Drinking Away the Future
Policy Solutions for a Sustainable Water Supply in the U.S.

Jennifer Fernandez
Kyle Hayes
Kavita Mak
Clint Silvey
David Trigaux

March 13, 2015

Acknowledgements:
Daniel Puskin
Kevin Nesline
Sonja Walti
Karen Baehler
Daniel Fiorino
Morgan Gopnik
Jillian Berk
Alexandra Resch
Kiri Anderer
Executive Summary

The sustainability of the U.S. water supply is fraught with challenges and inefficiencies. This paper addresses various facets of this problem with three primary policy alternatives. First, we propose that the federal government implement governance and pricing changes that facilitate widespread conservation. Second, we propose that consumers receive tax credits and information to curb household water use. Finally, we propose new financing mechanisms to encourage infrastructure upgrades and adoption of new irrigation technologies to reduce water consumption in both urban and agricultural areas. These three alternatives would be most beneficial if implemented together in a comprehensive solution—changes to the governance and pricing structure of water in the first alternative would multiply the impacts of second and third alternative.

An Overview of Water Scarcity Issues in the United States

Droughts and higher temperatures caused by climate change, coupled with increased water demand due to rapid population growth, are expected to severely diminish available supplies of water in many areas throughout the United States (Figure 1). In the face of multiple challenges, the U.S. system for allocating water is filled with inefficiencies that promote waste and discourage conservation, limiting the sustainability of this vital resource. Future supply of water is inadequate, unreliable, and costly unless we intervene with appropriate policy solutions.

Figure 1: Heat map of water sustainability risk in the United States

Issues increasing the need for action

Population growth and climate change-induced droughts are expected to severely diminish available supplies of water in the U.S. Climate change includes major changes in temperature, precipitation, and wind patterns, impacting water distribution and availability.\(^2\) In recent years climate change has had a significant effect on precipitation levels. For instance, in the southwest, widespread droughts occurred in 2002, 2003, 2007, and 2009 and during these years annual precipitation was roughly 25 percent below the 20th century mean.\(^3\) In addition, the projected demand for water will grow over time. The U.S. population is currently 321 million and is expected to grow to over 370 million by 2035 and near 400 million in 2050.\(^4\) But, the growth is not happening evenly throughout the U.S. Between 2000 and 2010 drier regions experienced higher growth rates, and some states in the Southwest grew at nearly double the
national average.\textsuperscript{5} If these trends continue, water policy will need to account for an overall decrease in water supply with growing demand over time.

\textbf{Consequences of Inaction}

Available drinking water supply comes from two different sources—surface water and groundwater—and both of these sources are at risk of a shortage in areas of the U.S. in the next 20 years.\textsuperscript{6} In recent years there has been a trend of declining surface water sources in drier regions of the U.S. Water levels in Lake Mead, the largest reservoir by total capacity in the U.S., have been steadily declining; in 2000 the average annual water level in the lake was 1204 feet compared to only 1088 feet in 2015.\textsuperscript{7} Depletion of surface water sources shifts water use to groundwater.\textsuperscript{8} But, groundwater is only renewable if it can be recharged, either through precipitation that percolates through the soil, or manmade diversions of surface water. Some states are exceeding the rate of recharge at unsustainable levels, such as Arizona, (1.1 million acre-feet [MAF]), and California, (1.5 MAF).\textsuperscript{9} Regions experiencing depletion of surface water sources have been relying on groundwater to meet demand, but there is also a finite supply of groundwater, and this source will eventually run dry if we continue to consume water at the current rate.

