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WATER INFRASTRUCTURE & ECONOMIC DEVELOPMENT

Fellowship Report

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June 2023

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Executive Summary

Water is inextricably linked to the economy as it shapes the wellbeing and prosperity of communities. The true economic impact of water infrastructure is often obscured within health, social, and environmental outcomes, as well as its direct effects on businesses. Water is a core component of public capital investments and operational expenditures. The water industry also employees a sizable portion of the national workforce which means water is linked to local wages and spending patterns. While water sector jobs are more heavily concentrated in large metro areas, they are consistently 1 to 2% of the workforce in all regions across the country[1].

The impact of water investment varies greatly by region, population density, and industry composition, but in general, sufficient, well-maintained water infrastructure can support sustainable economic development and boost the workforce over the long-term. Water infrastructure capital investments have a direct impact on water industry output and an indirect benefit to other industries in the economy as the labor force increases in the area[2]. Water infrastructure spending also provides indirect benefits to communities by attracting adjacent retail and service industries as well as supporting a healthy housing market[3]. Inversely, the failure to invest in water infrastructure can leave a community vulnerable to excessive damages from natural disasters and other shocks to the local economy that impact the tax base as well as discourage business investments.

The US water sector suffers from severe under-investment, which limits the economic potential of communities across the country. The heterogeneity of water based on location, quality, timing, and variability provides a clear case that water should be analyzed as more than a commodity in economic modeling[4]. The nexus between water and economic development highlights the impact of water infrastructure spending on the overall long-term prosperity of a community. The following literature review summarizes the current academic research on this connection and examines specifically how the deficit in US water infrastructure spending can have a material impact on sustainable economic growth.

Key Findings

Water and Industry

- Improves private industry performance and productivity
- Increased public investment in water is associated with an increase in private investment
- Increased investment in the water sector leads to industry wage growth for water and non-water intensive sectors over the long-term

Water and Society

- Failing or inadequate water infrastructure results in poor water quality and risk of greater damage in the aftermath of severe storms
- Water infrastructure investments can make economies more resilient to shocks and downturns
- Poor water infrastructure investments exacerbate inequality

Development Cycle of Water and Growth

- Public water investments lead to an increase in water sector output which increases public tax revenue
- Public water investments attract diverse adjacent local businesses making the economy more resilient to downturns
- Water infrastructure investment can strengthen a technical workforce
- Investing in water is an investment in anchor institutions and stable jobs

Factors that Impact Size of Economic Returns

- Rural vs. urban community
- Availability of skilled labor or training opportunities
- Methods used to generate additional funding

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1 Kane, Joseph, and Addie Tomer. "Renewing the Water Workforce." The Water Research Foundation, June 2018. https://www.waterrf.org/system/files/resource/2022-09/4751.pdf.

2 Pereira, A. M. (2001). On the effects of public investment on private investment: What crowds in what? Public Finance Review, 29(1), 3–25. https://doi.org/10.1177/109114210102900101

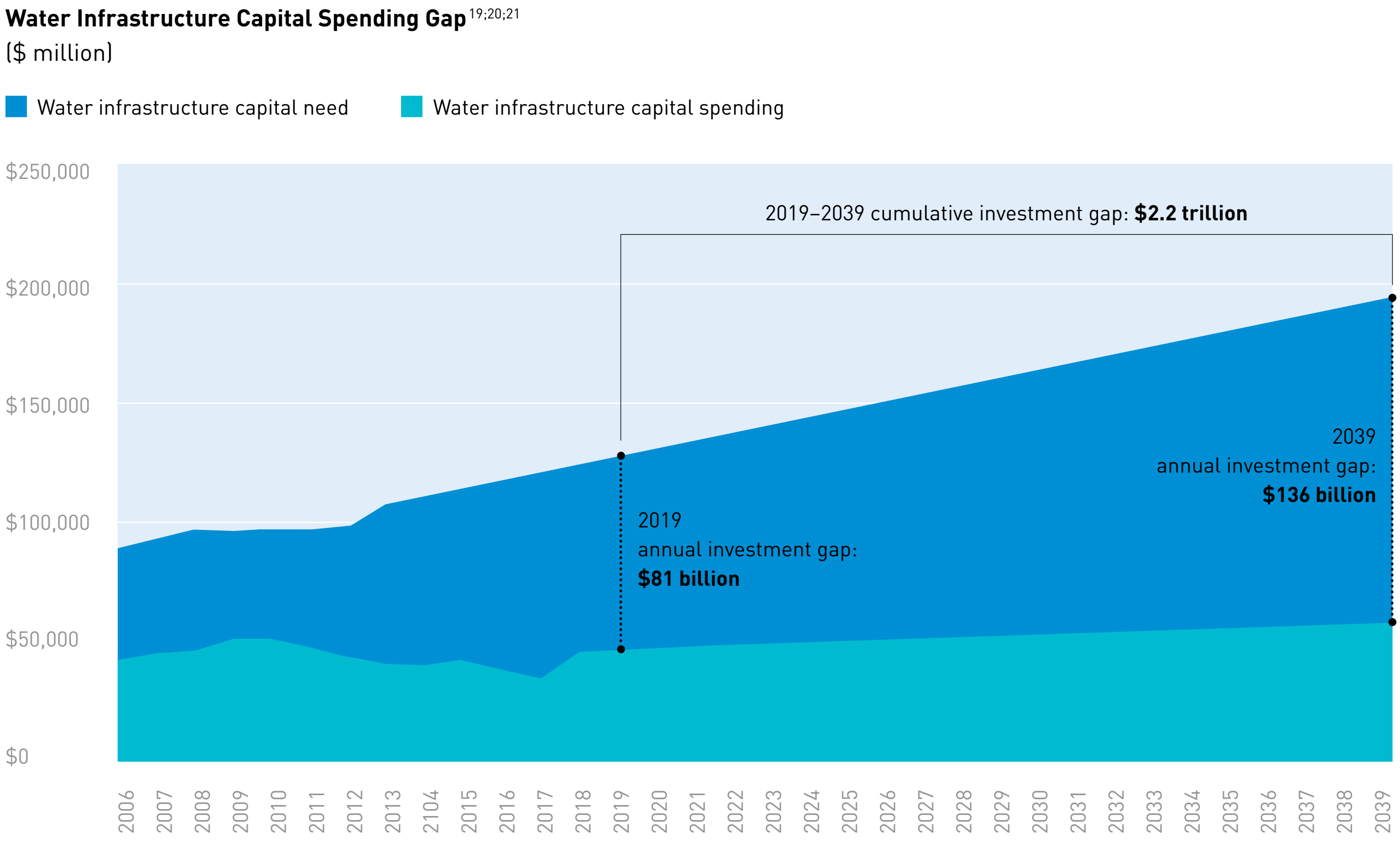
3 Bagi, F. S. (1970, January 1). Economic Impact of Water/Sewer Facilities on Rural and Urban Communities. AgEcon Search. Retrieved April 13, 2023, from https://ageconsearch.umn.edu/record/289691

