A Framework for Incorporating Water Efficiency into State-Level Climate Change Adaptation Planning

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Executive Summary

Anticipated climate change impacts include rising temperatures, more frequent and severe droughts, snowpack loss and variation in runoff timing, and rising sea levels, all of which may affect water supply availability for municipal and other uses. Using water more efficiently and lowering municipal demand creates greater resiliency to potential climate change impacts by improving water supply reliability, protecting watersheds, and easing flood management challenges. Diverse levels of government are engaging in planning and policy development to adapt to these potential challenges and build the resilience of their water supplies.

This paper focuses on regulatory and planning efforts to advance climate change adaptation related to water resources at the state level, as the use of drinking water resources is not addressed by existing relevant federal statutes, such as the Clean Water Act and the Safe Drinking Water Act. Given the diversity of types of water resources across the country and the various frameworks for water rights appropriations, there is wide variability in the governance structures overseeing water resources management across states. As climate change impacts and other constraints on water resources grow, this patchwork of regulations, plans, and programs merits investigation to inform future policy development.

State plans and policies on water management and climate change adaptation in all fifty states were reviewed to determine if states were pursuing municipal water efficiency as a climate change adaption strategy and how they were doing so. The regulatory review focused on specific data of interest, including 1) the type of plan or document 2) the climate change drivers for water efficiency 3) type of water efficiency measures and targets for water efficiency 4) entities designated to implement the water efficiency measures and 5) legal authority and provisions to enforce the strategy.

Findings show that half of all states have identified municipal water efficiency as a climate change adaptation strategy in state reports, plans, and policies. There were two primary mechanisms through which state-level government agencies define this connection: a dedicated climate change adaptation plan and a state water plan. These states were not all found in regions that have historically dealt with drought and water shortages, indicating that there is growing awareness that climate change is going to produce impacts on water supplies even in traditionally water-rich areas. This includes states such as Michigan, Oklahoma, Massachusetts, and West Virginia. There is variability in the substance of water efficiency goals and measures included in these plans, ranging from no specificity to detailed water efficiency strategies. Only six states have identified a target or quantitative goal to measure progress against, and these also vary in structure and ambition. Finally, there is broadly a lack of clarity about what entities are responsible and accountable for implementing water efficiency goals. Overall, the role and significance of these plans are unclear, and most fail to identify ways to compel local water providers or other stakeholders to implement water efficiency recommendations.

Based on the type of policy tools they employ and the diverse potential climate change impacts they face, California, Colorado, and Pennsylvania were selected for more in-depth examination.

A review of the policies, plans and reports in each state was conducted, supplemented by interviews with state agency representatives and water utility managers in Colorado and Pennsylvania.

The paper concludes with considerations for state policymakers as they consider how to build resilience to the impacts of climate change on shared water resources, and offers a potential framework that can enable more effective and practical pursuit of water efficiency strategies in diverse contexts. It suggests that regardless of whether state directives are voluntary or mandatory, there is a clear potential role for states, including disseminating resources and providing local agencies with credibility. States can improve the likelihood of implementation by stakeholders such as water providers by ensuring available funding and resources, by addressing potential negative impacts of increased efficiency, and by engaging utilities and peer agencies authentically and collaboratively. Careful consideration of how to construct efficiency targets and timelines for accomplishment can enable states to make meaningful progress towards resilience and remain flexible in the context of uncertain climate change impacts. Finally, mandatory policies may become more important to safeguard water supplies as water challenges grow, and states may benefit from focusing first on market-driven requirements that reduce enforcement burdens.

Table of Contents

List of Abbreviations

CADWR	California Department of Water Resources
CCAC	(Pennsylvania) Climate Change Advisory Committee
CWCB	Colorado Water Conservation Board
DEP	(Pennsylvania) Department of Environmental Protection
IBCC	Interbasin Compact Committee
SWSI	(Colorado) State Water Supply Initiative
SWCRB	(California) State Water Resources Control Board

Introduction

Climate change is affecting many components of the water cycle, changing where and when water is available for human use – and in what quantities. Specific impacts that affect water resource management throughout the United States include rising temperatures, more frequent and intense droughts, snowpack loss, variation in runoff timing, flood events and rising sea levels (USGCRP, 2009). Reduced water availability and increased competition for water supplies are anticipated in regions with subtropical climates. In already arid regions, such as the western and southern United States, drought frequency is projected to increase by the end of the 21st century (IPCC, 2014). In 2017, no state was unaffected by some level of drought or abnormally dry conditions (US Drought Monitor, 2017). In recent years, droughts have created significant impacts on water resources and water supply infrastructure. The costs of California's most recent five-year drought are still being tallied. Initial costs and legacies include more than 100 million dead trees, toxic algae in more than 30 lakes and waterways, and impacts on California's $47 billion farming industry (Jablon, 2017). More recently, cities such as Mexico City and Cape Town have faced water shortages that threatened supplies for residents and businesses.

While mitigation is a vital element of society's response to climate change, many of these changes, such as decreased precipitation and droughts, are considered unavoidable. Diverse levels of government must begin to adapt to these anticipated impacts (Farber, 2009). Increasingly, public policy is an important tool to reduce vulnerabilities to climate change and protect natural systems and resources (Adger et al., 2005). There is a growing community of experts investigating what adaptation policies will be required and how they can be effectively developed and applied (Ford, 2008). Governments at the community, regional and state levels are starting to conduct climate change adaptation planning, with the goal of adjusting to expected climate change impacts and its effects (IPCC, 2014). While the federal government may have an important role to play in terms of mitigation, local, regional, and state governments often own and administer the infrastructure and services that will be affected by climate change and may be more equipped and expected to prepare for those impacts (Farber, 2009).

Background Discussion

The Role of Water Efficiency in Climate Change Adaptation Planning

The International Governmental Panel on Climate Change has noted that management of water demand by users and adaptation by government are vital to meeting the uncertainties and challenges produced by climate change (IPCC, 2001). Water efficiency strategies can be considered a “no regrets strategy” to strengthen resiliency to climate change in numerous ways. Using water more efficiently and lowering demand for improves water supply reliability, protects watersheds, and improves flood management. Water efficiency strategies available to states might include demand-side measures, such as changing out residential and commercial fixtures and appliances for high-efficiency products, or supply-side measures, such as water loss control programs to stem the loss of treated drinking water in the distribution system (NRDC, 2013).

