their total water use.

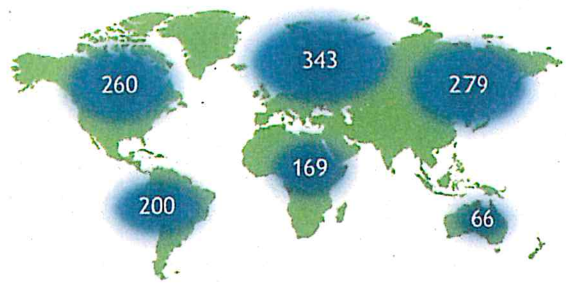
As noted in Table 1, water used in upstream processes, such as agriculture, flavor production, and production of raw materials, was not included in water use totals. Similarly, water used in downstream processes, such as distribution of finished product, was not included in water use totals. Upstream and downstream processes are addressed under Principle VI of *World Class Water Stewardship in the Beverage Industry*. It should also be noted that water contained in the final beverage product was included in water use totals and beverage production totals; however, any water added to finished product by users as ice or to dilute product was excluded. Further information on the processes included in water use may be found within each facility type's definition.

The member companies also submitted supplemental process information for their facilities; process-specific information such as package type, pasteurization type, and alcohol content was collected to evaluate trends observed during data analysis.

2011 Water Stewardship Benchmarking Results

Each year, the industry dataset continues to grow in size, with 2011 representing the most robust report to date, including over 1,600 facilities distributed across six continents. To maintain consistency in data evaluation, however, only facilities which reported data in each of the three study years were included in the subsequent analyses. Due to acquisitions, divestitures, site openings and closures, gaps in data reporting for specific facilities exist. The net result is a three-year data set for 1,317 facilities included in our analysis (Figure 1).

Figure 1: Continent Facility Representation (# of Facilities)

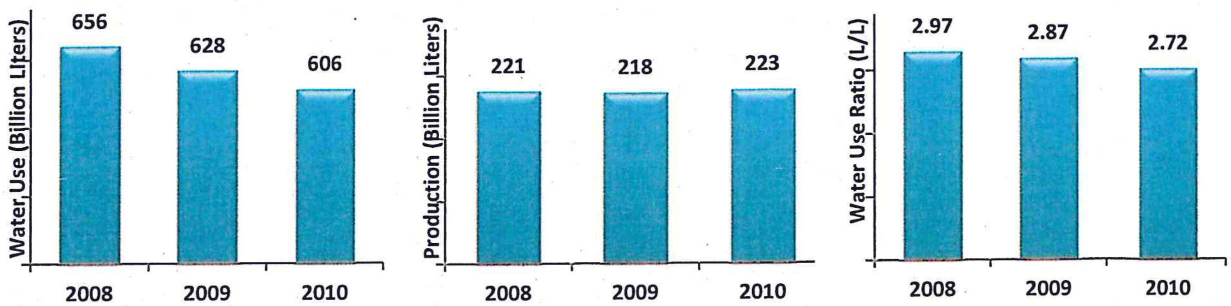


Analyses were conducted to determine industry water use, production, and water use ratio over the three year period (from 2008-2010). As seen in Figure 2 on the following page, the industry aggregate water use ratio improved by 9 percent from 2008 to 2010. Approximately 69 percent of facilities improved their water use ratio from 2008 to 2010. Aggregate beverage production remained relatively stable, increasing 1 percent from 2008 to 2010. Industry aggregate water use decreased approximately 8 percent from 2008 to 2010. By improving water use efficiency, the industry avoided the use of approximately 39 billion liters of water in 2010 - enough water to supply the entire population of New York City for eight days.

By improving water use efficiency, the industry avoided the use of approximately 39 billion liters

Further analysis was performed on each of the four facility types to identify specific trends in water use. Facility types, general process steps, and associated water use ratio trends are described in the next section. Notably, annual water use benchmarking has revealed the unique processes that use water at each facility type and the many variances between facility processes within the same facility types. BIER recognizes that, because of these unique processes, it is impossible to compare water use ratios across different facility types or with other consumer goods industries. Similarly, BIER abstains from "ranking" facility efficiency within beverage types, in consideration of the many unique characteristics and process variances within individual facilities.

Figure 2: Industry Trends in Water Use, Production, and Water Use Ratio



*Approximately **69%** of facilities improved their water use ratio from 2008-2010*

Bottling

For the purposes of the benchmarking study, bottling facilities were defined as:

> *Locations where concentrate, syrup, flavors/infusions, and/or bulk alcohol are blended with water and packaged into various container types. Bottling facilities also encompass facilities which receive finished bulk product (such as completely brewed beer or matured whiskey). No fermenting or distilling processes are conducted at bottling facilities.*

All nine beverage categories were represented in this facility type (see Table 1).

Bottling represented the largest data set of the study, with bottling facilities accounting for 74 percent (by volume) of the overall industry data set. Bottling facilities generally use the least amount of water to make a liter of product, since there are fewer water-intensive processes as compared to other beverage types (e.g. cooking, fermenting and distilling). Bottling facilities, however, typically package a mix of several different products and beverage types; 48 percent of these facilities had a beverage product mix of more than one type of beverage.

The bottling facility data set included a range of beverage types, processes, and production volume. For the purposes of this article, we will focus on the two largest sub-groups within the bottling data set: Carbonated Soft Drinks and Bottled Water.

Carbonated Soft Drinks

Carbonated soft drinks are defined as:

> *Non-alcoholic, flavored carbonated beverages; this category includes colas, ginger ales, and seltzers, but excludes non-carbonated beverages such as ready to drink teas, coffees, fitness drinks, energy drinks, and juice drinks.*

Facilities included in this sub-group reported a beverage production mix (percentage of each type of beverage produced at the facility, totaling to 100) of 50 percent or more carbonated soft drinks. Figure 3 shows the boundaries of the operations where water use was included in the benchmarking report.

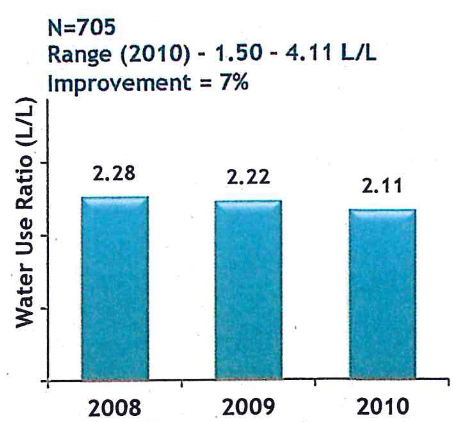
In 2011, 705 carbonated soft drink bottling facilities comprised this beverage category study set. Carbonated soft drinks were the most well represented sub-group with facilities located on six continents. This sub-group also contained some of the largest facilities by production volume in the entire study.

Of the 705 carbonated soft drink bottling sites, 74 percent showed an improvement in water use ratio from 2008 to 2010. As seen in Figure 4, the overall carbonated soft drink subset water use ratio showed a 7 percent improvement from 2008 to 2010.[3] Facilities with a beverage product mix of 100 percent carbonated soft drinks (544 facilities) showed a similar improvement of 8 percent from 2008 to 2010.

> *Of 705 carbonated soft drink bottling sites, 74% showed an improvement in water use ratio*

Figure 3: Process Map, Carbonated Soft Drinks

Figure 4: Carbonated Soft Drink Performance



[3] For all subsequent graphs, the following criteria apply: "water use ratio" represents a volume-weighted mean; "range" refers to the middle 80 percent of the 2010 data set; and "improvement" refers to the percent change in water use ratio from 2008 to 2010.

Bottled Water

Bottled water is defined as:

> *All unflavored bottled waters including spring water, purified water (produced by distillation, deionization, reverse osmosis or other processes), mineral water, sparkling bottled water, or well water.*

The study process data sheets offered three choices for specifying bottled water mix: spring water, natural water or mineral water. For the purposes of this article, data is presented for facilities that had a beverage product mix of 50 percent or more of any bottled water type. As seen in Figure 5, benchmarking accounts for water treatment (as applicable) and bottling processes.

In 2010, 112 bottled water facilities comprised this beverage category study set, representing 14 percent (by volume) of the bottling facility data set. As seen in Figure 6, the water use ratio range reported in this sub-group had the smallest range of all sub-groups.