4 Garrick, D. E., Hanemann, M., & Hepburn, C. (2020). Rethinking the economics of water: An assessment. Oxford Review of Economic Policy, 36(1), 1–23. https://doi.org/10.1093/oxrep/grz035

Background

The US suffers from aging, poorly maintained water infrastructure, which places communities at risk.[1] As the US addresses large infrastructure spending gaps and economic disparities in the context of a changing climate, the management of water resources will become increasingly more complex and vital for community wellbeing. According to a 2020 report from the Society of Civil Engineers (ASCE), most of the current US water infrastructure's pipes will need to go through a massive "replacement era" by 2040.[2] Water infrastructure built decades ago did not properly anticipate the ramifications of climate change that strain surface water flows and aquifer recharge rates as well as the increase in demand from population growth in water-scarce regions.[3] According to the ASCE 2016 assessment, the US needs to spend roughly $123 billion per year in water infrastructure to meet current needs, but annual spending continues to fall significantly below this recommendation.[4] As Graph 1 demonstrates, the total US water infrastructure spending is growing year over year, but the needs are outpacing expenditures to the point that the annual spending gap is projected to grow to $136 billion by 2039.

Graph 1: Water Infrastructure Spending Trails Behind Need



Source: ASCE, 2020. The Economic Benefits of Investing in Water Infrastructure: How a Failure to Act Would Affect the US Economic Recovery.

Water utilities recognize how this growing spending gap is an existential threat for their operations. According to the American Water Works Association's (AWWA) 2022 annual water industry report, the top three concerns sited by industry professionals were:

1) Renewal and replacement of aging water and wastewater infrastructure

2) Financing for capital improvements

3) Long-term drinking water supply availability[5]

1 uswateralliance.org. "The Economic Benefits of Investing in Water Infrastructure," August 26, 2020. https://www.uswateralliance.org/news/value-water-campaign-releases-new-economic-report.

2 Ibid.

3 Ibid.

4 American Society of Civil Engineers. 2020. Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future.

5 State of the Water Industry '22 EXECUTIVE SUMMARY. American Water Works Association. (n.d.). Retrieved April 7, 2023, from https://www.awwa.org/Portals/0/AWWA/ETS/Resources/2022_SOTWI_Executive_Summary.pdf

While the water sector understands the need for large-scale infrastructure spending, the communities they serve do not often recognize the true value of these investments. According to the AWWA report, the fifth highest concern in the sector is the "public's understanding of the value of water systems and services".[1] The sufficient supply of clean water is necessary for more than public health, but for dozens of industries such as agriculture and manufacturing, and the complex relationship between water and the economy must be brought to public attention.

Literature Review

A failure in the water sector has the potential to create an economic shock to local communities producing significant, long-lasting consequences. Research also suggests that investments in water infrastructure are a boon for industries, the local workforce, and society at large. The following literature review groups the economic research into three main areas: business, society, and the relationship between water investment and sustainable growth. Next, the paper reviews the research conducted to understand why returns on infrastructure spending are likely to vary across locations, spending categories, and time.

1) Water and Business

Water is a key component to industry, impacting virtually all consumer products, which has extensive implications for the performance of the broader economy. The American Society of Civil Engineers (ASCE) and the Value of Water Campaign released a joint report in 2020 on the economic opportunities achievable if the water spending gap is closed. They project that the impact to business would be tremendous, generating both additional GDP and job growth. Closing the gap would require spending $2.2 trillion above the baseline projections over the next 20 years, or roughly $109 billion per year until 2039.[2] Using 2019 water infrastructure data as a baseline, the economic impact study generated a 10 and 20-year economic projection to estimate the total gains to water-reliant industries and the economy at large if this spending is achieved. Meeting investment goals in water will improve efficiency in the water sector and communities could potentially experience both supply-side and demand-side improvements.

Public Water Investment Crowds-In Private Investment

Building off decades of public infrastructure research such as the catalyzing work of David Allan Aschauer in the 1990s, economist Alfredo M. Pereira found that public water infrastructure spending has a large crowding-in effect on other public and private business spending.[3] The crowding-in effect occurs when "public capital compliments private capital in the production and distribution of private output," which would then increase private company productivity/output. In contrast, the crowding-out effect in economic terms is when public spending reduces what private companies would otherwise raise to invest in additional capital. Past studies that aggregate public spending have produced mixed results, but breaking the public spending down by category sheds light on the relationship between water infrastructure and the private sector.

The Aschauer study found that core infrastructure, which includes everything from roads, public transit, electrical grid, and water infrastructure had an elasticity of 0.24 and was highly statistically significant.[4] The elasticity coefficient represents the relationship between inputs and outputs in terms of percentage changes. For a 1% change in water infrastructure, there is approximately a 0.24% increase in private sector output. The Pereira study disaggregated the types of core infrastructure and found similar positive results from increased public infrastructure for each category of capital spending. The Pereira study concluded that overall public spending crowds-in private spending at the aggregate and public investment in sewage and water supply systems had a modest, but statistically significant crowding in effect on overall private spending mostly driven by increases to transportation equipment. The general impact of public water and sewer infrastructure spending on private investment amounted to an estimated investment elasticity of 0.0129 meaning that a 1% increase in the water infrastructure investment led to a 0.01% increase in private sector investment.[5] When gross state production (GSP) is measured in billions of dollars these small percentages can equate to a large impact year over year.

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1 State of the Water Industry '22 EXECUTIVE SUMMARY. American Water Works Association. (n.d.). Retrieved April 7, 2023, from https://www.awwa.org/Portals/0/AWWA/ETS/Resources/2022_SOTWI_Executive_Summary.pdf

2 American Society of Civil Engineers. 2020. Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future.

3 Pereira, A. M. (2001). On the effects of public investment on private investment: What crowds in what? Public Finance Review, 29(1), 3–25. https://doi.org/10.1177/109114210102900101

4 Aschauer, D. A., & 1. (2002, April 19). Is public expenditure productive? Journal of Monetary Economics. Retrieved April 30, 2023, from https://www.sciencedirect.com/science/article/pii/0304393289900470

5 Krop, Richard A., Charles Hernick, and Christopher Frantz. "NACWA 50 Report." LOCAL GOVERNMENT INVESTMENT IN MUNICIPAL WATER AND SEWER INFRASTRUCTURE: Adding Value to the National Economy, August 14, 2008. https://nacwa50report.org/Content/documents/G3_R8_LocalGovtInvtInMunicipalWaterandSewerInfrastructure-Krop-et-al-2008.pdf.