The reduced supply of water from groundwater and surface water sources may have dire economic consequences. Groundwater overdraft would result in increased energy costs to pump water from lower depths. Unchecked water use in water scarce regions of the U.S. would lead to a sharp and uncontrolled increase in water prices, which would cause economic hardship for many households, particularly poor households. Additionally, significant economic impacts would be felt throughout the U.S. in rising food costs, as food production uses up to 100 times more water than drinking consumption.\textsuperscript{10} Food is also sensitive to water prices because states that are large producers of crops and livestock are also located in regions experiencing water scarcity.\textsuperscript{11}

Finally, increased water diversions from river systems would also have an effect on human health. Depleted water bodies in dry regions may increase the amount of particulate matter in the air and airborne particulates are associated with diseases like bronchitis, chronic cough, as well as acute and chronic morbidity.\textsuperscript{12} Moreover, groundwater overdraft would lead to contamination of groundwater sources, potentially impacting drinking water quality. Fertilizers and pesticides can concentrate in over-pumped groundwater sources, and this has already been a problem in agricultural regions, such as the Central Valley in California.\textsuperscript{13}

\textbf{Causes of the Problem}

\textit{Market Failure in Water Supply}

One of the root causes of water scarcity is the market failure associated with water being a common and openly accessible resource. In 1968, Garrett Hardin published an essay, \emph{The Tragedy of the Commons}, in which he argued that it is difficult to restrain the over-consumption of so-called ‘common pool resources’ such as water.\textsuperscript{14} In the case of water, it is to the advantage of each individual user to increase their consumption of water so that they benefit economically and prevent their competitors from consuming the resource. The end result is that users over-exploit the resource to the detriment of all. Federal and state governments have contended with the market failure of water supply by regulating the allocation of water as well as attaching a price to water, but these attempts have fallen short of successfully mitigating the water scarcity problem.
Institutional Failures in Water Rights Allocations

States have developed a system of water laws that govern the allocation of water, but these laws have resulted in a fragmented system of water governance, which is contributing to water scarcity issues, especially in the western states. Since water is scarcer in the West than in the East it faces greater demands to support industry and agriculture. In the West, water rights are not tied to property rights. Instead, laws that govern water allocation are based on prior appropriation rights meaning the first person to claim rights to the water owns it. In addition, in most states, groundwater use is not subject to regulation, leaving many water users to pump large volumes of groundwater with no check on over-extraction. One inefficiency with this system is that water was allocated among appropriators in a time when it was more plentiful, and allocations have not been adjusted to compensate for population growth and environmental changes that have reduced water supply. In recent years, prolonged periods of drought have strained the water supply, and under prior appropriation laws, the senior appropriator’s water rights do not diminish even when water supplies are scarce, resulting in over-allocation of available water. For instance, in three of the last eight years the lower Colorado basin exceeded its entitlement of 7.5 MAF. Other inefficiencies in the current system are restrictions on the transfer of water rights and a lack of incentives for conservation. An ideal water rights system would allow users with low marginal benefits from water use to sell their water allocation to a user with a higher marginal benefits. State governments, however, have set certain ‘preferential uses’ and created hierarchical categories of water use. Laws inhibit the transfer of water from a high preferential use category to a low preferential use category, undermining efficiency. In addition, in the current system, users must consume their full allocation of water, or risk losing it. This “use it or lose it” concept provides no incentive for users to practice water conservation, and instead encourages wasteful water use.

Inefficient Pricing Mechanisms for Water

Along with the fragmented system of water governance, inefficient pricing systems are also contributing to water scarcity problems. The price of water charged to water users is too low, and as a result the market for water fails on two counts. First, the low price of water does not account for the negative externalities of water consumption, leading water users to over-consume water, which compromises the amount of water available to future generations. Second, the price charged to consumers does not raise enough revenue to cover the long-term costs of supplying and distributing water.

The main reason water is underpriced is because of utility regulations. Most water distribution is regulated by public institutions, and often these institutions prohibit water suppliers and utilities from earning a profit. This structure requires water utilities to charge customers for only the short-run supply cost of water, which does not take into account long-term costs, such as major pipe rehabilitation and replacement costs. Additionally the low water price encourages more consumption of water than is economically optimal. In effect, the price of water facing consumers does not include the price of long-run provision of water (including extraction from more expensive sources) or the opportunity cost of other uses for water.

This pricing failure is manifest in the different pricing structures adopted across the nation. A 2002 survey of more than 150 cities indicates that residential customers typically face...
one of three pricing structures. Uniform pricing charges consumers the same amount for each
gallon used regardless of total use.