Of these 112 sites, 64 percent showed an improvement in water use ratio from 2008 to 2010. The overall bottled water sub-group water use ratio remained relatively stable from 2008 to 2010. Facilities with a beverage product mix of 100 percent bottled water (47 facilities) showed similar stability in water use ratio from 2008 to 2010.

*Of 112 bottled water sites, **64%** showed an improvement in water use ratio*

Figure 5: Process Map, Bottled Water

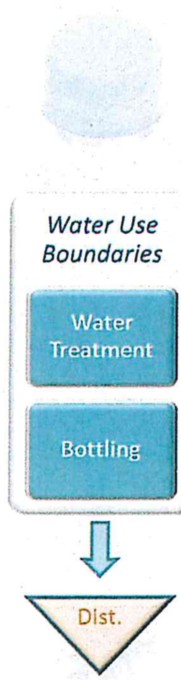
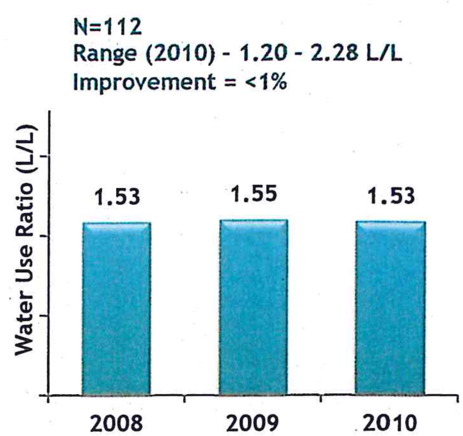


Figure 6: Bottled Water Performance



Brewery

For the purposes of the benchmarking study, a brewery was defined as:

> *A facility conducting all processes after the malting process to produce beer (mashing/lautering, boiling, fermenting, aging, and packaging).*

All breweries in this study conducted bottling operations on site; a small number also shipped product off site in bulk containers to a separate bottling facility. Breweries may have also produced other beverages (carbonated soft drinks, bottled water) in addition to beer, but in all cases, the majority of beverage product mix was beer.

Brewery (beer only) facilities accounted for 24 percent (by volume) of the industry data set, the second largest facility type of the study. As seen in Figure 7, benchmarking accounted for all process steps except for upstream agricultural growth, malting and distribution of finished product.

In 2011, 244 breweries were included in this beverage category study set. Of these breweries, 211 manufactured beer only, while 33 facilities produced other beverages in addition to beer. Figure 8 presents the water use ratios of the 211 facilities that produced beer only. The range in water use ratios observed in the brewery data set can be attributed to several factors, including:

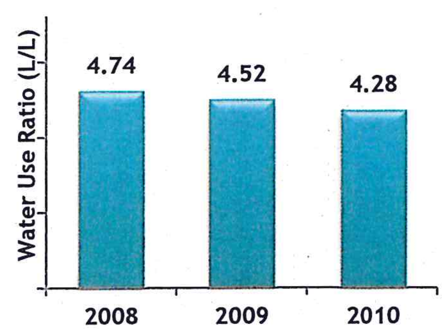
- package type (e.g. smaller packages - 12 oz. bottles - tend to require more water use than larger packages, like kegs) and
- facility size (e.g. facilities with larger production volumes report lower water use ratios).

Of these 211 breweries, 72 percent showed an improvement in water use ratio from 2008 to 2010. The water use ratio for breweries that produce only beer improved 10 percent from 2008 to 2010, the greatest improvement in the study.

Figure 7: Process Map, Brewery

Figure 8: Brewery (Beer Only) Performance

N=211
Range (2010) - 3.26 - 7.44 L/L
Improvement = 10%



Breweries also demonstrated a statistically significant improvement in water use ratio tied to increase in production: facilities that improved production more than 1 percent from 2009 to 2010 also experienced water use ratio decreases from 6 to 11 percent.

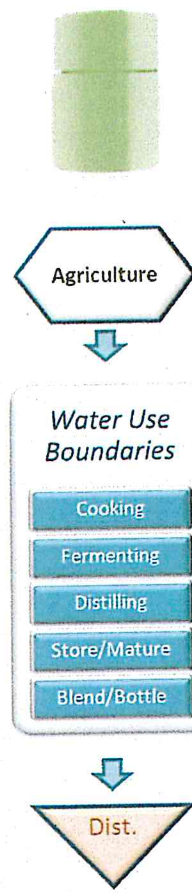
The water use ratio for breweries (beer only) improved 10% – the greatest improvement in the study.

Distillery

For the purposes of the benchmarking study, a distillery was defined as:

> *Any facility that receives agricultural inputs (grains, agave, molasses, etc.) and conducts processes (cooking, fermenting, distilling and storage/maturation) to make bulk alcohol.*

Figure 9: Process Map, Distillery



Production volume at distilleries is reported as "wine liters," or the bulk volume of alcohol produced at the facility independent of alcohol content. As seen in Figure 9, benchmarking did not account for upstream agricultural processes or distribution of finished product.

Similar to bottling facilities, distilleries produce a wide variety of products, each of which can require a different number of manufacturing processes that can impact the total water use at the facility, including differences in the distillation process itself. Facilities that produce a single product or product-type, however, experience lower water use ratios than those facilities that produce more than one type of spirit, due to reduced cleaning requirements.

Alcohol content is also a driver for water use ratio in distilleries. The spirits that result from the distilling process have a range of alcohol content; thus, a lower proof spirit has more water in the final beverage product than a high proof spirit. Additionally, due to transportation regulations and proximity to the bottling facility, some products are partially blended to a lower proof at the distillery.

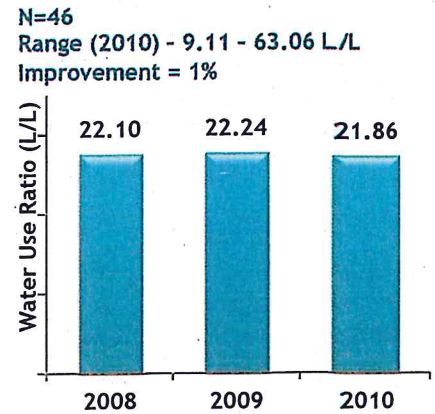
Forty-six (46) distilleries providing three years of data are included in the analyses. As seen in Figure 10, distilleries had the greatest water use ratio range in the industry data set. One of the main drivers for this range was the extensive

Cooling water use is one of the main drivers for the range of water use ratios for distilleries.

cooling water requirements of distilleries, coupled with the different types of cooling water processes. For example, a once-through cooling water system which draws from a surface water body typically uses more water than either an open recirculating or a closed loop cooling system.

Of these 46 facilities, 52 percent improved their water use ratio from 2008 to 2010. The distillery data set as a whole showed a slight improvement of 1 percent from 2008 to 2010.

Figure 10: Distillery Performance



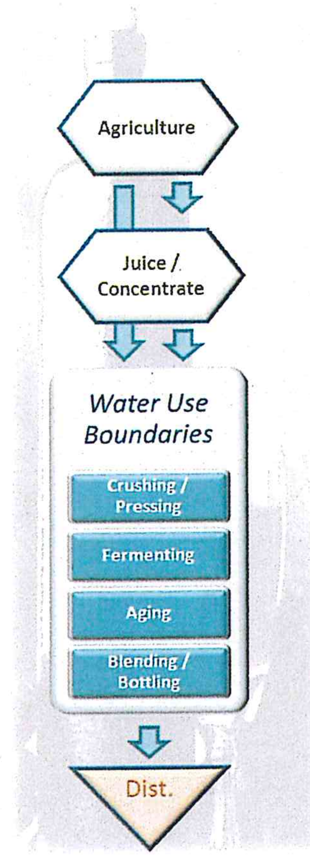
Winery

For the purposes of the benchmarking study, the scope of winery processes included:

> *The crushing and pressing of grapes, fermentation, storage/aging and bottling of product.*

As seen in Figure 11, water used for agriculture, including crop irrigation, was not included in total water use data. Water used for concentrate production and distribution also was not included in benchmarking.

Figure 11: Process Map, Winery



Wineries represented the smallest data set in the study, with 35 facilities reporting three years of data in 2010, accounting for less than 1 percent (by volume) of the industry data set. Like distilleries, wineries also had a large range of water use ratios among facilities, which was the result of: various facility sizes; type of inputs used (concentrated juice, grapes or both); and the type/blend of product (red, white or sparkling wine).