Water Investment Increases Private Output

Unlike the other forms of infrastructure such as transportation and education buildings measured in the Pereira study, water is a direct input in private sector production. Some of the most water-intensive industries rely on a steady supply of water to remain productive. With the proper investment in water infrastructure, industries would see their productivity increase which in turn would grow their output. The US Bureau of Economic Analysis (BEA) maintains a regional economic modeling tool to measure the potential economic impact of new major spending projects such as public infrastructure. This tool called the Regional Input-Output Modeling Systems, also known as RIMS II, allows policymakers and industry professionals to account for inter-industry relationships such as between the water sector and commercial businesses when aggregating their total economic impact. Thus, the tool can measure the multiplier effect that occurs when the water sector invests in water infrastructure. In a 2008 report, BEA found that "across the United States as a whole, for each additional dollar's worth of output of the water and sewer industry in a year, the dollar value of the increase in output that occurs in all industries is $2.62 in the same year.[1] These returns, however, vary by region of the country. At the low end, Washington D.C was found to have a private return on water investment of $1.22 for every $1 of additional public water industry output. The highest state multiplier was Texas, with a multiplier of $2.19. The overall national multiplier was 2.62 which is greater than the highest state multiplier because it captures spillovers among states and regions rather than the sum of each individual state's investment and outputs. The reasons that influence different levels of returns were not made in this report, but a deeper discussion of variables is discussed in Factors that Impact Economic Gains section below.

ASCE National GDP Estimates Continued

Returning to the American Society of Civil Engineers (ASCE) report from 2020 on the water infrastructure spending gap, the US has an opportunity to grow its industry output which in turn impacts trade and GDP. The report estimates that business sales would increase and the national GDP would grow by $4.5 trillion compared to the $2.2 trillion investment. Furthermore, this increase in output would have the added benefit of improving the US trade deficit because exports would become more competitive in the global market.[2] The report also predicts that service disruptions from not increasing water infrastructure investment will lead to a $2.9 trillion decline in gross domestic product (GDP) by 2039.[3]

Summarized below are the top 10 water intensive industries in the US based on how many gallons of water are necessary for $1 of output.

Figure 1: ASCE top 10 Water Intensive Industries Excluding Agriculture

Top 10 Water Intensive Industries		
Rank #	**Industry**	**Gallons per $1 of output**
1	Paint and coating manufacturing	123
2	Alkalis and chlorine manufacturing	38
3	Paperboard Mills	36
4	Wineries	34
5	Pesticide and other agricultural chemical manufacturing	30
6	Synthetic dye and pigment manufacturing	27
7	Adhesive manufacturing	21
8	Industrial gas manufacturing	21
9	Distilleries	14
10	Poultry processing	14

Source: ASCE, 2020. The Economic Benefits of Investing in Water Infrastructure: How a Failure to Act Would Affect the US Economic Recovery.

1 Krop, Richard A., Charles Hernick, and Christopher Frantz. "NACWA 50 Report." LOCAL GOVERNMENT INVESTMENT IN MUNICIPAL WATER AND SEWER INFRASTRUCTURE: Adding Value to the National Economy, August 14, 2008. https://nacwa50report.org/Content/documents/G3_R8_LocalGovtInvtInMunicipalWaterandSewerInfrastructure-Krop-et-al-2008.pdf.

2 American Society of Civil Engineers. 2020. Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future.

3 uswateralliance.org. "The Economic Benefits of Investing in Water Infrastructure," August 26, 2020. https://www.uswateralliance.org/news/value-water-campaign-releases-new-economic-report.

2) Water and Society

Access to sufficient, clean water is necessary for the health and prosperity of all communities. Furthermore, strong water infrastructure helps communities avoid exacerbating other societal challenges such as inequality, and it improves resiliency in the face of an environmental crisis such as a major storm.

Stormwater Management

When rainfall or snowmelt occur, the released water is split between groundwater absorption and passing through a community's water infrastructure. Sewer system infrastructure typically has either a combined stormwater and wastewater system where both sources of water mix or separate pipes for stormwater and wastewater. In the event that a system is unable to manage a sudden large volume of water or the system is damaged, hazardous flooding can occur. Overflows can also occur as the result of blockages, line breaks, and sewer defects that permit the stormwater and groundwater to overload the water management system.[1] This is particularly problematic in combined systems, as the overflowing water may contain raw sewage. Regardless of if the overflow is solely rainwater or wastewater or other runoff, the effect can have costly implications for the surrounding community. According to the EPA, the potential benefits of effective stormwater runoff management include:

- protection of wetlands and aquatic ecosystems,
- improved quality of receiving waterbodies,
- conservation of water resources,
- protection of public health, and
- flood control. [2]

Flooding and the overflow of toxic chemicals can have consequences for public health, home values, and businesses. Furthermore, environmental pollution and degradation of natural resources can further inhibit economic growth in an area for the industries that depend on them. Community water systems that are ill-equipped to handle natural disasters are likely to suffer depressed economic activity as businesses face interruptions and residents incur additional repair costs. Finally, stalled economic activity in the area may also encourage residents and businesses to relocate elsewhere in search of better opportunities.

One of the most salient examples of water infrastructure failures in the recent past occurred in the summer of 2005 when Hurricane Katrina struck New Orleans. According to a report published by the Department of Homeland Security, a number of emergency response steps went wrong in the aftermath of the hurricane, but the first notable failure was the breach of levees built to protect the city from flooding.[3] The levees were a project under the authority of the US Army Corps of Engineers and the Louisiana Levee District so while they were not the responsibility of any community water system, they are part of the water management landscape in New Orleans. When the levee broke, the Corps and Levee District initially disagreed as to whose responsibility it was to fix the levee and then failed to coordinate a response. Meanwhile, shelters that housed displaced residents quickly became overwhelmed and suffered from a lack of safe drinking water.

While levees and sea walls were not under the purview of a community water system, water infrastructure is holistic part of a community's defenses to natural disasters. Breaches along floodwalls to the 17th Street and London Avenue Canals used for regular stormwater caused severe flooding in the city's urban areas including the Central Business District, the blocks surrounding the Superdome, Lakeview, Mid City, the area around Tulane University, and Lakewood. Flooding and stormwater management need to be considered comprehensively in their impact the overall economic capacity of a city, especially in regions at high risk of flooding.

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1 Copeland, C. (2016, May 2). Green Infrastructure and Issues in Managing Urban Stormwater. Congressional Research Service reports. R43131. Retrieved April 7, 2023, from https://sgp.fas.org/crs/misc/R43131.pdf

2 "National Pollutant Discharge Elimination System (NPDES)." EPA. Environmental Protection Agency. Accessed April 4, 2023. https://www.epa.gov/npdes/npdes-stormwater-program.

