Title

Assessing the Potential of Urban Water Efficiency: with Focus on Outdoor Efficiency and the Commercial, Industrial, and Institutional (CII) Sector

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Assessing the Potential of Urban Water Efficiency: with Focus on Outdoor Efficiency and the Commercial, Industrial, and Institutional (CII) Sector

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by

Sonali Mariam Abraham

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ABSTRACT OF THE DISSERTATION

Assessing the Potential of Urban Water Efficiency:

with Focus on Outdoor Efficiency and

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by

Sonali Mariam Abraham

Doctor of Environmental Science and Engineering

University of California, Los Angeles, 2021

Professor Mark Gold, Co-Chair

Professor Jennifer Jay, Co-Chair

Climate change threats have become one of the most pressing issues of our time and California has felt this acutely. The state faced its driest period on record during the 2011-2017 drought, and in 2021, is faced with the start of yet another major drought. The state is dependent on a highly engineered water management system, with miles of distribution systems and large reservoirs to get water to its residents at the times it is needed. This system is no longer sustainable in the face of a changing climate. A key solution for California that is cost-effective and requires minimal new resources is water efficiency and conservation. In this dissertation, we examined the potential for efficiency to create new water supply and provide multiple other

benefits. We first examined and quantified the water savings available from each sector and in each hydrologic region across the state by adopting efficiency improvements such as efficient devices and climate-appropriate vegetation. Next, we reviewed the many benefits attributed to sustainable landscapes, i.e., landscapes that are irrigated efficiently, exist in harmony with their environment, and require minimal external input. In the next two chapters, we studied efficiency within the commercial, industrial, and institutional (CII) sector. We first evaluated through a quantitative analysis the outdoor water use patterns for CII customers at a water supplier in Southern California. Next, we evaluated factors that motivate and hinder decision-making at a CII site to encourage uptake of sustainable landscapes within the sector. We found that efficiency improvements can save between 2.1 to 3.2 million acre-feet of water statewide. Sustainable landscapes are a key solution that contribute to additional supply while also providing benefits such as groundwater recharge, improved water and air quality, and community benefits. For urban areas to harness their full efficiency potential, the CII sector needs to be part of the solution. We found opportunities for savings within this sector but also a need for more study and understanding. Our key final recommendations discussed the need for ambitious efficiency policy for existing buildings, more study into CII end-uses, and targeted and aggressive outdoor efficiency policy.

The dissertation of Sonali Mariam Abraham is approved.

Heather Cooley

Jessica Cattelino

Stephanie Pincetl

Jennifer Jay, Committee Co-Chair

Mark Gold, Committee Co-Chair

University of California, Los Angeles

2021

I dedicate this dissertation to:

my mother, Reena, for teaching me how to dream,

my father, Joseph, for always being my biggest cheerleader,

my sisters, Sanjana and Sandhya, for helping me laugh through the hard times and providing the grounding perspective only sisters can,

my partner, Colby, for seeing the best in me even when I couldn't,

and Brandy and Jax, for bringing me joy every day.

To the other special people in my life who believed in me and helped me reach where I am, my gratitude and love always.

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Chapter 2: Cooley, Heather, Anne Thebo, Sonali Abraham, Morgan Shimabuku, Sarah Diringer, and Peter Gleick. (In Prep) 2021. The Untapped Potential of California's Water Supply. Pacific Institute.

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Appendix B: Abraham, Sonali, Cora Kammeyer, and Heather Cooley. 2020. Sustainable Landscapes in California: A Guidebook for Commercial and Industrial Site Managers. Pacific Institute. https://pacinst.org/publication/sustainable-landscapes-santa-ana-river-PDF.

Chapter 2 was part of a broader body of work. My section was done with the help of Heather Cooley, Sarah Diringer, and Peter Gleick, all listed as co-authors for this publication. My portion of the work included data collection, analysis, and manuscript writing.

Chapter 5 was part of a broader body of work. My section was done with the help of Heather Cooley, and Cora Kammeyer, both listed as co-authors for this publication. My portion of the work included survey analysis, conducting interviews, and manuscript writing.

Appendix A was supporting material from the same report that Chapter 5 was from. This survey was developed in collaboration with Heather Cooley, Cora Kammeyer, Martha Davis, and Charles Gardiner. My role was review and analysis of survey results.

Appendix B was created with the help of Cora Kammeyer and Heather Cooley, both listed as co-authors on this publication. My role included manuscript writing and making decisions around structure and layout.

The names listed above are specific chapter acknowledgements. I would also like to thank some individuals below who helped me through the entire course of my graduate work.

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Vita

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Chapter 1: Introduction

In today's world, climate change threats to water supply are one of the most urgent issues we face. We're already witnessing the extreme effects of water-related crises around the world. In early 2018, Cape Town, in South Africa, declared a national disaster in the face of ongoing drought, with authorities warning that taps would run dry leaving 4 million people without water for basic human needs (Welch 2018; Baker 2018). In the southern part of India, the city of Chennai also came dangerously close to 'Day Zero' in 2019, with all major reservoirs drying up and the government having to truck in drinking water for its residents (Kumar-Rao 2019; Bloomberg News 2021). In 2021, both Cape Town and Chennai faced eerily similar situations, with localized flooding and high rainfall (Jordan 2021; The Times of India 2021). These similarities are far from a coincidence. Climate change and extreme weather events combined with rapid urbanization, and inadequately designed cities, have created disastrous situations in cities around the world and will likely continue to do so. There is an urgent need to rethink the way we build and rebuild our cities in this new normal.

Ten years after the driest drought in its history, the state of California is currently seeing the start of another significant drought (National Integrated Drought Information System and National Oceanic and Atmospheric Administration (NOAA) 2021). To provide enough water for its 39 million strong population, the state moves water from the north to population centers along the coast and further south via the State Water Project, and the Los Angeles Aqueduct, and west via the Colorado River Aqueduct. Sources of this water lie in the Sierra Nevada Mountains and the Rocky Mountains in Colorado. The increasing effects of climate change are projected to lead to more frequent and intense droughts for the state as well as a reduction of about 48% in the

Sierra Nevada snowpack, creating major challenges in maintaining a sustainable water supply in the future (Reich et al. 2018). Droughts have multiple impacts on a water system. Water quality and quantity are affected through a reduction in water supplies and concentration of contaminants in a reduced supply. Vulnerable ecosystems are affected through reduced instream flows. Droughts also often affect the most vulnerable sections of society. Rural communities, often dependent on single sources of water, are acutely affected by water scarcity (Pacific Institute 2021).

There are multiple strategies to best cope with this uncertain but imminent future. While there has been a historic tendency to prioritize management strategies that can yield a concrete return on investment and satisfy immediate needs, these large-scale systems are not adaptable or cost-effective in this new future (Tsegaye et al. 2020; Leigh and Lee 2019). Alternative strategies like water efficiency improvements have been shown to be cost-effective and can provide significant additional supply along with other benefits (S. E. Diringer, Shimabuku, and Cooley 2020; P. Gleick et al. 2014). This includes indoor efficiency improvements such as installing low-flow toilets or faucets, and outdoor improvements such as using weather-based irrigation and climate-appropriate plants.

Water used in outdoor landscapes represents half of all water used in California's urban areas (Hanak and Davis 2006). Landscape conversion that uses climate-appropriate, low water-use plants combined with efficient irrigation can save water and provide a host of other benefits. These conversions can also enhance stormwater capture, recharge local groundwater aquifers, improve water quality, and boost property values (S. Diringer et al. 2019; Clements et al. 2013; Center for Neighborhood Technology and American Rivers 2010). Sustainable landscaping is adapted to its environment, making use of natural conditions and minimizing the need for external input.

Addressing these climate change and water management challenges and making real change will require active participation from all state residents- including the business community. However, this has not been an easy task thus far. Business and regulation have long held tension in their relationship to each other. However, in recent years, with the increasing effects of pollution and climate extremes, businesses have shown interest in addressing water-related challenges (Schulte, Orr, and Morrison 2014; CEO Water Mandate 2015; Orr, Cartwright, and Tickner 2009; Sujamo 2016). *Not* addressing water challenges involve a significant financial risk for companies since businesses depend on water resources for a number of reasons, from operational to addressing drinking water needs for its employees (CDP 2020; Morrison et al. 2009; CEO Water Mandate, n.d.). As a result, companies are taking action towards more sustainable practices both onsite as well as beyond their fence-line (CEO Water Mandate 2013; CDP 2020; Barton 2010). At the same time, there are real concerns around greenwashing (de Freitas Netto et al. 2020) and while making use of strategies such as sustainable landscaping and water-efficient devices must be encouraged on CII properties, we also note that there is a need for a larger fundamental change in how businesses operate as well as higher levels of accountability.

In the following chapters, we assess the value-add of efficiency improvements to water resilience across California. Making small but effective changes in how people use water can make significant impact. In Chapter 2, we discuss what water savings are available from efficiency improvements, in the residential and commercial sector, and indoors and outdoors. We assess this statewide and by hydrologic region. This information creates an understanding of where we are and where we can strive to be, in how we use water in urban areas. This information can also lead to better-informed policy on where to target water savings. In Chapter 3, we study sustainable landscapes and its benefits. There is a lack of assembled information that connect landscapes and its known benefits, hindering uptake of these landscapes. Through this review, we better understand and document the benefits of sustainable landscapes and create information to motivate adoption of these landscapes. This also helps future researchers identify gaps in understanding and areas for further investigation. In Chapters 4 and 5, we investigate how the CII sector can contribute to water resilience in the state. Water conservation programs, particularly outdoor programs, have historically been focused on the residential sector. However, the CII sector has a lot of turf and impervious areas with large potential to reduce water use and gain other community benefits. In Chapter 4, we assess outdoor water use trends for a water supplier in Southern California to understand how the sector uses water outdoors and how this information can be harnessed for improved sustainability in the sector. In Chapter 5, we investigate factors that drive site-level decision-making in the CII sector when considering a sustainable landscape project. This information identifies the problem, suggests preliminary solutions, and creates a foundation upon which future research on the CII sector can be built.

Discussion on efficiency and the benefits that come with it is incomplete without an acknowledgement of the role of equity. Who receives benefits and therefore, how resources are allocated are key questions. Heckert and Rosan 2016 discuss the role of decision-making and how having a seat at the table plays inherently into whose voices are heard and go on to reason that equity can only be achieved “if there is an intentionality about how funds are distributed, which communities are priorities, how partners are chosen and cultivated, and which types of projects are implemented in which neighborhoods." Ensuring equitable distribution of benefits and costs among affected stakeholders will allow for an equitable and just water resilient system.

Chapter 2: Assessing the Untapped Potential of Urban Efficiency in California

Abstract

California's water management system reflects the mismatches between water supply and demand, with large distribution and storage systems across the state as well as rising water scarcity and climate extremes. There is an opportunity to rethink the state's water policies and strategies, and to implement effective responses that can provide both near-term relief and long-term benefits. A 2014 study, led by Pacific Institute, found that water-use efficiency could reduce statewide annual water demand by 2.9 million to 5.2 million acre-feet per year, or from 30% to 60%. Since that assessment was completed, California has experienced several events affecting water use patterns and consequently the potential for additional water supply alternatives. In this report, we reassess the potential for urban water efficiency to both reduce inefficient and wasteful water demands and expand local water supplies. During this analysis, we estimated that 2 to 3.2 million acre-feet can be saved statewide through urban efficiency improvements. The residential sector can save between 0.55 to 0.98 million acre-feet indoors and 0.64 to 1.1 million acre-feet outdoors. Savings in the CII sector amount to 0.3 to 0.5 million acre-feet indoors and 0.38 to 0.43 million acre-feet outdoors. Managing distribution leak efficiency across the state can save 0.16 million acre-feet.

Introduction

California is a land of hydrological extremes, including severe and persistent droughts, and damaging storms and floods, coupled with high water demand to support a large population, a robust agricultural sector, and substantial economy (State of California, California Natural Resources Agency, and California Department of Water Resources 2019). This results in numerous water management challenges. The wet season runs from October to April, but the largest demands for water come during the dry months of May through September. Most water falls in the north and in the mountains, but the greatest demands come from the large population centers along the coast and further south, and agricultural lands located further west (California Department of Water Resources 2021a). After suffering through the worst five-year drought in 1,200 years between 2012 and 2016, extreme drought has returned to California, and indeed, the entire western United States (State of California 2021).

California's water management system reflects the mismatches between water supply and demand, with hundreds of large dams to store winter flows, thousands of miles of aqueducts, canals, and distribution systems to move water from areas of abundance to areas of shortage, and uncounted wells to extract groundwater. The traditional approach to water management in California – building dams, extracting more and more water from rivers and streams, and pumping more groundwater - is tapped out. There is an opportunity to rethink the state's water policies and strategies, and to implement effective responses that can provide both near-term relief and long-term benefits.

The good news is that solutions to our water problem exist. A 2014 study, led by Pacific Institute, found that water-use efficiency could reduce statewide annual water demand by 2.9 million to 5.2 million acre-feet per year, or 30 to 60% (P. Gleick et al. 2014). This alternative could provide effective drought responses in the near-term *and* water-supply reliability benefits for the state while also reducing pressure on rivers and aquifers and lowering energy use and greenhouse emissions (Dziegielewski 1999; Maas 2009; Spang, Holguin, and Loge 2018). Since that assessment was completed, California has experienced several events affecting water use patterns and consequently the potential for additional water supply alternatives. Some, like the severe prolonged drought that prompted reductions in water demand, may have reduced the water efficiency and reuse potentials. However, others, like continued population growth and new technologies and practices, may have increased them. In this report, we reassess the potential for urban water efficiency to both reduce inefficient and wasteful water demands and expand local water supplies. We provide an overview of current water demand trends in California, and then describe our methods as well as the results of our analysis of the opportunities in increased urban water-use efficiency. Finally, we offer conclusions and a set of key findings.

This current work identifies the untapped potential to improve the ability of cities, industry, and individuals to cope with water shortages and droughts and to tackle longstanding water challenges in California. There are other approaches not addressed here, including behavioral changes that cut water use and a range of agricultural practices that can maintain a vibrant agricultural economy while reducing water use in that sector. A separate, earlier assessment by the Pacific Institute identified extensive savings potential in the agricultural sector (Cooley, Gleick, and Wilkinson 2014), and some of these approaches are being implemented. A new assessment of this critical water-using sector is needed but is beyond the scope of this study. In addition to technological changes, behavioral change that drives efficiency and conservation are important strategies. While this work is not focused on behavioral strategies, we recognize and note their importance. During the last drought between 2013-2016, the conservation success seen was largely behavioral. Methods like restrictions on watering days, and large media coverage were excellent for fast and quick water savings. Mini, Hogue, and Pincetl 2015 further showed that mandatory water restrictions resulted in savings of 23% across Los Angeles city while voluntary restrictions were not effective, demonstrating the link between behavior, policy, and efficiency. Comparably, Gonzales and Ajami 2017 studied rebound in water use post-drought and found that fundamental behavioral change sticks while rebound can be attributed to short-term policy changes. In addition, demographic factors such as socio-economic status, education, household size, etc. play a role in the uptake of different efficiency strategies (Berk et al. 1993; Mini, Hogue, and Pincetl 2014a).

Urban Water Use Trends, 1960-2016

Demand for water is a function of the state's population, choices about how much land to farm, what to grow, and how to irrigate it, the nature of industrial and commercial water use, and the efficiency of water-using technologies. We use data from the California Department of Water Resources to assess trends in urban use between 1960 and 2016. As shown in Figure 2-1, California water use has seen a dramatic 'decoupling' from population and economic growth in the past 40 years (Cooley 2020). Prior to 1980, water use, and population grew at a relatively similar rate. Beginning around 1980, water use began to stabilize despite continued population and economic growth. Between 1967 and 2016, gross state product grew by factor of five and the population more than doubled. During that same period, water use increased by only six percent. This decoupling was a result of improvements in water efficiency technologies and practices, as well as structural changes in the economy (Cooley 2020).

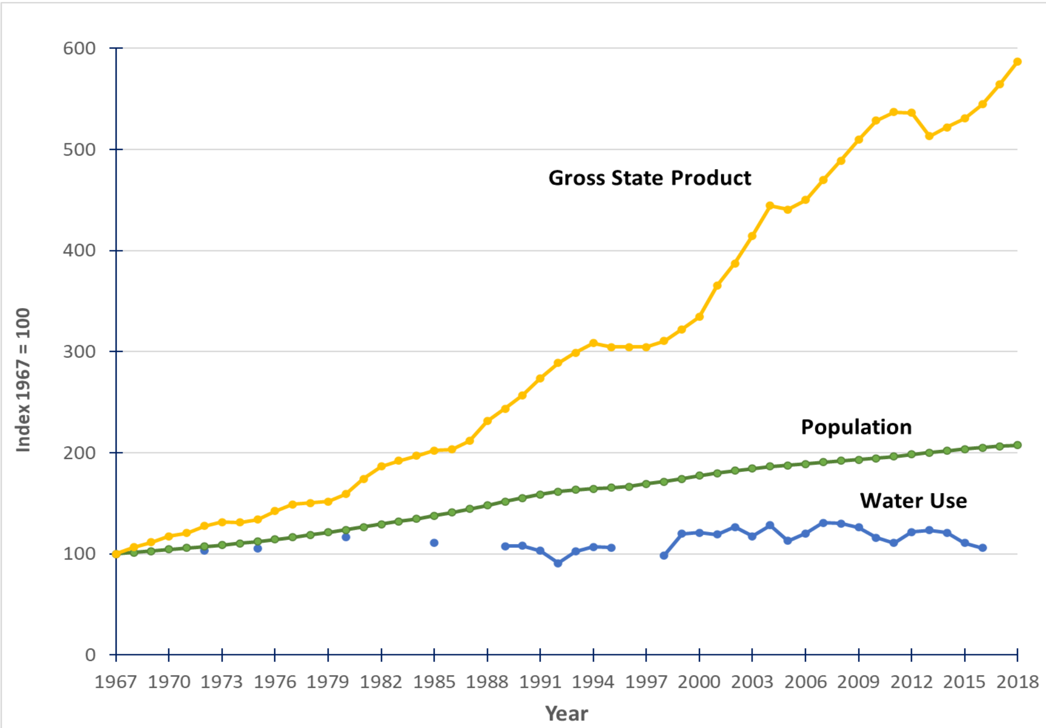

Figure 2-1. Statewide trends in population, gross state product, and total water use, 1967-2016. All values are indexed to 1967 values to allow for comparison among different datasets.

Source: Water use data from DWR. Population data from California Department of Finance (2018). Gross state product from US Bureau of Economic Analysis (2019). Adapted from (Cooley 2020).

Figure 2-2 shows trends in total, urban, agricultural water use, with the drought periods shaded in yellow. In 1960, total urban water use was 3 million acre-feet, or 177 gallons per capita per day (GPCD). Urban water use, total and per capita, saw a steady climb between 1960 and 1990. Between 1987 and 1992, a major drought led to dramatic decreases in urban water use. However, while water use continued to climb after the end of the drought, per capita water use stayed relatively flat in comparison. Since 2007, both total and per capita use have declined dramatically. By 2016, total urban use was 7.1 million acre-feet – levels not seen since 1995. From Figure 2-2, we also see that urban water use tends to be higher in dry years and lower in wet years. The onset of a drought leads to a decline in urban water use, likely due to conservation measures, as seen during both drought periods starting in 2005 and 2014. We are currently entering another drought and the state has asked residents to voluntarily cut water use by 15% (Office of Governor Gavin Newsom 2021). While there has been concern around water use rebounding to pre-drought levels, studies show that some conservation is likely going to stick, preventing a return to pre-drought per capita levels (Bolorinos, Rajagopal, and Ajami 2020; Gonzales and Ajami 2017). With droughts a regular occurrence in the state, a resilient water demand will help us prepare better for the future.

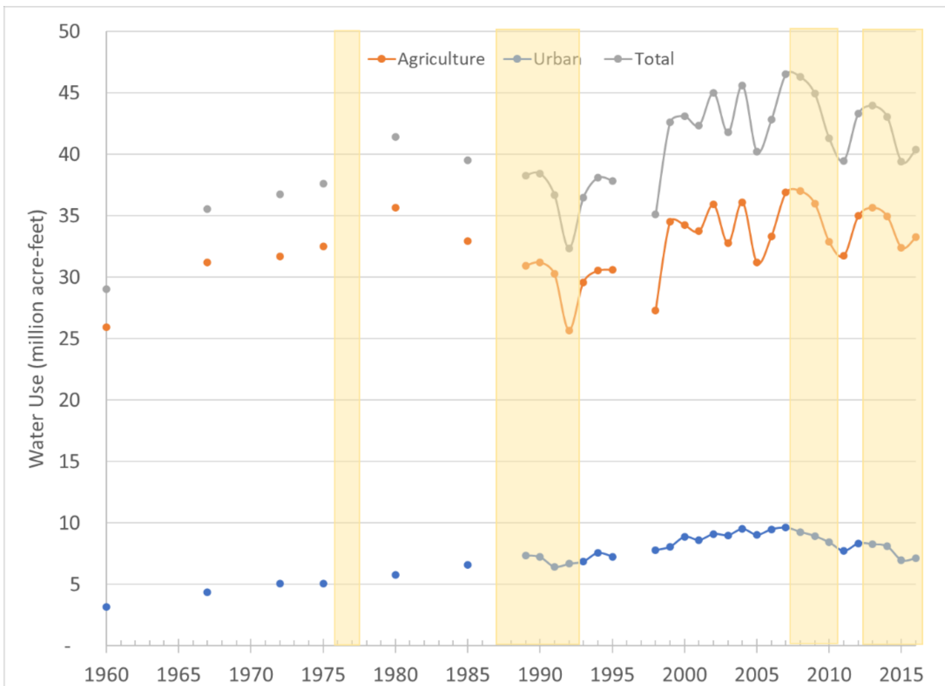

Figure 2-2. Statewide total water use trends, in million acre-feet, for the agricultural and urban sectors, 1960-2016. Source: Water use data from DWR. Adapted from (Cooley 2020).

Current Per Capita Demand

To assess current per capita demand, we used data from the electronic Annual Reporting (EAR) datasets from the California State Water Resources Control Board ('State Water Board') (State

Water Resources Control Board n.d.). While data from the Department of Water Resources was used to assess historical trends above, the EAR dataset provides more current and up to date estimate of per capita information. We use the EAR dataset for all our analysis in this study. The dataset and approach are discussed in the Methods section below. Since a discussion of per capita demand is essential for context, we include this discussion here.

We estimated current average urban water use, as an average of 2017-2019, in California is at 134 gallons per person per day (GPCD). Residential use is at 94 GPCD, 47 GPCD indoors and outdoors. Table 2-1 summarizes these findings.

There have been many estimates of efficient and reasonable indoor water use in California. Feinstein 2018 points to two core state standards summarized in the State's resolution on the Human Right to Water. As quoted in Feinstein 2018, "the 55 GPCD "provisional indoor standard" referred to in California Water Code §10608.20, and the 50 GPCD maximum for domestic use diversions filed in the California Code of Regulations (CCR §878.1) and repealed in 2015." While the 55 GPCD standard is somewhat subjective, the 50 GPCD value is more widely used and supported (Feinstein 2018). Our statewide estimate of 47 GPCD indicates significant progress has been made in indoor efficiency. We found that average indoor residential GPCD for all hydrologic regions was below 55 GPCD, and 7 out of 10 regions were below 50 GPCD.

Water use varies by region significantly. Overall, urban per capita varies between 180 and 70 gallons per person per day across the state. Absolute urban use however is higher in the more populated areas of the South Coast and San Francisco Bay hydrologic regions, while per capita use is highest in the Sacramento River, Tulare Lake, and Colorado River regions (Figure 2-3). Colorado River, Sacramento, and Tulare Lake regions, with the highest per capita urban use, also have the highest outdoor residential per capita use. Colorado River has an outdoor residential per capita use of 70 GPCD, 34% higher than the South Coast and 58% higher than San Francisco Bay. The reductions in per capita consumption in communities like San Francisco (The San Francisco Public Utilities Commission 2011) and Los Angeles (Los Angeles Department of Water and Power (LADWP) 2015) have been countered by an increase of outdoor water use in other areas. Inefficient water-using fixtures and appliances, water-guzzling lawns, leaks from water delivery systems still exist. These results are very significant in a drought situation, where impacts will continue to be felt more severely than if persistent and consistent water conservation and efficiency programs were in place.