As seen in Figure 12, the winery dataset was the only major beverage category to demonstrate an increase in water use ratio from 2008 to 2010. The dataset also reported the greatest decrease in production (28 percent) from 2008 to 2010.

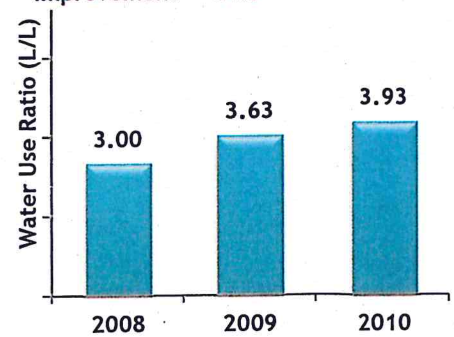
Production volume change at individual facilities showed a statistically significant correlation to water use ratio from 2009 to 2010. Similar to other facility types, most wineries that increased production from 2009 to 2010 also decreased water use ratio; however, facilities reporting production decreases of 3 percent or more also reported average water use ratio increases of up to 40 percent. This indicated that the size (or production volume) of a winery is a primary factor in determining its water use ratio.

Production volume of a winery is a key factor in determining water use ratio

***Note:** Wineries were the only major beverage category that did not improve water use ratio from 2008 - 2010*

Figure 12: Winery Performance

N=35
Range (2010) - 1.77 - 18.60 L/L
Improvement = -31%*



Water Scarcity Evaluation

In addition to the water use ratio evaluation, the 2011 report also included an evaluation of water use relative to water scarce geographies, using the World Business Council for Sustainable Development (WBCSD) Global Water Tool.[4] WBCSD roughly defines water scarcity on the basis of annual renewable water supply per person, denoting five levels of availability as defined in Figure 13.

Precise facility location data was available and used for water scarcity mapping for 1,195 of the 1,317 facilities reporting three full years of data to the study. Figure 13 presents an analysis of where efficiency improvements are being realized relative to general water scarcity indicator definitions of WBCSD. As seen in the figure, 151 facilities operate under extreme water scarcity and 164 facilities operate under water scarce conditions. These facilities comprise approximately 28 percent of the production volume represented by the 1,195 facilities.

Figure 13: Facility WUR Improvement vs. Water Availability

Annual Renewable Water Supply per Person (m3/person/year)	Number of Facilities	% Reporting WUR Improvement, 2008 - 2010
< 500	151	72%
500 - 1,000	164	69%
1,000 - 1,700	168	70%
1,700 - 4,000	287	72%
> 4,000	425	68%

In each water scarcity category, the majority of facilities reported an improvement in water use ratio from 2008 to 2010.

*The industry is making **significant improvement** in areas where water is scarce or extremely scarce*

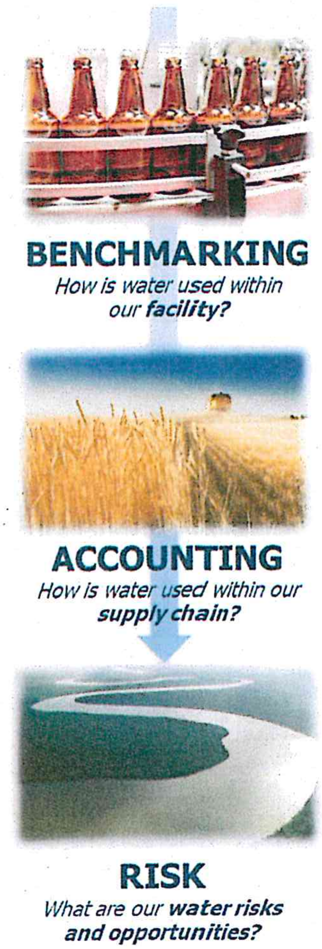
[4] World Business Council for Sustainable Development Global Water Tool (2011): http://www.wbcsd.org/web/watertool.htm

"Closing the Loop" on Water Use Efficiency

Five years of water stewardship benchmarking has provided BIER members with great insight into industry trends and performance for water used within the "four walls" of the facility. In recent years, though, the industry has also turned its attention to water use beyond the facility - quantifying water used for agriculture, package production and other aspects of the value chain, as well as examining the impact of production water use on regional resources, community partnerships, and local regulations.

Through these studies and best practice sharing, BIER members have begun to formulate a pathway of full circle water use quantification - a way to "close the loop" on water use by recognizing water use, consumption, risks and opportunities that reside along the complete value chain. BIER's sector leading initiatives include:

Figure 14: Full Circle Water Use Quantification



- **Benchmarking:** Water stewardship benchmarking is an important primary step in water use quantification. BIER members have conducted the study for five years and the intent is to continue to benchmark and identify new areas of facility-level information that could lead to new opportunities for improvement within production and bottling operations. Sharing of water reduction and conservation best practices will also continue into the foreseeable future.

- **Accounting for Water Use:** In December 2011, BIER released *A Practical Perspective on Water Accounting in the Beverage Sector*,[5] a guidance document designed to assist industry leaders in establishing consistency when conducting water footprint studies on their product(s). The document presents suggested approaches to water footprinting, guidance on how to set water inventory boundaries (indirect and direct water consumption), and data reporting requirements (transparency, alignment, data limitations and verification).

- **Water Risks and Opportunities:** BIER members have moved beyond mere quantification of water use and consumption along the value chain to instead assessing the physical, social and regulatory risks and impacts. To aid in these efforts, a BIER working group is currently preparing a water risk guidance document for member use. The document will evaluate existing assessment tools in detail, provide insight on what can be done to capitalize on opportunities or mitigate risks, and highlight case studies on risk management and opportunity development. The guidance document will be applicable both to companies who have not

---

[5] *"A Practical Perspective on Water Accounting in the Beverage Sector." Beverage Industry Environmental Roundtable, December 2011.*

completed risk and opportunity assessments, as well as to those who have already begun the process. BIER aims to have this document available in late 2012.

Next Steps

Five years of water stewardship benchmarking has provided BIER with exceptional insight into trends and figures that are now shared with external stakeholders. The 2011 study identified an overall improvement in industry-wide water use ratio, as well as within three of the four main facility types. BIER members also demonstrated significant water use improvements in water scarce operations. BIER members continue to improve upon the benchmarking study, identifying new process trends to analyze and new opportunities for best practice sharing to drive improved water stewardship practices across the complete value chain.

BIER plans to work with member companies to continue the annual water use benchmarking and to improve the quality and depth of data collected, adding an energy benchmarking component to the study in 2012. Acknowledging the importance of transparency, BIER plans to continue publishing select results of the benchmarking study to external stakeholders on an annual basis.

About the Beverage Industry Environmental Roundtable

The Beverage Industry Environmental Roundtable (BIER) is a technical coalition of leading global beverage companies working together to advance environmental sustainability within the beverage sector. Formed in 2006, BIER aims to accelerate sector change and create meaningful impact on environmental sustainability matters. Through development and sharing of industry-specific analytical methods, best practice sharing, and direct stakeholder engagement, BIER accelerates the process of analysis to sustainable solution development. BIER membership is listed in Figure 15.