3 Committee on Homeland Security and Governmental Affairs., Susan M. Collins, and Joseph I. Lieberman. Report, Hurricane Katrina: A nation still unprepared: Special report of the Committee on Homeland Security and Governmental Affairs, United States Senate, together with additional views §. S. Rept. 109-322 (2006). https://www.govinfo.gov/content/pkg/CRPT-109srpt322/pdf/CRPT-109srpt322.pdf

After a community experiences a crisis, its economy could take years to recover as businesses rebuild and families attend to the damage. Flood risk is not just increasing for coastal communities. According to an independent study by the First Street Foundation, Appalachia and the Pacific Northwest are also areas with higher risks of home flooding.[1] Unfortunately, low-income families are more likely to face the consequences of failed infrastructure and are least resilient in its aftermath.

Water and Poverty

Poor water infrastructure investment is more likely to have long-lasting negative economic impacts on low-income households. This is because failed water infrastructure is likely to exacerbate existing inequalities and systemic issues in a community. According to a 2019 report published by the National Academy of Sciences, Engineering, and Medicine, while urban flooding impacts a wide range of demographics, it is most harmful to low-income residents and minorities without the resources to overcome the damage and disruption.[2] Meanwhile, other past studies have shown that the low-income, majority minority communities experience the most stormwater damage, often as a result of a history of community divestment. An analysis conducted by Energy & Environment News corroborated past studies on urban flooding such as the research of University of Maryland and Texas A&M's Galveston campus. Both investigations found that homes in the lowest-lying areas or in neighborhoods without green space to absorb the water, were more often poor and majority minority communities.[3] In reference to the research findings, Texas A&M University flood expert Sam Brody explained "Urban flooding is a growing source of significant economic loss, social disruption and housing inequality." When large numbers of households do not have insurance or savings, the overall community could suffer from a protracted period of economic recovery. Public water infrastructure spending may not totally alleviate the flood risk for communities in the future, but poor stormwater management will generally have outsized impacts on low-income areas. Overall, poor water infrastructure can feed into existing inequalities related to housing and financial resources creating a greater divide that weakens a community's economic opportunities and makes it less resilient in the face of crisis.

Water Efficiency Investments Contribute to Water Affordability

According to a Circle of Blue analysis in 2020, more than 1.5 million households in a dozen major U.S. cities with publicly operated water utilities owe $1.1 billion in past-due water bills. Businesses, industries, and other commercial operations in those cities owed another $416 million.[4]

Utility debt is part of a vicious cycle for low-income households, forcing upon them a slew of trade-offs and an accumulation of late fees. In a white paper produced by the Pacific Institute in 2022, "Advancing Affordability through Efficiency," the researchers argue that investing in water efficiency and conservation programs are significantly more cost effective than investing in new water supplies, and most importantly, these measures reduce long-term costs for ratepayers.[5] These investments avoid large infrastructure investments and their on-going maintenance costs. Research has shown that low-income households often face extra barriers for accessing water efficiency programs that would improve their water affordability given that they are more likely to be renters and these utility-sponsored programs often involve upfront investments.[6] More research is needed to better understand the general distribution of economic benefits from water efficiency programs, but there are still ways to estimate cost-savings more broadly.

Through avoided cost estimates, economists can generalize the impact on utilities operations and maintenance costs as well as reductions in water bills based on the amount of water saved by efficiency programs. The Pacific Institute compiled findings from four utilities in the Western US, including cities in California and Arizona, that experienced large population growth but decreases in overall water consumption after implementing efficiency programs.[7]

1 Hersher, R., Jingnan, H., & Schmidt, S. (2021, February 22). A looming disaster: New Data reveal where flood damage is an existential threat. NPR. https://www.npr.org/2021/02/22/966428165/a-looming-disaster-new-data-reveal-where-flood-damage-is-an-existential-threat

2 "Framing the Challenge of Urban Flooding in the United States." The National Academies of Sciences, 2019. https://doi.org/10.17226/25381.

3 Frank, Thomas. "Flooding Disproportionately Harms Black Neighborhoods." E&E News, December 8, 2021. https://www.eenews.net/articles/flooding-disproportionately-harms-black-neighborhoods.

4 Walton, Brett. "Millions of Americans Are in Water Debt." Circle of Blue, August 5, 2020. https://www.circleofblue.org/2020/world/millions-of-americans-are-in-water-debt/.

5 Cooley, Heather, Morgan Shimabuku, and Christine DeMyers. 2022. "Advancing Affordability through Water Efficiency." Oakland, California: Pacific Institute. https://pacinst.org/wp-content/uploads/2022/09/WaterCostsWhitePaper_Final.pdf

6 https://pacinst.org/wp-content/uploads/2022/09/WaterCostsWhitePaper_Final.pdf

7 Ibid.

Each of these studies (Figure 2) found that the efficiency programs helped the utilities avoid capital and O&M expenditures and reduced utility bills for customers. These studies found that in the absence of efficiency programs, some communities would have paid significantly more for their water bills and connection fees. For example, the town of Gilbert, Arizona's population grew 230% between 1997 and 2015, while water use decreased which avoided a 6.1% increase in water bills and 81.7% increase in connection fees for customers. This study strongly suggests that water conservation saves the water sector and households during periods of population growth. Further research on the local economy after efficiency programs could test the causality of these cost savings on economic growth.

Table 2: Summary of Avoided Cost Estimates for Four Utilities in the Western United States (Pacific Institute)

	City of Westminster (Feinglas, Gray, and Mayer 2013)		Tucson Water (Mayer 2017b)		Town of Gilbert (Mayer 2017a)		Los Angeles Department of Water and Power (Chesnutt, Pekelney, and Spacht 2018)	
Years Compared	1980	2010	1989	2015	1997	2015	1990	2016
Population	Not Reported		512,000	717,875	75,144	247,542	3,650,000	4,100,000
Water Use (gpcd)	180	149	188	130	244	173	180	110
Costs Avoided by Water Conservation and Efficiency Improvements								
Avoided Capital Costs	$591,850,000		$350,862,732		$340,807,075		$9,455,060,179	
Avoided Operations and Maintenance Costs	$1,238,000 per year		$29,387,158 per year		$3,671,346 per year		$1,600,448,745	
Bill Impacts without Conservation								
Additional Charges on Annual Customer Bills	$596		$133		$38		$13.48 per Hundred Cubic Feet	
% Increase in Customer Bills	91%		13.3%		6.1%		36.4%	
Additional Connection Fees	$16,952		Not Reported		$7,733		Not Reported	
% Increase in Connection Fees	80%		Not Reported		81.7%		Not Reported	

Source: Pacific Institute, "Advancing Affordability through Water Efficiency." 2017.