Table 2-1. Urban, residential, indoor, and outdoor per capita water use for the state and by hydrologic region, average 2017-2019.

Hydrologic Region	Urban Gallons Per Capita Per Day (GPCD)	Residential-GPCD (RGPCD)	Indoor RGPCD	Outdoor RGPCD
Central Coast	111	76	44	32
Colorado River	179	113	52	61
North Coast	92	61	37	25
North Lahontan	68	93	52	41
Sacramento River	173	117	47	70
San Francisco Bay	109	70	41	29
San Joaquin River	152	105	51	54
South Coast	142	96	49	46
South Lahontan	139	96	49	47

Tulare Lake	175	110	46	64
STATEWIDE AVERAGE	134	94	47	47

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

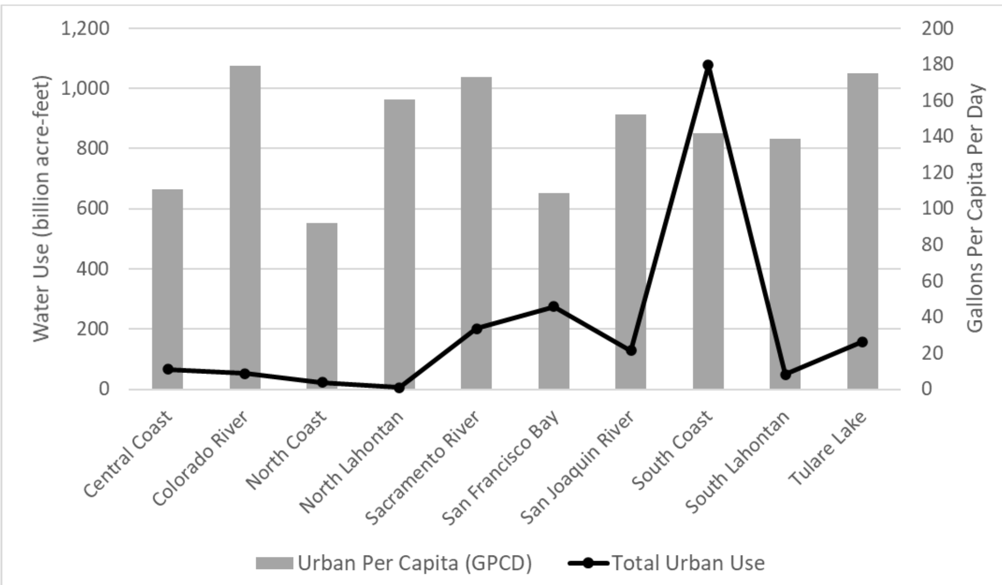

Figure 2-3. Total urban water use in billion acre-feet and urban per capita water use by hydrologic region, average 2017-2019.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

California has great potential to reduce the mismatch between water supply and water demand in all sectors, with strategies that are known to work, are cost-effective, and would provide resilience and flexibility during droughts that are likely to become more frequent and severe. These options include greatly expanded water treatment and reuse, more comprehensive and consistent stormwater capture, and expanded programs to improve the efficiency of water use in all sectors.

In this analysis, we evaluate the technical potential of urban water efficiency as an alternative option and make policy recommendations based on our findings.

Methods

Previous Pacific Institute analyses, including Gleick et al. (2003) and Heberger et al. (2014), evaluated California's water conservation and efficiency potential. In this analysis, we update these estimates using new data from state agencies to model the effect of increased deployment of water-efficient technologies. Our focus here is on technological solutions for using water more efficiently, rather than on behavioral changes, such as shorter showers. For every sector, we estimated current water use and efficient water use, with the difference between these values representing the water efficiency potential.

To estimate current water use, we used the electronic Annual Reporting (EAR) datasets (link) from the California State Water Resources Control Board (State Water Board). The EAR is an annual survey of public water systems that collects water system information, including water use by sector (residential use; commercial, industrial, and institutional; and water losses). Our estimate of current water use is based on EAR data for the years 2017, 2018, and 2019. This time-period was selected because it represented the most recent years for which data are available and was less affected by the mandatory restrictions put in place during the 2012-2016 drought.

Prior to analysis, we removed outliers and blanks from the EAR dataset. The EAR does not allow for a way to distinguish between actual zeros and unavailable data. All suppliers with entries of a zero across all three years of analysis were removed. For suppliers with entries of zeros for only one year, only the individual zero value was removed. To identify outliers, we calculated the relative standard deviation for each supplier, to compare their data across 2017, 2018, and 2019. We further examined the data for suppliers who had a relative standard deviation over 50%. The data for these suppliers was cross-checked with supplier-reported information in their Urban Water Management Plan (UWMP) and inaccurate values were excluded.

Water suppliers included in the EAR represent 88% of the statewide population. To develop a statewide estimate of the efficiency potential, numbers were adjusted to include the entire state using population estimates from the Department of Water Resources (DWR). Additional detail on how we determined current and efficient water use for each sector is provided in the following sections.

Residential Water Use and Potential Water Savings

Current water use was calculated from data provided by the State Board. Staff at the State Board calculated indoor residential use using the 'Landscape Irrigation Method'. This method uses the minimum residential gallons per capita per day (R-GPCD) and percent range of landscape irrigation values to estimate 'minimum month' outdoor R-GPCD; this is subtracted from R-GPCD to get indoor R-GPCD. Outdoor R-GPCD for each supplier was calculated as the difference between R-GPCD and indoor R-GPCD. We calculated values for 331 suppliers in total. We then aggregated suppliers using a simple average to obtain values for each hydrologic region. Indoor and outdoor R-GPCD values for each hydrologic region were scaled to statewide values by multiplying by the population in each hydrologic region for 2019 to generate an absolute water use for each region. This scaling was done for current and potential per capita values, and then subtracted to obtain absolute savings.

Potential residential indoor savings were calculated as a difference between current water use and water use if all households were equipped with efficient appliances and fixtures. The low estimate of water savings was based on appliances and fixtures that meet current California standards, and the high estimate was based on leading-edge technology. The leading-edge technology was determined according to those devices that had received the EPA WaterSense certification with the lowest flow rate. For each, the efficiency standard was multiplied by estimates of the frequency of use (e.g., number of flushes per day) to determine efficient use, in gallons per person per day. Table 2-2 shows the flow rate and frequency of use for appliances and fixtures evaluated. In total, we estimate that water use is 35 gpcd in a home equipped with appliances and fixtures that meet current California standards, and 25 gpcd in a home equipped with leading-edge technologies (Table 2-3).

Table 2-2. Water use and frequency of use for residential appliances and fixtures with California standards and leading-edge technology.

Indoor Appliance	California standards	Leading-Edge Technology	Units	Frequency of Use
Toilets	1.28	0.79	gallons/flush	4.76 flushes/person/day
Clothes washer (min. is front-loading)	21.15	13.72	gallons/load	0.35 load/person/day
Showerhead	1.8	1	gallons/minute	5.8 mins/person/day
Faucets	11.1	11.1	gallons/person/day	N/A
Dishwasher	5	1.95	gallons/cycle	0.1 uses/person/day

Note: (DeOreo et al. 2011) found that faucet water use was 11.1 gallons per person per day. We assumed that faucet water usage was determined by volume rather than by the flow rate of the device, resulting in a conservative estimate of water savings from faucets.

Source: The frequency of use for each end use was based on (DeOreo et al. 2011). California standards data from (California Building Standards Commission 2019). Leading-edge technology information from (Environmental Protection Agency (EPA) 2021).

Table 2-3. Residential indoor water use (in gallons per person per day) for homes equipped with appliances and fixtures meeting California standards and leading-edge technologies.

	End Use (gallons per person per day)	
Indoor Appliance	California standards	Leading-Edge Technology
Toilets (single-flush, tank-type)	6.09	3.76
Clothes washer	6.77	4.39
Showerhead	10.49	5.83
Faucets	11.10	11.10
Dishwasher (standard)	0.50	0.20
Household leaks	0	0
TOTAL	35	25

Note: Clothes washer values are calculated for front-loading washers.

Residential outdoor water use was calculated using the landscape water budget method, based on an evapotranspiration adjustment factor (ETAF), which accounts for the water needs of the plants present and irrigation efficiency. (cite) We assumed current outdoor water use to correspond to a 0.8 ETAF value based on findings from DWR (cite). This assumption is based on statewide irrigated area with a 20% buffer for area that is irrigable and not irrigated. We developed low and high estimates of potential water savings for each hydrologic region resulting from conversion of landscape to climate-appropriate vegetation. To develop a low estimate, we assumed a 0.55 ETAF value which is the current standard for new residential development under MWELO. This results in a 31% reduction in statewide residential outdoor use. As a high estimate, we assumed complete conversion to climate-appropriate vegetation and efficient irrigation, with a 0.37 ETAF value. This translates to a 54% reduction in statewide outdoor use.

Commercial, Industrial, and Institutional Water Use and Potential Water Savings

The EAR contains three major categories that in aggregate represent CII water use: (1) commercial and institutional; (2) industrial; and (3) large landscapes. While "large landscapes" represent outdoor use, both the "commercial and industrial" and the "institutional" water-use categories are a combination of indoor and outdoor uses. Based on EBMUD (cite), we assumed that 80% of the reported use for these categories represents indoor use, and the remaining 20% was outdoor use. Thus, indoor CII water usage was equivalent to 80% of reported CII use, and outdoor usage was equivalent to the reported water use for large landscapes and 20% of reported CII use. To scale values to encompass statewide population, we calculated the ratio between hydrologic region population from DWR for 2019 and population estimates from the EAR for each hydrologic region. We multiplied this ratio by our water use values for CII indoor and outdoor. Hydrologic region estimates were then aggregated to obtain a statewide estimate.

There are many ways that the CII sector can reducing indoor water use, reflecting the diversity of ways in which water is used inside the building. Some of these are similar to residential water efficiency measures, such as installing efficient toilets and urinals, while others are customized to meet a particular end use of water. However, limited data were available on water uses within the CII sector, and potential water savings. Given the diversity of uses and limited data, we reviewed available literature including policy documents, case studies, and water audits to identify water saving opportunities. One challenge was that the literature was highly variable and findings were site-specific. We estimated that CII water savings ranged from 30% to 50%, based on Gleick et al. (2003). Estimates from individual studies also fell within this range.

Outdoor water savings for the CII sector was based on the landscape water budget method. Here, we assumed current water use is at a plant factor of 1.0. We used a 0.45 ETAF to calculate a low estimate of potential savings following MWELO's standard for new commercial landscapes. For a highly efficient scenario or our high estimate of savings, we assumed a value of 0.37 ETAF corresponding to complete conversion to low water use plants.

Water Distribution Losses and Potential Water Savings

Urban water suppliers report water losses from their distribution systems in the EAR. Senate Bill 555, passed by the California legislature in 2015, requires water suppliers to comply with individual volumetric water loss standards by 2028. These standards were developed using an economic model for leak detection and repair actions (cite). We obtained data on reported water losses and individual performance standards for each urban water supplier from the State Water Board's Water Loss Control website (cite). We scaled all values to incorporate statewide population using population estimates from DWR for 2019. For our analysis, we estimated potential water savings for each water supplier based on the difference between reported water loss and the water loss performance standard. Water savings were summed by hydrologic region and statewide.

Results

In this analysis, we estimated that 2.1 to 3.3 million acre-feet can be saved statewide through urban efficiency improvements. Figure 2-4 summarizes these findings. Our previous analysis estimated this to be between 2.2 and 5.5 million acre-feet. There have been considerable improvements in efficiency since 2014, with aggressive conservation measures during the last drought and numerous programs to encourage outdoor water efficiency (State Water Resources Control Board 2015). Current residential water use is 30% lower than a prior analysis in 2014, and there are smaller reductions across all sectors (P. Gleick et al. 2014). However, there is still room for improvement. 1.2 million acre-feet of savings are available across just the residential sector, with only moderate efficiency improvements; this would reduce current residential use by 28%. Adopting high efficiency improvements in the residential sector would further reduce current water use by 54%. We estimate savings in the CII sector to range between approximately 780,000 and 1 million acre-feet, with about half each coming from the indoor and outdoor sectors. Making improvements in distribution system leaks can save 160,000 acre-feet. This additional supply would make significant impact to supply-demand imbalances.

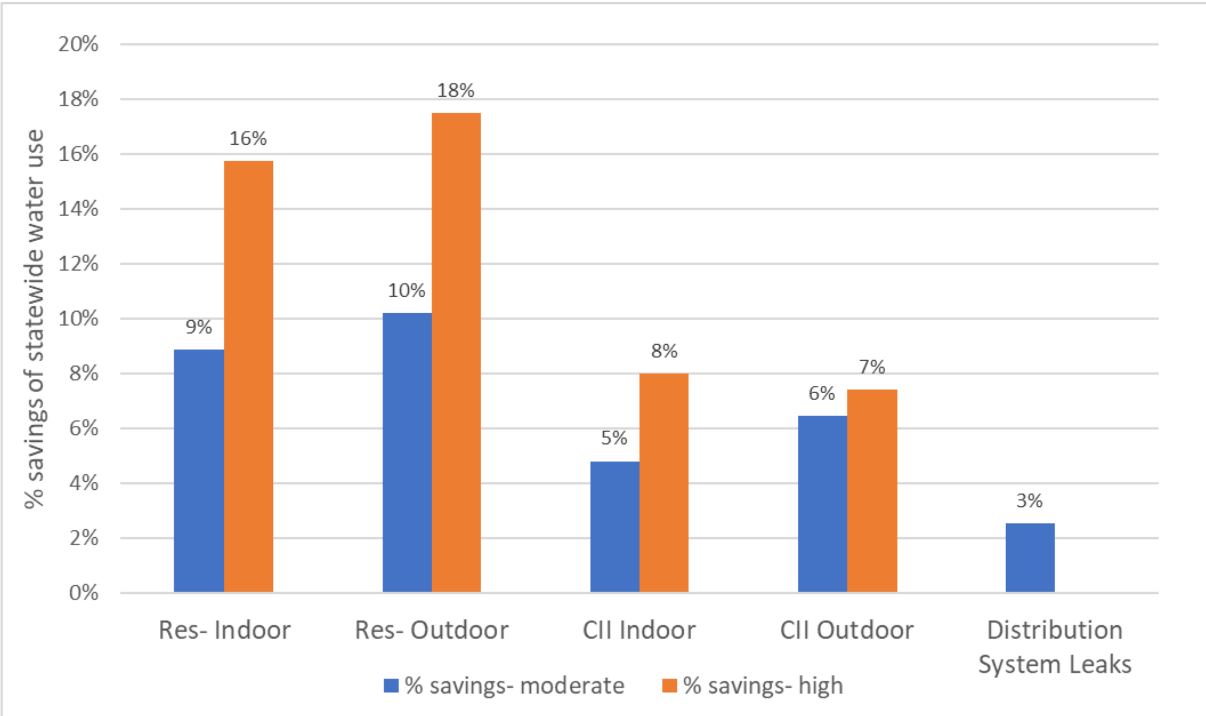

Figure 2-4. High and low estimates of urban water savings due to water efficiency improvements, in thousand acre-feet, by sector.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Residential Potential

In this analysis, we estimated that 2.1 to 3.2 million acre-feet can be saved statewide through all urban efficiency improvements. 58% to 65% of these savings are available across just the residential sector. Residential water use is concentrated on household devices indoors or landscape-related needs outdoors. There are many ways to reduce residential water use. Using more efficient devices such as low-flow toilets, high-efficiency clothes washer, and low flow faucets can significantly reduce per capita indoor water use. Similarly, switching to climate-appropriate landscape outdoors can considerably reduce residential water use. In our analysis, we found that switching to efficient practices can save 28% to 50% of residential water use. Approximately half of these savings are concentrated in the dry and populated South Coast hydrologic region. Savings available from outdoor use are about 10% higher than that from indoor use.

Indoor Residential

Indoor residential use stems chiefly from daily household activities such as showering, flushing, using the dishwasher, etc. Improved efficiency in these household devices leads to reduced water use indoors. Californians have made major strides in efficiency in the past decade, particularly indoors (DeOreo et al. 2011; Cooley 2020). However, there is still room for improvement. Studies have pinpointed significant potential in the adoption of increased efficiency in clothes washers and showers ((DeOreo et al. 2011; Los Angeles Department of Water and Power (LADWP) 2017)). A conservation potential study from LADWP found that majority of residential customers have adopted efficient toilets, faucets, and showers. However, there is still significant potential left in adoption of efficient clothes washers, over 65% of single and multi-family customers do not use efficient clothes washers (Los Angeles Department of Water and Power (LADWP) 2017).

Overall, this analysis found that Californians can reduce current residential use by 13% to 24% through indoor efficiency. Majority of Californians are already adhering to California device efficiency standards, making clear the progress the state has made in indoor efficiency. However, if we push beyond this and look toward leading-edge technology, water use savings almost double to 1 million acre-feet.

Regionally, corresponding to the highest population, the South Coast hydrologic region has the highest potential savings (Figure 2-5). By meeting state standards and leading technology, the region can save between 350 and 575 thousand acre-feet. San Francisco Bay has the second-highest potential savings, followed by Sacramento River. However, these trends are different on a per capita basis. Colorado River, followed closely by the North Lahontan hydrologic region have the most potential for water savings.

We use a water-budget method based on device efficiency to better understand efficient water use. Leading-edge technology sets indoor R-GPCD at its lowest at 25 GPCD, while California standards sets it at 35 GPCD. However, this method does not capture all household water-using devices, such as healthcare products, water softeners, or activities related to a hobby or home business. Additionally, this study assumes full market penetration of all efficient devices. While this is an unlikely situation in reality, this estimation provides a useful glimpse into *potential* savings possible given existing technology. This analysis also does not take active conservation into account.

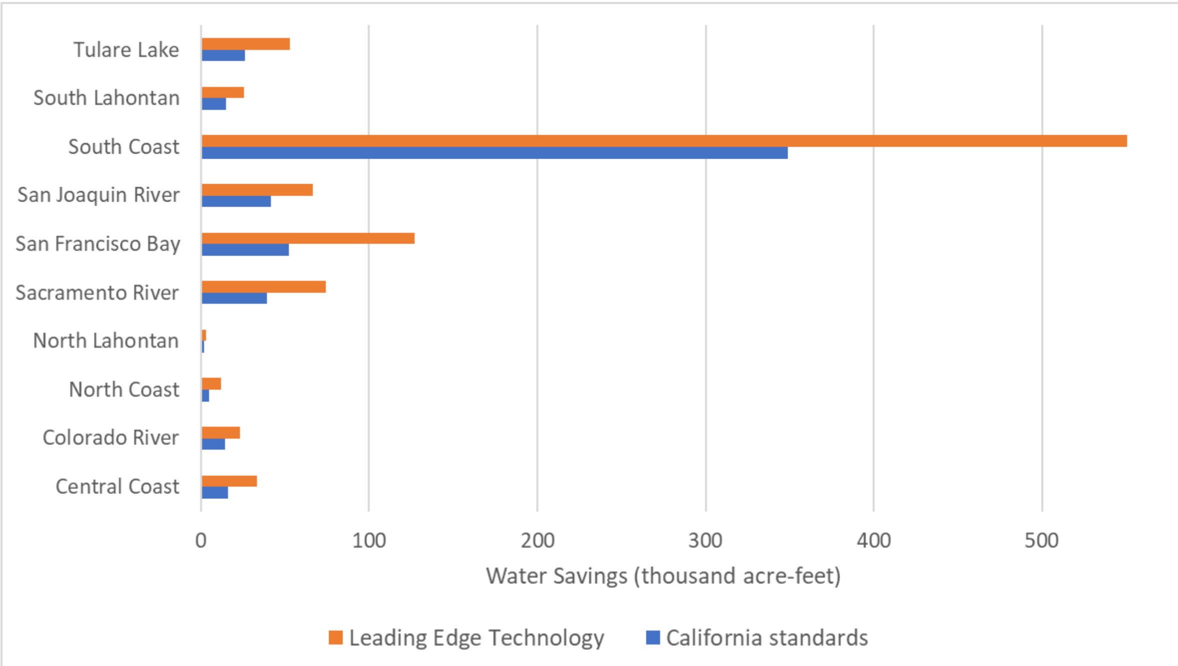

Figure 2-5. Indoor residential water savings in AF by hydrologic region if residents' devices met California device standards and leading-edge technology.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Outdoor Residential

We found that half of current residential use goes towards outdoor uses. Majority of outdoor use goes towards landscape irrigation requirements (Mini, Hogue, and Pincetl 2014b; Litvak et al. 2017). Outdoor use is difficult to estimate accurately due to inadequate outdoor metering, high dependence on weather, and variations across landscape area and type. However, it holds significant potential for water savings from efficiency and conservation. Outdoor use can be reduced by 25% to 40% through cost-effective techniques such as improved irrigation systems and better monitoring (Gleick, 2003). The simplest way to reduce outdoor water use is to change high water use landscaping to more water-resilient choices, such as climate appropriate vegetation. In addition to reducing water use, these landscapes have other benefits such as reduced need for maintenance and improved ecosystem benefits (Landscape Architecture Foundation n.d.).

In our analysis, we consider two efficient scenarios- moderate conversion to climate-appropriate landscaping, and complete conversion. We estimated that Californians can save up to 30% of current outdoor residential use or almost 650,000 acre-feet by moderate conversion which aligns with meeting MWELO standards, and up to 1.1 million acre-feet (or, 54%) by completely converting to climate-appropriate landscaping (Figure 2-6). The dry, hot, and populated areas of the South Coast hydrologic region have, by far, the highest water savings available.

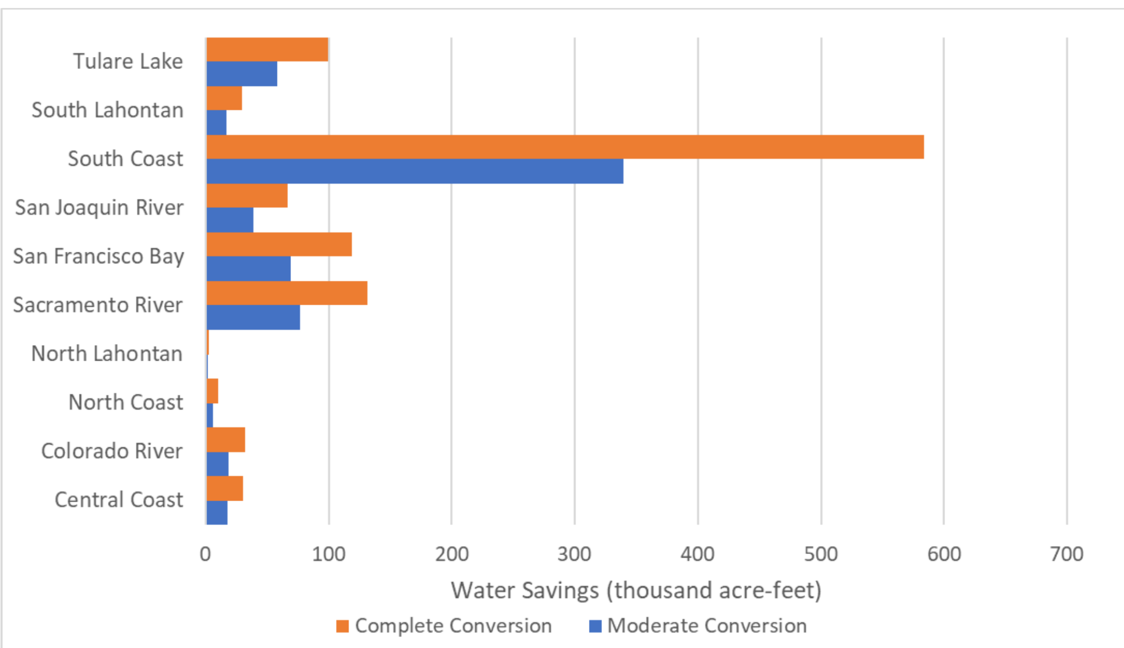

Figure 2-6. Outdoor residential water savings in AF by hydrologic region for moderate and complete conversion of landscape to climate-appropriate plants.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board

Commercial, Institutional, and Industrial (CII) Potential

The CII sector comprises of about quarter of the urban water use in the state. We estimate that savings in the CII sector can reduce current CII use by 40% to 55%, approximately half of these savings are available indoors and the other half outdoors.