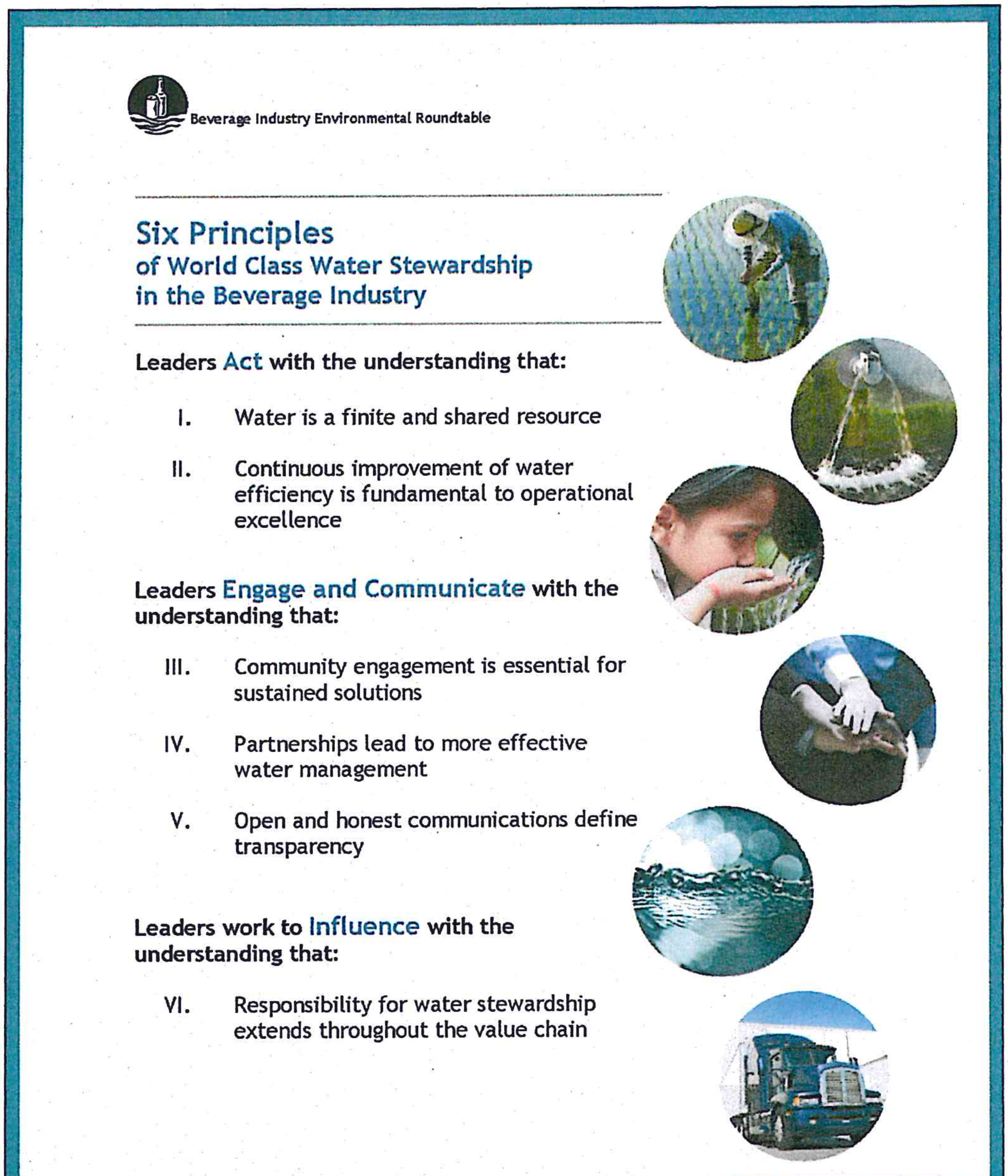
Figure 15: BIER Member Companies, 2011

BIER developed six principles of World Class Water Stewardship in the Beverage Industry (Figure 16) to help guide the beverage sector in pursuit of excellence in water stewardship. [6] Annual water use benchmarking supports Principle II and is designed to allow for the measurement of water use-reduction efforts.

Additional, recent BIER accomplishments include: the development of "Beverage Industry Sector Guidance for Greenhouse Gas Reporting", "A Practical Perspective on Water Accounting in the Beverage Sector", "Impacts and Dependencies of the Beverage Sector on Biodiversity and Ecosystem

[6] *World Class Water Stewardship in the Beverage Industry 2010: Water Efficiency and Beyond*, Beverage Industry Environmental Roundtable, November 2010.

Services: An Introduction", Beverage Category Greenhouse Gas Modeling, 5th Annual Water Stewardship Benchmarking Study, and dialogue initiatives with several trade, NGO and customer organizations to name a few. For more information, visit http://www.bieroundtable.com.


Beverage Industry Environmental Roundtable

Six Principles
of World Class Water Stewardship
in the Beverage Industry

Leaders Act with the understanding that:

I. Water is a finite and shared resource

II. Continuous improvement of water efficiency is fundamental to operational excellence

Leaders Engage and Communicate with the understanding that:

III. Community engagement is essential for sustained solutions

IV. Partnerships lead to more effective water management

V. Open and honest communications define transparency

Leaders work to Influence with the understanding that:

VI. Responsibility for water stewardship extends throughout the value chain

Figure 16: Six Principles of World Class Water Stewardship in the Beverage Industry

Addendum Three: Time Magazine Coverage of Tropicana's Alternative Fertilizer Pilot

Tropicana: Trying to Make a Greener Orange Juice

By **BRYAN WALSH** Thursday, Mar. 11, 2010

Newsfeed

- Culture Icons: The Portraits of Yousuf Karsh
- Who Is James Holmes, the Aurora Shooting Suspect?
- Reading While Eating for July 20: To The Moon

More on TIME.com

Oscar De La Renta at 80

Top 10 Things You Probably Didn't Know About Batman

John Wigmore / AgStock Images / Corbis

Correction Appended: March 12, 2010

How green is your orange juice? A couple of years ago, PepsiCo, which owns the orange-juice brand Tropicana, tried to size up the carbon footprint of the popular morning tonic. It found that each half-gallon carton of OJ is responsible for 3.75 lb. of CO_2.

What was particularly surprising was where much of that CO_2 was coming from. The single biggest contributor to Tropicana's carbon footprint wasn't the transport of the juice to stores or the energy required to operate a modern citrus farm. Rather, it was the fertilizer used to grow the orange trees. A great deal of natural gas is used to make nitrogen fertilizer, and a great deal of fertilizer is used on citrus trees — so much that fertilizer accounted for 35%, the largest share, of the carbon footprint of orange juice. "We thought it might be transport or packaging," says Tim Carey, director of sustainability and beverages for PepsiCo. "But the agricultural aspects of the operation are more

Most Popular » Full List »

MOST READ | MOST EMAILED

1. Olympic Uniforms: The Best, the Worst, and the Just Plain Weird
2. The Syrian Army Strikes Back: Eyewitness to Assad's Retaliation on a Rebel Town
3. How the Changing Monsoon Is Changing India
4. 50 Best Websites 2010
5. Why Romney Should Resist Calls to Release His Tax Returns
6. TIME's Review of The Dark Knight Rises: To the Depths, to the Heights
7. Counterpoint: Romney Should Totally Release His Tax Returns!
8. The Laser Beam 1,000 Times as Powerful as the U.S.
9. No Fading Away For MacArthur Over Here
10. Found: the Prettiest Baby Galaxy Ever

More News from Our Partners

Slate

- Blogging the Human Genome

important than we expected."
(See the top 10 green ideas of 2009.)

To make a greener orange juice, PepsiCo needed a greener fertilizer — and that's exactly what the company is experimenting with. Working with a pair of agricultural companies — Yara International and Colorado-based Outlook Resources — PepsiCo will test low-carbon fertilizers at one of its producer farms in Bradenton, Fla. If successful, the greener fertilizers could lower the carbon footprint of PepsiCo's citrus growers by as much as 50% and reduce the total carbon footprint of Tropicana orange juice by up to 20%. Given how much fertilizer is used throughout the U.S. farming system as a whole — more than 13 million tons of nitrogen in 2007 alone — a greener way to help plants grow could put a serious dent in U.S. carbon emissions.

Inorganic nitrogen fertilizer — the sort used by most farms in the U.S. — is made through the Haber-Bosch process, which fixes nitrogen to make ammonia, which is then used to make the nitrates and other chemicals that feed plant growth. It requires a lot of natural gas to help make the ammonia; agriculture eats up as much as 5% of global natural-gas consumption. As a fossil fuel, natural gas has a high carbon content, which means nitrogen fertilizer has it too. (Conventional fertilizer also releases nitrous oxide, a greenhouse gas that has about 300 times the warming power of CO_2.) The need for natural gas also puts a strain on farmers; fertilizer prices are closely linked to natural-gas costs, leaving farmers vulnerable to huge price swings, especially if gas begins to be used more frequently for electricity. "It's something we always have to worry about," says Mac Carraway, who runs SMR Farms in Bradenton, which is hosting PepsiCo's fertilizer trial.