3) Self-Enforcing Cycle of Growth

The Crowding in Effect of Funding and Its Social Gains

Returning to the Pereira study in 2000, infrastructure can improve private business efficiency and increase output which can reciprocally improve public investment in water and sewer systems. According to the study, when the private sector grows its GDP, the public sector grows its tax revenue which then leads to larger public investment in water and other spending areas.[1] For every dollar invested in water and sewer infrastructure, the private sector would see an increase in long-term marginal productivity of $6.35 added to its GDP.[2] This cycle of growth would continue to feed itself slowly over the long-term.

1 Krop, Richard A., Charles Hernick, and Christopher Frantz. "NACWA 50 Report." LOCAL GOVERNMENT INVESTMENT IN MUNICIPAL WATER AND SEWER INFRASTRUCTURE: Adding Value to the National Economy, August 14, 2008. https://nacwa50report.org/Content/documents/G3_R8_LocalGovtInvtInMunicipalWaterandSewerInfrastructure-Krop-et-al-2008.pdf.

2 https://nacwa50report.org/Content/documents/G3_R8_LocalGovtInvtInMunicipalWaterandSewerInfrastructure-Krop-et-al-2008.pdf

Job and Wage Growth

Expanded economic activity and industry productivity also create jobs and wage increases at the household level, further spurring growth in the overall economy. According to the American Society of Civil Engineers (ASCE) report, closing the water infrastructure spending gap would create roughly 800,000 jobs naturally and household disposable income would rise by over $2,000 per household.[1] If the US does not close its spending gap for water infrastructure, production will go down. As production goes down, workers would see reductions in wages and an estimated 636,000 jobs would be lost annually by 2039. It should be noted that adverse health impacts caused by poorly maintained water infrastructure also come with a large financial cost to families and the healthcare sector.

Non-water intensive industries, housing, and intertemporal findings

In an economic study evaluating the impact of a proposed water project in Las Vegas that expanded water supply, the industries projected to experience the largest employment gains were the least water-intensive sectors.[2] In the study, researchers applied a general equilibrium model to simulate the Las Vegas economy in 2030 and 2050 under expected Colorado River water shortages as predicted by the Southern Nevada Water Authority in 2017. The simulation tracked the impact of a proposed $15.5 billion (2011 dollars) water project in 2030 and 2050 to compare the economic impacts before and after the water supply was expected to become supply-constrained without the water investment. In other words, the baseline scenario would not be supply-constrained in 2030, but would be by 2050 without the proposed water supply project. In the simulation, the project to expand water supply was primarily funded by rate increases for the residents. Thus, the businesses using the most water in production were paying a larger share of the water investment costs.

This rate increase financing method passed on the costs of new water infrastructure to water-intensive businesses and depressed their employment growth in the short term. Interestingly, the constrained water limited housing development, resulting in higher housing values which benefited specific types of households. High home values strained household spending for non-home or landowners, but was a temporary benefit to wealthier households that are more likely to own property. The study found that the higher cost of municipal water after the proposed water project would slightly reduce industrial output, population, and tax revenue, but 20 years later these variables all saw positive gains beyond the baseline's performance. Overall, investment in the water project resulted in long-term increases in business output and employment by 0.83% and 0.97% respectively. In real numbers, these small percent increases amounted to over 10,000 additional jobs and $661 million in additional output in Las Vegas over the baseline in 2013 dollars.

The researchers extrapolate from these findings to suggest that since other industries receive an outsized indirect benefit from water infrastructure without incurring the costs of using the water this type of spending could "ultimately tilt cities' industrial composition toward less resource-intensive sectors.[3] More research on communities with different industry compositions and water project types would substantiate the external validity of such a claim.

Non-water intensive industries, housing, and intertemporal findings

Having strong water infrastructure is appealing to outside companies looking to invest in new operations. While parts of the US face water stress and insecurity because of geography and climate conditions, business analysts suggest the Great Lakes region of the US appears to be emerging as a "Water Belt."[4] Access to a sufficient supply of clean water has the potential to attract new business investment to a community and site selectors are paying attention to set their businesses up for success. To create a water belt, the source must be useful, meaning it is free of heavy pollutants. According to Site Selection Magazine, communities such as Cleveland that have seen population loss and contracting economies in the past have significant emerging opportunities with their water resources if they can properly manage its use.[5] During a period of high industrial activity in the 1960s, Cleveland became infamous for the Cuyahoga River Fire, but after the evolution of environmental regulations for the river and Lake Erie took effect, Cleveland's invaluable resources have rebounded. Proper water infrastructure investment and conservation efforts will continue to protect this natural resource and attract new economic opportunities.

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1 American Society of Civil Engineers. 2020. Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future.

2 Zhong, Hua, Michael H. Taylor, Kimberly S. Rollins, Dale T. Manning, and Christopher G. Goemans. "Who Pays for Water Scarcity? Evaluating the Welfare Implications of Water Infrastructure Investments for Cities." The Annals of Regional Science 63, no. 3 (2019): 559–600. https://doi.org/10.1007/s00168-019-00943-w.

3 https://doi.org/10.1007/s00168-019-00943-w.

4 Daughters, Gary. "Water Supply: Could This Be the Dawn of the Water Belt: Site Selection Magazine." Site Selection. Accessed January 6, 2023. https://siteselection.com/issues/2021/may/water-supply-could-this-be-the-dawn-of-the-water-belt.cfm.

5 https://siteselection.com/issues/2021/may/water-supply-could-this-be-the-dawn-of-the-water-belt.cfm.

Economic Opportunity in The Water Workforce

Implementing water infrastructure projects is an investment in a sector with numerous employment opportunities. Water workers encompass a broad set of people who may design, construct, manage or operate water infrastructure. The positions can include titles such as engineers, mechanics, machinists, chemists, business analysts, and human resources specialists. A full list of the most common positions can be found in the Appendix (Table 1). Water jobs are part of the economic opportunities a community possesses, and water utilities have the potential to serve as anchors for areas with high levels of unemployment and poverty.[1] An anchor institution is generally defined as a large organization, most often public or nonprofit entity, that is largely fixed in its current location such as colleges, hospitals and health-care facilities, utilities, and faith-based organizations.[2] In economic downturns these types of institutions are unlikely to close or move which makes them stable employment opportunities.

Water utility companies make up roughly 82% of the water workforce according to a 2016 labor analysis.[3] Water jobs have higher concentrations in the nation's largest metro areas, but they are consistently 1 to 2% of the workforce in all regions across the country.[4] Their presence in areas with low advanced education and employment opportunities indicates their potential to strengthen the local workforce through the provision of transferable skills. According to the Bureau of Economic Analysis (BEA) input-output model described earlier in this paper, increases in water industry output have a direct effect on new jobs. For every additional job created within the water and sewer industry, approximately 3.68 jobs are created across the US in other industries.[5]

Workforce development roadblocks

The ability to scale-up the water workforce to support a new water investment project is crucial to the success and economic returns of the project. However, the US has more water workforce needs than people to fill those positions, which is expected to get worse over the next decade. The water workforce faces a notable age gap and runs the risk of a growing number of unfilled positions if it does not address its weak career development pipeline. Although water jobs are shown to have higher hourly earnings compared to other occupations nationally and a positive employment growth outlook, the current share of employees below the age of 25 is lower than national employment statistics (Chart 1).