With 40 out of 50 states anticipating water shortages before 2024 and many already experiencing periodic shortages, proactive water efficiency should be a vital strategy to prepare for the impacts of climate change (USGAO, 2014). Despite the evidence that water efficiency can support climate change resiliency in many ways, it is unclear if many governments—whether federal, state, or local—are considering water efficiency an important strategy in their adaptation planning.

State-Level Involvement in Climate Change Adaptation Planning

Considering water efficiency as a climate change adaptation strategy prompts an important question about water governance. Water governance in the United States is extremely fragmented. It also involves a complex landscape of diverse federal, state, and local stakeholders with often overlapping roles in managing various water resources such as groundwater, surface water, and effluent.

There is no overarching federal policy or agency governing the management of water resources that flow between and across state lines. Despite this, the federal government develops and oversees regulations and actions under its Commerce Clause authority that can influence management at the state and local level. This includes water resource development for federal purposes and major pieces of legislation such as the Clean Water Act and the Safe Drinking Water Act, which require water providers to meet compliance targets related to water quality (Mandarano et al. 2008). The federal government may establish mandatory standards for adaptation efforts or provide funding for adaptation (Farber, 2009). In recent years, there have been calls for greater federal leadership to steward sustainable water management through a more coherent, integrated policy, as well as through more facilitation and funding of local and regional water management efforts (Garrick, 2014). The states retain primary responsibility for water management, maintaining authority over administration of water rights and acting as stewards of water as the public's resource. However, they typically exercise limited authority over the allocation and use of those resources and the ability of state governments to mandate and enforce water management directives at the local level varies from state to state (Bates, 2012). In addition, there are numerous relevant intra-state stakeholders, such as regional entities, watershed or basin-level groups, local governments, and water providers (WGA, 2006). Local water providers, including municipalities, private water companies, and smaller special districts typically hold decision-making power related to water supply.

The federal government has nonetheless taken some important steps to advance sustainable water management and specifically urban water efficiency. The Energy Policy Act of 1992 established new higher-efficiency standards for plumbing fixtures, including toilets, showerheads, urinals, and faucets manufactured after 1994. This Act confirmed the importance of efficiency and conservation as important and realistic strategies to stretch water supplies for the future while also limiting water cost increases (Vickers, 1996). As of 2014, efficient toilets mandated by the Energy Policy Act had already saved at least 18.2 trillion gallons of water, or sufficient supplies for the cities of Los Angeles, Chicago, and New York for 20 years (AWE, 2014). The federal government also operates cooperative federalism arrangements that support increased efficiency, such as through funding for State Revolving Funds that finance efficiency programs or the U.S. Bureau of Reclamation's WaterSMART grant program.

As the primary responsibility for water resource management is deferred to the states, state governments can compel local governments to make investments in water efficiency that support overall resiliency of water supplies. This review intends to provide an overview of state-level plans and policies that recognize water efficiency as a climate change adaptation strategy, how this strategy is described and detailed across states, and implications for future planning efforts. As more states take up climate change adaptation planning, the goal of this Masters Project is to provide some guidance for policymakers and regulatory agencies at the state level interested in designing or amending existing plans that aim to pursue water efficiency as an adaptation strategy.

Data and Methods

Data of Interest

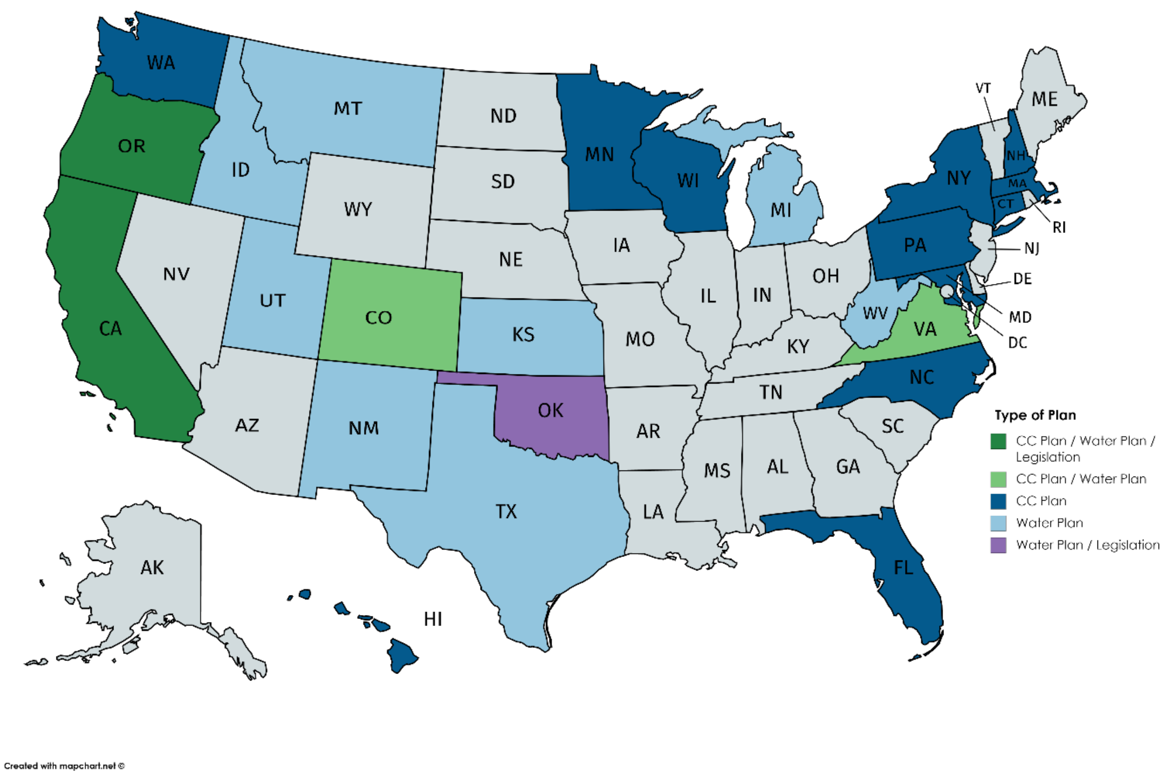
This analysis was conducted based on a survey conducted by the Alliance for Water Efficiency in support of their 2017 Water Efficiency and Conservation State Scorecard. The Alliance for Water Efficiency collected information on state-level climate change adaptation planning efforts from regulatory agencies in all fifty states. Those responses and the plans they referenced were reviewed for inclusion of municipal water efficiency strategies. Additional review of state statutes, regulations, plans, and programs located through publicly available information was conducted. Where multiple plans existed, the most recent and relevant plans were selected for review.