Yara and Outlook Resources are trying to cut carbon by reducing the need for natural gas in their fertilizer. Yara, the world's largest fertilizer company, is experimenting with calcium-based fertilizer that would almost completely eliminate nitrous oxide emissions, cutting its overall greenhouse-gas impact. The company is also working on improving the energy efficiency of its production plants, which further cuts the carbon attributed to its fertilizer. "The fact is, we now have the technology to reduce emissions," says Sandro Pippobello, director of premium offerings at Yara North America. "We think this can work for a variety of crops, especially high-value ones."
(See pictures of the world's most polluted places.)

Outlook Resources, by contrast, looks to make fertilizer through more renewable resources, eschewing imported natural gas in favor of organic, locally sourced feedstocks. The local sourcing helps cut the carbon emissions associated with transport, while the use of organic and renewable feedstocks like biofuels cuts carbon emissions further. Outlook also claims that its fertilizer is more efficient, so less of it has to be used — which helps prevent the water pollution associated with fertilizer runoff. "Eighty percent of the fertilizer in the U.S. is imported," says Scott Dyer, the chief of scientific solutions for ERTH Solutions, which is making the fertilizer for Outlook. "Local sourcing is a food-security issue."

PepsiCo will use the two alternative fertilizers for a multiyear pilot study at SMR Farms to see whether the switch could cut Tropicana's carbon footprint without losing crop yield, which would raise overall costs. If the study is successful, PepsiCo might be able to start using greener fertilizers throughout its agricultural supply chain, which could have a major impact on U.S. farming and the corporation itself. And if natural-gas costs rise in the future, which is a serious possibility if utilities come under pressure to switch from cheaper but more polluting coal, it could help cut costs. "There have to be commercial advantages as well," says Carey. "But sustainability is ultimately about being a better company."

The original version of this article misstated that more than 13 billion tons of nitrogen were used in fertilizer in the U.S. in 2007. In fact it was 13 million tons.

See TIME's Pictures of the Week.

See the Cartoons of the Week.

We Recommend


Biden: “We Will Not Do It Their Way Again”


The Value of Google Earth’s Antarctic Expedition

Police: 14 Dead in Colorado Theater Shooting


Next-Gen iPhone Images Leak as Tim Cook Drops a Hint

PRINT | EMAIL | REPRINTS | SHARE

Techland

- The Ten Most Influential Women in Technology
- With Lawsuit Settled, New iPad Goes On Sale in China
- Sports Illustrated Olympics iPad App Now Available

Moneyland

- The "Action Gap": Why Workers Refuse to Save More for Retirement
- Olympic Scammers Go for the Gold as Games Near
- Would You Pay $520 in Interest to Borrow $375? 12 Million Americans Did Last Year

Top Stories on TIME.com


At Least 12 Dead, Dozens Injured, in Shooting Rampage at Colo. Movie Theater


From Kim Polese to Marissa Mayer — Women in Tech Have Come a Long Way


Why Romney Should Resist Releasing His Tax Returns

Opinion

- Breaking Bad and the Downfall of the White 'Anyman'
- Why Bain Matters
- Why I'm Standing By Huma Abedin

Addendum Four: Summary of Casa Grande "Near Net Zero" Plant Progress

Casa Grande

Near Net Zero

Frito-Lay North America is committed to demonstrating Performance with Purpose through delivering sustainable growth by investing in a healthier future for people and the planet. Since 1999, Frito-Lay has implemented conservation programs that utilize innovative approaches and technologies to reduce the resources needed to make its products. These efforts have been recognized by national, state and local organizations across the country.

A few years ago, Frito-Lay set out on an ambitious mission to transform an existing facility so that it would run primarily on renewable energy sources and recycled water while producing nearly zero waste. We called this effort "near net zero." We chose the Casa Grande, Arizona facility because of its location, where sunlight is plentiful and water conservation is important, and its size – big enough to be effective, yet small enough to be manageable. Frito-Lay invested and implemented a combination of technologies to enable Casa Grande to significantly reduce the use of key natural resources and reduce the site's overall environmental footprint.

Using innovative technologies, our Casa Grande facility is generating 2/3 of all energy used from renewable sources and is working towards significant reductions:

75% of water is recycled

50% reduction of greenhouse gases

80% reduction in the use of natural gas

LEED

In October 2009, Frito-Lay Casa Grande became the company's, the State of Arizona's and the U.S.'s first snack food manufacturing facility to be certified LEED 2.0 Existing Building Gold.

Fun Facts

- Built in 1984, the Casa Grande facility employs more than 350 associates.
- Casa Grande produces about 100 million snacks a year, including Lay's and Ruffles potato chips, Doritos and Tostitos tortilla chips, Crunchy Cheetos cheese snacks, Fritos corn chips and SunChips multigrain snacks.

Renewable Steam

- The newly installed 60,000 lb/hr biomass boiler, which uses wood and agriculture waste as its combustion energy source, will produce all the steam needed for the manufacturing plant and reduces natural gas use by over 80%.
- The biomass boiler uses 4,000 lbs of wood waste per hour

Renewable Electric

- Five separate and distinct solar photovoltaic (PV) solar fields, installed throughout the property, produce nearly 10 million KWHs of electrical power.
  - Two solar fields of single axis tracking PVs with more than 18,000 solar panels were installed on 36 acres of the facility's agriculture property.
  - The three additional PV fields installed by the plant include: a dual axis tracking system, a single axis covered parking lot and 10 sterling engine dual axis tracking systems.

Zero Landfill

As of 2010, the facility sends less than 1% of their overall waste to landfill, through extensive recycling and reusing food waste for cattle feed.

Recycled Water

- Installed in July 2010, the water recovery / reuse facility combines Membrane Bio Reactor (MBR) and Low-Pressure Reverse Osmosis (LPRO) technology to recycle from 50% to 75% of process water.
- All recycled process water used in the facility meets EPA primary and secondary drinking water standards.

Addendum Five: Columbia University Earth Institute Gujarat White Paper

Columbia Water Center
EARTH INSTITUTE | COLUMBIA UNIVERSITY

2011
INDIA
AGRICULTURE

COLUMBIA WATER CENTER WHITE PAPER

Addressing the Water Crisis in Gujarat, India

March 2011

Kapil Narula
Ram Fishman
Vijay Modi
Lakis Polycarpou

Columbia Water Center
EARTH INSTITUTE | COLUMBIA UNIVERSITY

Addressing the Water Crisis in Gujarat, India White Paper

March 2011

Columbia Water Center
Earth Institute, Columbia University

Columbia Water Center gratefully acknowledges the support of the PepsiCo Foundation in carrying out this work.

Columbia Water Center's mission is to creatively tackle the issue of global water through innovations in technology, public policy and private action. Combining the rigor of scientific research with the impact of effective policy, we aim to design reliable, sustainable models of water management and development that can be implemented on local, regional and global levels.

Columbia Water Center
500 W 120th St, S.W. Mudd Room 842, New York, NY 10027
212-854-1695 watercenter@columbia.edu
http://water.columbia.edu

TABLE OF CONTENTS

ABSTRACT

This paper presents the results of the Columbia Water Center's study of the severe groundwater crisis in the Mehsana region of Northern Gujarat, India. The study concludes that the current pattern of groundwater exploitation is both costly for the state and unsustainable for farmers, and could lead to the complete failure of agriculture in the area within a few years if left unchecked.

The study, funded by the PepsiCo Foundation, was conducted as the first phase of a CWC project to design more sustainable policy options to help conserve water and energy while improving farmer incomes in North Gujarat; future papers will outline the initial outcomes of the area pilot project along with resulting recommendations for policymakers in the area.

INTRODUCTION

Over the last several years, scientists have grown increasingly alarmed about the depletion of groundwater in many parts of India. However, even in a country with severe, widespread looming water shortages, the case of North Gujarat stands out.

For more than three decades now, the farmers of North Gujarat have been productively utilizing the rich groundwater resources of the region in order to cultivate a variety of crops and a thriving dairy industry. The state of Gujarat (along with the Government of India) has also played its role in supporting this enterprise by providing these farmers with a variety of subsidized inputs, including reliable electricity for pumping groundwater as well as marketing and price supports.

Unfortunately, because of the low levels of natural recharge of local aquifers, groundwater tables have fallen steadily throughout the same period. The groundwater situation is now so dire that the future of agriculture in North Gujarat is in jeopardy. Farmers are the first to suffer, as they must continually invest in deeper wells and more powerful pumps to irrigate, but nonetheless face a decline in both the quantity and quality of the water they are able to pump.