The CII sector is extremely diverse. It comprises of a range of businesses including offices, retail stores, hotels, industrial warehouses, and manufacturing plants. Consequently, the water-related needs of these businesses are vastly different. A manufacturing plant may use large amounts of water if producing a water-intensive product, a hotel may also use large amounts of water for its guests while a retail store or office will use water only for minimal indoor needs. Additionally, the sector collects minimal data on water use and it is often not public information. As a result, it is challenging to develop an estimate of the efficiency potential for the CII sector.

Indoor CII

Indoor efficiency improvements in the CII sector are varied. Some measures are similar to those adopted in the residential sector whereas others are more unique to the CII sector. Simple measures include adopting low flow toilets, faucets, and other indoor devices. Different businesses can also adopt efficiency measures specific to their operations. A food service company can install a more efficient refrigeration system, or a laundry or hotel can switch to a high efficiency clothes washer. An East Bay Municipal Water District study cited an 85% reduction in water use by switching to more efficient laboratory equipment in one case. One of the measures that reaps high savings are improvements in the efficiency of cooling towers; one estimate cites a 21% reduction in water use by improving cooling tower efficiency (Lelic and Blair 2004). LADWP’s conservation found significant potential in improving the efficiency of cooling towers; only 14% of LADWP’s CII customers had adopted this (Los Angeles

Department of Water and Power (LADWP) 2017). The study also found more potential for adoption of efficient toilets, faucets, and showers in the CII sector compared to the residential sector.

We estimated that statewide CII savings from indoor efficiency improvements range between 300,000 and 500,000 acre-feet, or 30% to 50% of CII indoor water use. Figure 2-7 shows available savings by hydrologic region. Savings available in the South Coast region are half of available statewide savings. This region is populated with a rapidly growing economy, leading to high CII activity. While efficiency has made significant progress in the residential sector, there is still much room to do so in the CII sector.

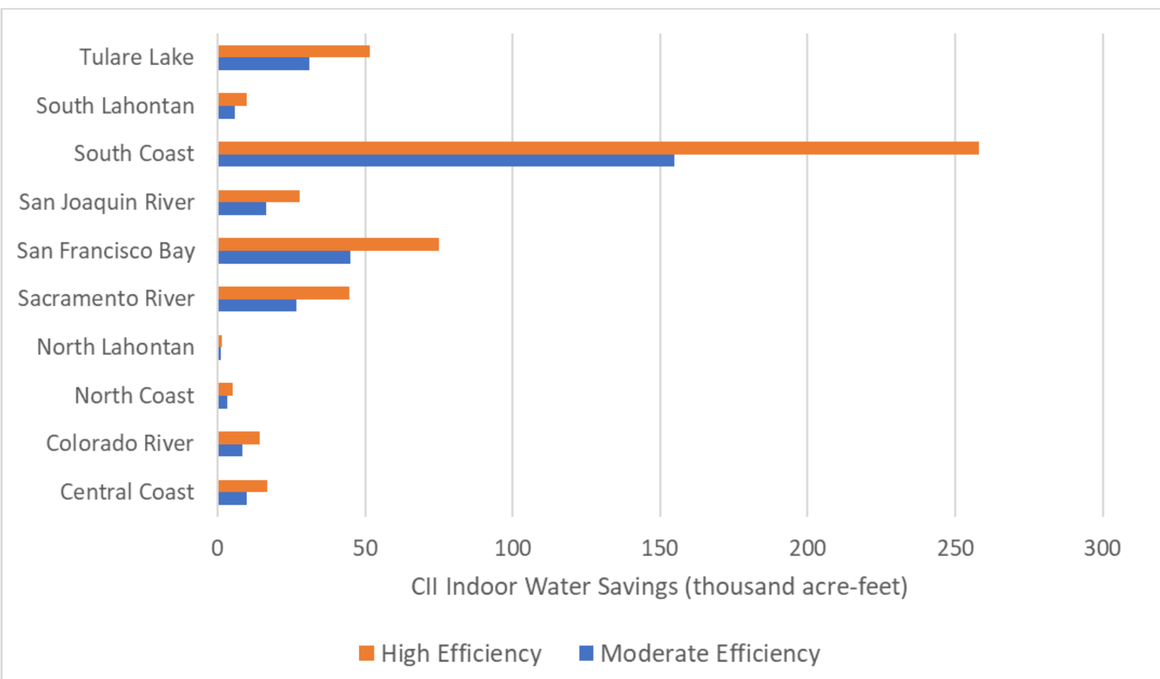

Figure 2-7. High and low estimate of indoor CII water savings in thousand acre-feet by hydrologic region.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Outdoor CII

Outdoor CII or large landscape uses include irrigation of public spaces like parks and government institutions, street medians, etc. Efficiency improvements can include landscape changes and technological improvements such as weather-based irrigation or drip irrigation. In our analysis, like residential outdoor potential, we focus on the potential savings available for moderate and complete conversion to climate-appropriate plants. We estimate savings between 400,000 and 465,000 acre-feet for moderate and complete conversion respectively (Figure 2-8). This reduces water use by 55% to 63% of outdoor water use pre-conversion, showing immense potential to reduce water use in this sector through just landscape changes. The most savings are available for the South Coast, followed by the San Francisco Bay region.

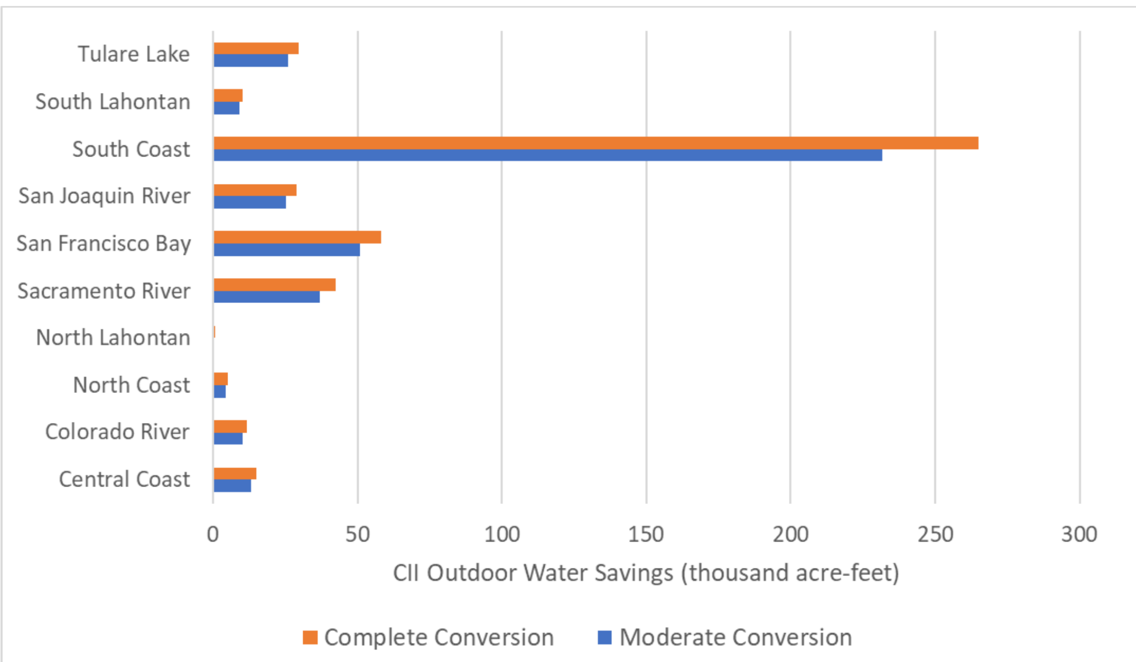

Figure 2-8. Outdoor CII water savings in thousand acre-feet by hydrologic region for a moderate and complete conversion to climate-appropriate plants.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Comparing total indoor and outdoor potential

Our analysis estimated potential water savings from indoor efficiency improvements, including both residential and CII, to range between 0.86 and 1.5 million acre-feet (Figure 2-9). Indoor efficiency has made significant strides in recent years, with policy and rebates that encourage conversions to efficient devices, while outdoor urban use is often touted as a ‘golden bullet’ for future water savings. We estimated potential savings from outdoor efficiency improvements to range between 1 and 1.6 million acre-feet, 70% of this comes from the residential sector and the remaining from the CII sector (Figure 2-9). In prior analysis, outdoor water conservation potential was estimated to be between 1.3 and 2.9 million acre-feet. These updated estimates show that while Californians have made progress, we still have a lot more potential to exploit.

Indoor residential gallons per person per day vary regionally. Table 2-4 shows absolute and per capita savings available for each hydrologic region. While the absolute savings are highest in the highly populated centers of the state like South Coast and San Francisco Bay, the per capita savings show a different story. Per capita savings outdoors is highest in Colorado River, Sacramento River, and Tulare Lake. Sacramento River has the highest outdoor per capita savings available of 55 GPCD, 25% higher than that available for South Coast and 52% higher than that for San Francisco Bay. Indoor per capita savings do not mirror outdoor savings. Savings available indoors are more evenly spread across regions. Colorado River is the only region that has one of the highest savings available indoors and outdoors.

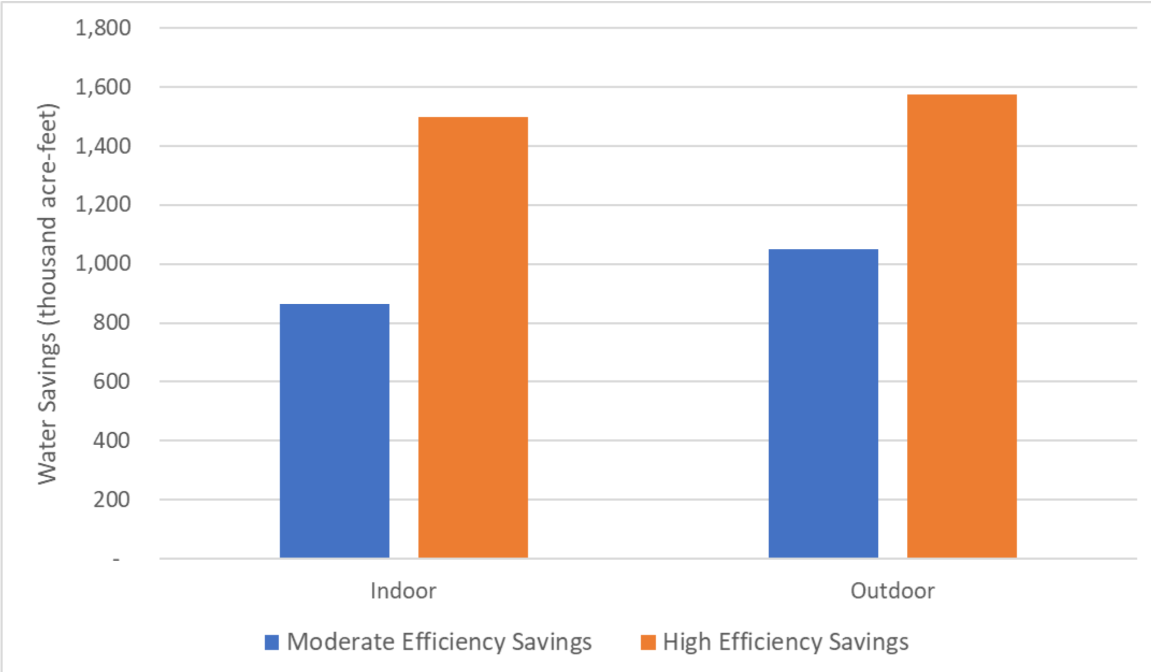

Figure 2-9. High and low estimate of statewide savings available from efficiency improvements indoors and outdoors.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Table 2-4. Total and per capita water savings available from moderate efficiency improvements indoors and outdoors, by hydrologic region, average 2017-2019.

	Indoor Savings		Outdoor Savings	
Hydrologic Region	Total (AFY)	Per Capita (GPCD)	Total (AFY)	Per Capita (GPCD)
Central Coast	25,836	14.10	30,864	16.85
Colorado River	22,682	24.81	29,098	31.83
North Coast	7,694	10.08	10,353	13.56
North Lahontan	2,718	25.97	1,803	17.23
Sacramento River	66,144	18.40	113,741	31.64
San Francisco Bay	97,194	12.53	119,881	15.46
San Joaquin River	58,349	22.57	64,106	24.79
South Coast	503,709	21.58	571,029	24.46
South Lahontan	20,938	19.07	26,281	23.94
Tulare Lake	57,338	20.72	83,882	30.31
STATEWIDE	862,601	19.27	1,051,037	23.48

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board

Distribution System Leaks

It is estimated that 6 billion gallons of treated water is lost every day in the country (American Society of Civil Engineers (ASCE) 2021). In California, issues around pipe age, pipe construction and material quality are few of the major issues plaguing the distribution system infrastructure (Naik and Glickfeld 2015). Distribution system leaks can be very costly and can reach in the millions of dollars in some cases. Leaks can also significantly damage confidence of customers in their water supplier and cause the loss of revenue that would otherwise go into upkeep of the water system (American Water Works Association (AWWA) 2016). Managing leaks can be achieved through several possible best management practices. This can be utility-scale water audits or timely replacement of aging infrastructure.

If the state complied with their water loss performance standards, we estimate a 42% reduction in water lost in leaks and savings of almost 160,000 acre-feet (Figure 2-10). If all leaks were managed, 400,000 acre-feet of water could be saved. This has energy implications, financial implications, and creates additional supply that is otherwise being completely wasted. The highest savings are available in the South Coast and Sacramento regions.

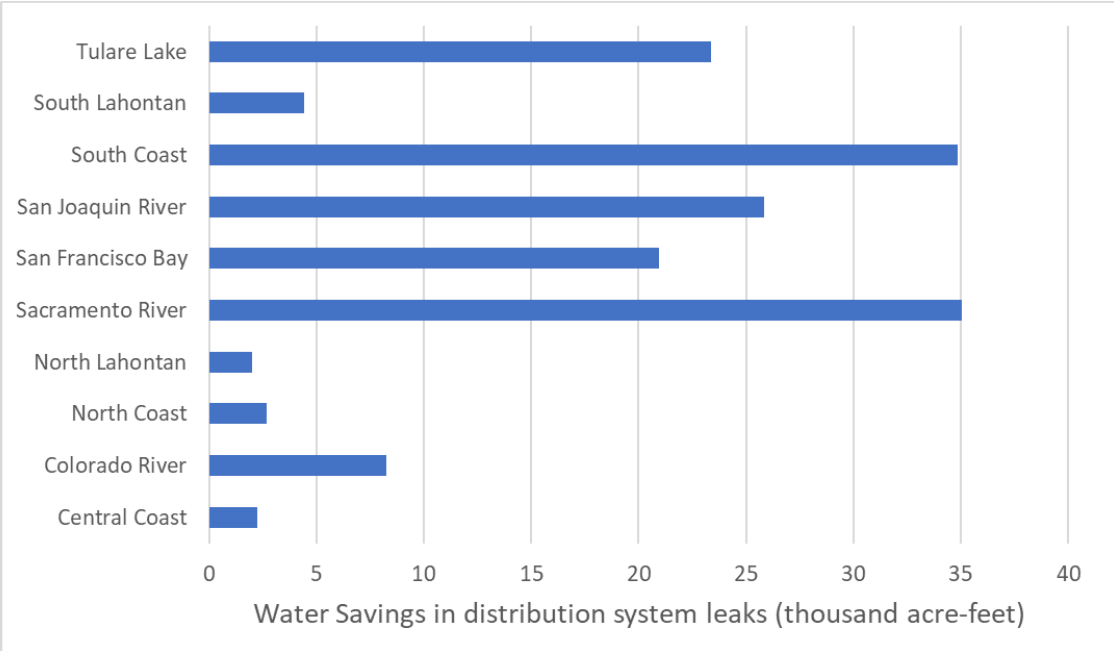

Figure 2-10. Urban water savings from complying with performance loss standards on distribution system leaks, in thousand acre-feet, by hydrologic region.

Source: Water use data from Electronic Annual Reporting (EAR), State Water Resources Control Board.

Discussion

As climate change creates a new normal in California and the world, the need for a resilient water supply becomes of the utmost importance. The easiest and cheapest form of new supply is water conserved. In 2003, the Pacific Institute published its first study quantifying the potential water savings available if Californians used water in the most efficient way possible in every urban sector (P. Gleick et al. 2003). This study estimated that one-third of California's water supply at that time, or 2.3 million acre-feet could be saved with existing technology. In a subsequent study in 2014, the Pacific Institute showed that statewide urban water use could be reduced by 2.9 million to 5.2 million acre-feet through efficient urban water use (P. Gleick et al. 2014). Since 2014, the state has gone through a major drought and water use has been on a steady decline. At the same time, technology has improved with the advent of better monitoring and detection systems as well as indoor and outdoor water-saving devices, for example, Flume is an easily installed intelligent monitoring system that provides real-time water use information and alerts residents about possible leaks (Flume Inc. and Mayer 2021).

In this analysis, we estimated that 2.1 to 3.2 million acre-feet can be saved statewide through urban efficiency improvements. Our key findings are discussed below.

Key Findings

Outdoor efficiency remains the sector with the highest untapped potential

By far, the biggest potential available is by making aggressive but simple improvements in the outdoor sector. Our analysis estimated that 1.6 million acre-feet, 70% of this in the residential sector and 30% in the CII sector, can be saved by converting all outdoor landscape to climate-appropriate landscaping. These savings alone would reduce current total urban water use by 25%. This type of conversion is relatively simple but reaps hugely significant, long-term benefits in water savings and by providing numerous co-benefits including reductions in energy use and GHG emissions, flood risk mitigation, and health benefits (Center for Neighborhood Technology and American Rivers 2010; Netusil et al. 2014; Cooley et al. 2019).

Further, there is a notable difference in where the highest absolute savings are compared to per capita savings. While there is the greatest potential for total savings in the highly populated areas of the state, there is greater potential for per capita savings in smaller regions. Therefore, targeted programs, although for a smaller number of people, in these regions will go a longer way in making significant impact.

The CII sector holds unexplored potential, in savings and study.

This study estimated that statewide indoor savings amount to 0.86 to 1.5 million acre-feet, and about 34% of these savings are in the CII sector. Further, we estimated that moderate efficiency improvements can cut indoor water use in the CII sector by half. However, while indoor residential efficiency is widely studied (DeOreo et al. 2011; 2016), there is lack of study around CII efficiency. We used best available estimates in our analysis to estimate that up to 1 million acre-feet of water can be saved in the CII sector with efficiency improvements. However, the most recent comprehensive end-use study of the CII sector was completed in 2003 (P. Gleick et al. 2003), and state-issued best practices date back to 2013 (California Department of Water Resources 2013). There is an urgent need for an updated comprehensive end-use study of the CII sector, that can parse out industry-specific water use and indoor and outdoor uses.

There remains potential for water savings indoors.

This study estimated that statewide indoor savings amount to 0.85 to 1.5 million acre-feet. This includes adoption of efficient devices such as low-flow toilets, high efficiency dishwashers and clothes washers, etc. Some studies show that while residential adoption of high efficiency toilets, faucets and showers are close to saturation, high efficiency clothes washers hold significant potential for additional savings while in the CII sector, there is most potential in cooling tower efficiency (Los Angeles Department of Water and Power (LADWP) 2017). However, as discussed below, information and analysis are needed to fully understand where there lies most potential for water savings. A simple way to create systematic improvements in indoor efficiency is through device standards. We found that federal device standards were outdated and should take best available technology into account. Using federal standards, residential indoor gallons per person per day was 58 GPCD while California standards set it at 35 GPCD. Average indoor residential use in California was estimated to be 47 GPCD. We also found that the leading-edge technology available for every device was considerably lower than every federal standard. Updating these standards will make a strong impact on indoor efficiency at the national level.

There is need for updated end-use studies and better data collection.

Up-to-date studies that look at end-use and market saturation of indoor devices would contribute greatly to better understanding the potential in indoor water savings. While studies in the past required extensive resources to conduct flow-trace analysis (DeOreo et al. 2016), technological advances have made it easier to conduct such studies today (Flume Inc. and Mayer 2021). Studies that disaggregate indoor and outdoor use would be very useful in getting a more accurate and current understanding of efficiency potential. Better data is key for a more precise analysis. Separated indoor-outdoor metering and adoption of advanced metering infrastructure will go a long way in collecting better data.

There is also a need for better data collection around distribution system leaks. We found that 160,000 acre-feet of water could be saved if all urban suppliers adhered to their performance standards. Better data around water wasted in leaks will lead to better informed standards and more savings.

This analysis used EAR data which encompassed 88% of the state's population and only large urban suppliers. While we did scale our analysis to encompass the entire state, datasets that collected information for the entire state will be more accurate and provide a clearer understanding of potential statewide savings.

Conclusion

The untapped potential to improve efficiency and augment supplies in California is large. Water efficiency can provide 2.1 to 3.2 million acre-feet of water in new supplies and demand reductions, providing both a buffer from severe drought in the near term, and permanent improvements in the reliability and resilience of the state's water system and natural ecosystems. These approaches also reduce the energy and greenhouse emissions associated with the state's water system and reduces the impacts of water withdrawals on sensitive natural ecosystems.

The effort here to identify the technical potential to increase water-use efficiency is just the first step. Just as important is defining and adopting the legal, economic, and institutional programs to capture this potential.

Chapter 3: A Review of the Benefits of Sustainable Landscapes

Abstract

In water management, there has been a historic tendency to prioritize management strategies that can yield a concrete return on investment and satisfy immediate needs. However, in the face of an increasingly variable climate, larger incidence of extreme weather events, increased pollution, and growing population, there is growing uncertainty in the ability of these systems to be adaptable and cost-effective. Sustainable landscaping can be adopted by a single property and provides benefits around water security and resilience, as well as additional benefits such as creating habitat, reducing energy use and enhancing community livability. While sustainable landscapes have been increasing in popularity, there lacks literature that collates evidence of benefits attributed to these landscapes. This review examines how sustainable landscapes have been defined in literature and the co-benefits attributed to them. This resource also provides information that can be used directly to secure support for installing sustainable landscape strategies on a property, whether residential or commercial.

Introduction

In water management, there has been a historic tendency to prioritize management strategies that can yield a concrete return on investment and satisfy immediate needs. These strategies are typically part of centralized water infrastructure that lends itself to bigger, single-purpose projects and economies of scale. Historically, centralization of these systems proved necessary due to large costs and resource-intensive needs and enabled cities to provide clean water to large numbers of people (Marlow et al. 2013; Brown, Farrelly, and Keath 2009). However, in the face of an increasingly variable climate, larger incidence of extreme weather events, increased pollution, and growing population, there is growing uncertainty in the ability of these systems to be adaptable and cost-effective (Tsegaye et al. 2020; Leigh and Lee 2019). Subsequently, there has been recognition of a need for a better way of operating (Pahl-Wostl 2007; Niemczynowicz 1999; Marlow et al. 2013; Brown, Farrelly, and Keath 2009). Pahl-Wostl 2007 discusses this as a need for an integrated approach "encompassing all environmental factors of the resource base, technologies and human beings." This broader movement towards more sustainable water management incorporates and encourages decentralized strategies (Urich et al. 2011; Marlow et al. 2013; Tsegaye et al. 2020; Leigh and Lee 2019).

Decentralized strategies are smaller systems that operate with a higher degree of autonomy within a larger system (Tsegaye et al. 2020). This can include strategies such as an onsite wastewater treatment plant at a manufacturing factory, or a rainwater cistern at a single-family residence. Concerns around the cost-effectiveness of these strategies have been challenged in recent studies, showing that non-traditional water management options such as efficiency and stormwater capture are cost-effective on a per volume basis when compared to many traditional sources (Cooley, Phurisamban, and Gleick 2019; S. E. Diringer, Shimabuku, and Cooley 2020). In addition, many of these strategies can provide additional co-benefits, thereby increasing their cost effectiveness (S. E. Diringer, Shimabuku, and Cooley 2020).