Table 1 : Most Common Occupations in the Water Sector

Water occupations	Employment	Share of employment
Plumbers, Pipefitters, and Steamfitters	324,500	19.3%
Construction Laborers	149,513	8.9%
Water and Wastewater Treatment Plant and System Operators	115,840	6.9%
Operating Engineers and Other Construction Equipment Operators	79,900	4.8%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	70,811	4.2%
First-Line Supervisors of Construction Trades and Extraction Workers	56,021	3.3%
Office Clerks, General	47,602	2.8%
Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	46,510	2.8%
Heavy and Tractor-Trailer Truck Drivers	38,548	2.3%
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	35,141	2.1%
Electricians	34,800	2.1%
Pipelayers	33,810	2.0%
General and Operations Managers	33,788	2.0%
Hazardous Materials Removal Workers	26,850	1.6%
Septic Tank Servicers and Sewer Pipe Cleaners	26,320	1.6%
Water Workforce Total	**1,679,971**	
Water utility occupations	**Utility employment**	**Share of utility employment**
Water and Wastewater Treatment Plant and System Operators	102,520	34.4%
Meter Readers, Utilities	17,500	5.9%
Electricians	14,900	5.0%
Plumbers, Pipefitters, and Steamfitters	12,850	4.3%
Pipelayers	9,880	3.3%
Industrial Machinery Mechanics	9,870	3.3%
Office Clerks, General	9,654	3.2%
Maintenance and Repair Workers, General	7,820	2.6%
Septic Tank Servicers and Sewer Pipe Cleaners	7,510	2.5%
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	7,080	2.4%
General and Operations Managers	4,441	1.5%
Bookkeeping, Accounting, and Auditing Clerks	4,124	1.4%
First-Line Supervisors of Office and Administrative Support Workers	3,570	1.2%
Landscaping and Groundskeeping Workers	3,537	1.2%
Customer Service Representatives	3,415	1.1%
Water Utility Total	**297,787**	

Source: Brookings Metropolitan Policy Program, Renewing the Water Workforce (2018). p.17

1 Kane, Joseph, and Addie Tomer. "Renewing the Water Workforce." The Water Research Foundation, June 2018. https://www.waterrf.org/system/files/resource/2022-09/4751.pdf.

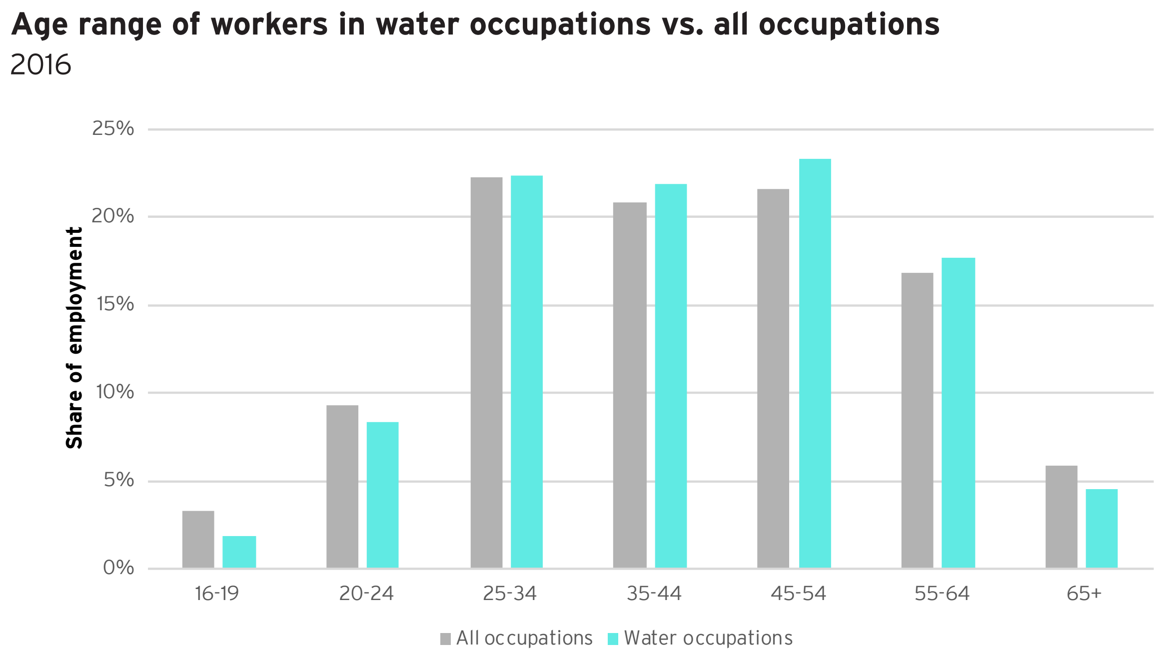
2 Schildt, Chris. "Key Strategies to Advance Equitable Growth in Regions." PolicyLink. U.S. Department of Housing and Urban Development. Accessed October 7, 2022. https://www.policylink.org/resources-tools/advance-equitable-growth-in-regions.

3 https://www.waterrf.org/system/files/resource/2022-09/4751.pdf.

4 https://www.waterrf.org/system/files/resource/2022-09/4751.pdf.

5 https://nacwa50report.org/Content/documents/G3_R8_LocalGovtInvtInMunicipalWaterandSewerInfrastructure-Krop-et-al-2008.pdf.

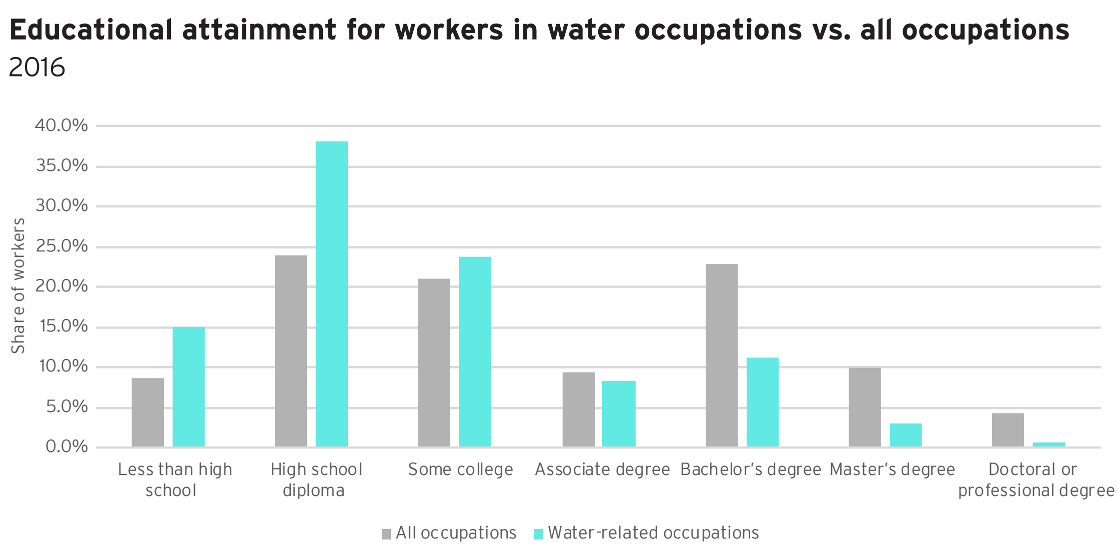
Chart 1: Percent of water workforce over 45 disproportionately higher than US rate