The effect of acute water shortages goes beyond immediate impacts on farmers, however. Under the current subsidy system, each year the government is forced to finance increasing amounts of expensive electricity for irrigation pumping, even as the benefit of pumping for farmers stagnates or declines as the amount of water available decreases. In addition, high consumption of electricity for irrigation puts pressure on the electrical grid and reduces available electricity for other sectors.

This situation is not unique to North Gujarat. Many parts of India where agriculture is dependent on groundwater are or will soon be facing similar problems. However, the situation in this part of Gujarat is extreme. While the severity of the situation in North Gujarat places great pressure on Gujarat's farmers and the energy sector, it also provides the state with an opportunity to not only reverse the trend, but to also show the way forward for the rest of the country.

For the initial phase of its Gujarat project, the Columbia Water Center conducted an analysis of the water crisis in the Kukarwada sub-district in the Mehsana region. The study included a detailed survey of farmers and well operators in the region, along with an analysis of local hydrology, current energy policy and the potential for combining new incentive structures with water-saving technology to stabilize or reverse groundwater depletion in the region.

We have identified enormous potential for improvements in water and energy use that can generate very large reductions in energy costs while maintaining food production and farmers income.

For example, a water savings of 30% through well established technologies and practices can allow the power utility in North Gujarat (UGVCL) to free up as much as 2.7 billion units of electricity for use in non-agricultural sectors, and would reduce groundwater extractions by a corresponding amount.

Our survey results indicate that farmers in the area possess considerable openness and interest in adopting new, more water and energy efficient irrigation practices. Despite the potential, however few farmers have adopted these technologies and practices to date. We believe that the missing ingredient is a proper incentive structure that could dramatically accelerate the rate of adoption and the modernization of agriculture in Gujarat.

STUDY REGION

The study region covers a total geographical area of 180 sq. km. It forms a part of two districts: Mehsana and Gandhinagar, and three talukas (counties), Vijapur, Visnagar (in Mehsana district) and Mansa (in Gandhinagar district).

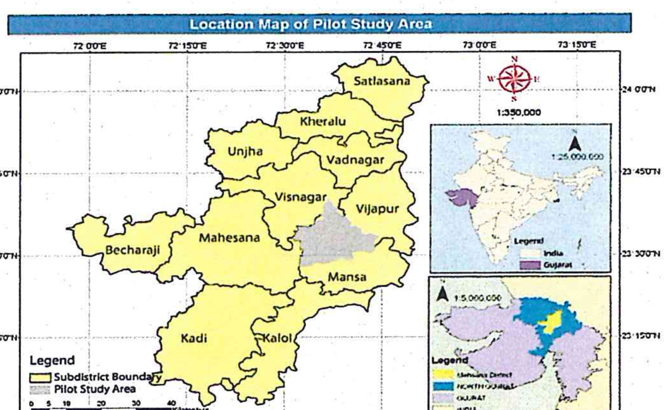


Figure 1. Extent of study region (shown in shaded grey)

Mehsana district is characterized by hilly upland in the northeast, followed by shallow alluvium and residual hills, rolling to a gently sloping vast, sand and silt tract, alluvial plains in the southwest. Alluvial plains are the single most prominent geomorphic unit and cover the major part of the district.

The region has a semi-arid climate characterized by extreme temperatures, erratic rainfall and high evaporation (potential evaporation is more than twice the normal annual rainfall). Over 90% of the annual rainfall occurs during the southwest monsoon period between June and September. July and August are the wettest months, receiving more than 70% of the annual rainfall. The mean annual rainfall is around 738 mm. The year-to-year variability also ranges from 45 - 50%. The district experiences agricultural droughts (defined as 25 – 50% negative departure of annual rainfall from mean annual rainfall) almost every third year. Severe and rare droughts (defined as 50 to 75% and more departure from annual mean) have an average recurrence interval of five to six years.

This part of India, like many others, experiences decadal shifts in rainfall, so one can be deceived by a decade of higher rainfall, followed by significantly lower rains for multiple years as seen in the figure below. The area is currently in a period of high rainfall.

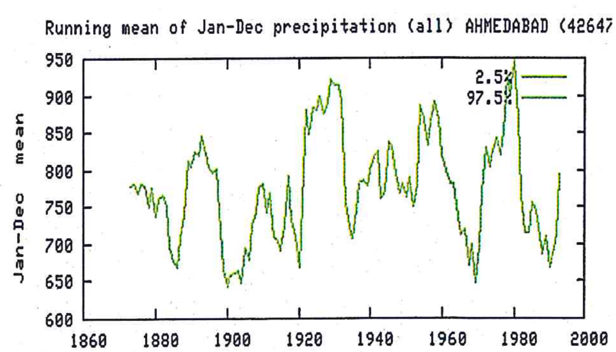


Figure 2. Rainfall in the study region

Agriculture accounts for around 90% of the total water use followed by domestic and industrial water use. More than 80% of the land area is under cultivation. Of the total area under cultivation, around 65 -70% is irrigated. Net area irrigated in the study region is estimated to be around 10,000 hectares. Almost 55 – 60% of the working population is engaged in agriculture and agro related activities.

FARMER AND WELL OPERATOR FIELD SURVEY

To more accurately assess the groundwater situation in the region, Columbia Water Center designed and commissioned a detailed survey of irrigation water use in the area. The survey was conducted by the Taleem Research Foundation.

The survey centered around 170 tube-wells used for irrigation in the area; a single well can service a number of farmers. Well-operators (most of whom are also farmers) were the principal respondents, although the responses of other farmers at the well at time of the interview were also recorded.

Respondents were asked about their perceptions of the groundwater situation, energy use, frequency and amount of irrigation, agricultural practices (cropping schedules, crop preferences, major constraints to crop production) among other questions.

In addition, the team coupled results from energy data that UGVCL (the local power utility) agreed to share for the purpose of the study. The study area consisted of 22 feeders, totaling about 700 customers. These measurements allowed the team to determine accurate baseline usage. Finally, results of the survey and energy data were integrated with regional data about water use taken from observation wells.

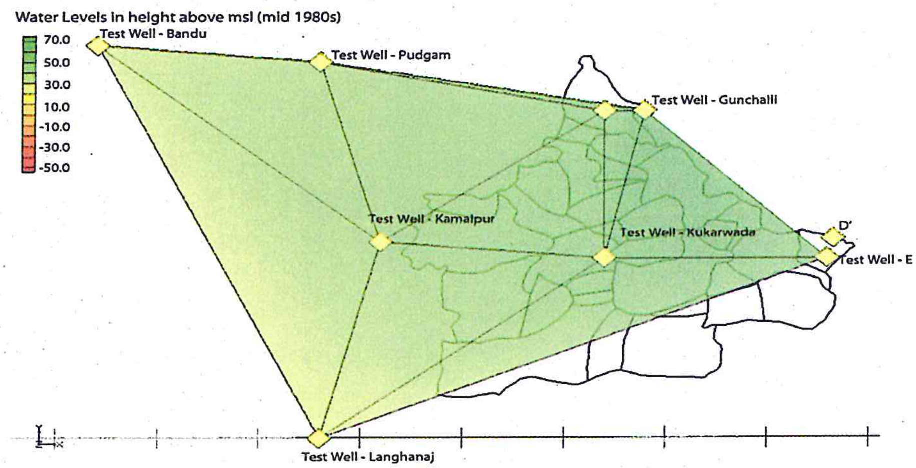
SUMMARY OF FINDINGS

Water tables in the study area have been falling steadily over the last 15-20 years, and have reached about 600ft below ground level, risking irreversible salinization of aquifers. The declining trend is seen in observation wells and confirmed by farmers' own recollection of water depth. The rate of decline is anywhere between 9 feet per year (based on observation wells) to 20 feet per year (based on farmer recollections).

Furthermore, this steep decline has occurred during a relatively wet period. In the next decadal period of low rainfall this rate could more than double, especially if farmers increase cropping intensity.

> 82% of wells reported the appearance of salt in their water over the last 5-15 years.