Sustainable landscaping is an example of a decentralized strategy, that can be adopted by a single property and provides benefits around water security and resilience, as well as additional benefits such as creating habitat, reducing energy use and enhancing community livability. In California, sustainable landscapes have been gaining popularity in recent years. In Southern California especially, droughts have become a regular occurrence, and climate-appropriate landscapes are a simple way to create local water resilience. Increasing works extolling the benefits of these landscapes can be found in utility and non-profit literature and in anecdotal evidence. Additionally, there are numerous tools at the local and state-level in California that encourage the adoption of these landscape strategies to conserve water and enhance water and climate resiliency. The Model Water Efficient Landscape Ordinance (MWELO) is the primary policy tool used statewide to create standards for sustainable landscapes and push adoption from the top (*Model Water Efficient Landscape Ordinance (MWELO)* 2015). It was originally instituted in 1993 via the 'Water Conservation in Landscaping Act' to improve water efficiency practices in California's urban landscapes, and updated in 2015 in response to a critically severe drought to prevent water wastage on urban landscapes. The ordinance applies to residential, commercial, industrial and institutional projects that require a permit, plan check, or design review. It sets minimum standards for landscape design including soil, irrigation, plant requirements, including a 'ceiling' for an outdoor water budget. Utilities provide financial incentives through rebates for replacing turf and installing sustainable landscape strategies (SoCal Water$mart, n.d.). Cities have instituted parcel taxes based on impervious surface to encourage strategies that can infiltrate stormwater and prevent water pollution (Culver City 2016).

While sustainable landscapes have been increasing in popularity, there lacks literature that collates evidence of benefits attributed to these landscapes. In 2019, the Pacific Institute developed a framework for systematically incorporating the multiple benefits of water management strategies into decision-making (S. Diringer et al. 2019). This framework involves three key steps. First, identifying benefits under five key themes, any associated trade-offs, and beneficiaries; second, characterizing and integrating benefits through analysis; and third, incorporating benefits into decision-making. This study is modeled around providing information that is required in the first step of this framework, for the consideration of a sustainable landscape project. This review examines how sustainable landscapes have been defined in literature and the co-benefits attributed to them. It seeks to understand the benefits that sustainable landscapes provide according to the literature and the extent to which those benefits have been quantified. This information will help in creating a more cohesive and informed understanding of sustainable landscapes and allow future researchers to identify gaps more easily in the literature. When used independently or as part of a process identified in the multi-benefit framework (S. Diringer et al. 2019), this resource also provides information that can be used directly to secure support for installing sustainable landscape strategies on a property, whether residential or commercial.

Methods

Researchers at the Pacific Institute developed a comprehensive library of resources related to benefits cited to water management strategies (Pacific Institute 2019) along with a comprehensive report that details benefits of water management strategies around key overarching themes (S. Diringer et al. 2019). For this review, we assess benefits of sustainable landscapes, based on five overarching themes adapted from S. Diringer et al. 2019- Water, Energy, Land and Environment, People and Community, and Equity as an Essential Lens. S. Diringer et al. 2019 grouped key themes based on sets of unique benefits identified through an extensive literature search, interviews with subject matter experts, and stakeholder discussions. Since the resource library encompasses strategies much broader than just sustainable landscapes, we narrowed it down to focus on resources that are linked to sustainable landscaping. This set of literature was supplemented by searching for resources among three main databases- EPA's National Service Center for Environmental Publications, Web of Science's Core Collection, and Google. These three databases were chosen to get a range of resources including scientific and social science journal articles, policy and grey literature, and blogs and short articles.

There are many terms for sustainable landscaping practices that enhance ecosystem services and work with natural systems to create a more sustainable and resilient urban environment. From experience and a thorough literature search, we used the key search terms of 'green infrastructure', 'low-impact development', 'nature-based solutions', and 'sustainable landscapes'. We also used search terms based on the key strategies of (1) 'xeriscaping' or 'climate appropriate vegetation or plants', (2) 'rain garden' or 'bioswale', (3) 'permeable pavement'. For each benefit category (i.e., water, energy and greenhouse gases, etc.), we identified the key benefits (e.g., stormwater capture, carbon sequestration, air quality) based on work from S. Diringer et al. 2019. To gather literature in each search engine, we combined each of these as category + benefit to search for literature, for example, '*green infrastructure* AND *water'* or '*bioswale* AND *air quality'.* While we considered literature using any of these terms, we use the term ‘sustainable landscapes’ to refer to these practices within this study. We evaluated each resource to identify whether it studied the connection of a landscape strategy with a specific benefit, and further, if the benefit was quantified in any way. We focused on literature that connects specific landscape strategies (such as climate-appropriate plants, rain garden, permeable pavements, etc.) with benefits.

Green infrastructure or sustainable landscapes can include the practice of planting trees. The benefits that come with trees have been studied widely (Donovan and Butry 2010; McPherson et al. 2017; Safford et al. 2013; Laverne and Winson-Geideman 2003). Trees sequester carbon dioxide, intercept rainfall in their canopies, and reduce stormwater runoff. They also provide community benefits of shading, reducing temperature, and provide aesthetic and health benefits. Since a lot of research and study has been conducted around trees, this report draws a distinction between sustainable landscaping practices and planting trees and will focus on the former.

Discussion

We define sustainable landscapes as those outdoor landscapes that are in balance with local climate and ecology and actively contribute to watershed health by providing economic, social, and environmental benefits. The key elements of these landscapes are building healthy, living soils; preserving vegetative cover; using climate-appropriate plants; treating water as a resource and using irrigation to supplement rainfall; and conserving material resources (Cooley et al. 2019; American Society of Landscape Architects 2009; Metropolitan Water District of Southern California 2017; Green Gardens Group (G3) 2018b). A sustainable landscape is unique to a climate and geography and works in harmony with its surroundings, requiring minimal external inputs.

Below, we summarize the various benefits associated with sustainable landscape strategies, as reported in literature.

Benefit: Water

Sustainable landscaping practices enable key water-related benefits around water supply augmentation, water quality improvement, and flood risk mitigation.

Climate-appropriate plants are adapted for the environment in which they are planted. This means that they require minimal external input, including water. A study from the University of California Davis quantified the water savings between grass and a native species; the study estimated that native plants use 60% less water than the non-native grass (Shapiro et al. n.d.). In a non-residential environment in Northeast China, a study tracking water use for two species revealed that the non-native tree species relied on groundwater in addition to soil water whereas the native species used only soil water (Song et al. 2019). This was especially pronounced in low soil moisture conditions. While water use was not quantified, it was hypothesized that non-native plants, being maladapted to the surrounding climate, extracted water from deeper sources than native species (Song et al. 2019; Antunes et al. 2018; Ewe and Sternberg 2002).

Removing turf provides the foundation for being able to install these other beneficial practices. Turfgrasses are highly water-intensive, and their removal has become a practice commonly used to promote water conservation and realize long-term reductions in water demand across the state of California as well as the broader Western U.S. An early study of landscape conversions in Southern Nevada showed savings of 76% in water use by converting landscape to climate-appropriate plants (Sovocool, Morgan, and Bennett 2006). In one of the few studies that evaluated the efficacy of this practice more recently, Pincetl et al. 2019 investigated the efficacy of a turf removal program in Los Angeles and showed that while residents did make significant changes to their lawns, replacing almost 15% of household lawns with shrubs and 10% with artificial turf, they also noted that there is a need to monitor these long-term programs to quantify the level of water savings achieved. Further, the paper also noted the need to switch from turf to native plants, rather than artificial turf which will not provide the additional benefits. This further exemplifies the need for a clear understanding of benefits so that there is effective implementation.

Permeable pavements are systems that allow capture and infiltration of stormwater and rainwater. This strategy can improve water quality and are able to filter out pollutants including heavy metals and organic compounds (Newman et al. 2002; Scholz and Grabowiecki 2007; Dierkes et al. 2000). In a study of infiltration capacity, Andersen, Foster, and Pratt 1999 showed that an optimally designed permeable pavement system can capture 55% of a 15mm/h storm event.

Rain gardens, also called bioretention areas, are one of the most widely used sustainable landscaping practices. One of their most valuable benefits is the ability to filter runoff and improve stormwater quality. Osman et al. 2019 performed a comprehensive review of the nitrogen removal efficiency of bioretention systems, detailing removal rates of up to 93% and 99% for ammonium and nitrate respectively. Line and Hunt 2009 studied two bioretention areas near a highway in North Carolina. They found that pollutant load reduced by 24% to 83%, with the highest reduction being in total suspended solids (TSS). They also concluded that much of this reduction can be attributed to a reduction in stormwater runoff volume. Rain gardens are also effective at capturing runoff and rainwater. A study showed that a simple bioretention area of four squared meters and 80 cm depth is able to infiltrate water from an impervious surface ten times its size (Ozores 2017). Increased infiltration and capture contribute to climate resiliency and flood risk mitigation by keeping water off impervious surfaces and out of sewers and drain systems (S. Diringer et al. 2019; Denchak 2019; Shimabuku, Diringer, and Cooley 2018).

Case studies are an effective way to get a quick look at real practices in place and how they work. An EPA study covering 17 case studies of sites that installed sustainable landscape practices and assessed benefits from across the United States showed benefits around stormwater management, water pollution abatement, and groundwater recharge (United States Environmental Protection Agency 2007). Similarly, among a series of 156 global case studies of sites that have adopted sustainable landscape strategies from the Landscape Architecture Foundation, 100 cite stormwater management benefits, of which 30 are related to planting trees; 64 cite reduced water demand; 40 cite water quality benefits; and 4 cite recharge and replenishment benefits (Landscape Architecture Foundation n.d.).

Benefit: Energy and Greenhouse Gases

The main energy-related benefits that occur in the literature are around reduced energy use, reduced GHG emissions, and increased carbon sequestration.

Sustainable landscape strategies reduce energy demand through direct or indirect ways. Strategies such as rain gardens and permeable pavements that reduce stormwater runoff directly reduces the need for onsite stormwater pumping and therefore energy demand. Sustainable landscapes also require less mowing and waste hauling, which suggests that this would require less energy needed for regular upkeep practices. A sustainable landscape designed to revamp a parking lot saved almost $9000 in annual mowing costs by using native plants (Landscape Architecture Foundation 2015). However, while these benefits are mentioned in multiple reports, quantification of these localized, small-scale energy impacts have not been studied widely (Denchak 2019; Cooley et al. 2019). In 2009, the City of Philadelphia considered managing their stormwater through a 50% LID option that would manage runoff from 50% of impervious surfaces in Philadelphia through green infrastructure. Their analysis compared the use of traditional infrastructure with a 50% LID option and showed a net energy savings over the 40-year planning period of nearly 370 million kilowatt hours (kWh) of electricity and nearly 600 million British thermal units (Btus) of natural gas (Raucher and Clements 2010). These savings were a result of vegetation providing shading and cooling, and insulation and reduced heat due to green roofs.

Garrison et al found that incorporating sustainable landscape practices in Southern California and the San Francisco Bay Area can save over 1 million MWh of electricity and correspondingly reduce emissions by over 500,000 metric tons of carbon dioxide (Garrison, Wilkinson, and Horner 2009). Energy savings were calculated as the difference between energy for sustainable landscape strategies (groundwater pumping, onsite capture and use, treatment, etc.) and current marginal water supplies (imported water systems, desalinated ocean water, etc.). For example, climate-appropriate plants reduce water use which will then reduce the amount of energy needed to transport and treat water that would have been otherwise used. Reducing water use and/or using an alternative water supply, such as stormwater capture or rainwater harvesting, can offset energy demand of a more energy-intensive centralized water supply.

In water-stressed regions like Southern California, energy demand can be reduced indirectly by offsetting demand due to an energy-intensive water supply. The water-energy nexus has been widely studied and the linkages between the water supply system and associated energy use has been well-documented (Plappally and Lienhard V 2012; P. H. Gleick 1994; B. Chen 2016; DeNooyer et al. 2016; Fang and Chen 2017; Stokes-Draut et al. 2017). The extent of energy savings available by offsetting demand from your traditional water supply can be significant and is based on the energy intensity of your water supply. For example, a water system that requires transportation over long distances is particularly energy-intensive (Plappally and Lienhard V 2012); In California, the supply and conveyance section of the water system uses at least 7.7% of statewide electricity use (GEI Consultants/Navigant Consulting, Inc. 2010). Some supplies are inherently more energy-intensive as well, such as groundwater (under certain conditions) and desalination (GEI Consultants/Navigant Consulting, Inc. 2010; Plappally and Lienhard V 2012).

By acting as a carbon sink, green spaces and healthy soils can contribute to reducing GHGs in the atmosphere. Planting vegetation provides a direct reduction of GHG emissions. Plants are excellent GHG sinks with the ability to store excess carbon from the atmosphere, by way of photosynthesis (Paquette et al. 2009). Nowak et al. 2013 estimated that as of 2005, total tree carbon storage in U.S. urban areas was at 643 million tons and annual sequestration at 25.6 million tons. Trees are significant carbon sinks and when incorporated into green infrastructure, have a strong positive impact on atmospheric carbon. W. Y. Chen 2015 conducted a study of 35 major Chinese cities where urban green spaces, which includes trees and other vegetation, represented about 6% of the total land area of these cities. The study found that nearly two million tons of carbon was sequestered by the vegetation in these spaces. Numerous other studies calculate the value of urban trees in carbon sequestration and storage capacity (Escobedo et al. 2010; McPherson, Xiao, and Aguaron 2013). The carbon sequestration ability of non-tree species can be extrapolated from these findings, but scientific literature focuses largely on trees, likely because the sequestration benefit is more significant in trees.

Indirect ways to reduce GHG emissions includes improving soil carbon potential. However, few studies are available on the soil carbon storage potential of green infrastructure. Pouyat, Yesilonis, and Nowak 2006 showed that urban soils have the potential to sequester large amounts of soil organic carbon, particularly in residential areas where good management and lack of disturbances provide support. Further, good land management practices that build soil health can contribute to carbon sequestration as well (Shrestha et al. 2018). Another indirect way to reduce emissions is by offsetting the emissions from a carbon-intensive water supply system. For example, adopting a gravity-fed graywater system instead of a tapping into your utility's imported water system can reduce GHG emissions (Malinowski et al. 2015).

Benefit: Land and Environment

Sustainable landscape strategies can provide benefits to the terrestrial environment.
The primary environmental benefits identified in the literature are reduced air pollution, increased habitat and biodiversity, and to a lesser extent, improved instream flows.

The effect of trees on improving air quality has been recognized broadly. Bottalico et al. 2016 found that urban forests in Florence, Italy removed ozone and particulate matter (PM) in the atmosphere, with PM_{10} removal ranging between 0.00176 to 0.0247t/ha depending on the species. Nowak, Crane, and Stevens 2006 studied pollution removal rates for five different pollutants by urban forests in 55 U.S. cities. The study found that air quality in cities improved by an average of under 1%. This improvement was the greatest for particulate matter, ozone, and sulfur dioxide, and varied based on local climate and pollution concentrations. While trees have been widely studied, emerging studies show that shrubs and vegetation can also provide benefits. Currie and Bass 2008 showed that strategies like walls planted with shrubs can provide air quality benefits and, in some cases, can be equivalent to planting trees in urban areas.

The connection between stormwater and instream flows depends on hydrology. Direct connections between landscaping strategies that influence stormwater and improved instream flows are difficult to demonstrate. However, indirect connections can be inferred. If adopted at a large enough scale, sustainable landscaping strategies can have significant effects on watershed-scale hydrology, protecting streams from sudden changes in flow (Pennino, McDonald, and Jaffe 2016). Damodaram et al. 2010 shows the benefits of sustainable landscape strategies in mimicking natural flow regimes and reducing peak runoff volumes and flood risk. The paper also applies the premise that degradation of instream ecosystem health occurs as a result of increased urbanization, indicating a connection between urban changes and instream flows.

The creation of urban habitat and biodiversity conservation have been widely touted as critical benefits of sustainable landscapes and green infrastructure. Yet, the connection between urban habitat and biodiversity, and landscaping strategies is difficult to quantify. Salomaa et al. 2016 notes that while biodiversity benefits are acknowledged and promoted though European governmental bodies, the ambiguity in definitions and aims makes it difficult to draw a clear connection between the two. Morash et al. 2019 reported that rain gardens support biodiversity and ecosystem resilience when designed to have a diverse range of plants (or ‘polyculture gardens’) that are well-suited for the climate. Cook-Patton and Bauerle 2012 found that ecologically diverse vegetated roofs provide biodiversity benefits, noting that the species must be carefully and strategically selected based on location and objective.

Benefit: People and Community

Anecdotally, landscapes provide mental health benefits, increased health and wellness, community cooling effects, and reduced need for maintenance.

Trees and plants help mitigate air pollution as discussed above. This provides a corollary health benefit as well. A study found that total pollution removal by trees and forests in the United States provides a health benefit valued at $6.8 billion (Nowak et al. 2014). Venkataramanan et al. 2019 conducted a systematic review of the health and social wellbeing benefits of green infrastructure. They found that while many studies show a connection between green space and health, there is a lack of quantitative measurements about the impact and only 33% of their reviewed literature studied impacts based on measured data. Tzoulas et al. 2007 also investigated this claim and looked at mechanisms by which green space and health are connected. They concluded that there is a strong public health component to green space. This could occur through the mitigation of air pollution and lowering of temperatures, or increasing the time spent outdoors and thereby improving outdoor physical activity. The paper also suggested a more passive exposure as beneficial, where exposure to green space after stressful events can lower blood pressure and stress. Similarly, Ulrich 1984 showed a correlation between exposure to nature and improved health by simply having a 'green view' from patients' windows. There are also studies that show a connection between lower level of obesity and exposure to increased green space, although there are multiple possible conflating factors and further research needs to be done to establish this linkage (Ellaway, Macintyre, and Bonnefoy

2005; Lachowycz and Jones 2011). One study survey showed that people who lived in areas with high levels of green space had 40% lower chance of being obese than those who didn't (Ellaway, Macintyre, and Bonnefoy 2005). However, another study that reviewed literature on linkages of obesity and green space found a lack of consistent findings, particularly around mechanisms for how this connection may work, for example, physical activity versus mental wellbeing (Lachowycz and Jones 2011).

Houlden et al. 2018 came to a similar conclusion for the connection between mental wellbeing and green space, showing while there are positive correlations between green space exposure and improvements in mental health, there is also a need for more research and measurements. Particularly, the study identified the lack of longitudinal studies, identifying only 6 out 50 papers that reported this.

In assessing the economic benefits of sustainable landscapes or green infrastructure, majority of studies use hedonistic price models to estimate the benefit to property values (Venkatraman et al 2017). This method allows for a dollar value estimation by measuring "a household's marginal willingness to pay for environmental attributes." Trees, particularly, have been studied broadly to estimate their economic value in residential areas. A study showed that green streets added $8,870 to a house sale price in a Portland neighborhood (Donovan and Butry 2010). Netusil et al. 2014 expanded on these findings, showing that the maintenance cost of these green spaces is more than made up for when considering a public investment in green infrastructure. Bird 2004 calculated an economic benefit of the public health provided by green spaces. The study found that UK National Health Service would save more than 1.8 million GBP if a subset of residents used their proximity to green space for physical activity. While economic evaluations are often used as markers in evaluating these strategies, it should be noted that they discount more behavioral drivers such as personal desire and perspectives (Baptiste, Foley, and Smardon 2015).

One of the biggest benefits that arise from sustainable landscape are reduced operation and maintenance (O&M) needs and costs. Climate-appropriate plants require reduced irrigating and mowing, saving labor and cost that would otherwise be required in a traditional landscape. The garden/garden case study in Santa Monica showed that a California-friendly garden that used native plants generated 56% less green waste and required 68% less maintenance than a more traditional garden (City of Santa Monica 2013). Similarly, another case study, based in Pittsburgh, Pennsylvania, documented that conversion from a traditionally irrigated landscaped to native plants reduced irrigation demand by 99% (Landscape Architecture Foundation 2012b). Three case studies in the Landscape Performance Series document a reduction in mowing, with reductions in cost of up to $87,500 or 89% by using native landscaping (Landscape Architecture Foundation 2010; 2012a; 2015). While case studies proved useful, we found a lack of scientific literature that documented reduced O&M needs.

Equity as an Essential Lens

Who receives these examined benefits is a significant aspect of this discussion. Many of these benefits are highly dependent on access to green spaces. Neighborhoods that invest in rain gardens and green streets are often a result of who has the resources and capacity to apply for available public funding. In a study conducted among diverse residents of neighborhoods in Detroit, Michigan, Carmichael et al found that while residents are confident in the multiple benefits provided by green infrastructure, they pointed to barriers around differing access to resources to implement these practices based on race and property ownership.

The term ‘climate gentrification’ or ‘green gentrification’ has gained traction in recent years to describe the phenomenon of climate injustice, where minority communities who have historically contributed the least to climate change are also the ones bearing the largest burden of its consequences. This term also applies to how green infrastructure is applied in the country and globally. Anguelovski et al. 2019 advocated for increased research by climate scientists into how these inequities persist and are perpetuated by green infrastructure, reasoning that ‘new green value cannot be harnessed without land cleanup and revaluation, dispossession and accumulation, and displacement of socially and racially vulnerable groups.’ Shokry, Connolly, and Anguelovski 2020 studied this form of gentrification in Philadelphia and found that green resilient infrastructure, which includes both sustainable landscape strategies and broader climate-protective infrastructure, was concentrated in wealthier areas, so that they did not benefit the most socio-ecologically vulnerable populations. In addition, low-income and minority residents were moving out of wealthier areas and into areas without climate resilient infrastructure. Multiple other studies have argued similar points elucidating that this type of environmental gentrification can be harmful with long-term consequences (Curran and Hamilton 2012; Wolch, Byrne, and Newell 2014; De Sousa Silva et al. 2018). Therefore, *where* sustainable landscape strategies are situated are critical in who benefits. This is inextricably linked to who makes these decisions and who has a seat at that table. Equity or environmental justice indices are one way to remove bias and situate these projects where there is the most real need. These indices can help to identify neighborhoods using factors around environmental exposure and risk as well as socioeconomic variables (Zhu, Ren, and Liu 2019; Heckert and Rosan 2016).

Conclusion

Sustainable landscapes have gained popularity in the recent past. This review provides a basis to connect concrete benefits to these landscapes. There is a lot of research and understanding around water-related benefits of sustainable landscapes. However, more work must be done in understanding the GHG and carbon sequestration implications, as well as social and community benefits. Overall, there was a lack of longitudinal studies that studied the benefits of sustainable landscape strategies over time. We found a strong absence of quantified studies in assessing social effects of sustainable landscapes, particularly around benefits of reduced O&M. We hypothesize that this may be due to difficulty in measuring these parameters due to the indirect nature of these benefits, and the long timeframe of the project. There needs to be further research and understanding in this area. Collaborating with social scientists and cross-pollinating research will be highly beneficial.

In addition to understanding and quantifying these benefits, it is equally important to have tools that encourage and motivate the adoption of these landscapes. Laws can play a strong role in shifting cities towards a more sustainable future. Local ordinances like Measure W in the city of Los Angeles, which taxes impermeable area, and the Net Zero Water Ordinance in the city of Santa Monica, that requires new residential property not to exceed past property water use, are innovative ways to create a top-down system that incentivizes residents and property-owners to install sustainable landscapes and create long-term water resilience. Expanding these ordinances to apply in other cities across the state and ensuring they also apply to the CII sector will go a long way in creating impact.

Overall, this information will help elucidate gaps in understanding, and provide clear references for those looking to understand the benefits of implementing sustainable landscape projects, whether they be residential homeowners, commercial businesses, non-profits, or utilities. Often entities need to show clear evidence of benefits to facilitate adoption of a sustainable landscape, this review provides information that will facilitate this process.

Chapter 4: An Assessment of Commercial, Industrial, and Institutional (CII) Outdoor Water Use Trends at a Southern California Water Supplier

Abstract

Companies are dependent on water for a multitude of reasons operationally, ranging from manufacturing to drinking water needs for its employees. Risk to these water resources will affect a company financially, operationally, and reputationally. To help mitigate these risks, companies are taking action towards more sustainable practices both onsite as well as beyond operational boundaries. Sustainable landscapes provide an avenue for meeting and exhibiting sustainability commitments. In this analysis, we study outdoor commercial, industrial, and institutional (CII) water use trends for a water supplier located in Southern California for potable and recycled irrigation customers. The Supplier utilizes a budget-based billing system. We found that CII outdoor water use is seasonal in nature, with overall water use is higher in the summer but peaks in drier years is driven by winter water use. We evaluated efficiency by comparing water use with budget allocation. A substantial majority of irrigation customer exceed their allocated budget annually; 50% of potable irrigation customers, and 14% of recycled irrigation customers. Overall, recycled irrigation accounts use less water per square foot than potable irrigation accounts. We also found the potential for significant savings if CII customers met their allocated budget. If all potable irrigation accounts met their allocated water budgets, approximately 137 million gallons or 400 acre-feet of water can be conserved. Further, if all potable irrigation accounts were at MWELO standards of 0.45 ETAF, about 1,000 AF of water can be conserved.