Source: Brookings Metropolitan Policy Program, Renewing the Water Workforce (2018).

As water employees begin to retire, skilled workers will not be readily available. According to the Bureau of Labor Statistics, between 2021 and 2031 approximately 1.7 million infrastructure workers on average will leave their jobs each year due to retirement and other transitions.[1] Given that the worker shortage will be felt across all infrastructure jobs, the competition for technical workers will likely create a significant challenge for the water sector and especially for smaller, more rural communities. Rural communities already face difficulties to maintain a water workforce when they are forced to compete with other communities and metropolitan areas that can offer higher wages. This issue is expected to grow as more of the water workforce retire faster than new workers can be trained. While increased water infrastructure investment has been shown to add jobs to the sector and indirect sectors, it is vital that communities have a job pipeline in place so those new positions are properly staffed over the long-term.

Chart 2: Majority of water jobs require a high school diploma alone



Source: Brookings Metropolitan Policy Program, Renewing the Water Workforce (2018).

1 Kane, Joseph, and Addie Tomer. "Renewing the Water Workforce." The Water Research Foundation, June 2018. https://www.waterrf.org/system/files/resource/2022-09/4751.pdf.

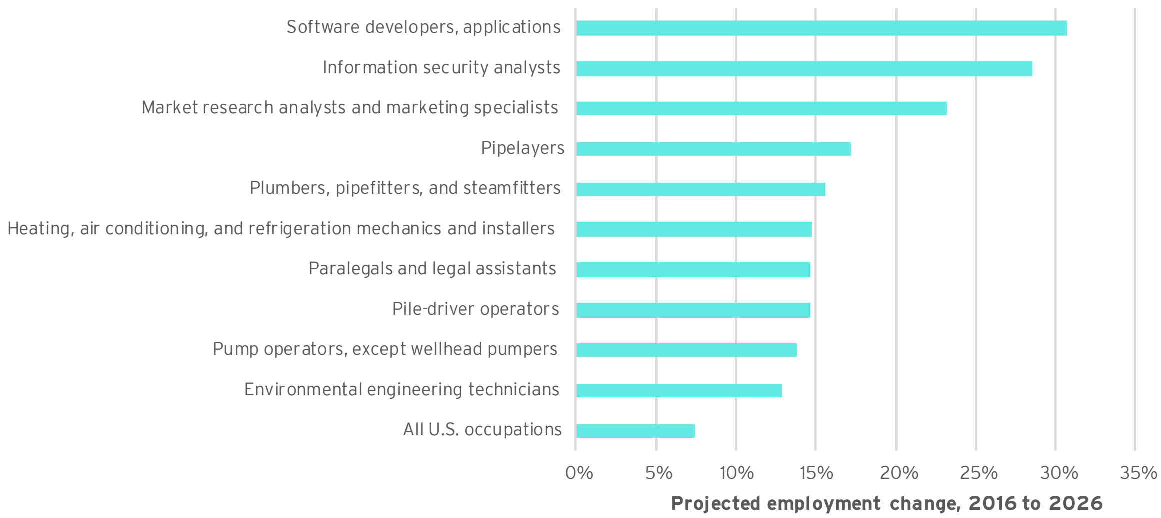
Many water jobs do not require college degrees (Chart 2) but do involve years of on-the-job training to perform effectively. For example, 34.6% of water treatment operators indicated in a Brookings report's survey that they needed 2 to 4 years of on-the-job training. Finally, not only do these jobs require higher degrees less-often, but they exceed average wages for comparable positions.[1] Investing in water infrastructure increases jobs in the water sector which offer both a competitive salary and low barriers to entry.

Factors that Impact Economic Gains

Technical Capacity Limitations

Although this literature review provides evidence that investing in water infrastructure can lead to job growth both indirectly in the surrounding community and directly within the water sector, there is a concerning caveat to jobs in the water sector. Given the technical nature of certain water jobs and the years of on-the-job training involved, job growth is dependent on available labor and a technical workforce. Investing in new water infrastructure projects is a commitment to a long-term project. Communities may be deterred from applying to funding for large-scale projects because of limited capacity or uncertain capacity to manage an ongoing, highly technical project. Lastly, as competition for labor increases in the water sector, rural communities may lose out to larger, urban municipalities that can offer higher wages. This cycle will perpetuate the staffing shortage even after rural communities address local training gaps. Overall, the demand for water workers is already in a state of growth (Chart 3), but communities that cannot staff their water projects properly will struggle to fully realize the economic gains of such expensive initiatives.

Chart 3: Selected Water Occupations Projected to See Faster Employment Growth (2016 -2026)



Source: Brookings Metropolitan Policy Program, Renewing the Water Workforce (2018).

Rural vs Urban

Another factor that impacts economic gains is the location and composition of the community. In a study conducted by the USDA Economic Research Service, urban communities saw larger returns to water infrastructure investment than rural communities even when controlling for income, demographics, and employment rates.[2] The average urban water and sewer facility cost roughly one-third more than the average rural facility but created twice as many permanent jobs, generated three times as much in private investment and added funds to the property tax base. The ability for urban water and sewer projects to induce larger benefits than rural projects could be attributed to a variety of features of urban communities, but most likely has to do with the larger number of beneficiaries in urban environments as well as the difficulties procuring supplies in rural environments.

1 Kane, Joseph, and Adie Tomer. "Renewing the Water Workforce: Improving Water Infrastructure and Creating a Pipeline to Opportunity." Brookings. Brookings, March 9, 2022. https://www.brookings.edu/research/water-workforce/.