In much of the study area, water levels are either approaching or already below mean sea level, which increases the risk of intrusion of saline or brackish water, an irreversible transition that could end agriculture in the area. In our sample, 82% of wells reported the appearance of salt in their water over the last 5-15 years. Other changes in water quality include increasing temperature (reported by 52%) fluoride (30%) and dust (30%).



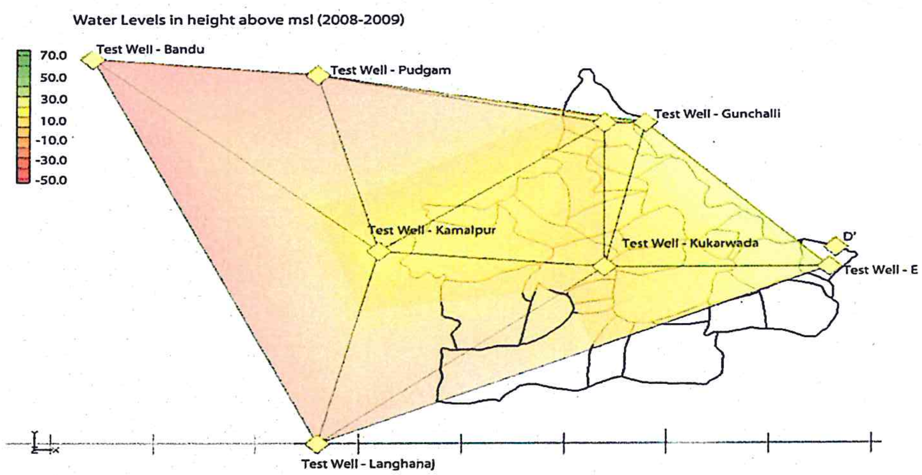


Figure 3. The two maps show groundwater levels obtained from test wells in the study area (outlined). Colors show the estimated average groundwater level between the different test well points. The first map shows data from the mid-1980s; groundwater at that time was mostly above sea level. The second map from the same area in 2008 and 2009 shows a groundwater level that has already dropped below the average sea level for much of the area. Where groundwater drops below sea level, there is a greatly increased chance for saltwater to enter underground aquifers and contaminate wells.

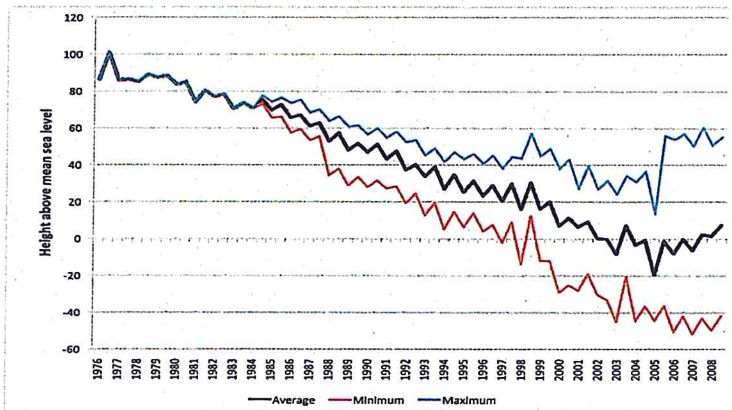


Figure 4a. Declining water tables. Water table dropping by an average of 9 feet per year, based on data from observation wells. The water table rises during Monsoon, drops between monsoons, with drop generally larger than recharge.

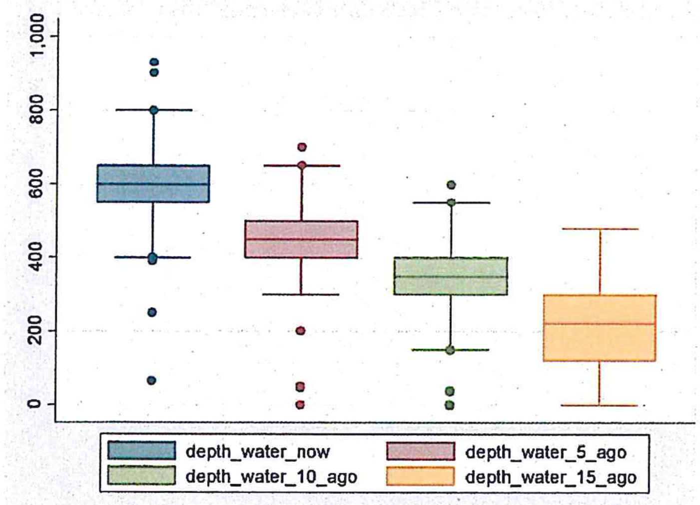


Figure 4b. Farmers themselves report an even steeper ongoing decline of 20 feet per year.

Farmers are adversely influenced by the falling water tables. They need to continuously drill deeper wells and buy more powerful pumps. Based on our surveys, a conservative annualized estimate of these costs amount to Rs 5,000 per hectare. Although the horsepower usage and the depth of wells have increased dramatically over time (Figure 2), an average well can now irrigate only about 60% of its command area during the Rabi, or winter-crop season. Farmers recall a significant increase in the number of hours needed to irrigate a single unit of land since they installed their current pump. Furthermore, nearly all respondents expected the water table to continue its decline, and on an average expect water to last for about six years. Once that happens, farmers plan to deepen their wells (30%), migrate (30%) or restrict crop cultivation to the rainy season (20%). More than half of farmers in the area plan to abandon irrigated agriculture.

Energy use appears to have increased over the last two decades without a matching increase in irrigated area. In other words, the "drop per unit of energy consumed" continues to deteriorate.

A simple calculation based on the water requirement during the Rabi (winter) season for wheat suggests that the energy required to lift water from the current average depth is about 8,000 kilowatt hours per hectare. Our survey results suggest that the motors used for pumping are such that nearly 10 horsepower capacity is installed per hectare of irrigated land.

If this capacity were operated for eight hours of electric supply hours per day, the energy needed would be about 6,000 kWh of electricity during the winter-crop season. (Energy consumption data from feeders in the study area suggest a value about 20% higher. A 20% higher reading on the utility side is indeed quite plausible if one takes into account the distribution losses and possible under-reporting of horsepower from the survey.)

While data on energy use is not available to us over a significant time scale, the increase in horsepower over time suggests a significant increase in energy use over time. This is consistent with the fact that the water table has fallen precipitously, which increases the amount of energy needed to lift a given amount of water.

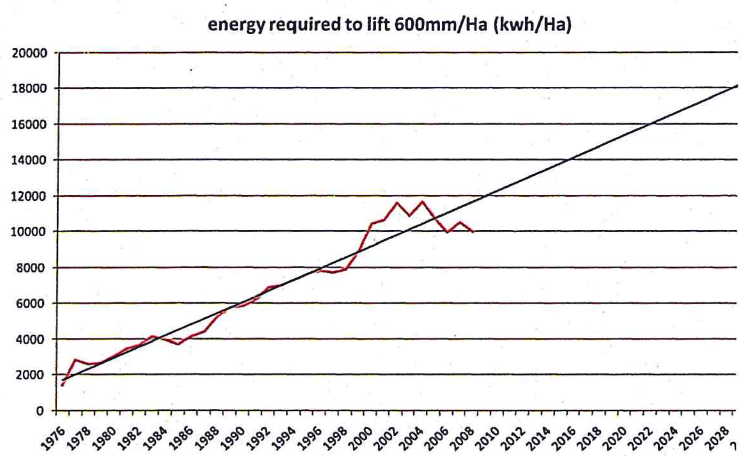


Figure 5. The increase in the amount of energy needed to pump the same amount of water.