Introduction

Addressing water challenges will require active participation from all sectors of society. In the face of increasing water scarcity, pollution, and a changing climate, the business community has shown real interest in addressing water-related challenges (Schulte, Orr, and Morrison 2014; CEO Water Mandate 2015; Orr, Cartwright, and Tickner 2009; Sujamo 2016). Companies are dependent on water for a multitude of reasons operationally, ranging from manufacturing to drinking water needs for its employees. Risk to these water resources will affect a company financially (CDP 2020; Morrison et al. 2009; CEO Water Mandate, n.d.). Therefore, companies face risk to their internal processes due to external factors, such as drought or declining basin health (Schulte, Morrison, and Gleick 2012, 7; Sujamo 2016). Consequently, businesses are taking steps to integrate sustainability in their operations and beyond. (CEO Water Mandate 2013; CDP 2020; Barton 2010). For example, leading companies such as Procter & Gamble and Gap Inc. have made public commitments to sustainability, signifying a broader shift within corporations toward sustainability (Procter & Gamble 2020; Gap Inc. 2019).

Sustainable landscapes provide an avenue for meeting and exhibiting sustainability commitments. Business properties are disproportionately landscaped with turf grass and have large impervious areas (Cooley et al. 2019). In addition, businesses can often serve as examples for the larger community. However, historically, most urban sustainability programs and outreach focused on the residential community.

In this analysis, we study outdoor water use trends for a water supplier (‘the Supplier’) located in Southern California. Since 2016, the Supplier has implemented water rates based on a water budget, charging progressively more per unit of water past a certain threshold or budget, and has incorporated dedicated irrigation meters for its commercial properties, requiring irrigation meters to be installed on all new commercial properties after a certain date. 95% of all CII customers in this Supplier's service area have separated indoor-outdoor metering. This case study examines commercial outdoor water use trends in the Supplier's service area with the aim of understanding (1) characteristics that drive efficiency in commercial outdoor water use, and (2) potential for water savings from outdoor efficiency improvements. These questions contribute to a larger understanding of how the CII sector uses water outdoors, information that is currently absent in literature, and can help to tailor policy and programs to the sector. The findings are applicable more broadly to areas with a similar semi-arid climate.

Supplier Background

The Water Supplier studied in this analysis serves over 170,000 customers in Southern California. The region is characterized by a semi-arid, Mediterranean climate with mild winters and dry summers and average precipitation of 14 inches annually. Population in the region increased by 0.41% annually between 2000 and 2020 and is expected to grow another 0.2% annually, over the next ten years.

The supplier's water supply portfolio comprises of two main sources- 79% of supply comes from imported water and the remainder from recycled municipal wastewater. Imported water, provided by regional wholesalers, is sourced from the Colorado River, via the Colorado River Aqueduct, and the Sierra Nevada mountains in northern California, via the State Water Project (Klausmeyer and Fitzgerald 2013).

The Supplier's customer base includes residential and commercial, industrial, and institutional (CII) customers. Residential uses comprise the slight majority of use at 51%, and commercial, industrial, and institutional CII uses make up 17%. The remainder of uses are taken up by public spaces, either for recreation or transportation.

Commercial, industrial, and institutional (CII) customers

The CII customer class is one of the most varied groups of customers. This category includes everything from offices, retail stores, and groceries, to hotels, universities, and manufacturing plants (Alliance for Water Efficiency, n.d.). Within the Supplier's service area, there are over 600 different business types (for e.g., hotels, retail stores, hospitals, etc.) operating within the region, and over 10,000 individual businesses. 95% of all CII customers in this Supplier's service area have separated indoor-outdoor metering. Therefore, water usage is measured and billed indoors and outdoors. Outdoor metering is assumed to correlate to irrigation needs. For outdoor water use needs, CII customers are serviced by either potable or recycled water. While recycled water is increasingly becoming part of the potable water supply, in this case, the Supplier's recycled water is non-potable. To distinguish to two types of accounts, we refer to them as 'potable irrigation accounts' and 'recycled irrigation accounts' in this study. The Supplier selects accounts to switch over from potable irrigation to recycled water largely based on size; larger square footage accounts are considered 'low-hanging fruit' to offset potable water usage. The Supplier exercises greater oversight of recycled irrigation accounts, e.g., canceling a recycled water contract if water is grossly misused. There is also a mutual understanding that accounts provided recycled water are expected to be 'good water stewards.'

The Supplier uses a tiered water billing rate system; CII customers who use water above a certain threshold are progressively charged more per unit of water. This type of billing system is often considered 'sustainable' and is adopted to encourage long-term water efficiency and account for changing climatic conditions(Barr and Ash 2015; Schmidt and Lewis 2017;

Pardiwala and Phan 2019). If designed well, this system can facilitate better social equity in how customers pay, adapt to varying water conservation behaviors, and provide a price signal for efficient water use (Barr and Ash 2015; Pardiwala and Phan 2019). For this Supplier and in most tiered systems, Tier 1 is the most efficient use of water and is billed at the lowest rate. The threshold for “efficient use” is based on the customer class and source of water (i.e., non-potable, potable, recycled). There are two types of charges within a tiered rate- the fixed charge and the variable charge. The fixed charge is independent of water use and is intended to cover almost all the supplier’s fixed costs for providing the service. This fixed charge is constant for all accounts. The variable charge is dependent on the volume of water delivered to a customer. For the Supplier’s CII customers, Tier 1 corresponds to the total allowable water budget. Tier 2 accounts for 101% to 125% of your water budget, Tier 3 to 126% to 150%, and Tier 4 to over 150%. Customers are billed monthly, and the water budget is correspondingly calculated monthly as well. Outdoor water use budgets are calculated based on irrigable area, evapotranspiration rate (ET), and evapotranspiration adjustment factor (ETAF), according to:

Outdoor Water Use Budget (gallons) = Irrigable Area (in sq. ft.) * Monthly ET (inches) * ETAF * 0.62

We use the term ‘ETAF’ to maintain consistency with language from the Department of Water Resources (DWR) (*Model Water Efficient Landscape Ordinance (MWELO)* 2015).

The Supplier offers a range of rebates for its commercial customers to encourage water saving practices. For outdoor use, these are drip irrigation, high efficiency nozzles for large rotary, rotating spray nozzles for pop-up spray heads, synthetic turf, turf removal, and weather-based irrigation controllers. A breakdown of the outdoor rebates available and account adoption is shown in Figure 4-1. Understanding how water use is impacted upon adoption of these rebates can be a useful tool to understanding the efficacy of these rebates. However, we were unable to assess rebate-specific account trends in water use due to lack of sufficient data. We note that there is need for more research in this area and there are a lack of studies that assess the long-term effects of rebate programs and factors that affect its effectiveness (Pincetl et al. 2019; Mayer, Lander, and Glenn 2015).

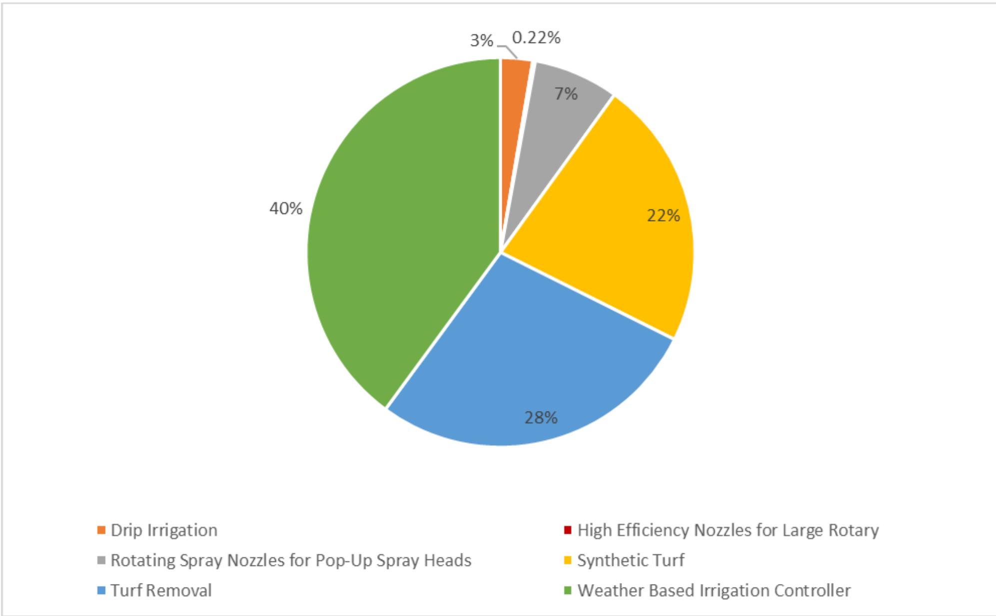

Figure 4-1. Breakdown of commercial irrigation accounts that have adopted outdoor rebates within the Supplier's service area, 2009-2020, where the total number of accounts that have adopted rebates is 451.

Methods

This study used primary data analysis. All raw data were provided by the Supplier. The Supplier provided monthly customer billing data for 2016 to 2020 for all commercial dedicated irrigation accounts as well as recycled water irrigation accounts. In addition to billing data, the Supplier also provided information on customer water use characteristics (i.e., landscape area, water budget allocation volume, and ETAF) and rebate adoption information (i.e., date and type of rebate adoption).

Commercial irrigation accounts included a wide range of building-types, including business offices, retail stores, industrial warehouses, hospitals and universities. Due to lack of identifying information, we were not able to match business-type with account number. However, we did have information on the account numbers for golf courses. Since golf courses are unique water consumers and can skew analysis towards high water consumption, we excluded these accounts from our analysis. Data were anonymized through the removal of all identifying information. Data analysis was performed using R and Microsoft Excel.

Data Cleaning and Organization

To prepare the data for analysis, monthly account-level data were aggregated to (1) annual data and (2) seasonal data by summing water use and ET values and averaging square footage. Seasonal values were calculated by designating June, July, and August as summer months, and November, December, and January as winter months

119 accounts that reported no water usage during the study period were removed from the dataset such that accounts analyzed had some level of irrigation occurring. For correlation analysis, outliers were identified as being outside the bounds of 3 times the standard deviation above or below the mean. Since this is customer-level data, differentiating between erroneous data and accurate data is tricky. Therefore, correlation analysis was performed with and without the presence of outliers.

Data Analysis

The aggregated annual and seasonal data were analyzed to obtain summary statistics and overall trends. Since 2016 was a drought year and 2020 was severely impacted by COVID-19, particularly for commercial businesses, we used account averages from 2017, 2018, and 2019 as our values for analysis. This enabled us to get the most ‘average’ and uninfluenced value for water use and water use-related characteristics.

To test for overirrigation, we used ETAF as a proxy for ‘efficient use’. Evapotranspiration Adjustment Factor (ETAF) values for each account-year combination were calculated using the following formula:

ETAF= [Water use (gallons)] / [Irrigable Area (sq ft) * Annual ET (inches) * 0.62],

with 0.62 being a conversion factor.

The Supplier did not consider effective precipitation in calculating outdoor budget volumes, and therefore, due to lack of data and to maintain consistency, it was not considered in this calculation. The term ‘ETAF’ is adopted from language from the Department of Water Resources (DWR) and the state-instituted Model Water Efficient Landscape Ordinance (MWELO) (*Model Water Efficient Landscape Ordinance (MWELO)* 2015). This value corrects for plant type and irrigation efficiency.

We examined efficiency by comparing water use with Supplier and State-prescribed thresholds. To determine water budgets for commercial accounts, the Supplier established an ETAF based on account type. The ETAF is 0.7 for potable irrigation accounts, 0.8 for Recycled irrigation accounts, and 1.0 for public spaces. At the state level, ETAF is governed by the Model Water Efficient Landscape Ordinance (MWELO). This legislation was originally instituted in 1993 via the ‘Water Conservation in Landscaping Act’ to improve water efficiency practices in California’s urban landscapes. In 2015, in response to a critically severe drought, Governor Brown signed Executive Order (EO B-29-15), directing the Department of Water Resources (DWR) to update MWELO to prevent water wastage on urban landscapes. The ordinance applies to residential, commercial, industrial and institutional projects that require a permit, plan check, or design review. It sets minimum standards for landscape design including soil, irrigation, plant requirements, including a ‘ceiling’ for an outdoor water budget. Enforcement is left up to local land use authorities. Every county or city can institute their own WELO, using MWELO as guidance. MWELO is in effect if a region does not have their own WELO. MWELO’s water budget allowance sets ETAF at 0.45 for all commercial landscapes using potable irrigation. It sets an ETAF of 1.0 for areas designated as ‘Special Landscape Areas’, defined as “an area of the landscape dedicated solely to edible plants, recreational areas, areas irrigated with recycled water, or water features using recycled water” (*Model Water Efficient Landscape Ordinance (MWELO)* 2015). In this analysis, we studied overirrigation by comparing current account ETAF values with the Supplier’s prescribed threshold for ETAF as well as MWELO standards.

To test factors that influence how commercial customers apply water on their outdoor landscapes, we performed correlations on ETAF and square footage, as well as ETAF and total water use. The Pearson correlation coefficient provides a value between +1 and -1, indication strength of a linear relationship between the two variables being analyzed. A value closer to + 1 implies a stronger positive relationship and anything closer to -1 a stronger negative relationship. Anything below 0.2 or -0.2 is considered insignificant.

Results

Overall Trends

Table 1 presents a summary of some key statistics for potable irrigation accounts and recycled irrigation accounts, as an average for 2017-2019. This includes total number of accounts, mean square footage, and outdoor water use relative to allocated budget. The total number of accounts each year did not vary by more than 3%, therefore we assumed that each year was comparable to the next. Potable and recycled irrigation accounts were relatively similar in number. However, recycled irrigation accounts had almost double the mean square footage in landscape area compared to potable irrigation accounts. It is important to note here that there is an internal bias in landscape area since the Supplier selects customers for recycled water services based on having larger landscaped areas. However, normalizing for landscape area, potable irrigation accounts were higher water users per square foot, and relative to water budget. Potable irrigation customers used 1.5 times more water per square foot than recycled water customers. About half of all potable irrigation customers exceeded their allocated budget, whereas only 14% of recycled water customers exceeded theirs.

Figure 4-2 and Figure 4-3 show trends in summer and winter water use for potable and recycled irrigation accounts as well as precipitation trends between 2016 and 2020.
From the precipitation trends, we observed that 2018 and 2020 had lower precipitation. 2016 was the end of the 2013-2016 drought and we saw the tail-end of drought conditions that year as well. 2017 and 2019 are relatively wetter years.

For potable irrigation accounts, water use peaked in 2018, at 15% higher than 2016 water use volumes. 2019 water use was the lowest water use year and was 21% lower than the previous year. Total outdoor water use peaked in 2018, and then in 2020, and was driven by an increase in winter water use. Between 2017 and 2018, summer use increased by 54% while winter use increased by 88%. Similarly, between 2019 and 2020, summer use increased by 15% while winter use increased by 85%. Between the entire time frame of analysis, summer water changed to a lesser degree than winter water. There was a 16% difference between the highest and lowest values across the five-year timespan for summer water use, whereas that for winter water use is 54%.

For recycled irrigation accounts, like potable irrigation accounts, water use peaked in 2018. Water use in 2018 was 5% higher than in 2016. However, it dropped 25% to the lowest level in 2019. Mirroring potable irrigation trends, peaks in total water use were driven by winter water use. Between 2017 and 2018, summer use increased by 5% while winter use almost quadrupled.

As seen in Table 4-1, on average, potable irrigation accounts applied water at a rate of 19.4 gallons per square foot of landscape. Recycled irrigation accounts applied water at 12.9 gallons/sq. ft., 33% lower than potable irrigation accounts.

Table 4-1. Summary statistics for Potable Irrigation and Recycled irrigation accounts, as average of 2017, 2018, and 2019.

	Sample Size	Mean Square Footage	Mean Water Applied (Gallons/Sq ft)	Mean water use relative to allocated budget	Percentage of accounts over allocated budget
Potable Irrigation	1192	54,225	19.40	320%	51%
Recycled Water	1121	127,184	12.91	63%	14%

Note: Averages were calculated as weighted averages. Recycled irrigation accounts have a higher square footage due to bias in selection of customers.

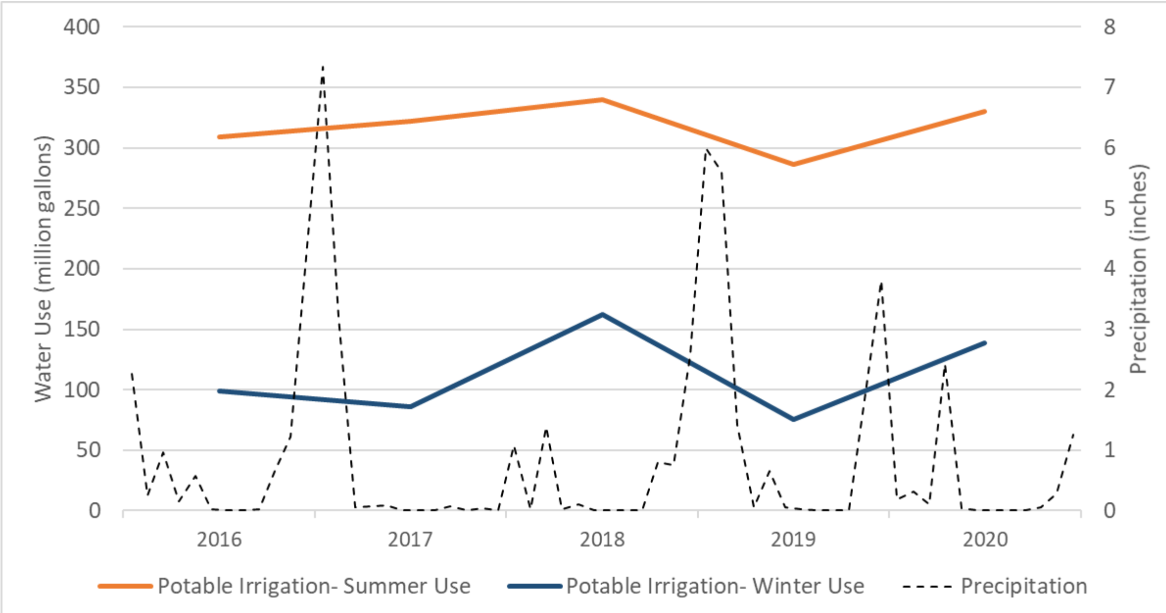

Figure 4-2. Water Use trends for CII potable irrigation accounts and precipitation trends, 2016-2020.

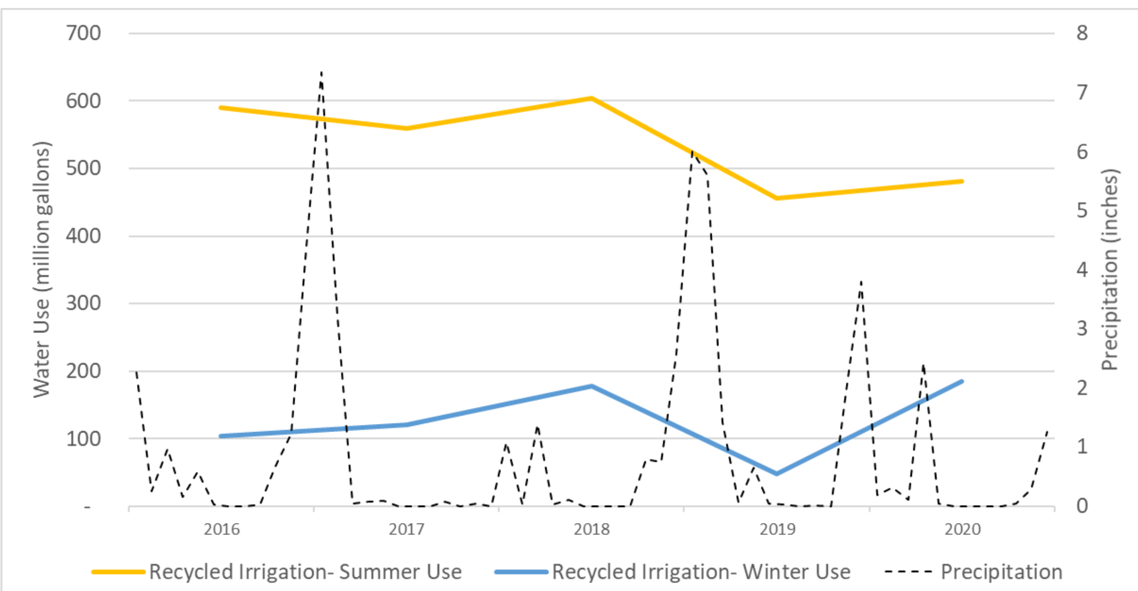

Figure 4-3. Water Use trends for CII recycled irrigation accounts and precipitation trends, 2016-2020.

Inefficient water users

To understand the level of inefficiency within the system, we first looked at water use trends compared to the allocated water budget. Figure 4-4 illustrates the trend in water use relative to budget (as a percentage) for potable and recycled irrigation accounts between 2016 and 2020 annually and seasonally. Recycled water accounts used significantly lower water relative to their budget, across all years and seasons. Potable accounts used 95 to 115% of their water budget annually, while recycled accounts used 59 to 67%. Both recycled and potable accounts exceeded their budget more in the summer compared to winter.

Next, we compared account water use with two parameters- supplier-mandated standards and state-mandated standards. First, we compared account water use with outdoor water budget allocation, instituted by the supplier, to better understand the percentage of accounts that were exceeding their outdoor water budget and by how much. To calculate an outdoor water budget, the Supplier sets ETAF at 0.7 for commercial potable irrigation accounts and 0.8 for Recycled irrigation accounts. To help irrigators with salt build up, the Supplier provides a higher ETAF for recycled irrigation customers to flush salts. Recycled irrigation accounts that are designated 'public spaces' are set at an ETAF of 1.0. We calculated the total water savings available if all accounts met their outdoor allocation. The outdoor allocation corresponds to the allowable water use in the Supplier's tiered budge-based water rates system. Any usage over the allotted allocation is billed at a higher price per unit of water. Table 4-2 shows the percentage of accounts that exceeded their allocated water budget. 14% of recycled irrigation accounts and 50% of potable water accounts exceed their allocation. A higher percentage of accounts exceeded their allocation in the summer months (52%) compared to winter months (28%). We also found that for potable irrigation accounts, the largest fraction of accounts (35%) was within 15% under and 31% over their allocation. However, for recycled irrigation accounts, the largest fraction (37%) was between 37% to 67% below their allocated budget.

Table 4-4 shows water savings available if accounts met their efficiency thresholds. We found that 137 million gallons of water can be saved if potable irrigation accounts adhered to their allocated water budget. This is 15% of their original water use volumes. For recycled irrigation accounts, adhering to their water budget would save 30 million gallons of water, which is 2% of their water use.

Second, we compared account water use with efficiency standards, in the form of ETAF values, prescribed by the State. The ETAF threshold that counts towards ‘inefficient use’ is governed based on MWELO, at the state level (*Model Water Efficient Landscape Ordinance (MWELO)* 2015). The ordinance sets ETAF at 0.45 for commercial potable irrigation spaces, and 1.0 for ‘special landscape areas’, which includes those irrigated using recycled water. 76% or 935 potable irrigation accounts irrigated over the MWELO-prescribed ETAF thresholds, whereas only 7%, or 75 recycled irrigation accounts irrigated over their threshold. Table 4-3 summarizes these results. Comparing winter and summer, both account types exceeded their MWELO threshold more in summer than winter. 75% of potable irrigation accounts exceeded this threshold in summer compared to 57% in the winter.

Table 4-4 shows water savings available if accounts met their MWELO thresholds. If potable irrigation accounts were at MWELO standards, these accounts can save approximately 35% of their water use, or 314 million gallons. Recycled irrigation accounts can save 1% of their original water use by achieving MWELO thresholds, which is 12 million gallons.