Figure 2: Prevalence of Water Rate Structure in the U.S.

<table>
<thead>
<tr>
<th>Rate Structure</th>
<th>Residential</th>
<th>Non-Residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>37.2%</td>
<td>45.9%</td>
</tr>
<tr>
<td>Increasing block</td>
<td>29.1%</td>
<td>17.6%</td>
</tr>
<tr>
<td>Decreasing block</td>
<td>30.4%</td>
<td>33.1%</td>
</tr>
<tr>
<td>Other</td>
<td>3.4%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

Two other structures, increased block and decreased block, create usage brackets and charge certain rates for usage in each bracket. In increasing block structures, customers are charged a higher rate when they enter a new usage bracket. Decreasing block structures give consumers a “volume discount” by charging them less once they enter the new usage brackets. The survey indicates that non-residential customers are more likely to face uniform or decreasing block structures, and decreasing block water pricing is a popular tool to attract water-intensive industries.

Some consumers also face seasonal rates where prices adjust based on peak and off-peak water use seasons. In addition, these structures typically rely on volumetric charges to cover the fixed costs of a utility provider like infrastructure investments. Under this structure, decreasing water consumption will result in decreasing revenues and a financial shortfall for the provider. This creates a disincentive for utilities to support conservation measures as conservation will necessitate requests for politically unpopular rate increases. This condition is observed in biennial rate survey data, which shows that median water rates have increased 93 percent between 2000 and 2012 while per capita water consumption has decreased from 150 to 112 gallons per day between 2000 and 2012.

Finally, pricing failures are particularly acute in agriculture. A 1999 review of the U.S. Bureau of Reclamation’s water supply policy demonstrates that the Bureau was not effective in encouraging conservation. The body, which provides water to 20 percent of irrigated land in the western U.S., designed increasing rate water pricing structures so that the first, lowest price tier encompassed the needs of most irrigation. In addition, the Bureau prices water based on an antiquated “ability-to-pay” concept devised from the 1939 Reclamation Project Act. This approach completely divorces pricing from the long-run water supply costs, including construction costs of new infrastructure.

Inefficiencies in Water Distribution and Use

In addition to market failure in water supply, another main cause of water scarcity in the U.S. is a water distribution system filled with inefficiencies that result in wasted water. Three areas where there is a large amount of water lost due to inefficiencies are water supply infrastructure systems, agricultural irrigation systems, and household water use.

Decaying Infrastructure

In 2001, an American Water Works Association (AWWA) report cautioned that the U.S. is approaching the end of the lifespan of a considerable share of the underground water-carrying pipes that make up the nation's water infrastructure. Research by the American Society for Civil Engineers gives American water infrastructure a D grade. The deterioration of the United States' water infrastructure is responsible for the loss of almost 6 billion gallons of water each
day. This number constitutes about 14 to 18 percent of the country’s daily use of water, adding up to a wasted 2.1 trillion gallons per year. In effect, only 82 to 86 percent of drinking water actually makes it to the consumer.

**Agriculture Problems**

Agriculture is one of the largest users of water in the U.S. and has a significant impact on water supply. Recent estimates show that agriculture is responsible for 80 percent of consumptive water use nationwide and accounts for as high as 90 percent of water use in some Western states. Advances in efficiency have stabilized demand since 1970, but it remains above replacement level, exacerbating current shortages. Further complicating the problem, many states that are major agricultural producing states are also facing the severest water shortages. Irrigation systems are a major inefficiency with sprinklers and other inefficient methods (94% of total irrigation methods) watering the earth, not the crops.

**Household Water Consumption**

Domestic water use accounts for 25 percent of total consumptive use in the U.S., meaning it does not return to the stock. This accounts for 100 gallons per person each day, nearly twice the consumption use in Europe. Overuse of domestic water will grow with population growth.