Plans were reviewed to better understand the role of water efficiency and the implications of the plan, policy, or program. The regulatory review focused on specific data of interest in each state, including 1) the type of plan or document 2) the climate change drivers for water efficiency 3) water efficiency measures and targets for water efficiency 4) agencies or entities designated to implement the water efficiency measures, and 5) legal authority and provisions to enforce the strategy. These attributes do not represent a standard but provide a framework for what might be included in a plan or policy.

Regulatory Review: Findings and Discussion

States differ with respect to which agency or agencies have oversight of water management, which are responsible for climate change adaptation planning, and where a connection between climate change and water management may be made.

Figure 1. Overview of Mechanisms for Linking Climate Change and Water Efficiency



Mechanisms for Linking Climate Change and Water Efficiency

States may target water supply resiliency as part of a water-focused plan or may have independent plans to address climate change challenges. A stand-alone plan may be referred to by many names or phrases such as climate action, climate adaptation, climate resiliency, or climate preparedness. This review disregarded the formal title of a plan and included plans with some component focused on improving resilience to water-related climate change impacts.

Twenty-five states had identified municipal water efficiency as a climate change adaptation strategy. There were three primary mechanisms through which state-level government agencies established this linkage and devised recommendations to pursue water efficiency. These included: a dedicated climate change adaptation plan, a state water management plan, and in the case of one state, a drought resiliency plan. In addition, specific legislation to support or enforce these efforts was found in a few states. Results are summarized in Table 1 in the Appendix. In some states, plans from third-party organizations existed and were often more robust than the state-led plan. These plans were not included in this analysis.

Dedicated climate change adaptation plans were most common. Seventeen states recognized impacts on water resources and identified municipal water efficiency as a resiliency strategy in their climate change adaptation plan. Most of these plans were developed between 2009 and 2017, indicating that this is a growing trend. State plans governing water resources appear to be becoming more prevalent. Twelve states had an approved or draft State Water Plan or Water Resources Strategy recommending water efficiency to build resiliency to climate change impacts. Some states also had a drought or emergency response plan. In most cases, these plans outlined actions triggered by a drought or as a drought increases in severity. In a few cases, such as New Mexico, these plans explicitly cited changing weather patterns and recommended municipal water use efficiency to build resilience to drought. (New Mexico Drought Task Force, 2006). California was an outlier as the only state that developed legislation requiring water efficiency in response to climate change. The Governor's Executive Order B-37-16 "directed state agencies to develop a new approach to long-term water conservation" to increase resiliency to future droughts, leading to legislation currently under consideration (CA DWR et al. 2017).

Climate Change Impacts

Climate change impacts on water resources cited by states were relatively consistent. Primary impacts addressed included reduced amount and timing of precipitation, decreased snowpack, earlier runoff timing, warmer temperatures, and rising risk of drought frequency, length, and severity. The consequences for water supplies included groundwater and surface shortages, storage challenges and increased summer demand for water. Even in traditionally water-rich regions, states cited analysis indicating that climate change could affect water resources. Massachusetts notes that "under the high emissions scenario, the occurrence of droughts lasting one to three months could go up by as much as 75% over existing conditions" (Commonwealth of Massachusetts, 2011).

Water Efficiency Measures

Although the states were similar in their inclusion of municipal water efficiency as an adaptation strategy, the substance of specific efficiency measures varied significantly across plans. Reactive water efficiency strategies often focused on water use restrictions when drought occurs, while a proactive strategy focused on efficiency to increase the stability of water supplies and reduce risks. This review focused specifically on proactive water efficiency measures designed to build resiliency to future impacts on water resources. Numerous states, including Idaho, Montana, and Minnesota, do not reference any specific strategies.
The most commonly referenced water efficiency measures were those targeted at residential and commercial water users. Landscape programs and water loss control programs targeting utility distribution losses were also frequently referenced. Massachusetts, New Mexico, and Washington all referenced examining how state plumbing codes can be revised to increase water efficiency. Four states to date, Colorado, California, Texas, and Georgia, have passed legislation requiring the sale of EPA WaterSense-labeled fixtures and appliances. Washington, Oregon, and California were unique in that they noted the connection between water and energy and recommended that energy efficiency be pursued as a means of saving water embedded in the production of electricity.

Many water efficiency investments and programs deliver multiple benefits to utilities and the communities they serve and should be considered regardless of anticipated climate change impacts. Long-term efficiency efforts that reduce overall demand help water systems delay or avoid costly infrastructure investments, consequently keeping water rates lower for customers.

They also prepare water systems to be more resilient to climate change, by increasing available water supplies and lowering demand in anticipation of dry periods or flooding that may disrupt the system. Other more short-term water efficiency initiatives are specifically designed to prepare for or adapt to a warming climate. These might include drought-triggered actions such as drought rates or outdoor watering use restrictions.

Water Efficiency Targets

Only six states, California, Texas, Colorado, Michigan, Oklahoma, and Oregon, defined goals or targets for their water efficiency recommendations.

The Texas State Water Plan indicated that 1.2 million-acre feet of supply by 2070 should come from municipal conservation, commercial, industrial, and institutional conservation, and drought management measures (TWDB, 2017). The Colorado Water Plan "sets a measurable objective to achieve 400,000 acre-feet of municipal and industrial water conservation by 2050" (CWCB, 2016)". Oregon's Executive Order 15-09 includes a 15% reduction target only for state agency-owned land and facilities (State of Oregon, 2015). In 2012, Oklahoma passed the Water for 2060 Act, which stated that "the public policy of this state is to establish and work toward a goal of consuming no more fresh water in the year 2060 than is consumed statewide in the year 2012" (Water for 2060 Act, 2012). California's targets are currently being reviewed. In April 2015, as the state entered its fourth year of drought, Gov. Jerry Brown ordered urban water agencies to reduce water use by 25 percent on average within a year. Later, each water agency was assigned a tailored water use reduction goal. The current proposed legislation will assign standards for urban water suppliers to set targets for indoor use, outdoor irrigation, and commercial, industrial, and institutional water use (CA DWR et al., 2017).