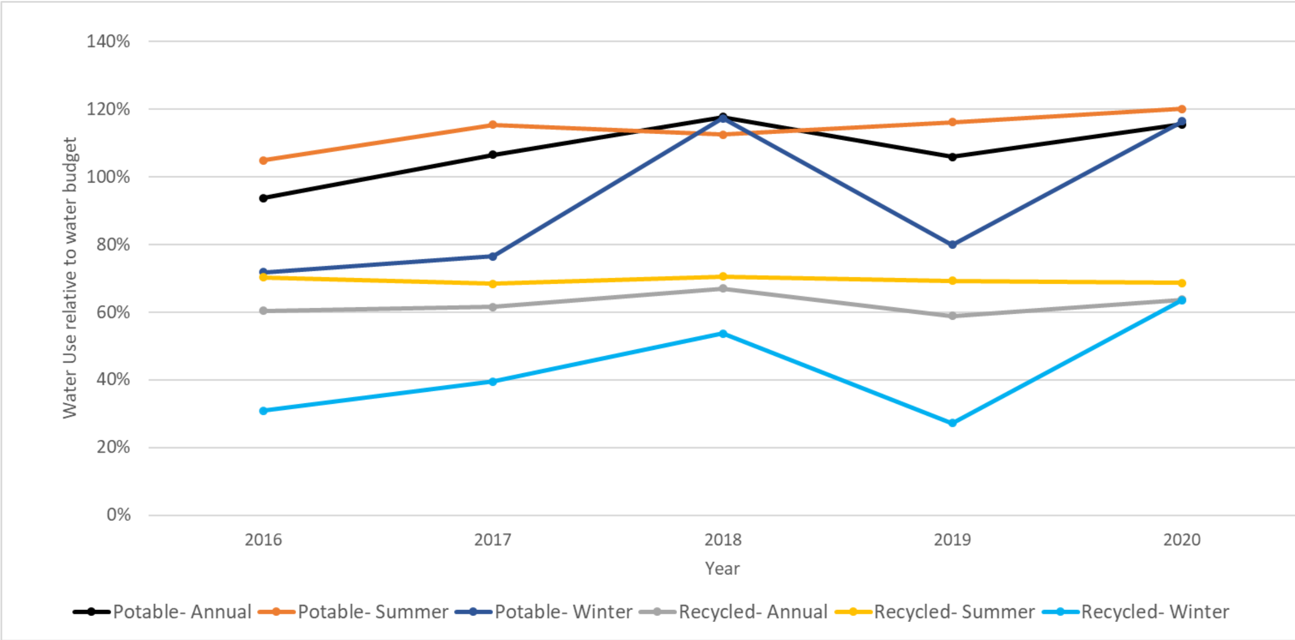

Figure 4-4. Water use relative to budget for potable and recycled irrigation accounts, annual and seasonal, 2016-2020.

Table 4-2. Percentage of accounts exceeding allocated water budget, potable and recycled irrigation CII accounts, average of 2017-2019.

Account-type	Number of accounts	% of accounts exceeding allocation-annual	% of accounts exceeding allocation-summer	% of accounts exceeding allocation-winter
Potable Irrigation	1225	50%	52%	28%
Recycled Irrigation	1142	14%	18%	5%

Table 4-3. Percentage of accounts exceeding efficient use as prescribed by MWELO, potable and recycled irrigation CII accounts, average of 2017-2019.

Account-type	Number of accounts	% of accounts exceeding MWELO standard-annual	% of accounts exceeding MWELO standard- summer	% of accounts exceeding MWELO standard- winter
Potable Irrigation	1225	76%	75%	57%
Recycled Irrigation	1142	7%	9%	3%

Table 4-4. Water savings in gallons and as a percentage of water use if all potable and recycled irrigation accounts met (1) Supplier-prescribed thresholds, (2) MWELO-prescribed thresholds, average of 2017-2019.

		(1) If accounts were at Supplier standards		(2) If accounts were at MWELO standards	
Account-Type	N	Water Savings (gallons)	Savings as % of original volume	Water Savings (gallons)	Savings as % of original volume
Potable Irrigation	1225	137,076,610	15%	314,526,194	35%
Recycled Irrigation	1142	30,302,103	2%	12,425,652	1%

Factors affecting inefficient water use

To better understand the factors that drive inefficient water use, we examined the relationship between ETAF, and water use and landscape area. We assume ETAF to be the dependent variable that stands in as a proxy for efficiency. We test the dependency of ETAF on landscape area and water use. A linear relationship between ETAF and landscape area will help us understand whether accounts with larger landscapes are applying more water per sq. ft. Whereas, a linear relationship between ETAF and absolute water use will help us understand whether accounts that use more water are more inefficient than those who use less.

However, all correlation results were not found to be significant (Table 4-5). It can be surmised that there is no linear correlation between ETAF and water use, or between ETAF and landscape area. Yet, this test was limited to only two dependent variables, and it is possible that multiple factors are at play. While landscape area and water use may be factors in determining outdoor water efficiency, it likely cannot be used independently to make judgements on efficiency.

Table 4-5. Correlation results, to test factors driving efficient water use

	ALL	Summer	Winter
ETAF + Sq. Ft.			
With Outliers In	0.033224	0.034188	0.011914
Outliers Removed	0.052045	0.042564	0.017483
ETAF + Water Use			
With Outliers In	0.03196	0.042909	-0.00799
Outliers Removed	0.046064	0.037851	-0.0139

Discussion

Seasonality

Overall, CII outdoor water use at the water supplier studied were seasonal and dependent on weather. There is extensive research that supports the seasonal drivers of water use in the residential sector (Akuoko-Asibey, Nkemdirim, and Draper 1993; Mini, Hogue, and Pincetl 2014a) , showing that precipitation and temperature are key factors that drive water consumption. While there are not similar studies for the commercial sector, we see that water use trends in this study follow this pattern. Summer and winter water use follow similar trends, with spikes in drier years. Total water use peaked in 2018, and then in 2020, and was driven by an increase in winter water use. Between 2017 and 2018, summer use increased by 54% while winter use increased by 88%. Similarly, between 2019 and 2020, summer use increased by 15% while winter use increased by 85%. 2018 was a dry year, with low levels of precipitation and higher possibility of drought. However, 2017 and 2019 saw higher precipitation. This suggests that CII users are increasing their irrigation use in the winter in dry years.

This trend is replicated for Recycled irrigation accounts as well. However, in this case, while 2018 was still the highest water use year, recycled irrigation water use increased to a lesser extent than potable irrigation accounts. These results suggest that these CII outdoor water use, similar to residential use, is seasonal in nature. Winter water use shows the most increase in a dry year.

Efficiency drivers

Water conservation can be incentivized by price-based and non-price-based strategies (Schwabe, Baerenklau, and Dinar 2014). According to Schwabe, Baerenklau, and Dinar 2014, price-based strategies are those that focus on changing the price of water where non-price-based include all other demand management practices. This Supplier uses a mix of both strategies, using budget-based rates and offering commercial outdoor rebates.

We found that 50% of potable irrigation accounts irrigated over their allocated budget and 76% irrigated over MWELO-prescribed thresholds, as seen in Table 4-2 and 4-3. Accounts tended to exceed their budget more in the summer compared to winter. However, when looking at trends of water used relative to the allocated budget, we found that the most *change* happened in the winter water use. While summer water use relative to budget hovered around 110% across all years, winter water relative to budget varied between 72% and almost 120%. These peaks in water use relative to budget correspond to drier years. This suggests that accounts are changing their behavior more significantly in the winter than the summer. However, they are using more water, in magnitude, in the summer.

We found similar trends among recycled irrigation accounts. However, like earlier findings, the magnitude is lower for recycled water. 14% of recycled irrigation accounts exceeded their allocated budget. Recycled water users tended to exceed allocation more in the summer than winter. Examining water use relative to budget trends, we found parallel trends among the recycled irrigation accounts as seen in potable irrigation accounts. Recycled water users also tend to change their behavior more in the winter compared to summer, although overall water use is higher in the summer.

Budget-based rates have been shown to incentivize water conservation in residential households. A study showed Eastern Municipal Water District, located in Southern California, reduced household water usage by 10 to 15% by adoption of tiered budget-based rates compared to a uniform budget at the same level of pricing (Schwabe, Baerenklau, and Dinar 2014). In the case of outdoor residential use, the Irvine Ranch Water District reported a 61% decrease in outdoor water use in the 13 years after introduction of allocation-based rates. Further, an empirical analysis of data from a water district in Southern California showed that household customers make changes to their water use based on changes in the level of a water budget (Pérez-Urdiales and Baerenklau 2019). However, studies have not focused on the effect of an outdoor water budget in the commercial sector, and more research is needed to fully understand the efficacy.

In studying the link between landscape size and water use with efficiency, we found no significant linear correlation between efficiency and larger landscapes, or efficiency and water use. We hypothesize that other factors play roles in driving water use. Internal behavioral factors such as business function, ambition, and landscape maintenance may play a role (Cooley et al. 2019).

Comparing recycled and potable irrigation accounts

If we compare recycled versus potable customers, this analysis suggests that recycled irrigation accounts tend to be more conscious water users. While patterns in water use for potable and recycled irrigation accounts were similar, the magnitude of water use differed. Recycled water irrigation accounts used 33% less water per square foot than potable irrigation accounts. Additionally, while absolute summer water use is much higher for recycled irrigation customers, winter water use is comparable in magnitude. This suggests that recycled irrigation customers are using less water, particularly in winter, than potable irrigation customers. The Supplier selects accounts to switch over from potable irrigation to recycled water largely based on size; larger square footage accounts are considered ‘low-hanging fruit’ to offset potable water usage. The Supplier also exercises greater oversight of recycled irrigation accounts, e.g., canceling a recycled water contract if water is grossly misused. There is also a mutual understanding that accounts provided recycled water are expected to be ‘good water stewards.’ These factors likely contribute to recycled irrigation customers using less water per square foot than potable irrigation customers.

We also looked at how far ‘off’ accounts are from their allocated budget. For potable irrigation accounts, majority of the accounts fall approximately 20% higher or lower than the allocated budget. This suggests that accounts are, to some extent, driven by the level the budget is set at. On the other hand, for recycled water account, the water use for majority of the accounts fall 40% to 60% lower than their allocated budget, suggesting that these accounts are less driven by the budget level and tend overall to use less than allocated. This suggests that the budget is possibly set higher than necessary. Recycled irrigation accounts tend to be more under-budget than potable irrigation accounts. It important to note that there are some skewing factors at play. Recycled irrigation accounts are subject to a higher ETAF of 0.8 compared to 0.7 for potable irrigation accounts. In addition, about 300% more recycled irrigation accounts compared to potable irrigation accounts are designated as ‘public spaces’ and are given a 1.0 ETAF threshold. Due to unavailability of data, we were not able to analyze these accounts individually.

Potential for added savings

To understand the extent of water savings available, we compared current water use with water use at MWELO and Supplier standards. If all potable irrigation accounts met their allocated water budgets, approximately 137 million gallons or 400 acre-feet of water can be conserved. Further, if all potable irrigation accounts were at MWELO standards of 0.45 ETAF, about 1,000 AF of water can be conserved. For recycled irrigation customers, 30 million gallons or 100 acre-feet of water can be conserved if customers met their allocated water budget.

Conclusion

Outdoor water use for commercial accounts are affected by several factors. There is a strong seasonal and weather-related component. On a year-to-year basis, accounts tend to overirrigate in the summer months. However, increased water use in the winter drives demand in dry years, suggesting that CII customer behavior changes in the winter to a larger extent than the summer. While there are potential opportunities in winter, conservation programs in summer will yield most savings.

We also hypothesize that other factors such as business function, and expertise of landscape maintenance likely play strong roles in outdoor water use. We find that there is no strong correlation between water-use efficiency and either landscape size or water use. Targeting accounts on the basis of size or traditionally ‘high’ water use may not be the most effective way to reduce waste and inefficiency. Recycled water users in the study were found to be more conscious water users and use less water relative to their water budget and per square foot. These findings can be utilized by water agencies to better tailor commercial rebate programs and provides information on ways to target commercial customers more effectively.

We find a strong need for more research and long-term study into several aspects of water use in the CII sector. Some important areas are quantifying and understanding the efficacy of outdoor rebate programs in the CII sector, particularly turf removal, and parsing out factors that drive outdoor water use in the CII factor. Additionally, a big area for improvement is the accessibility and availability of data in the CII sector. Water suppliers collect a lot of useful information and enabling this to be used for research will go a long way in creating more informed policy and management.

Chapter 5: Understanding Behavioral Drivers for Adoption of Sustainable Landscapes in the Commercial, Industrial, and Institutional (CII) Sector

Abstract

California's water resources are under increasing pressure from increasing weather variability spurred by climate change, and a rapidly developing economy and population. Addressing these challenges and making real change will require active participation from all its residents- including the business community. However, historically, most urban sustainability programs and outreach focused on the residential community and overlooked the CII sector. This study, based on a survey and round of interviews, aimed to understand what factors affect business decision-making around sustainable landscapes in the commercial, industrial, and institutional (CII) sector. To incentivize adoption of sustainable landscapes among the CII community, we recommend that those interested in engaging with the business community consider the following, (1) tailoring materials and resources around sustainable landscapes for the business community, (2) creating awareness around and expanding financial incentives, (3) better understand business decision-making, (4) create pathways for landscape professionals to gain skills needed in sustainable landscaping.

Introduction

Landscape irrigation is one of the most significant uses of water in California (Hanak and Davis 2006). Especially in areas in Southern California and inland, hotter summer and drier climate coupled with large lot sizes lead to high water use. Installing low water-use plants and improving irrigation efficiency can provide significant water savings and provide a host of other benefits including enhanced stormwater and groundwater capture and recharge, better air and water quality, and improved community livability (PPIC Water Policy Center 2016; Diringer et al. 2019; Clements et al. 2013; Center for Neighborhood Technology and American Rivers 2010). Any combination of these strategies implemented in outdoor landscapes are referred to as 'sustainable landscapes', defined as those landscapes that are in balance with local climate and ecology and actively contribute to watershed health by providing economic, social, and environmental benefits (Cooley et al. 2019; American Society of Landscape Architects 2009; Green Gardens Group (G3) 2018a; Metropolitan Water District of Southern California 2017).

People choose to install sustainable landscapes for several reasons. An Alliance for Water Efficiency (AWE) study surveyed residential customers that participated in landscape transformation programs and found that residential customers are largely motivated by the aesthetic appearance, easy maintenance, and the ability to conserve water (Alliance for Water Efficiency 2018). For single family homes, landscape transformation was shown to reduce water use by 7% to 39% (Alliance for Water Efficiency 2018). Social factors such as comparison with a neighbor or receiving messaging encouraging water conservation were found to incentivize water conservation through landscape conversion (Schultz, Javey, and Sorokina 2019; Alliance for Water Efficiency 2018; Addo, Thoms, and Parsons 2019). Residential customers were shown to use 8% less water when given water bills that compared their water use with that of similar homes in the area (Schultz, Javey, and Sorokina 2019). A study looking specifically at drivers for biodiversity in residential landscapes have also documented an innate sense of responsibility to the community and 'wonder for nature' (Goddard, Dougill, and Benton 2013). It is important to note that demographic factors play a role in residential customer uptake of sustainable landscapes, and water conservation strategies in general (Mini, Hogue, and Pincetl 2014a; Inman and Jeffrey 2006; Addo, Thoms, and Parsons 2018). A survey of landscape transformation customers also revealed barriers around lack of customer knowledge, complicated requirements, and a lack of landscape contractor expertise (Alliance for Water Efficiency 2018).

California's water resources are under increasing pressure from increasing weather variability spurred by climate change, and a rapidly developing economy and population (Heberger, Cooley, and Gleick 2014; Hanak and Davis 2006). Historically, most urban sustainability programs and outreach focused on the residential community and overlooked the CII sector (Worthington 2010; Renzetti 2015). A study of nine water agencies looking at turf rebate program statistics found that only 7% of CII customers participated in these programs compared to 93% of residential customers (Seapy 2015). A sector often forgotten when it comes to sustainability, the business community has strong potential to create lasting change.

Historically, there has been friction between the business community and environmental regulation, stemming from fears that costs of compliance are too high, regulations will cause increased job losses, and will reduce overall economic productivity and competitiveness. For example, the Clean Air Act in 1970 required a reduction in emissions from motor vehicles with the use of catalytic converters. While the auto industry opposed this, it was discovered that the cost of compliance was 65% lower than industry citied and ultimately the regulation reduced carbon emissions per mile by 35% and created significant impact on the polluting effects of cars in the future (Gerard and Lave 2005). Evidence has shown that while there may be short-term negative impacts, these are insignificant compared to longer-term trends in the economy (Dechezleprêtre and Sato 2017). Additionally, the benefits of environmental protection to society outweigh any adverse impacts (Gray 2015).

In recent years, in the face of increasing water scarcity, pollution, and a changing climate, businesses have made real shifts towards understanding and mitigating their risk to the environment (CDP 2020; Schulte, Orr, and Morrison 2014). This phenomenon, termed ‘corporate water stewardship’, is founded on the understanding that water is a resource that must be socially, economically, and environmentally equitable in its use, and is realized through an inclusive process that requires a company to look not just within its operations, but beyond its operational fence line as well (CEO Water Mandate 2015; Sujamo 2016). Companies adopt water stewardship to mitigate three major types of risk- physical, reputational, and regulatory (CEO Water Mandate, n.d.; Orr, Cartwright, and Tickner 2009; Richards 2016). Physical risk manifests in the form of limited access to water resources, due to drought or water pollution for example. Reputational risk establishes itself when a company’s reputation to its stakeholders (for e.g., customers, investors, communities) is affected in a negative way due to wasteful water practices. Regulatory risk results when changes in laws or governance system affect a company’s management of its water resources or water-related processes. These three types of risk manifest due to internal or external factors. Internal factors are those directly in the control of a company, such as operational processes. On the other hand, external factors are those that the company does not have direct control over, such as hydrology of the region and watershed health (Schulte, Morrison, and Gleick 2012, 7; Sujamo 2016). All these risks will also result in financial impacts. The financial impacts associated with water risk are much higher than the cost of addressing them making it beneficial for businesses to address and proving the ‘business case’ for water stewardship (CDP 2020).

While studies have investigated corporations and water risk, there is less research on the site-level scale (UN Global Compact CEO Water Mandate et al. 2019). We use this study to investigate sustainability decisions at the site-level. This study aims to understand what factors affect business decision-making around sustainable landscapes in the commercial, industrial, and institutional (CII) sector. This study is based on a business survey and round of interviews to develop recommendations on engaging businesses and encouraging their adoption of sustainable landscapes. This work is informed by a project conducted by Pacific Institute in the Santa Ana River Watershed (Cooley et al. 2019). While this paper is focused on Southern California, the learnings are applicable broadly.

Methods

It is important to understand the practical barriers and drivers that existing businesses in the region face when considering installation of a sustainable landscape. For this, we conducted a survey targeted at businesses in the region and followed up with interviews with the respondents. The survey was sent out via email directly to business representatives working in southern California and a number of business associations serving the region. The survey, which can be found in Appendix A, focused on information around the company’s financial and operational decision-making process, project status, details about the project if implemented, and the mechanics of the process in any case. We received eight responses in total, out of which six were based in the Santa Ana River Watershed while two were in the broader Southern California area. The respondents were half commercial and half industrial, with facilities that ranged between

10,000 to 50,000 square feet. Four out of the seven companies had implemented a sustainable landscaping project, two had considered it, and one had not considered the option. All except one company had decision-making power over their outdoor landscape.

We followed up with in-depth interviews with five out of eight of the respondents, representing hospitality, manufacturing, and technology sectors with medium to large facilities, based in Southern California, inland of Los Angeles County. The five companies are serviced by four different water suppliers; two of the companies had the same water supplier. Three out of four of these water suppliers were supplied with imported water through the Metropolitan Water District of Southern California. The interviews dove deeper into survey answers to get a more nuanced and detailed understanding of how businesses approach a sustainable landscaping project. A guiding list of questions used during the interviews is in Appendix A.

Results

After surveying companies on their sustainable landscaping projects and decision-making, we interviewed five out of the eight survey respondents to better understand their process. Out of these five companies, three had implemented a sustainable landscape project, and the remaining two had both considered plans but had not implemented a project. The companies that implemented a project focused on removal of turf and installation of low water use plants citing ease and convenience as big factors. Water efficiency and cost considerations were motivating factors for all companies. Table 5-1 summarizes these findings.

Table 5-1. Summary of the results of interviews conducted with five anonymized companies on attitudes towards adoption of sustainable landscape projects.

Company	Implementation Status on Sustainable Landscaping project	Motivators	Barriers	Landscape type
A	Implemented	Aesthetics, water and energy savings, corporate sustainability goal	Funding, inability to 'show' water savings due to lack of outdoor metering	Removal of turf
B	Did not implement, but did consider	Cost savings, reputational benefits due to contributing to sustainability, corporate sustainability goal	Funding, lack of internal resources, inability to prove a good business case	
C	Implemented	Customer feedback, contributing to sustainability due to being situated in a water-stressed region	Funding, lack of a corporate directive	Installation of low water use plants, Expansion of permeable areas by reducing impermeable areas
D	Did not implement, but did consider	Cost savings, corporate sustainability goal	Funding, lack of internal resources, inability to prove a good business case	
E	Implemented	Aesthetics, cost savings	Inability to 'show' cost savings, difficulty in identifying suitable landscape professional	Installation of low water use plants

Motivations

The way each company approached adopting a sustainable landscape was dependent on the type of company. Two of the interviewed companies were public-facing or customer-facing. Both these companies had implemented landscape projects and cited positive customer feedback as strong motivators. For one of the companies that did not implement a project, landscaping was a minor water user and they focused water efficiency on operational, more water-intensive processes. We found that the existence of corporate sustainability goals was a strong motivator. Three of the interviewed companies had sustainability goals, in the form of water reduction goals, established at the corporate level. Companies with sustainability goals exhibited more of a robust sustainability culture, where both site and corporate staff more easily accepted sustainability practices. Site staff were assured of corporate buy-in of sustainability projects and were further incentivized to adopt practices that could help reach this goal.

We also found that the potential of water and cost savings were a driver for all companies. In addition to saving water, two of the companies mentioned reputational drivers around contributing to the water resiliency of the community. Two of the companies citied aesthetics as a motivating factor. Both companies were public-facing and likely spurred by customer feedback as a result of aesthetics.

Barriers

We found that four out of the five interviewed companies cited the inability to 'show' benefits as a barrier to implementing sustainable landscape project. A lack of understanding around sustainability practices, particularly maintenance, and inability to quantify benefits meant that both converted landscapes focused on xeriscaping. For example, one company implemented a landscape project primarily involving turf removal because it is 'simple and well-known'. Neither company explicitly implemented stormwater or rainwater capture. In addition to motivating sites, we also found that lack of directives from the corporate level created a disincentive to implement a sustainable landscape. The two companies that did not have established sustainability goals faced a disconnect between corporate and site staff. While there was general awareness of being located in a water-stressed region, there was a lack of communication around the need to address this. One company had been recently bought by property owners who were focused on creating a 'lush' landscape, while the other was unsure of how much water they needed to save since no benchmarking or baseline water use had been established. For all companies, in addition to the lack of funding, budget timing was a factor as well. Internal budget deliberations and allocations were decided at a particular time of the fiscal year, and any potential landscape projects would need to be proposed at that time.

Funding sources were another big piece of this puzzle and had a big influence on whether projects were carried through past the consideration stage. Four out of five companies mentioned difficulty in identifying funds for a project as a direct barrier. However, none of the companies had sought outside funding for their projects- either in the consideration or implementation stage. Companies stated that they were not aware of any rebates and did not know how they would approach this. In addition to identifying funding, the financial evaluation of a project was also cited as a barrier. While two companies had allocated sustainability funds that were not subject to the same ROI and requirements as other projects, the others faced assessing sustainability projects with traditional financial metrics that do not evaluate these projects justly. One company understood that these projects would need to be evaluated differently but was unsure of how this would be done. The remaining two companies needed to show cost reductions associated with the project to be able to use company funds.

Overall, we found that every company was aware of being situated in a water-stressed region and felt an internal need to contribute to addressing the problem rather than adding to it.