**Evaluation Criteria**

We selected four criteria with which to evaluate potential policy alternatives.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>Degree to which solution provides gains in increasing water supply or decreasing demand in the next 20 years.</td>
</tr>
<tr>
<td>Cost Efficiency</td>
<td>Degree to which solution provides most effectiveness with least cost</td>
</tr>
<tr>
<td>Political Feasibility</td>
<td>Degree to which solution can gain political and public support</td>
</tr>
<tr>
<td>Equity</td>
<td>Degree to which solution ensures equitable access and costs for low-income and marginally disadvantaged groups</td>
</tr>
<tr>
<td>Timeframe</td>
<td>Length of time needed to implement the solution</td>
</tr>
</tbody>
</table>

**Alternative 1: Formation of Regional Authorities to Govern Water Use and Reforming Water Pricing**

In this alternative, the federal government would form regional water authorities to govern water use in the major river basins in the U.S. These regional water authorities would also facilitate the implementation of efficient pricing structures for agricultural, industrial, and residential use. Currently there are no overarching regional authorities overseeing water use; rather a patchwork of state laws govern water use in most regions, which results in fragmentation of the water supply system. The formation of these regional authorities would encourage states and water consumers to work cooperatively to develop water use reduction plans.

The formation of regional water authorities should be modeled closely after the Murray-Darling Basin Authority, which was formed by the Australian national government in 2007 to
deal with water scarcity issues in the semi-arid region of southeastern Australia.\textsuperscript{34} The situation in southeastern Australia mirrors the situation in the western U.S.; water was governed by an inefficient and fragmented system of state laws, which prompted the Australian national government to step in to combat water scarcity challenges. The major components of the Murray-Darling Basin Authority were a long-term basin plan that set sustainable diversion limits, capping the amount of water that can be diverted from the river, as well as the formation of a national agency known as the Commonwealth Environmental Water Holder, to buy back unused water rights from water users. This buy back program was highly successful, and has returned nearly 3 MAF of water back to the Murray-Darling river system since 2007.\textsuperscript{35}

In a similar U.S. system, the regional water authorities would consist of a board with representatives from each state in the river basin as well as other important actors in the region’s water supply system, including representatives from water and irrigation districts, major municipalities, utilities, agriculture, and environmental groups. The purpose of the authority would be to develop a long-term sustainability plan—similar to what was done in Australia—for the region, and administer a buyback program, which would enable water users to sell portions of their water allocation back to the regional authority. The authority would also be charged with facilitating a more efficient pricing scheme as well as a water trading system—which would help transfer water from low-value to high-value uses.

The buyback program for unused water rights will be an important component of this policy alternative. The program will address one of the significant causes of inefficient water use in the dry regions of the U.S., the use it, or lose it system of water rights.\textsuperscript{36} The buyback program will also provide a financial incentive for water users to engage in more efficient water use by introducing real tradeoffs into decision-making. This will help preserve water for future use as well as ensure that river systems have enough flows to maintain wildlife habitat.

The table below shows how a similar program could be implemented in a major river basin in the U.S., the Colorado River basin, which has a similar climate and land use as the Murray-Darling Basin in Australia. The federal government may also replicate this system in other river basins throughout the U.S.

**Model of a Regional Water Authority for the Colorado River Basin**

| Key Actors | • Federal: The U.S. Bureau of Reclamation, the owner of major reservoirs in the Colorado River basin, including Lake Mead and Lake Powell.  
• State: States in the Colorado River Compact of 1922: Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming.  
• Others: Representatives from major municipalities, irrigation and water districts, farming coalitions, environmental groups. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance Structure</td>
<td>The federal government will create and fund the authority and fill the governing board, which will consist of representatives from each of the states and other major actors. The board, in cooperation with stakeholders and the public, will develop a long-term sustainability plan for the basin, which will govern water use.</td>
</tr>
</tbody>
</table>
| Actions | • The federal government will fund a buy-back program to purchase unused water rights from users to encourage conservation.  
• The federal government will encourage regional bodies to facilitate adoption of |
pricing structures through regulation and incentives that adequately price water from all water sources.
- The members of the authority will cooperatively develop the long-term sustainability plan that will re-allocate water among users in the basin and set sustainable limits to water diversions for the basin.
- Each state will be responsible for developing a state implementation plan that details how they will meet the sustainable diversion limits.