Authority, Implementation, and Enforcement

The review attempted to understand what agencies were responsible for implementing the water efficiency recommendation and what enforcement mechanisms might promote or require implementation. The role of water suppliers was of interest, as any state-level efficiency or conservation goals will impact local water suppliers. Many states also have regional entities that oversee local water suppliers, and one or more state agencies that are responsible for managing water availability and promoting water efficiency. There appears to be broad variability in the lead agency's powers and legal authority to implement or enforce strategies in their plans. In at least three states, no information is provided relative to these questions. In others, numerous organizations are cited, ranging from state agencies to regional groups to local water providers, with little clarity about what organization is responsible for what aspect of the recommendation. Provisions to compel or legally require agencies to implement the water efficiency strategies were rare. When mentioned, they typically involved making conservation planning or specific conservation strategies, such as efficiency-oriented rates, a condition for eligibility for funding. Only California, Oklahoma, and Oregon appear to have legal authority to implement or enforce provisions in their adaptation plans.

Regulatory Review Conclusions

This review provides a cursory discussion of the strategies and tools for incorporating water efficiency into state-level climate change adaptation planning. Half of states recognize water efficiency as a vital adaptation strategy and are making this connection in plans and policies at the state level. Importantly, these states are not all found in regions that have historically dealt with drought and water shortages, indicating that there is growing awareness that climate change is going to produce impacts on water supplies even in traditionally water-rich areas. This pattern may also indicate that climate change adaptation planning is viewed by state agencies as a mechanism for advancing existing water efficiency goals.

There is variability in the substance of water efficiency goals and measures included in these plans, ranging from no specificity at all, to lists of detailed water efficiency strategies. Most states have not identified any kind of target or quantitative goal to measure progress against. Finally, there is broadly a lack of clarity about who or what entities are responsible and accountable for implementing water efficiency goals.

Overall, the role and significance of these plans are unclear. States may be assigning less importance to water efficiency because more extensive water resource planning is happening at a community or basin-level. Most appear to have few ways to compel community water providers to implement the recommendations and settle for “promoting” water efficiency. There are incentive-based mechanisms that could help motivate water utilities, such as making a conservation plan a requirement to access funding from a State Revolving Fund or collaborating with regional or federal agencies to offer support, like the U.S. Bureau of Reclamation’s WaterSMART Grant program, but it is unclear from existing plans if states are pursuing this path.

California, Colorado, and Pennsylvania provide interesting examples to evaluate these questions further. California is one of the few states with a history of legislation requiring water efficiency in response to and in preparation for climate change impacts. Colorado has an adaptation plan and the Colorado Water Plan, which establishes efficiency targets, implementation authority, and incentive-based mechanisms to encourage compliance. Pennsylvania presents a case that is more typical of the rest of the country. An adaptation report accompanying their state-led Climate Change Action Plan recognizes the need for water efficiency and recommends state leadership, but this does not appear to be supported by specific strategies, targets, or implementation direction. The next section describes these states’ efforts in more detail.

Limitations

There are several limitations of this review. It assumes a comprehensive examination of state rules, plans, and programs. This is difficult to achieve given the variability in the way states address water resources planning and regulations, and their ability to pursue climate change adaptation planning in a different context. Consequently, water efficiency goals driven by climate change planning may be connected and aggregated or may be scattered throughout various regulations and plans authored by diverse state agencies. This examination is also not a complete review of legal frameworks, governance structures, or implementation, all of which might produce different conclusions about state-level efforts. More comprehensive research could more fully characterize how water efficiency is being considered by state agencies and how they are working with stakeholders to achieve them.

Case Studies

California, Colorado, and Pennsylvania were chosen for deeper analysis based on the results of the regulatory review. First, all three states had identified municipal water efficiency as an important climate change adaptation strategy. Second, each pursued water efficiency in a different combination of mechanisms, including legislation, plans, and reports. Finally, each state is in a different geographic area subject to different climates. The same data examined during the regulatory review were investigated further, and semi-structured interviews were conducted with seven individuals in Colorado and Pennsylvania, representing state agencies responsible for the plan and water providers of different sizes. Interviews were not conducted with California representatives due to time constraints and given that California is currently the only state pursuing legally-mandated water efficiency requirements. Selected information, quotes, and comments from these interviews have been incorporated into the case study descriptions and the following discussion section. See Appendix B for the list of questions utilized.

Table 1. Case Study Interview Participants

Organization	Title
State Agency Representatives	
Colorado Department of Natural Resources: Colorado Water Conservation Board	State Water Conservation Specialist
Pennsylvania Department of Environmental Protection	Energy & Sustainability Project Manager
Water Provider Representatives	
City of Fort Collins, Colorado	Water Conservation Program Manager

Northern Water, Colorado	Public Information Officer Water Records and Accounting Manager
City of Philadelphia, Pennsylvania	Climate Change Adaptation Program Manager
Lehigh County Authority, Pennsylvania	CEO

California's Making Conservation a Way of Life Framework

California goes several steps beyond other states' efforts to address the water supply impacts of climate change. California's climate change adaptation plan, Safeguarding California, is one component of a long-established and aligned set of plans and efforts across the state's water sector. Together, they seek to address the impacts of climate change across the water cycle comprehensively and coordinate among federal, state, and local resource managers. Numerous conservation-focused policies were implemented in reaction to the recent drought, though several were lifted when the drought was declared over. A new piece of legislation is being debated in the state legislature to adopt mandatory requirements as part of a long-term water conservation effort to increase resiliency to future droughts (CA DWR et al. 2017).

Climate Change Impacts on Water Supplies

According to the most recent assessment of climate change impacts, California water managers should expect a reduced amount of total available water. While precipitation may increase, warming will reduce overall water available by increasing the evapotranspiration rate. More frequent and severe droughts may become common. Less precipitation will fall as snow, and more will fall as rain, causing reduced snowpack (Hanak et al., 2011). Finally, rising sea levels will threaten California's water supply through saltwater intrusion within the San Joaquin-Sacramento Delta (CA DWR, 2015).