Companies understood their role in the larger community and expressed desire to be able to 'be an example' for those around them. Our interviews indicated a sense of commitment towards sustainability, and interest in sustainable landscapes from businesses. However, lack of knowledge, information, and resources on the benefits, evaluation and implementation of these projects often hinder widespread adoption.

Discussion and Recommendations

During the course of this work, through the survey, interviews, and conversations with various facility managers in the Santa Ana region, we gained a foundational understanding of the main barriers and drivers behind adoption of sustainable landscapes for these commercial and industrial sites. We recognize that the sample size in this chapter is small. However, there is a dearth of information around sustainable landscapes in the CII sector and therefore these results and conclusions are intended to provide a foundation upon which further research and future study can be built upon. Below we document some key learnings from this study. This is intended to help better understand where there is need for further investigation and where initial solutions may be targeted.

Create resources tailored to the business community that connect business interests and landscape benefits.

Sustainable landscapes have benefits that range from saving water and energy, to improving mental health and community livability (S. Diringer et al. 2019; Center for Neighborhood Technology and American Rivers 2010). For example, an NRDC study found that a bioswale and rain garden that can manage 1 inch of runoff from adjacent impervious area can result in over $2 million worth of benefits, including energy savings, increased property value, and stormwater fee reduction (Clements et al. 2013; Hutchins et al. 2019).

However, while businesses have started considering the value of sustainability beyond pure financial considerations, the multi-benefit aspect of sustainable landscapes is still largely unexplored in most businesses (Clements et al. 2013; Hutchins et al. 2019). Projects that interviewees implemented or considered were turf-removal or installation of low-water use plants. Many also cited efficient irrigation practices. However, we found that stormwater capture, rainwater capture, and groundwater infiltration are not widely known or used. Further, lack of knowledge made it challenging to apply them to a project in a way that can benefit the business and address their needs.

Resources that connect landscape benefits to business interests are a useful way to create knowledge and therefore, an easier path to adoption of sustainable landscapes (Haanaes et al. 2011). Moreover, resources that are tailored to businesses can increase the effectiveness (Tracy A. Boyer, D. Harshanee W. Jayasekera, and Justin Q. Moss 2016). For example, for a company looking to reduce costs, installing a sustainable landscape that reduces stormwater runoff (Line and Hunt 2009), which in turn reduces the extent of stormwater permits and fees can be a win-win solution. For a public-facing company, improved green space on a CI property not only provides positive aesthetics but also improves employee wellbeing and productivity (American Society of Landscape Architects 2009). For a company with a water replenishment goal, showing how the recharge potential of landscape strategies such as increased infiltration through curb cuts can contribute to their goal will create added incentive and help with internal buy-in. A resource that elucidates such links can help businesses more quickly make connections between a sustainable landscape and business goals and objectives.

When creating resources for the business community, in addition to connecting landscapes with business interests, we also found that it is beneficial to use terminology and examples that resonate with the business community. For example, using language that speaks to reducing water-related or financial risk can appeal more to businesses.

Encourage awareness of existing financial incentives and create broader financial incentives

Financial considerations are a significant factor in a company's decision-making process (Doane and MacGillivray 2001). In this study, businesses looked at cost through a water and energy bill reduction, some needed to show a set ROI to gain buy-in for a project, and some companies, usually those with separate sustainability budgets, evaluated the broader economic value of a sustainability project.

The Metropolitan Water District of Southern California (MWDSC), whose service area all the companies fell under, offers a $2/sq foot turf removal rebate for commercial properties through the SoCal Water$mart Program (SoCal Water$mart, n.d.). Similar programs are offered by retail water suppliers which can be additive when coupled with MWDSC or its partner wholesalers' programs. However, none of the eight companies surveyed for this study had considered using any sort of external funding source around installation of a sustainable landscape. None were aware of any rebates available to them and did not know how to find them. This signals a need for better outreach from water agencies and other organizations that are targeted at the business community to improve awareness of existing rebates.

We found that financial incentives such as rebates can help make a sustainable landscape project more appealing to private property owners in the initial stages by reducing capital cost required. Outside of traditional rebate programs, there are alternative effective incentives that cities have implemented. The City of Philadelphia incentives reduction of sewer overflow through green infrastructure on non-residential properties. They do this through a ‘parcel-based fee system’ proportional to impervious area; owners can reduce this fee by retrofitting with green infrastructure practices (Valderrama et al. 2013). Measure W in Los Angeles County achieves a similar goal through a parcel tax based on impermeable area. The Green Roof Property Tax Abatement in New York City provides a one-year tax cut for the construction of a green roof on commercial buildings (The Georgetown Climate Center, n.d.). Programs that can approach landscapes from a multi-benefit perspective hold a greater incentivize for businesses to prioritize strategies that provide a wide range of benefits, while still meeting the company’s needs.

Understand the Complexity and Diversity within Business Decision-Making Processes. The process behind reaching a decision within a company is varied and dependent on the specific company. Adams and Frost 2008 found that sustainability reporting varied considerably across companies. The study found that this was because a wide range of corporate roles were responsible for sustainability-related work, a high number of staff were involved, and the process for making decisions ranged widely from informal to highly formalized.

For companies that are farther along their sustainability ‘journey’, it may be easier to make decisions around sustainability projects whereas others may need to go through more levels of decision-making. Haanaes et al. 2011 termed these companies ‘embracers’ and ‘cautious adopters’, differentiating their approaches to decision-making. Hutchins et al 2019 analyzes a study by Parris and Kates 2003 that looked at development of sustainability indicators and cites factors such as “level of control that business decision makers have, the effort required to incorporate them into decision-making processes, and the financial burden associated with implementation" as key factors in selecting final choices.

In our study, we found similar views within the companies we interviewed. The decision-making process for sustainability projects, including landscapes, took place at multiple levels in a company. For a sustainable landscape project, approval had to be gained from site-level operational staff, site-level managerial staff, and staff and leadership at the corporate level. Staff involved came from various departments including finance, sustainability, and facilities.
This meant that each person approached the project with different objectives. Each person also required materials and resources that speak to their role to understand the project and make an informed decision. For example, a financial manager may need a project ROI, a sustainability manager may instead need to understand what environmental goals could be achieved through the project, and a facilities manager may need to understand the labor and time demands of the project. We also found that this can be further complicated if the property is not owned by the company; the property owner will have a say in the process as well. Further, timing for these decisions is pre-determined and occurred at a specified time of the year due to budget cycles and when projects can be proposed and approved. Navigating these dynamics, parsing out the challenges that occur as a result, and planning a subsequent project can be challenging. Therefore, thoroughly understanding these dynamics can be of significant support when engaging with a business.

Create pathways for education and awareness to ensure appropriate landscape maintenance.

Sustainable landscapes require specialized expertise in order for them to thrive and provide the many multiple benefits they have to offer (Hartin et al. 2014; Green Gardens Group (G3) 2018a). Landscape professionals skilled in this area understand the water needs of climate-appropriate plants, are well-versed in guiding or redirecting runoff to be most efficient, understand the importance of healthy soils, and can make connections between various aspects of the landscape to offer a holistic perspective of the sustainable landscape (Sonoma-Marin Saving Water Partnership, n.d.). In this study, businesses disclosed being reluctant to change their existing landscape professionals because of a long-term relationship with their existing landscape contractor and choosing a landscape professional based on ease and convenience. The businesses were not independently aware of the difference in care needed for a sustainable landscape and depended highly on the landscape contractor's expertise and recommendations. Since adequate maintenance is key to the health of a sustainable landscape and the benefits it can provide, creating awareness of the importance of adequate maintenance and creating pathways for education of commercial landscape contractors is critical. One of the most straightforward ways to do this is through certification programs available across the state (Sonoma-Marin Saving Water Partnership, n.d.).

Conclusion

Sustainable landscapes have strong potential to change the way water is used on commercial properties. This study provides a strong basis upon which we hope future research will be built upon. The CII sector holds significant potential in making an impact on water resilience for the state, and more understanding into how to harness this potential will be key. Our interviews indicate a sense of commitment towards sustainability, and interest in sustainable landscapes from businesses. However, lack of knowledge, information, and resources on the benefits, evaluation and implementation of these projects often hinder widespread adoption.

This work, as detailed above, elucidated the need for a set of resources that could speak to business interests, simplify the landscape transformation process, and enable businesses to fully understand and realize the impact sustainable landscapes can make on their sites and businesses. In response, we created a Sustainable Landscapes Guidebook for CII Site Managers. This guidebook aims to guide a site manager interested in installing a sustainable landscape. A fully formatted version of this guidebook is attached in Appendix B.

Appendix 5A

List of Interview Questions for Survey Respondents

1. If they have an existing sustainability program in place and gauging response on the survey qn- 'Do you (or someone in your company) discuss sustainable landscape management with the person/entity that has management and decision-making control for landscaping around your facility?'
   a. How and at what level does your business set its sustainability goals/objectives/priorities? Are there specific targets and objectives your facility is trying to meet or is sustainability framed more in terms of corporate values?
   b. Has your company invested in other water-saving measures on this property? Indoor, outdoor, education/awareness?
   c. Are landscape-related projects a first choice in improving the sustainability of your business? Or is it of lesser importance?
2. Follow-up to barriers:
   a. I see you listed ____ as a barrier in the survey. Could you elaborate?
   b. Tell me more about your internal approval process and any challenges or resistance you encountered there.
   c. Tell me more about cost considerations and what you had to do to justify the expenditures.
   d. Tell me more about external approvals and permits you had to get. How would you make that process easier?
   e. If you got rebates or other external funding, was that process straightforward? Did the requirements for receiving the funds align with what you were trying to achieve?

f. What would you change to make this type of project more valuable for your company? For the watershed and community?

g. What would you change to make this type of project easier to implement?

3. *(For those that implemented a project)* Now that the project has been implemented, do you feel it was a worthwhile investment/would you do it again?

a. How did you feel about the overall benefits of the project? Were they higher, lower, or as expected? Did anything surprise you?

b. Prior to doing this project, were you aware of the multiple benefits that these projects can provide (e.g., reducing flooding, recharging groundwater, reducing GHG emissions, boosting the aesthetic value, saving money)? If yes, which ones?

c. Did your understanding of the benefits of these projects play a role in choosing the type of project to implement?

d. If you were able to quantify water savings:

i. How much did you save? How did you do this?

ii. Why did you calculate these savings? Was it a company/project requirement? Did it help secure future backing for these kinds of projects?

iii. Were you surprised by the results? Were the water savings higher, lower, or as expected?

e. If you didn’t quantify this, why not?

4. Financial Metrics:

a. If you calculated ROI, what was the result?

b. If you didn't calculate ROI, did you use any other financial metrics to determine whether to move forward with this project, or to assess the project (e.g., payback period, benefit ratio, NPV, etc.)?

c. How did you feel about the results of your financial analysis? Was it higher, lower, or as expected? Did anything surprise you?

d. Are there specific project threshold values that would be required in order to move forward with an investment (e.g., a payback of x years)?

e. If you didn't calculate ROI or any specific financial metrics, why not? What were the specific barriers to doing so?

f. How are sustainable landscaping projects evaluated with respect to other company projects? Are they capital improvement projects? If not, how do you classify them?

5. When planning for the future of your business, how do you factor in water risk?

   a. What is your primary concern? Lack of reliable supply? Water quality? Future cost? Future reliability with climate change?

6. How did you find and who did you as choose your landscape design contractor?

   a. What motivated you to choose that firm? Cost, reputation, recommendation, convenience?

   b. What level of guidance/advice was provided by the landscape design contractor? Were they experienced in the multi-benefit aspect of sustainable landscape, or was it more of aesthetic perspective?

7. *If the company stated that they do know of businesses in the area pursuing sustainable landscape design*- Are they willing to share this information; who are they? Is there a specific contact person we could talk to?

Appendix 5B

Sustainable Landscapes in California: A Guidebook for Commercial and Industrial Site Managers

Note: Fully formatted, published version is available at https://pacinst.org/wp-content/uploads/2020/08/Sustainable-Landscapes-in-California-Pacific-Institute-2020.pdf.

What is this Guidebook?

This guidebook provides simple steps for considering, selecting, and installing sustainable landscape practices. While not the only resource needed, it can serve as a useful reference and direct you to other helpful resources. The guidebook is intended for site managers of commercial and industrial properties interested in adopting sustainable landscape practices. This includes those involved with the day-to-day operations of the site, such as a facility manager, or those involved in operations or sustainability at the corporate level. In this guidebook, we use "you" to refer to the user of the guidebook; "company" and "business" to refer to the organization that is seeking to adopt sustainable landscape practices; "site" to refer to the area where the sustainable landscape practices would be installed; and "project" refers to the sustainable landscape being considered, which encompasses the continuum from initial ideas to a concrete plan and professional design.

Sustainable Landscapes: What and Why?

California Cities Face Many Water Sustainability Challenges

Pressures on water resources are intensifying due to aging infrastructure, population growth, and climate change, among other factors. With vast expanses of water-intensive turf and impermeable pavement, California's urbanized communities are ill-adapted to these pressures. Outdoor use represents about half of all water used in urban areas, and even more in the hottest, driest parts of the state. Runoff from lawns carries fertilizers and pesticides into waterways. Impermeable pavement impedes groundwater recharge; contributes to higher peak flows; and carries oils, metals, and other toxins into rivers, estuaries, and the ocean.

Sustainable Landscapes Foster Water-Resilient Communities

The good news is that there are sustainable landscape options available for California's communities, and businesses can be part of the solution. **In this guidebook, we use the term "sustainable landscapes" to refer to landscapes that are in balance with the local climate and ecology and actively contribute to community and watershed health by providing economic, social, and environmental benefits**. This could include practices like turf replacement, as well as the installation of bioswales and rain gardens, permeable pavement, green roofs, and rain tanks and cisterns. There are four key elements of sustainable landscapes:

1. **Build healthy, living soils.** Healthy soils are the foundation for all the benefits of sustainable landscapes.

2. **Choose climate-appropriate plants.** Using plants, preferably natives, that are suited to the local climate boosts biodiversity and saves water.

3. **Treat rain as a resource.** Sustainable landscape design helps water slow down and sink into the soil in rain gardens or bioswales.

4. **Irrigate efficiently.** With healthy soils and the right plants, supplemental irrigation needs will be low after an initial period to establish the plants. When irrigation is needed, it should be applied efficiently.

Sustainable Landscapes Provide Benefits to Your Business *and* Your Community

Sustainable landscape practices provide multiple benefits. Replacing turf with climate-appropriate plants that are irrigated efficiently can save water and reduce vulnerability to drought. Incorporating bioswales, rain gardens, and other green infrastructure into sustainable landscapes reduces pressure on local water supplies, reduces flooding, and improves water quality. In addition, utilizing rainwater to irrigate plants is more cost effective than using potable water. Sustainable landscape features like rain gardens and bioswales help slow rainwater so that it can sink into the soil. They can also provide habitat for wildlife, sequester carbon, improve air quality, improve soil health, boost property values and community livability, and increase resilience to climate change.

Transforming to a Sustainable Landscape is Within Reach

Through a series of simple steps, this guidebook will help you to consider, select, and install sustainable landscape practices.

Step 1: CONSIDER

Why do you want to change your landscape?

Step 2: IDENTIFY and UNDERSTAND

Who would be involved?

What sort of information do they need?

Step 3: ASSESS

How does your landscape look and perform?

Step 4: SELECT

Who is best suited to implement your vision?

Step 5: TRANSFORM

Install the landscape!

Step 1: CONSIDER Motivations and Concerns

When considering a landscape project, the first step is to examine the motivations for the project and any concerns. Gathering this information early in the process will help to make more informed choices, prioritize landscape designs, and address potential obstacles. **Worksheet A** can help you document your motivations and concerns.

Worksheet A: Understanding the Why and Why Not

The following questions can help you explore motivations and concerns. If you do not know an answer, ask for input from your supervisor, coworkers, or landscape maintenance provider.

- What **motivates** your company to consider changing the landscape? (check all that apply)

  ☐ Conserve water

  ☐ Reduce water bills

  ☐ Improve aesthetics

  ☐ Meet corporate sustainability goals

  ☐ Improve property value

  ☐ Be a steward of the environment

  ☐ Demonstrate sustainability commitment to local community/employees

  ☐ Obtain sustainability certification (e.g., LEED[1])

  ☐ Reduce maintenance costs and/or time

  ☐ Reduce flooding or water damage

  ☐ Other: __________________

[1] Leadership in Energy and Environmental Design. https://www.usgbc.org/leed.

- What are your company's **concerns** about changing the landscape? (check all that apply)
  - ☐ Installation cost
  - ☐ Maintenance cost
  - ☐ Time investment
  - ☐ Changed aesthetics
  - ☐ Disruption to operations (parking, noise, etc.)
  - ☐ Other: ________________

Step 2: UNDERSTAND Decision Making

Numerous people are likely involved in decisions about the landscape, from those responsible for financial decisions to those responsible for maintaining the landscape. To alter the landscape, it is important to consider how decisions are made for your site, who should be involved, and what information is needed. Decision makers typically fall into the following categories:

1. **Property management:** those who own the property or control its management;
2. **Financial management**: those who make decisions about facility budgeting and/or project financing, such as the site manager or company finance department;
3. **Compliance:** those responsible for ensuring compliance with internal and/or external policies and guidelines. See Box for guidance on local agencies who may play a role;[2]
4. **Landscape maintenance:** those who manage and perform landscape maintenance;[3] and

[2] Other than public entities, there might also be an employee within your company, such as an environmental health and safety manager, sustainability manager, or operations and maintenance manager who may also need to be consulted.
[3] A sustainable landscape requires specific care and expertise and often requires more care during an initial period of establishment, and less maintenance in the long term.

5. **Others:** those who may be affected by or interested in the project, such as staff involved in the operational aspects of the project, community members impacted by its outcomes, or others.

In addition to identifying the decision makers, it can also be useful to identify those that may care about specific project outcomes. Sustainable landscapes can provide multiple benefits, and these benefits may be of interest to people inside and outside the company. In some cases, the benefits accrue to the business or site owner; in other cases, they accrue to employees or the broader community.

For example, replacing a lawn with a sustainable landscape that includes several trees can reduce water use and provide additional community benefits. The business would benefit from costs savings due to reduced water use, while staff get an improved green space in which to spend their lunch break. Further, the whole community may benefit from more trees.

The multiple benefits provided by sustainable landscapes can improve the cost-effectiveness of the project and provide an opportunity to publicly demonstrate the company's commitment to the triple bottom line: people, planet, and profit. Lastly, identifying those who care about project benefits will help advance the process. Engaging with those who affect the process (like regulators, leaders within your company, or investors) and those affected by the process (like employees and local community members) can help garner support for the project and avoid hindrances later. This engagement is important throughout the process.

Worksheet B can help you to identify stakeholders and understand decision making.

Worksheet B: How are Decisions Made, and What Information is Needed?

There are multiple people who might play a role in the project, whether to plan, implement, or maintain the new landscaping. Recall your company's motivations from Step 1 and consider any co-benefits, beyond water savings, that you might want to incorporate into the sustainable landscape. These can inform decision making and any information needed to support that process.

Answering the following questions will help you better understand decision making. If you do not know an answer, seek input from your supervisor or coworkers.

- **Property management**
    a) Who owns the site?
    b) Who has management control of the landscape?
- **Financial management**
    a) Who makes decisions about budget and finances for the site? List their name(s), position(s), and what role they play in budget decisions.
    b) How would the project be funded?
        - Are there any restrictions or requirements associated with this funding source? For example, is there a return-on-investment threshold, a certain number of bids required, or a certain timeline to follow?
        - Are rebates available from the local water provider or stormwater agency? (see Box)
    c) What other information would be needed?
- **Compliance**

Who influences or controls decisions around internal and/or external regulatory compliance, including enforcement of permits pertaining to stormwater management and/or outdoor water use? This could include the employee in charge within your company and/or regulatory agencies in your region (see Box 1 for guidance). List their name(s), position(s) if applicable, and the role they play in making decisions about the landscape.

- **Landscape maintenance**

  It is important to understand the current approach to landscape maintenance at the site so you can assess whether it is appropriate for a new type of landscape. The following questions will help in that consideration.

  a) Who maintains the landscape and irrigation system at the site?

  b) Do they have sustainability experience? (refer to Box 4 for guidance)

  c) If not, would they be willing to obtain training on how best to maintain a sustainable landscape?

- **Other decision makers**

Are there any other people or organizations that may play a role in influencing the decision to convert to a sustainable landscape? For example: local watershed managers, neighbors adjacent to the site, etc. List their name(s), position(s) if applicable, and the role (if any) they play in making decisions about the landscape.

Box 1. Understanding Local Regulations and Permitting Requirements

Your local water utility, city, or county likely have permitting requirements or other specifications for businesses to follow when installing a sustainable landscape. These include:

Local Permitting

Depending on the size of your property and of proposed changes, local government may require a permit or official review of the project. While the department in charge may vary, it is typically the planning or engineering department, either for the city or county. To understand what permits the site may be subject to, it is best to consult city staff who can direct you as needed.

Model Water Efficient Landscape Ordinance

The Model Water Efficient Landscape Ordinance (MWELO) establishes a structure for planning, designing, installing, maintaining, and managing water-efficient landscapes in California. It applies to rehabilitated landscape projects equal to or greater than 2,500 square feet that require a building or landscape permit, plan check, or design review. It also applies to new landscaping projects greater than 500 square feet. Check with your local water utility to determine MWELO requirements and whether the site is subject to them.

Stormwater Permits

Some large sites are subject to stormwater permitting requirements. Check whether your site has a stormwater permit, and if so, its requirements. To get clarity on stormwater permitting regulations, check with your local water utility who can direct you to the relevant stormwater department.

Step 3: ASSESS the Site

The site assessment is an opportunity to explore how the landscape functions and identify possible improvements. The time required depends on the size of the site, with small sites taking less than 30 minutes and large sites taking 60 minutes or more. Consider asking those responsible for maintaining the landscape and those familiar with the irrigation system to join you on the assessment. Note that in some regions, water utilities offer free site assessments (see Box 2).

Box 2. Your Water Utility Can Help

> Your local water utility can be a source of information and assistance throughout this process.
>
> An early check of the information and resources available can save time and effort in the long run. Consult with your local water utility to find out if **site assessments and/or irrigation audits** are available. In addition, check to see if any **rebates** are offered for landscape transformation. Some water utilities provide rebates of $1 to $3 per square foot of turf replaced. If rebates are available, check eligibility requirements and review the application process *before* making any changes.
>
> *Note: If the site is in California, this tool can help identify your local water utility: www.waterboards.ca.gov/waterrights/water_issues/programs/drought/water_supplier.shtml*

3.1. Gather Key Information Before the Site Assessment

There are several pieces of information that would be helpful to review before and during the assessment. These include:

1. ***Site plan:*** The site plan provides the layout of the site, including landscaped areas, roads, walking paths, etc. This plan will help you stay oriented during the assessment and identify landscape zones. Ideally, it should include measurements or estimates of turf area, other planted area, hardscape area, and building footprint.

   If a site plan is not available, a screenshot from Google Maps can be a good alternative. Search for your site on Google Maps using satellite view, zoom in until your site fills the frame, and print a screenshot.

2. ***Irrigation system and schedule:*** The irrigation system and schedule should include information on the locations of the water meter(s), irrigation controllers, irrigation zones, type of irrigation system in each zone, and the duration and frequency of irrigation.

3. ***Maintenance schedule:*** The maintenance schedule should include the frequency, duration, and cost of maintenance. This information will help you assess the resource-intensity of the existing landscape and opportunities to save time and/or money.

4. ***Stormwater management or drainage plan (if available):*** The stormwater management plan should include a map and/or description of the stormwater infrastructure located on the site. This will help you identify stormwater drains, downspouts, and other stormwater infrastructure.

5. ***Tree care plan (if applicable):*** While typically requiring less frequent maintenance, trees require specialized care. If your landscape has trees, there may be a separate schedule and plan for maintaining them.

6. ***Lawn or turf care plan (if applicable).*** Turfgrass typically requires more care and maintenance than other plants. If your landscape has turfgrass, there may be a different irrigation or care plan for those areas.

3.2. Conduct the Site Assessment

Evaluate each section using the table in Worksheet C. Before you start, consider dividing the space into smaller sections. These areas can be divided intuitively. This initial assessment will help you to identify the major issues and improvements needed in each area. If you decide to move forward with the project, a landscape professional will develop a more detailed landscape design. However, it can be helpful to think about the kinds of changes you would like to see based on your company's motivations and concerns (Step 1) and the current condition of the landscape.