**The Power of Price**

In addition, the federal government would allow water authorities to facilitate more effective pricing mechanisms to increase efficiency in water use. This change includes enabling providers to implement one of the structures identified by the EPA as enabling conservation: Increasing Block Rates, Time of Day Pricing, Water Surcharges on excessive use, and Seasonal Rates. In addition, pricing structures would be shifted from emphasis on variable costs based on volumetric usage to fixed costs in order to ensure rates cover the provider’s fixed costs while not penalizing conservation. While falling short of the ideal pricing structure (charging long-term marginal cost) these structures send information about scarcity to consumers by increasing prices with increased use and support conservation.

Olmstead and Stavins demonstrate that price changes are superior to non-price changes for allocating resources efficiently. First, they note that the elasticities for residential water demand are similar to those of electricity and gasoline, ranging from -0.05 in the short-run to -0.69 in the long-run across various studies. This means that consumers are sensitive to price changes and will change their behavior in the face of a price increase to save money and maximize their welfare. In addition, Olmstead and Stavins demonstrate that when compared with non-price interventions like outdoor water restrictions, price changes achieve the same conservation with less welfare loss. Olmstead shows that replacing a two day per week outdoor water restriction with a market clearing drought price achieved the same conservation and welfare gains of $81 per household per summer drought in 12 American and Canadian cities. These gains result from consumers exercising choice in their adaptation to scarcity and heterogeneous responses amongst consumers. Pricing has also proven effective at encouraging behavioral changes in the agricultural community (discussed below).

Additionally, real world examples and research indicate that savings are achievable through pricing reform. In Southern California, the Irvine Ranch Water District instituted individualized rates for consumers, leading to a 19 percent reduction in water consumption. Water providers also saved $33.5 million over five years by not paying significantly higher prices to import water during a severe drought. A study from Georgia indicates that water savings are also achievable in agriculture. When measuring water withdrawals in the Flint River Basin, the study finds that a $1 increase in the price of water decreases water use by .007 acre-feet. The authors illustrate this by comparing it to the drought prices enacted in California during a severe drought in the early 1990s. An increase of 20% relative to the California drought price would result in a 16 percent decrease in agricultural water consumption.

There are two important caveats to pricing changes that are mitigated by implementing them with new governance structures. First, Krause et al assert that the current understanding of price elasticities is incomplete because water has traditionally been priced within a narrow range. Consumer response to significant price increases is unknown and extrapolation from current understanding can lead to misguided predictions. A second caveat is that different groups of
consumers will react in varied ways to price increases\textsuperscript{1}. Implementation of new price structures within the structure of a new governing authority will facilitate learning and information sharing regarding true price elasticities and differential responses to price.

**Alternative Two: Home Use Innovations**

Increased prices from a more effective governance and pricing system would encourage more households to take control over their usage to save both water and money. We propose a two-pronged approach: tax credits and behavioral nudges through disclosure.

**Tax Credits**

To facilitate these changes for residential water users, the federal government would provide tax credits to subsidize home retrofits and lawn removals in favor of native plants. Additionally, regional authorities would facilitate development of information mechanisms like utility scorecards targeted at changing water use behaviors amongst residential consumers.

Outdated toilets and faucets consume disproportionate amounts of water. Additionally, outdoor water use accounts for 30 percent of average household use, or 96 gallons per day.\textsuperscript{46} This incentive for home retrofits would be modeled after the success of Santa Monica's "Bay Saver Toilet Retrofit Program" which offered $75 in rebates for toilet replacement. 53 percent of the city took part in the program, and the city saw a 14 percent reduction in use and $9.5 million in net savings.\textsuperscript{47} The proposed solution would expand this program to include faucets, showerheads and lawn removals in favor of native plants. Likewise, in Los Angeles, the “Turf Terminator” program that encourages lawn removals sees an annual saving of 250M gallons of water.\textsuperscript{48} The proposed program would build off this success and be utilized through the federal government for scale.