Water Efficiency Goals and Strategies

The Safeguarding California Plan of 2009 included a clear role for urban water efficiency. This led to the Water Conservation Act of 2009, also known as SB X7-7. SB X7-7 mandated a statewide 20 percent reduction in demand, which would result in a reduction in demand of 2 million acre-feet by 2020 (SWCRB, 2010). The California Water Action Plan was released in 2014 and updated in 2016 with the goal of increasing water system resiliency and reliability while restoring ecosystems. Speaking to the pressures of future population growth and climate change, it called on state agencies to evaluate and update targets for additional water use efficiency beyond the 20% and to "Make Water Conservation a Way of Life" (CNRA, 2016). As the state entered its fourth year of drought in April 2015, Gov. Jerry Brown ordered urban water agencies to cut water use 25 percent on average within a year. The order called for specific strategies to achieve these savings, including replacing 50 million square feet of lawns with native and drought-tolerant landscaping, a consumer rebate program for appliance change outs, efficiency in large landscape settings, and prohibition of outdoor irrigation with potable water in new development. This emergency-driven order provided funding for implementation of efficiency efforts, placing the State Water Resources Control Board in charge of overseeing the order (Office of Gov. Brown., 2015). In 2016, the Governor's Executive Order B-37-16 required the state to develop more customized water efficiency targets for individual communities, enact permanent water efficiency measures, and institute more stringent enforcement mechanisms (California Drought, 2016). Legislation proposed in early 2017, entitled, "Making Water Conservation a California Way of Life" explicitly identified urban water use efficiency as the primary approach to deal with droughts amplified by climate change. The report on the legislation notes that "conservation alone cannot ensure a long-term sustainable water supply and drought protection for all Californians; however, a deep-rooted conservation ethos is fundamental to changing individual and societal behaviors and making progress toward these desired outcomes" (CA DWR et al., 2017). A cornerstone of the legislation is the requirement that the State Water Resources Control Board set long-term urban water use efficiency standards for the state's 409 suppliers. These new standards, to be developed collaboratively, are envisioned to recognize past water efficiency investments by water suppliers and consider the “unique climatic, demographic and land use characteristics of each urban water agency’s service area” (CA DWR et al., 2017).

Responsibility for Implementation

Responsibility for implementation falls primarily to water suppliers; both those that provide water to end-use customers and wholesale water providers. The California Department of Water Resources and the State Water Resources Control Board play important roles collaborating to determine and communicate policies, provide support for implementation, and monitor and enforce targets and other regulations (CA DWR et al., 2017).

Approach to Compliance and Enforcement

During the drought, water providers were required to conduct monthly, public reporting of water consumption data. Information Orders or Conservation Orders were issued to water suppliers that were not meeting established targets and standards. Some action orders include limits on outdoor irrigation, increased investments in conservation staff resources, and outreach to high-volume water users, among others (CA SWRCB [no date]). To support the forthcoming legislation, CADWR and the SWCRB will develop compliance criteria. CADWR will provide technical assistance as needed, while the Water Board will retain enforcement discretion for suppliers that are out of compliance. These suppliers may also not be eligible for state funding opportunities (CA DWR et al. 2017).

Colorado Climate Plan and Colorado Water Plan

Colorado Revised Statute 24-20-111 calls for the development of a state climate plan addressing both adaptation and reduction of greenhouse gas emissions. The Colorado Climate Plan was published in 2015, with the stated goal of helping “to improve Colorado’s ability to adapt to future climate change impacts and increase Colorado’s state agencies level of preparedness" (CODOT, 2015). The Climate Plan references the first State Water Plan published shortly after in 2016, noting that the recommended adaptation strategies for water "support the work and build on the foundation laid by Colorado's Water Plan," and demonstrating cohesion across planning efforts (CODOT, 2015).

Climate Change Impacts on Water Supplies

Colorado experiences a semi-arid climate, receiving an average of only 17 inches of precipitation per year and relying primarily on snowpack for water supplies. The Climate Plan notes that "in the past 30 years Colorado has warmed substantially, bringing earlier snowmelt, shifting peak runoff by as much as a month, and increasing drought severity," trends which are likely to accelerate due to warming (CODOT, 2015). While municipalities consume only seven percent of the state's water supply, Colorado is also anticipating a potential doubling in population by 2050 (CWCB, 2016). If population increases while the climate warms and precipitation decreases as projected in some scenarios, the state may need an additional million acre-feet of water annually to meet municipal demands (CODOT, 2015).

Water Efficiency Goals and Strategies

Both the Climate Plan and Water Plan include a strong water efficiency component and reference conservation as an important "no and low regrets" action as established through previous Statewide Water Supply Initiative (SWSI) and Interbasin Compact Committee (IBCC) work, reflecting a shared lexicon and integration of efforts. Colorado's Water Plan sets a measurable objective, defined as a result expected from implementation, to achieve 400,000 acre-feet of municipal and industrial water conservation by 2050. This goal was originally developed as a stretch goal by the IBCC as part of a scenario planning process to address the previously identified water supply gap. It was later incorporated into the Water Plan by the CWCB. The IBCC is a 27-member committee comprised of appointed representatives of various sectors and government levels, established to facilitate conversations between basins. The

Water Plan does not prescribe specific water conservation actions. Rather, it points to best practices, including "landscape efficiencies, water loss management, and inclining block-rate structures" and highlights successful efforts within the state (CWCB, 2016).

Responsible Parties for Implementation:

Colorado water providers are responsible for implementing the plan. The Basin Roundtables are responsible for implementing conservation strategies in their Basin Implementation Plans. The CWCB is tasked with thirteen actions, including adopting incentives for water utilities, providing technical assistance, funding, and training for utilities, conducting education and outreach, expanding funding, evaluating barriers to greater conservation, and developing partnerships, among others. Two years after the Plan's creation, CWCB and others are actively implementing the actions outlined, providing regular updates at CWCB Board meetings.

Approach to Compliance and Enforcement:

The Colorado Water Plan has no legal basis for enforcement. One important enforceable provision relates to previously enacted legislation, which requires water providers that deliver more than 2,000 acre-feet of water per year to have a water conservation plan approved by CWCB. All water utilities must have an approved conservation plan to apply for and receive state financial assistance for conservation projects. Other related legislative efforts have focused on incentives to drive implementation such as a law enacted in 2015 to encourage more participation in a rainwater harvesting pilot program (State of Colorado, 2015). The plan indicates that further legislation is being actively considered (CWCB, 2016).