2 Bagi, F. S. (1970, January 1). Economic Impact of Water/Sewer Facilities on Rural and Urban Communities. AgEcon Search. Retrieved April 13, 2023, from https://ageconsearch.umn.edu/record/289691

Areas for Further Research

Green Infrastructure

Green infrastructure is a type of water or environmental project that can advance environmental health, help with stormwater and flood management, and improve water conservation. As communities develop, natural spaces become more fragmented and natural processes are increasingly interrupted. Unlike traditional conservation practices, green infrastructure is focused on efficient land use and sustainable community development. Generally, new developments along fragile ecosystems such as wetlands and riparian zones hinder environmental resiliency and reduce the ability to support wildlife, trap sediments keeping water clean, and maintain plant life.[1] As discussed earlier in this paper, flood control helps avoid additional costs for homeowners and could likely prevent additional municipal costs to repair public infrastructure such as roads, schools, and powerlines. Green infrastructure encompasses a wide variety of projects, but ultimately has the goal of preserving environmental "hubs" and "links" which enable the landscape to support networks of natural processes. [2]

The aggregate economic values of such projects merit further research. Case studies from specific community projects have found positive returns from investing in green infrastructure, but less is known about regional impacts. For example, after Grayslake, Illinois implemented a conservation development plan to protect environmental resources around the community which bordered large nature preserves, the project was estimated to improve the real estate market while saving around $1.4 million during construction from limiting environmental impacts.[3] Many of the economic studies conducted in the last decade to analyze the relationship between green infrastructure and property values use a hedonic price model where households are asked to estimate their willingness to pay for changes in property attributes.[4]

Water Quality Improvements

Beyond expanding water supply, infrastructure investments can improve water quality for community residents. More research is needed to link the health benefits to overall economic growth. Improved community health is likely to contribute to a more productive, prosperous workforce, but to what extent water infrastructure investments have improved public health requires more economic research. In the USDA Economic Research Service study on the effects of water infrastructure investment on rural versus urban communities sited earlier, the only communities evaluated were those in economic distress already. The paper concludes that building new water and sewer facilities for the benefit of safe drinking water and waste-water regulations would likely produce different economic results.[5] Furthermore, communities with less need for major water capital investments might simply benefit from the short-term construction jobs and sale of materials, but further research is necessary to determine the effect of improved water quality and management on the community overtime.

Water Efficiency and Conservation Spending

Similar to green infrastructure, there is a gap in research linking efficiency improvements and conservation to economic productivity. Most of the existing economic research measures capital investments which increase water supply. Other water project spending such as when utilities sponsor the replacement of toilets and shower heads with more efficient products not only saves households money, but likely benefits local commerce as those households have more money to spend on other goods and services. Secondly, the efficiency programs likely have an impact on water rate changes overtime as the variable costs to the water systems are reduced. Avoided cost studies are helpful for understanding savings, but still leave open the opportunity to measure the economy overall. Future research could potentially quantify the community benefits from such efficiency and conservation projects.

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1 Benedict, Mark A., and Edward T. McMahon. "Green Infrastructure: Smart Conservation for the 21st Century." National Academies of Sciences. The Conservation Fund, April 30, 2001. https://trid.trb.org/view/643710.

2 https://trid.trb.org/view/643710

3 Buntin, Simmons B. "Prairie Crossing in Grayslake, Illinois : Unsprawl Case Study." Terrain.org. Accessed April 21, 2023. https://www.terrain.org/unsprawl/9/.

4 https://www.sciencedirect.com/science/article/abs/pii/S0301479719306267

5 Bagi, F. S. (1970, January 1). Economic Impact of Water/Sewer Facilities on Rural and Urban Communities. AgEcon Search. Retrieved April 13, 2023, from https://ageconsearch.umn.edu/record/289691

Water Efficiency and Conservation Spending

The way in which utilities operate is likely to determine the success of their investment projects. For example, a utility company's ability to evaluate and select the most appropriate infrastructure project for its community will impact the level of economic returns accrued from that project. An expensive, inappropriate project that overburdens the tax base with rising costs could stunt economic activity and delay the long-term economic returns from investing in water infrastructure. Some research currently exists that finds regional investment in capital projects mitigates financial risks for water utilities.[1] Better outcomes for water utilities are likely to feed into the job growth within the sector and economic gains in the surrounding community. More research is needed to link different financing strategies and management agreements to the success and impact of water infrastructure investment.

Conclusion

Water infrastructure spending has a distributed effect among industries and households in a community with spillover effects on the wider regional economy. It improves productivity in businesses reliant on water and the water sector itself, which produces jobs and grows wages. The water infrastructure also has indirect benefits for adjacent businesses and environmental health that can fortify a community against economic downturns and unforeseen climate impacts. The US spends roughly $50 billion on water infrastructure annually but has failed to keep up with aging water systems and population trends. The new federal funding, including the Infrastructure Investment and Jobs Act and Inflation Reduction Act, will more than double this spending across years of new projects, which are vital for meeting future water needs.[2] Studies have confirmed that failing to invest properly in water infrastructure puts communities at financial and safety risk which could take decades to fully recover from. A lack of adequate water infrastructure development burdens households which can depress household spending and dissuade new business investment in the area.

The field of environmental economics, particularly methods that evaluate environmental benefits, could provide avenues to assess the economic value of water quality improvements and green infrastructure investments. Prior research indicates that water quality of recreational water bodies, such as lakes, has an economic value for nearby households.[3] In addition, consumers have stated and revealed preferences for improvements in drinking water quality.[4] Green infrastructure investments could also be assessed using these methods, asking households their willingness to pay for green infrastructure improvements, such as green stormwater solutions.

Investing to expand and conserve water supplies supports a healthy housing market and makes communities more resilient to future climate risks that could exacerbate water scarcity and disrupt economic activity. Furthermore, investing in water infrastructure is an investment in the water workforce which provides a stable career path with competitive wages, a boon for local economic development. Given the many ways that water touches peoples' lives, investing in the infrastructure to properly manage this resource is a key to sustaining economic activity and community wellbeing.

1 Gorelick, David E., David F. Gold, Patrick M. Reed, and Gregory W. Characklis. "Impact of Inter- utility Agreements on Cooperative Regional Water Infrastructure Investment and Management Pathways." Water Resources Research 58, no. 3 (March 2022). https://doi.org/10.1029/2021wr030700.

2 "President Biden Introduces Plan for $111 Billion in Water Infrastructure Investment." US Water Alliance, n.d. https://uswateralliance.org/news/president-biden-introduces-plan-111-billion-water-infrastructure-investment.

3 Egan, Kevin J., et al. "Valuing Water Quality as a Function of Water Quality Measures." American Journal of Agricultural Economics, vol. 91, no. 1, Feb. 2009, pp. 106–23. DOI.org (Crossref), https://doi.org/10.1111/j.1467-8276.2008.01182.x.

4 https://mannyteodoro.com/wp-content/uploads/MTeodoro-2022-Rate-Increase-Framing-Experiment_AWWA-WaterSci_Preprint.pdf