**Behavior Change**

Even with water efficiency upgrades, these efforts are best done in concert with information provision aimed at reducing consumption. In Northern California, a pilot program by the East Bay Water District found a 5 percent reduction in water use in homes which received a scorecard comparing their water use to their neighbors’. Due to the success of the pilot, the program is now set to expand.\textsuperscript{49}

Similar results have been observed in the energy industry. Opower, a startup that partners with utilities to show how their energy use compares to similar sized households, have saved residents over $250 million dollars on their home energy bills.\textsuperscript{50} These interventions known as “social learning” or “conditional cooperation” show consumers both what the “norm” is for usage and creates competition to do better than their peers. Creating a program analogous to water would save nearly 575 billions of gallons of water annually\textsuperscript{2}.

\begin{figure}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
 & Percentage of Personal Use & Traditional Use & Post-Retrofit Use \\
\hline
Toilets & 21\% & 6 g/flush & 1.28 g/flush \\
\hline
Faucets & 12\% & 2.2 g/min & 1.5 g/min \\
\hline
Showers & 11\% & 2.5 g/min & 2 g/min \\
\hline
Outdoor & 30\% & 96 g/day & 0 g/yr \\
\hline
\end{tabular}
\caption{A summary of retrofits and projected savings}
\end{figure}

\begin{itemize}
\item \textsuperscript{1} A survey conducted by Krause et al demonstrates that reactions to price changes correlate with characteristics like age, income, and even political or religious preference.\textsuperscript{45}
\item \textsuperscript{2} According to the US Census, there are 115M households in the US and if each saved roughly 5,000 gallons annually there is an estimated 575 billion gallons overall savings
\end{itemize}
Alternative Three: Infrastructure and Technology Investments

Given that proposed pricing reforms (Alternative 1) only approximate the ideal price, more policy tools are needed to encourage optimal infrastructure upgrades and conservation. As Alternative 2 addresses domestic consumption, we propose that the U.S. invest in water conservation in the water distribution system, both in urban areas where distribution systems are failing and on farms, which use inefficient technology to water crops. The best tool to achieve these goals is a federal loan program targeted to water conservation projects that includes private funds to supplement federal spending.

Urban Infrastructure

American cities have grown rapidly over the last century, and the infrastructure for many metropolitan areas has near the end of its lifespan. The price of water is too low and this prevents municipalities from investing in needed repairs. Between 14-18 percent of drinking water fails to reach the consumer due to leaking pipes. But, technology and infrastructure upgrades may help prevent this significant loss of water. For instance, in Miami-Dade County, a smart monitoring system that detects leaks in pipes is estimated to conserve 20 percent more water. Furthermore, storm water reuse systems in southern California, which divert water to recharge the groundwater aquifer can serve as an important source of water for urban areas. Despite the potential gains in water conservation that are possible with these projects, many barriers exist that prevent their implementation. Municipal officials face a combination of poor long term planning, a lack of political will, and a lack of unallocated capital that currently prevents investment. Additionally, multi-jurisdictional projects are exceedingly difficult to coordinate, and there are few funding sources to support these large-scale, regional projects.

Rural Infrastructure

Technological upgrades in farm irrigation systems have the potential to conserve a large amount of water. Sub-surface drip irrigation (SDI) reduces water consumption between 40 to 70 percent compared to traditional gravity flow and sprinkler irrigation systems. But, SDI only constitutes 6 percent of irrigation systems. Additionally, SDI has proven effective at increasing crop yields, up to 20% in crops such as corn. Since water prices are so low, farmers do not have an incentive to upgrade their irrigation systems to more efficient ones. But, even if prices rose, SDI would still have high capital costs to install ($1,000/acre) and face higher energy and labor costs to operate it (SDI requires pressurized water and regular maintenance).