Pennsylvania Climate Adaptation Planning Report and State Water Plan

The 2008 passage of the Pennsylvania Climate Change Act, Act 70 authorized the Department of Environmental Protection (DEP) to prepare Pennsylvania's Climate Change Action Plan. The

2009 final Plan recommended actions to reduce the state's greenhouse gas emissions. Upon its publication, the DEP's Climate Change Advisory Committee (CCAC) agreed that action plans should include a recommendation to the Governor to address adaptation. The Pennsylvania Climate Adaptation Planning Report (Report) was finalized in 2011, but not incorporated in later updates to the Climate Change Action Plan (PA DEP, 2011). The Action Plan is currently being revised and the 2018 update will include a robust adaptation component (A. Landis, personal communication, January 12, 2018).

Climate Change Impacts on Water Supplies:

Climate change is projected to produce multiple changes that may impact water supplies in Pennsylvania. These include a 7°F median warming by the end of the century, a decline in snowfall, longer dry periods and droughts, and an increase in soil-moisture-related droughts partly due to increased temperatures. These drier summers will create low flow conditions, possible restrictions for water users, and increased irrigation needs (PA DEP, 2011). As of 2003, there were more than 2,100 community water systems within the state servicing 10.5 million people, and nearly 1,200 non-community water systems servicing an additional half million people. Public water supply comprises 16% of the state's water use, and commercial and industrial use make up another 10% (PA DEP, 2009).

Water Efficiency Goals and Strategies:

The report included several recommended water efficiency strategies, which were categorized as "no regret, low-cost priorities". The report encouraged "statewide water conservation and water use efficiency, not just in time of drought but at all times, so that both conservation and efficient water use become routine to Pennsylvanians". The DEP also encouraged restrictions on outdoor watering during droughts (PA DEP, 2011). There was no quantitative metric for achieving this goal. The 2011 Report also references the State Water Plan of 2009, noting that the Plan sets the stage to "promote water conservation and water efficiency programs‖ on a watershed basis" (PA DEP, 2011). This indicates some coordination between the Climate Change Advisory Committee and the Office of Water Resources Planning, though it is unclear if the State Water Plan is meant to be the primary platform for pursuing water efficiency goals. The 2009 State Water Plan makes water conservation and efficiency one of its three primary recommendations and outlines specific actions and strategies. An update to the Water Plan is underway (PA DEP, n.d.) The forthcoming 2018 Climate Action Plan Update will include numerous water-focused strategies and some related to water efficiency. Several enable funding for water efficiency retrofits in buildings, while others require changes to codes and standards (A. Landis, personal communication, January 12, 2018).

Responsible Parties for Implementation:

Several state agencies have authority over water resources, including DEP, Department of Conservation and Natural Resources, the Fish and Boat Commission, and the Department of Community and Economic Development. No specific state agency or stakeholders are explicitly assigned implementation responsibility for the water efficiency strategies, though certain strategies appear to be assigned to the State. The report recommends that the state establish the authority and funding to proceed with implementation and monitoring of a state adaptation plan. The 2018 update of the Action Plan will have a comprehensive adaptation section, and the DEP is working on a plan to support implementation and tracking. It will include adaptation actions that can be taken by state and local government agencies, businesses, and citizens, including local water providers (A. Landis, personal communication, January 12, 2018).

Approach to Enforcement and Compliance

Under the terms of Act 70, adaptation planning is not statutorily required to be included in the planning process and the CCAC does not have the authority to implement or enforce adaptation planning. The adaptation strategies in the 2018 Update will be mostly voluntarily (A. Landis, personal communication, January 12, 2018).

Discussion Themes

Role of the State

The role of the state in advancing water efficiency as a climate adaptation strategy is multi-layered and varies across states. While very few state governments appear to view themselves as the ultimate steward of resources and require water management practices, even voluntary plans can play an important role to advance water efficiency.

The state can serve as a coordinator and central planning point, creating and promoting a shared vision for sustainable water management that can advance local efforts. The CWCB considers its role to be bringing people together who might not otherwise be connected and aiding them do it (K. Reidy, personal communication, January 24, 2018). The Pennsylvania DEP also sees its Climate Action Plan as providing a shared operating picture of future climate trajectory that can be used by a variety of stakeholders to identify focus areas and create consensus (A. Landis, personal communication, January 12, 2018). This shared vision can bolster community-level adaptation efforts in several ways. State-level initiatives can provide support local actors proposing initiatives to the city councils or elected Boards that govern them. The City of Fort Collins, Colorado tied strategies in its water efficiency plan to the Water Plan, noting that the state guidance gave their recommendations greater credibility. “When you have a city council, it typically helps to have a connection to an existing standard or best management practice; whatever is that helps them know it isn’t coming out of thin air and is founded in something someone else is doing,” noted Liesel Hans, Water Conservation Program Manager at Fort Collins, Colorado (L. Hans, personal communication, January 31, 2018). The Colorado Water Plan has spurred some utilities to do more than originally envisioned. Fort Collins has expanded a city planning effort to align water resources and land use, in part due to state-organized workshops on this issue, while Northern Water staff is expanding their efficiency plan partly in response to the State Water Plan (K. Rademacher and B. Werner, personal communication, February 14, 2018) (L. Hans, personal communication, January 31, 2018).

The state can also build awareness of climate change amongst a variety of key stakeholders and establish climate change adaptation as a priority. In Philadelphia, the state's Climate Action Plan indicates that the "state takes this seriously, and therefore as a major city and water utility, we should take this seriously," providing further justification for the Water Department's adaptation work (J. Rockwell, personal communication, January 12, 2018). State-level efforts also promote awareness and education amongst citizens. Consumer awareness of the need to conserve and the implications of lack of action is vital to building support for successful municipal water conservation programs (J. Rockwell, personal communication, January 12, 2018). In Colorado, the Governor's endorsement of the plan has created heightened awareness amongst general citizens, which supports greater investments from local water providers (K. Rademacher and B. Werner, personal communication, February 14, 2018). State efforts may also build awareness amongst state-level elected officials, leading to organic expansion of water efficiency. For example, a Colorado state senator took notice of land use and water resources planning strategies in the Water Plan and introduced a bill requiring Colorado's Department of Local Affairs and CWCB to work together to advance this issue (K. Reidy, personal communication, January 24, 2018).