Worksheet C: Current Landscape Conditions

Landscape Area	Area 1	Area 2	Area 3	Area 4
Write a short description of each landscape area. If you have access to an irrigation plan, it is helpful to divide these areas based on irrigation zones (also sometimes called hydro zones).				
Landscape Area Conditions (check all that apply for each area)				
Drainage and Grading	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Do you have a stormwater or drainage plan for this area? (Y/N)				
Is there visible damage from water pooling on any part of the pavement? (Y/N)				
Where does the water flow to?				
Visible storm drains in paved areas				
Visible gutters that empty into paved area				
Visible gutters that empty into planted area				
Hidden gutters (built into the building) that empty into storm drain				
Other				
Hardscape	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Concrete or asphalt				
Gravel, decomposed granite, cobblestone, other				
Irrigation	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Do you have an irrigation plan for this area? (Y/N)				
Is the area irrigated with recycled water (purple pipe)? (Y/N)				
Type of irrigation				
Spray irrigation[4]				
Drip irrigation[5]				
Condition of irrigation system				
Are there irrigation lines or fixtures that are visibly broken?				
Is this area regularly wet and soggy?				
Are some spots drier than the rest of the landscape?				
Are some spots more wet than the rest of the landscape?				

[4] A device for applying irrigation water by spraying it into the air through sprinklers. See Glossary in Appendix B for more details.

[5] Method of controlled irrigation in which water is slowly delivered to the root system of multiple plants. See Glossary in Appendix B for more details.

Is there visible damage from water spray on building walls or pavement?				
Planting	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Soil conditions				
Does the soil seem hard packed?[6]				
Is there moss growing on the soil?[7]				
Is there 3 inches of bark or mulch on the soil?[8]				
Plant type(s)				
Turfgrass				
Flowers				
Shrubs and bushes				
Trees				
Desert plants (cactus, succulent)				
Other				
Plant conditions				
Overgrown				
Healthy				
Unhealthy				
Dead				
Maintenance	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Are pesticides and/or herbicides used? (Y/N)				
Critters and Creatures	**Area 1**	**Area 2**	**Area 3**	**Area 4**
Gopher holes				
Bird nests				
Leaves eaten by bugs				
Wildlife (birds, squirrels, butterflies, etc.)				
Miscellaneous (any additional observations?)	**Area 1**	**Area 2**	**Area 3**	**Area 4**

While your company will likely hire a professional to design the landscape (see Step 4), you may

[6] Plants do not grow well in highly compacted soil since it is difficult for the roots to penetrate.
[7] Moss is an indication of overwatering.
[8] MWELO regulations require 3 inches of mulch on all exposed soil surfaces of planting areas except in turf areas.

have ideas for possible changes after assessing the site. Table 1 provides a list of sustainable landscape practices for consideration. These practices can save money, decrease water use, reduce flood risk, improve landscape health and aesthetics, and more.

If you are interested in understanding your site's current water use, check whether your site has a readable outdoor irrigation meter. If not, outdoor water use may be listed separately on your water bill.

You can estimate the potential water savings of your transformed landscape through a simple calculation (see Box 3).

Table 1. Examples of Landscape Changes to Improve Sustainability

Planting
Convert to climate-appropriate plants
Apply mulch or compost to soil
Add trees for shade
Remove turfgrass
Drainage and Grading
Install a rain garden
Install rain barrel(s) at gutter downspouts
Direct gutter downspouts into planted area instead of paved area
Change pavement grading so water flows towards planted areas
Add contours to the landscape to help retain rainwater
Hardscape
Replace concrete or asphalt with permeable pavement
Install curb cuts to allow water in paved area to flow into planted area
Irrigation
Eliminate or decrease irrigation where possible
Install a weather-based irrigation controller
Convert from spray irrigation to drip irrigation
Fix damaged or broken irrigation lines and fixtures
Maintenance

Reduce or stop use of pesticides and herbicides
Utilize organic fertilizers
Reduce mowing frequency

Box 3. Estimating Water Savings

How much water can be saved by adopting sustainable landscape practices? Water savings can be estimated using a simple formula:

$$\text{Water Use (gal/yr)} = (\text{Area} \times ET_0 \times \text{Plant Factor} \times 0.62) / \text{Irrigation Efficiency}$$

Where:

Area = the landscaped area to be converted, measured in square feet.

ET_0 = amount of water evaporated from the soil and plant surfaces and transpired by the plant. Use the table in Appendix C to determine your evapotranspiration (ET) zone and the total annual ET_0 associated with your site, or consult your local water utility for a more accurate value.

Plant Factor = factor for adjusting the ET value based on plant type. General values can be found in Appendix C.

Irrigation Efficiency = a measure of the irrigation system efficiency. Guidance from MWELO sets this at 0.75 for spray and 0.81 for drip irrigation.

0.62 = a static conversion factor.

Let's say that we are replacing a 3000 sq. ft. lawn in Riverside County in Southern California (ET zone 9) that is spray irrigated with low water-use plants that are drip irrigated. In this example, ET_0 is 55.1, and we use a plant factor of 0.8 for turf and 0.3 for low water-use plants. Additionally, we assume an irrigation efficiency of 75 percent (0.75) for the existing landscape and 81 percent (0.81) for drip irrigation on the converted landscape.

Here is how the example calculation looks:

Current Water Use = (3,000 x 55.1 x 0.8 x 0.62) / 0.75 = 109,318 gallons per year

minus

New Water Use = (3,000 x 55.1 x 0.3 x 0.62) / 0.81 = 37,958 gallons per year

Water Savings = 71,360 gallons per year

Note: The Model Water Efficient Landscape Ordinance (MWELO) governs new development and retrofitted landscape water efficiency standards. https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Model-Water-Efficient-Landscape-Ordinance.

Step 4: SELECT Landscape Design

At this stage, you should understand the motivations for installing sustainable landscape practices, the decision-making process, and some of the practices that could be adopted. The next step is to identify and select a landscape professional(s) that can help design, install, and/or maintain the landscape.[9] The selection process depends on both landscaping needs and the company's decision-making process. If you already have a landscape professional(s) in mind, the steps below can help you to determine whether they have adequate experience with sustainable landscapes.

4.1. Identify Landscape Professional(s) to Design, Install, and Maintain the Landscape

Proper design, installation, and maintenance of a sustainable landscape requires skills and techniques that differ from those associated with a conventional landscape. To select an appropriate professional, you can either search online or seek recommendations from other businesses that have undertaken a similar project. When selecting a landscape professional, some things to consider include:

- **What kind of landscape professional(s) do you need?**

  Some professionals may specialize in installation, maintenance, or design. Others may do all three. There are also landscape professionals who specialize in the care of plants or trees. Before selection, check the services provided and review their portfolio to ensure that their landscape 'style' aligns with your vision for the company's landscape.

[9] This could be for design, architecture, maintenance, or construction. Some companies specialize in one of these activities while some are equipped to do two or more.

- **Do they have sustainability expertise and experience?**

Whether you use a professional you are already familiar with or a new one, it is important to ensure that they have experience working with sustainable landscapes (see Box). One way to assess their expertise is based on professional degrees, accreditations, or memberships in trade associations.[10] These qualifications provide an indication of the quality of service, and some provide accreditation specific to sustainable landscapes. If your company is committed to a landscape professional that does not have relevant experience or expertise, a number of training programs are available.[11]

- **Are they properly licensed and insured?**

Ensure that the landscape professional has a certification of insurance for liability and workers' compensation. Without this, your company could be liable for accidents during the landscape project. It is also important to check to make sure they have a business license and are certified to perform the services offered.

- **Do they have a good reputation?**

Conduct a simple online search to ensure that reviews for the landscape professional are positive. An online search through the Better Business Bureau (www.bbb.org) can also provide information on whether there have been any complaints against the landscape

[10] The Chino Basin Water Conservation District has a list of some relevant accreditations: https://www.cbwcd.org/412/Hiring-Certified-Landscape-Professionals. Examples include the Qualified Water Efficient Landscaper (www.qwel.net) and the California Landscape Contractors Association Water Management Certification Program (https://www.clca.org/certification-center/water-management-certification/).

[11] Examples include Green Garden Group's Watershed Wise Training (https://greengardensgroup.com/watershed-wise-landscape-training/wwlt-landscape-professionals), ReScape Landscape's programs (https://rescapeca.org/education/for-professionals/), the Qualified Water Efficient Landscaper (www.qwel.net), and California Landscape Contractors Association Water Management Certification Program (https://www.clca.org/certification-center/water-management-certification/).

professional in the past. Be sure to ask for references so that you can personally assess their work.

4.2. Communicate Priorities and Concerns

It is important to communicate your company's priorities and concerns (Step 1) and findings from the initial site assessment (Step 3) to your potential landscape professional(s). Inquire whether the professional can help with local permitting or regulations the site might be subject to (Box). This will help the professional design and install a sustainable landscape best suited to your business's needs. Further, if you would like the landscape to be certified by a third party as sustainable (Box), it is important to bring that up with your landscape professional. As part of this process, consider whether your company's work style and ethic align with that of the landscape professional. It is very important to be able to have an open and constructive channel of communication with whomever you choose.

4.3. Choose a Landscape Design and Professional

Assemble the findings from sub-steps 4.1 and 4.2, the site assessment (Step 2), the landscape bids (if applicable), and information from Step 1 to make a final decision about whether to move forward with a landscape conversion, and what design and professional you want to go with. After selecting a landscape professional, create a clear contract to make sure that this working relationship will go as smoothly as possible.[12]

Once the design is selected, it may be possible to get more detailed estimates of the benefits of converting the landscape, such as water savings and stormwater capture.[13] In many cases, the

[12] The Morton Arboretum provides guidance on how to write a strong contract. See page 16 of https://www.mortonarb.org/files/14CT_SLRCA_02-25-14_CP_fin.pdf.

[13] There are many tools that can help quantify environmental benefits. The Multi-Benefit Resource library can help to narrow down and identify available resources: https://pacinst.org/multi-benefit-resource-library/.

landscape professional can help with this. You can also refer to Box 3 for guidance on estimating water savings. If you know how much the company pays for water, you can also calculate cost savings.

Box 4. Identifying Landscape Professionals with Sustainability Expertise

Sustainable landscapes require expertise and care to both install and maintain. When hiring a landscape professional, use these guiding questions to identify whether the professional has the necessary background and experience in caring for sustainable landscapes.

- What is your firm's experience installing and/or maintaining sustainable landscapes?
- Can you give me some examples of methods you use?
- Are you familiar with Green Garden Group's watershed approach to landscaping? (greengardensgroup.com/watershed-approach-to-landscaping/)
- Does your firm have expertise or experience in plant and soil types, i.e. what works best for the environment, the type of care it needs, etc.?
- What experience do you have installing water-efficient irrigation systems?
- What is your experience in selecting and installing climate-appropriate plants?
- What do you know about permeable hardscapes?
- Do you have experience with water-efficient irrigation systems, and improved irrigation demands such as pruning, mulching, and earthworks?
- Do you have any experience working with stormwater management and water reuse?
- Can you share some photos of projects you have done involving sustainable landscaping?

Box 5. Sustainability Certification Programs

Certification from a respected third-party organization is a great way to publicly demonstrate your company's commitment to sustainability. The two most common sustainability certification programs related to landscapes are LEED and SITES, both international programs. Other certification programs include Ocean Friendly Gardens, California ReScape Rating System, and Audubon Lifestyles Certification.

LEED Existing Building Operations and Maintenance (EBOM) Certification

LEED EBOM is a green building certification program that encompasses an entire site, so it is broader that just the landscape. But if your company is already considering pursuing LEED certification for the site, sustainable landscaping is a key component under the Sustainable Sites credit category. Sustainable Sites allows projects to earn points based on how the landscape is sustainably designed and maintained.

SITES Certification

SITES is Green Business Certification Inc.'s comprehensive rating system for developing sustainable landscapes.

Ocean Friendly Garden Certification

The Ocean Friendly Gardens program, run by the Surfrider Foundation, is focused on the principles of conservation, permeability, and retention. To receive recognition as an Ocean Friendly Garden, a site must adhere to simple criteria aligned with those three principles.

California ReScape Rating System

The ReScape Rating process gives companies and property owners confidence that specific environmental goals have been met, and publicly demonstrates the company's commitment to environmental stewardship and a healthy community.

Audubon Lifestyle Certification

Through participation in the Audubon Lifestyle Certification process, ISC-Audubon assists business owners and landscape professionals who desire to manage their landscapes sustainably.

These programs all require planning, action, and documentation beginning at the design phase, so if your company is interested in pursuing certification, it is important to start early.

Step 5: TRANSFORM the Landscape

As the new landscape is being installed, it is important to **verify that the landscape is being installed according to sustainable landscape principles and as defined in the plan**. A simple check is to assess whether the four sustainable landscape principles identified in **Error! Reference source not found.** and any permitting requirements are being met (see Box). For quality control and assurance, consider to what extent the following items match the site plan developed:

- number and type of plants;
- irrigation system components;
- depth of mulch applied; and
- direction of water flow on and off the project site.

In addition, consider conducting an irrigation audit to help ensure that water savings goals are achieved. Ask about the kind of **warranty** provided by the landscape professional and ensure they stick to it. For example, will they replace a plant if it dies within a year of being planted? Will they guarantee that the landscape can handle large storm events?

As the new landscape nears completion, ask your landscape professional to **develop a maintenance plan.**[14] This will help ensure that the new landscape can flourish after installation. Remember to incorporate this maintenance plan into the landscape maintenance contract. Further, consider developing a performance-based maintenance and irrigation contract such that,

[14] Douglas Kent + Associates (http://www.bewaterwise.com/assets/ca-friendly-maintenance-book.pdf), and the Association of Professional Landscape Designers (http://apldca.org/wp-content/uploads/2018/08/G3-APLD-CA-Watershed-Approach.pdf) have developed landscape maintenance guides that serve as good references.

for example, your company would only pay for the water needed to maintain the landscape, not for excess irrigation.[15]

Once the landscape conversion is complete, you may want to **measure and track the benefits of the new landscape,** such as reductions in water and energy use, cost savings, improvements in employee wellbeing, etc. This can help support the case for future sustainability projects and verify the benefits of a sustainable landscape. It can also provide the basis for a performance-based maintenance plan. To monitor water use, consider installing a separate outdoor irrigation meter if the site does not already have one. Alternatively, a simple sensor working in tandem with your main meter can provide real-time information on outdoor water use. [16] It is important to note that water savings might not appear immediately with a new landscape since plants need additional water to get established.

Measuring and tracking these changes can also create information that can encourage adoption of other sustainable practices within your company—either on your site or on other properties that the company may own. This information, if published or circulated, can encourage other companies to install sustainable landscapes, scaling your company's contribution to the environment and community (refer to Box 6 for ways to publicize your company's sustainable landscape). These measurements can be conducted in-house if staff have relevant expertise, or the company can work with a third-party partner.

Box 6. Publicizing Your Sustainable Landscape

[15] A summary of this type of contract is explained by Heaviland Landscape Management: https://www.heaviland.net/landscape-agreements/

[16] For example, Flume Tech provides these types of easy-to-use sensors: https://flumetech.com/

Your new landscape is now a beautiful example of sustainability in action, and you probably want to celebrate and share the success story! There are many ways you can do this, including:

- Partner with a research institution (such as a university or nonprofit organization) to monitor benefits. This can result in publishable findings that will verify the benefits of your landscape and motivate others to replicate them.
- Develop communication materials for your website. By taking photos, creating infographics, and producing flyers to be posted on your website or other platforms, you can show your community and clients your commitment to sustainability.
- Create educational opportunities. Installing informational signs on the landscape can raise awareness and teach your employees and the community about the importance of sustainable landscapes and your contribution.
- Check whether your water utility or city has recognition programs. Often, utilities and cities have programs that publicly acknowledge companies that install sustainable landscapes for their contribution to betterment of the community and environment.

Chapter 6: Conclusion

After its worst wildfire season on record in 2020 (Migliozzi et al. 2020), the state of California is currently seeing the start of another significant drought, only ten years after the driest drought in its history (National Integrated Drought Information System and National Oceanic and Atmospheric Administration (NOAA) 2021). The Sierra snowpack, which provides 30% of the state's freshwater supplies, is significantly below normal and 2021 has been noted as the third driest year on record for the state (California Department of Water Resources 2021b). In early August, in the face of increasing drought conditions, the state suspended water diversions from the Sacramento-San Joaquin delta (State Water Resources Control Board 2021c) and the Russian River watershed (State Water Resources Control Board 2021b; 2021a) to protect drinking water supplies and minimize impacts to fish habitat and the environment. Fifty counties across the state have declared a drought state of emergency, and the state has asked residents to voluntarily reduce their water use by 15% forecasting a savings of up to 850,000 acre-feet (Executive Department State of California 2021a; 2021b; Office of Governor Gavin Newsom 2021).

The state is faced with a future of more frequent drought and climate extremes, increasing pollution, growing urbanization, and a rising population. Managing our water in an intelligent and innovative manner is a key part of creating a healthy and equitable future for California. In the previous chapters, we discussed the role that efficiency can have in building a sustainable water future. When we optimize our water supplies with conservation and efficiency, we leave more water for the environment, for those who may need it more, and for times we may need it more. When used in conjunction with strategies such as stormwater capture and wastewater reuse, we create an integrated water system that benefits people and the environment (Mika et al. 2018).

In Chapter 1, we found that urban efficiency holds the potential to save between 2.1 to 3.3 million acre-feet statewide showing that simple efficiency improvements over the long-term can make drastic impact to the state's water use. Further, we also found that the state can save 1 to 1.8 million acre-feet by making outdoor efficiency improvements. Sustainable landscaping is a simple and highly effective way of creating long-lasting impact and a climate-resilient system. In Chapter 2, we discuss how these landscapes can not only save water but also provide multiple other benefits for the community and the environment. These include reducing energy and GHG emissions, improving air quality, creating biodiversity, and improving individual wellbeing and community livability. In Chapter 1, we found that there is also significant water efficiency savings potential within the CII sector. The CII sector comprises of about quarter of the urban water use in the state and efficiency can reduce CII use by 46% to 58%, with approximately half of these savings available indoors and the other half outdoors. In Chapter 3, we delved into the trends of outdoor water use within the CII sector to better understand how utilities can better tailor programs for the CII sector, for example, targeting winter CII water use in drier years. In Chapter 4, we found that while the CII sector is often overlooked in discussions around outdoor sustainability and water resilience, there is interest and potential to reduce water use in their landscaping. The sector is driven by both financial and sustainability impacts. However, the CII sector is diverse and needs resources and information tailored to the field to increase uptake of sustainable landscapes.

Below, we list key policy recommendations and areas for future research to advance water efficiency in urban areas in California. These recommendations build on findings and learnings from our four core chapters.

1. **Maximize indoor efficiency through ambitious standards and ordinances**

   While considerable progress has been made in adoption of efficient indoor devices in the residential sector, there is still room to make improvements in other areas. Indoor per capita use is not uniform across the state or across sectors.

   a. Encourage indoor efficiency in the CII sector.

      i. Create water-use benchmarking information by industry through research, to create a baseline understanding of water use.

      ii. Create indoor water use standards for the CII sector by process end-use or industry, through consultation with business representatives.

   b. Motivate adoption of indoor efficient appliances on existing development.

      i. Require the retrofitting of appliances to meet California device standards, when a residential or commercial building undergoes alterations, improvements, or sale, and adopt state and/or local enforcement mechanisms to ensure compliance.

      ii. Create large-scale rebate programs for efficient washing machines.

      iii. Require all new development to install efficient indoor devices.

      iv. Provide greater subsidies for low-income communities to adopt efficient appliances through state or local incentive programs and create awareness of such programs.

2. **Expand Efforts to Improve Outdoor Water-Use Efficiency**

   a. Expand and improve upon MWELO as a policy tool for outdoor water use efficiency.

i. Improve clarity of the guidance through improved communication and collaboration between state and local agencies who administer MWELO and the users.

ii. Improve MWELO enforcement statewide.

iii. While SB 407 requires retrofit upon sale for some indoor plumbing fixtures, this can be expanded to outdoor uses. Expand the impact of MWELO by creating requirements for retrofit on sale for MWELO guidance on existing residential and commercial buildings.

b. Facilitate regulatory changes that would offset the use of potable water supplies for outdoor water needs.

i. Create local and state ordinances that strongly promote the use low-impact-development and greywater outdoors, with a multi-benefit lens.

ii. Encourage low-impact-development that enhances groundwater supply augmentation, creating further supply.

iii. Legalize direct potable reuse of recycled water with suitable public health safeguards.

c. Ban non-functional turf. Californians can learn from a similar law that has been enacted in Las Vegas, banning 'non-functional grass', which applies to ornamental lawns common to office parks, street medians, etc. (Jacques 2021).

d. Provide education programs and technical support to residents and businesses seeking to transform their landscape.

e. Support training programs for landscape professionals on installing and maintaining sustainable landscapes.

3. **Create better quality and more accessible data across the state**

    a. Standardize definitions and terms across state water-related datasets.

    b. Create systems within reported data to distinguish between zeros, unavailable information, and not applicable information.

    c. Encourage the use of dual metering indoors and outdoors on residential and commercial properties through state incentives for local suppliers.

    d. Facilitate the use of Advanced Metering Infrastructure (AMI) among water suppliers and enable the information collected to be stored and used for research. This can be accomplished by requiring the use of AMI by a certain date and creating state rules to enforce this.

    e. Improve accessibility of water billing information and customer water use information for research, while upholding privacy guidelines. For example, anonymize all data and make it publicly accessible at the census track level.

    f. Encourage the development and use of innovative technology in monitoring and collecting water use information through state grants and incentive programs.

4. **Improve and scale existing tools to advance efficiency**

    a. Expand and make mandatory tiered water rate structures to further advance efficiency through steeper tiers and encourage the adoption through a statewide policy or incentive.

b. Require mandatory water use cuts during drought periods and similarly, build on learnings from past drought events to optimize water savings in times of crisis.

c. Scale and expand innovative local ordinances, such as expanding Santa Monica's net zero water ordinance to other regions and sectors or expanding Measure W in Los Angeles to other parts of the state.

5. **Investigate gaps in research to further understanding and improve effectiveness in water efficiency**

    a. Conduct statewide and regional end-use and saturation studies in homes, businesses, and institutions to identify which indoor uses hold the greatest savings opportunities to create more targeted indoor efficiency programs.

    b. Study effectiveness of turf rebate programs, including longitudinal studies on water use and correlation with demographic data, to understand how to tailor future programs and create accountability around where resources are used.

    c. Study effectiveness of their existing conservation programs to understand what works and what does not. If done by water supplier, results should be publicly accessible to improve accountability and so that future programs can be tailored to be most effective.

    d. Investigate cultural factors driving water use efficiency, particularly outdoor efficiency and landscape transformation, to understand how to shift perception towards willing adoption of these practices.

    e. Explore new and innovative ways to engage with the CII sector that take business drivers and barriers into account.

f. Study factors driving outdoor water use in the CII sector such as lot size, environmental factors, socioeconomic and demographic factors.

California is the home of cultural institutions like Hollywood and some of the most beautiful natural landmarks in the world including Yosemite National Park and 840 miles of scenic coastline. It is home to almost 40 million people with a diverse set of demographics (United States Census Bureau 2019). The state leads agricultural production in the country and has the fifth largest economy in the world (California Department of Food & Agriculture 2020; California Department of Finance 2018). It also a state with diverse landscapes and varying climates. California has led the country in environmental regulation in the past, being the first state in the country to limit global warming pollution from cars and establish efficiency standards for appliances (Natural Resources Defense Council (NRDC) and Environmental Defense n.d.). However, with a changing climate and increasing urbanization, California also faces its share of challenges. The state has witnessed increasing droughts, wildfires, and extreme temperature in recent years. While we need all resources to be managed sustainably, water is a key piece of this. Reducing the amount of water we use, creates new supply, and safeguards the state’s future. Harnessing the power of simple change through increased efficiency will create resiliency within our water system over the long-term. In addition, California can serve as an example for the rest of the country and even the world. We hope this work contributes to creating a water resilient future for California that is also equitable and just in its allocation of resources.

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