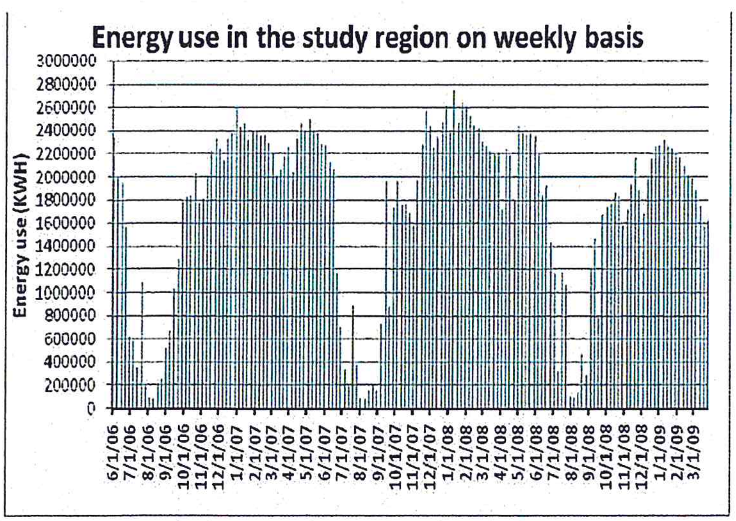


Figure 6. Energy use peaks during dry periods

At depths from which groundwater is currently extracted, tubewell irrigated agriculture as practiced today is probably not financially viable. If farmers had to pay for the energy used, they would find it unprofitable to engage in agriculture. It is estimated for the study region that the utility provides about 10,000 kWh of electricity per hectare over the year, worth about Rs 40,000 per hectare. (By contrast, the average kWh per hectare for India as a whole is 1,600 kWh per hectare).

The utility currently recovers on average roughly Rs 10,000 per hectare through flat horsepower-based tariffs, representing a subsidy of about Rs 30,000 per hectare.

We estimate the net income from crops to be about Rs 20,000 per hectare per year, which suggests a net economic loss of Rs 10,000 per hectare. Livestock-based gains could increase the income figures from this value, but are unlikely to change the overall equation.

> After applying the energy subsidy, our study suggests a net economic loss of Rs 10,000 per hectare.

Even with heavy subsidies for electricity and purchase support, farmer income has stagnated. Farmer livelihoods and their evolution were studied in detail by looking at what was cropped and the reported yields of major crops, including both food and non-food or cash crops. Along with market prices collected from APMC (agriculture produce marketing commission) it was possible to estimate crop derived agricultural income per hectare for the study region.

Income was estimated by assuming a hypothetical hectare on which the representative mix of crops grown in the county is farmed. Using the annual evolution in this mix, the crop yields and market prices, we computed the gross revenue from agriculture on this hypothetical hectare. The time series of this evolution is shown in Fig. 7 both in real terms and in inflation adjusted terms, for years 1990-91 to 2008-09. Based on the crop mix and the crop water requirements, the evolution of the water needs per hectare is also shown in Fig. 7.

Crop	Area (hectares)	Crop	Area (hectares)
Cotton	1820	Castor	424
Wheat	1200	Potato	991
Bajri	615	Jowar	528
Winter fodder	287	S.fodder	85
Tobacco	413	Fruits	180
Vegeta-bles	60	Others	7

Table 1. Major crops grown.

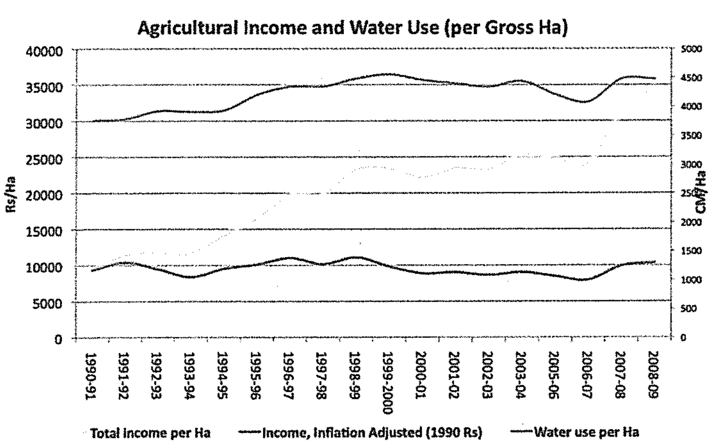
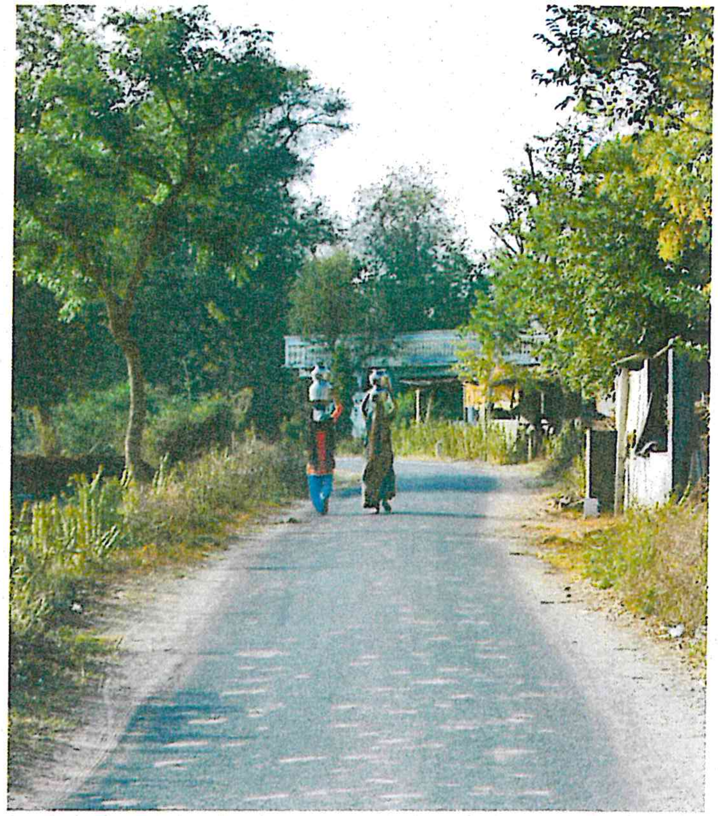


Figure 7. Farmer income trends.

The results reveal that modest yield increases combined with growing more cash crops does generate more income, but when adjusted for inflation that increase in income is not dramatic. Real physical income seems to be more or less stagnant, at least on a per-unit irrigated land basis. (Agricultural income could potentially still be increasing through the expansion of irrigated area, income from livestock through the domestic use of fodders or other factors not captured in our estimates. The important point is that real, direct revenue from irrigated crops has not risen significantly).

Potential practices and technologies do exist to increase water and energy use efficiency, but they are, with few exceptions, not adopted in the study area. Promising technologies and techniques exist for saving energy and water, but survey results show that these technologies are overwhelmingly not adopted in the study area. For example, only 9 out of 136 wells surveyed make any use of drip irrigation or sprinklers. The main reasons farmers give for lack of adoption are high cost (mentioned by 60% of farmers), land fragmentation (23%) and lack of familiarity (16%).

Broader effects. As deeper wells accelerate the use of electricity, the state will have to make attempts (some of which it is already undertaking) to cap the subsidy amounts to the utility. It is not clear whether a greater investment in improved dissemination of technology, additional localized research and creating improved market conditions for high value crops alone could stabilize or reverse groundwater depletion. However large expenditures by the state to subsidize water and electricity consumption could be crowding such investments.



CONCLUSIONS

Farmer and well operator surveys confirm what many observers knew already—that the groundwater crisis in North Gujarat is severe and likely to get worse.

Farmers are already suffering, with as many as half of those surveyed saying that they plan to give up irrigated agriculture at some point in the near future. On a per unit land basis, farmer incomes have stagnated as well.

Furthermore, the cost of electricity now required to pump water from increasing depths is so high that it would render agriculture unprofitable if not for government subsides. The depletion of groundwater has turned agriculture into a net economic loss for the state of Gujarat, a situation that can only get worse if current trends continue.

Perhaps most alarming, continued depletion of groundwater resources for irrigation at the current rate creates the risk of permanent saltwater intrusion into aquifers, a development that would put an end to agriculture in the area.

However, numerous technologies and practices that could save significant amounts of water and energy already exist, and farmers surveyed showed considerable interest in applying them, as long as they have the needed support. Such support could come in the form of greater extension outreach and research on water-saving technologies, but will most likely require a new incentive scheme that will reward farmers for water conservation without costing the state money.

Such a scheme offers the potential for a long-term win-win change for farmers and the utility, through a reduction in water use that does not compromise farmers' income. This would slow (stabilize or even reverse) the decline of the water table and preserve the vibrant agriculture of the region.

In partnership with local partners and with financial support from the PepsiCo Foundation, the Columbia Water Center is designing and implementing a pilot program in Gujarat to provide farmers with a financial incentive to conserve water and energy while supporting them to implement conservation technologies.