There may be other needed roles for the state, such as a clearinghouse for adaptation resources for water providers and other groups to understand what resources, partnerships, and third-party organizations are available to them (J. Rockwell, personal communication, January 12, 2018). In California, where local water providers are required to implement water efficiency strategies, the state plays an important management and enforcement role. When implementation authority is assigned to local governments or agencies, the state must assign sufficient authority to these entities to effectively govern the resource, and has an important role in driving accountability, ensuring that local entities are held responsible for their progress against goals (Kiparsky et al., 2017).

Target-Setting and Timelines for Water Efficiency Strategies

Targets

The regulatory review revealed that it is relatively rare for state-led plans to include a target or goal for municipal water efficiency, and those identified varied in structure and ambition. A quantifiable target can help build a shared understanding of the desired outcome and serve as a framework for measurement, monitoring, and adjustment of strategies.

States are measuring efficiency in various ways, each with benefits and challenges. California's previous targets included percentage reductions of up to 36% for some communities and as low as 4% for others. The forthcoming legislation will identify similar tailored community-level reduction targets and performance measures for specific end uses such as residential and commercial use. Colorado selected their savings goal of 400,000 acre-feet in part due to the complexity of a fragmented water utility industry, noting "water systems are so individualized, and they have such an individual water portfolio that it makes it very hard. You have to trust them to do what's best for their water system" (K. Reidy, personal communication, January 24, 2018). Texas utilized a similar approach, aiming for 1.2 million acre-feet in municipal and commercial conservation. Oklahoma has adopted a goal that focuses more on efficiency, or their ability to grow without increasing water use. Compared to a savings goal or one based on gallons per capita per day, this type of goal may reflect a more accurate assessment of the impact of water conservation but is also difficult to measure and communicate (K. Reidy, personal communication, January 24, 2018) (L. Hans, personal communication, January 31, 2018). Michigan and Oregon include more modest goals to achieve within shorter timeframes. Michigan aims to increase the number of businesses, industries, and municipalities pursuing efficiency by 20% by 2020, while Oregon challenges state agencies alone to reduce use by 15% (Mich. Office of the Great Lakes, 2016) (ORWD, 2015).

A goal may be more successful if carefully considered by state agencies. Regulators should consider the data needed to develop a target and collection mechanisms to implement if necessary. In developing their target, the CWCB spent significant amounts of time interviewing and surveying water providers to understand baseline state-wide demand and water conservation activity, as well as what active conservation opportunities remained. State capacity to implement the plan and monitor progress toward a goal must also be available (A. Landis, personal communication, January 12, 2018). In Colorado, adopting a goal identified previously by a diverse group of stakeholders within the water community gave the goal more credibility as a state initiative (K. Reidy, personal communication, January 24, 2018).

Identifying a goal also presents potential challenges. While a goal provides consensus on the outcome, it may create confusion for those asked to achieve it. Representatives of the City of Fort Collins noted the lack of clarity around how each utility's efforts ladder up to the 400,000 acre-feet goal and that "it's hard to know if we're doing enough or should be doing more given our service area size" (L. Hans, personal communication, January 31, 2018). A fixed target set for a fixed date may also be problematic considering dynamics of climate change science, and regulators should consider a flexible approach to goal-setting. The CWCB is producing climate change-driven scenarios that are constantly evolving and will result in adjustments to the water efficiency target over time (K. Reidy, personal communication, January 24, 2018). Finally, the water savings identified as a goal may not automatically translate into additional water. This depends on how utilities use conserved water, for example, banking water for drought response as opposed to using it for new growth.

Timeline

Nearly all the state plans that include a target also include a specific timeline in which to achieve the outcome. These ranged from ten years to a 50-year planning horizon, in the case of Texas and Oklahoma. In developing goals, states should consider the timeline carefully.

A longer planning timeframe presents multiple benefits and is perhaps appropriate given the nature of both municipal water efficiency efforts and climate change science. Unlike infrastructure projects such as building new reservoir storage, water efficiency requires bringing diverse stakeholders together to collaborate, while navigating constantly-evolving political contexts. Water efficiency strategies are diverse, with some requiring simple changes to enable more funding, while others entail long-term behavior change modification programs and ongoing investment to achieve permanent change. According to CWCB staff, their 35-year planning timeline is "not that long of a runway because it takes so long for people's attitudes and behaviors to change" (K. Reidy, personal communication, January 24, 2018).

However, a distant planning horizon can reduce the urgency of implementation. The CWCB has addressed this by pursuing short-term goals that support the larger target, aiming to achieve "what we can do in the next five years to try to influence things, but then always have in the back of your mind what the long game is out to 2050". The state is currently investing more than $1 million in a multi-year water loss control training. This is intended to secure significant water and cost savings in the early years of implementation, but also create awareness of system operations and grow utility staff capacity that will lead to greater efficiencies down the road (K. Reidy, personal communication, January 24, 2018). These questions become more complex when water shortages are not imminent and climate change impacts are more uncertain. A dynamic and flexible approach to climate change adaptation can be part of the solution. One approach might be to define critical thresholds for certain conditions, such as drought or temperature, which provide evidence of more permanent changes. Julia Rockwell of the Philadelphia Water Department suggested states react to "red flags you identify, and you could then take a more targeted approach to policy" (J. Rockwell, personal communication, January 12, 2018).

Implementation Feasibility

Plans with thoughtful and regionally-appropriate water efficiency strategies are limited in value if these strategies are not put into practice. The processes behind plans reviewed here offer insights that can improve likelihood that local and regional actors will carry out the recommendations. In the two years since the launch of the Colorado Water Plan, the CWCB has focused on implementation and communication, delivering regular Implementation Update Fact Sheets and tracking metrics for efficiency strategies. The Pennsylvania DEP is considering steps to advance implementation of adaptation components in the 2018 plan (A. Landis, personal communication, January 12, 2018).