Financing Mechanism

In this alternative, we propose that the federal government create a National Infrastructure Bank (NIB), to finance infrastructure projects aimed at improving water conservation. The bank would bring together public start-up funds to initially capitalize the venture, as well as private investment. Water infrastructure has user fees, which would help draw private investors (similar user fee based investments can be seen in toll roads and bridges nation-wide). The federal government would evaluate and select projects based on project effectiveness and how well the project could address regional water scarcity. The NIB would give loans to qualified municipalities, regional authorities, or farmers at below-market rates. Reports suggest that $400 billion to $1 trillion dollars are required over the next twenty years to eliminate these inefficiencies. NIB investments will complement existing infrastructure
financing programs, which currently can only provide 50 percent of the necessary funds to meet the nation’s infrastructure needs. 67

<table>
<thead>
<tr>
<th>Policy</th>
<th>Solutions</th>
<th>Challenge</th>
<th>American University</th>
<th>Fernandez, Hayes, Mak, Silvey, &amp; Trigaux</th>
</tr>
</thead>
</table>

| Figure 4: Breakdown of water savings from infrastructure investments |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| **Public Money for Infrastructure** | $250-$400 billion dollars |
| **Private Money for Infrastructure** | $300-$500 billion dollars |
| **Total Money Required (Next 20 years)** | $400 billion-$1 trillion dollars |
| **Status Quo Agricultural Use** | 70-80% of all water |
| **Status Quo Losses from leaks** | 14-20% (180-220 billion gallons) |
| **Potential Agricultural saving** | 40-50% of all water |
| **Potential Leak Reduction savings** | 180-220 billion gallons |
| **Gallons Saved/Dollars in Investment** | $0.59/$1.43/Gallon saved |

An NIB holds several advantages as a financing mechanism. Its partnership with the private sector makes it more lucrative than other purely public alternatives. 68 The NIB’s use of both public and private funds allows it to make loans at below-market rates and avoid cost over-runs, which burden 25 percent of projects solely receiving public financing. 69, 70 An NIB would be able to work with regional water authorities (Alternative 1) to finance multi-jurisdictional projects. Today, most infrastructure financing is done at the state level, which does not cover larger scale, regional projects, and an NIB would be beneficial in closing this gap. 71 The NIB will be staffed with experts who will choose projects based on a competitive application process and subject applications to a rigorous cost-benefit analysis. 72 An NIB can also reach out to potential clients, either directly to city planners or farmers, or through associations.

**Conclusion**

The proposed alternatives we have discussed in governance and pricing, home retrofits and information provision, and infrastructure and technology upgrades aim to reduce overall water consumption at various points in the water distribution system. The federal government should implement each of these solutions simultaneously. As demonstrated in Figure 5, each solution works along a different timeline and contains strengths and weaknesses. With pricing changes as the foundation, these solutions work in conjunction with one another to create multiplied water savings by encouraging residential, agricultural, and industrial consumers to pursue conservation through home and infrastructure upgrades. Governance reforms allow for these changes to be implemented nationwide. In sum, we propose this three-fold solution as the best method for ensuring an affordable, sustainable drinking water supply over the coming decades.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Effectiveness</th>
<th>Cost Effectiveness</th>
<th>Political Feasibility</th>
<th>Equity</th>
<th>Timeline</th>
<th>Key Takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance and Pricing</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Mid-Long Term</td>
<td>Murray-Darling: 3 MAF returned to rivers</td>
</tr>
<tr>
<td>Demand-Side Home Interventions</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Short-Term</td>
<td>575 billion gallon net potential savings</td>
</tr>
<tr>
<td>Infrastructure and Irrigation</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Mid-Term</td>
<td>Infrastructure investment saves 420 billion gallons</td>
</tr>
</tbody>
</table>

| Figure 5: Outcome Matrix detailing the key elements of each proposed solution. |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Governance and Pricing | High | Moderate | Low | Moderate | Mid-Long Term | Murray-Darling: 3 MAF returned to rivers |
| Demand-Side Home Interventions | High | Moderate | High | Moderate | Short-Term | 575 billion gallon net potential savings |
| Infrastructure and Irrigation | High | Moderate | Moderate | High | Mid-Term | Infrastructure investment saves 420 billion gallons |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |

| | | | | | | |
| | | | | | | |
End Notes:


50. Laskey, A. (Director) (2013, February 1). How behavioral science can lower your energy bill. TED Talk. Lecture conducted from TED.