First, financial resources are a vital component of implementation of a voluntary plan. While all strategies in the Colorado Water Plan are voluntary, the state has allocated approximately $1 million for implementation work in 2017-2018 and has an annual water efficiency grant fund for utility programs. This has helped avoid the perception that the Plan is an "unfunded mandate," and has facilitated collaboration with water providers (K. Reidy, personal communication, January 24, 2018). Second, state-level staff capacity to support, monitor, and assess implementation is nearly as important. An interagency group with legislation-directed resources and authority could be best suited to take on this role in some states, given the number of state, regional, and local entities often involved in implementation (A. Landis, personal communication, January 12, 2018). For smaller utilities, a state staff resource that could be deployed to support local efforts could also encourage implementation (K. Rademacher and B. Werner, personal communication, February 14, 2018). Implementing adaptation actions within state agency operations, such as Oregon has done in requiring a 15% usage reduction by state agencies, is also an important first step and sends a signal to stakeholders. Finally, states should consider how to maintain funding and focus for efficiency strategies over a long period of time, given that many water efficiency strategies depend on customer behavior patterns that are difficult to permanently change. California's experience demonstrates the long-term investments needed in changing individual values and behaviors.

Today, Californians are using 18% more water than they were in 2017, and nearly as much as they consumed before the drought emergency (Guerin, 2018).

Interagency and Utility Engagement

A survey of municipalities on adaptation activity conducted by Amundsen et al. (2010) found that a “lack of a clear defined role for municipalities in adaptation policies is a barrier for them in their work on these issues.” Considering the fragmentation of the water industry, states seeking to address climate change impacts on water resources need to understand the legal responsibility and authority of all implicated entities and coordinate closely with them.

In current planning efforts, utility engagement appears to lead to more robust implementation. Regular consultation of the Colorado utility community has bolstered awareness and support for Water Plan (K. Reidy, personal communication, January 24, 2018) (K. Rademacher and B. Werner, personal communication, February 14, 2018). Pennsylvania’s Report appeared to be less well-known amongst utility stakeholders (J. Rockwell, personal communication, January 12, 2018) (L. Gross, personal communication, February 1, 2018). The DEP plans to engage the Office of Water Resources and issue-specific advisory committees to create alignment with the State Water Plan and better promote the new Climate Action Plan to the water community (A. Landis, personal communication, January 12, 2018). California’s current proposed legislation includes a robust public process for stakeholders in development of performance measures.

Interagency coordination is also critical given the number of agencies cited across plans as having a hand in water management. Even in states where collaboration amongst state agencies is highly valued, this requires effort and initiative (K. Reidy, personal communication, January 24, 2018). State-level climate change adaptation programs can benefit from a feedback process with departments or groups responsible for overseeing water resources. This ensures water resources planning efforts are adapted to reflect the latest in climate change science. It also is an important contributor to implementation, as it ensures state goals are shared with the water management community that will need to implement ideas locally (A. Landis, personal communication, January 12, 2018).

Considering Utility Impacts

Previous studies have identified several barriers to successful adaptation policies and potential unintended consequences of increased water efficiency. State policymakers can maximize implementation success by considering potential impacts of proposed policies and developing efforts to equip utilities to manage negative outcomes.

A directive from the state to implement adaptation strategies may create new burdens for municipalities due to a lack of competence within the municipality or a lack of funding to address adaptation needs (Amundsen et al. 2010). Smaller water systems may be disproportionately impacted. Specific consideration of these systems and how they can contribute to the water efficiency goal without straining resources will help build support for the effort (K. Rademacher and B. Werner, personal communication, February 14, 2018). In California, the current, revised legislation appears to reflect this learning by requiring DWR to propose guidance specifically to address drought planning in small communities.

One potential unintended consequence of water efficiency is decreased water sales and utility revenue shortfalls. As the California drought spurred increasingly stringent reduction requirements, many water agencies raised rates to cover revenue shortfalls (Sablow, 2016). Some water providers, often found in water-rich regions, employ declining block water rate structures which reward more water use with lower prices and may face concerns about impacts of conservation on the utility's financial health and customer base (L. Gross, personal communication, February 1, 2018). Research has proven that although conservation may increase rates in the short-term, long-term water efficiency investments decrease utility costs by avoiding or deferring capital infrastructure projects and keep customer water rates lower over time (AWE, 2017). State-level organizations can help mitigate the short-term financial impact through education and outreach on the relationship between conservation and rates.

State plans could also consider how to support innovative utility business practices and new funding streams to stabilize revenue.

Finally, declining water flows have recently been identified as an impact of expanded efficiency and have affected some part of the water treatment and distribution system for 50% of California utility respondents during the drought in a recent survey. These included additional operations and maintenance costs to address physical degradation and potential pathogen growth, more staff resources to manage the system, and the need to accelerate planned system upgrades to meet compliance requirements. In enacting state-wide water efficiency investments, states can help utilities be prepared for such potential outcomes through education, guidance, and funding (CUWA, 2017).

Enforcement and Compliance

As states expand their roles as stewards of their water resources, they must choose to make the water efficiency strategies they select voluntary or mandatory for the intended audience. With few states requiring action on many water efficiency strategies, it is difficult to fully assess the benefits and challenges of either approach.

Mandatory investments in water efficiency present multiple benefits, including more predictable water savings leading to greater water supply reliability and environmental impacts such as improved stream flow and watershed health. However, many states may struggle to adopt and implement mandatory requirements. Baseline data on water withdrawal, consumption data, and conservation activity is needed to develop requirements and then assess compliance and enforce, particularly considering the potentially negative impacts such requirements may have on water providers. Many state agencies also do not currently have the legal authority to pursue mandatory action. In both California and Colorado, states with the strongest directives on water efficiency, the Governor’s office primarily drove current requirements by giving state agencies the legal authority to adopt, implement, and enforce efforts. Conversely, Pennsylvania's Climate Adaptation Planning Report was not advanced with the larger mitigation efforts as originally envisioned, in part because adaptation was not part of the scope of the original legislation (A. Landis, personal communication, January 12, 2018).

Mandatory requirements and regulations may become more necessary and common as water resource challenges become more acute and climate change science offers more clarity on coming threats. In Colorado, both state representatives and water managers voiced expectations that a natural outcome of assessing their implementation efforts, coupled with population and economic growth, may be more regulations targeting water use (K. Reidy, personal communication, January 24, 2018) (K. Rademacher and B. Werner, personal communication, February 14, 2018). The state is now identifying what climate change scenarios might require more regulation to meet the water demand gaps. Market-based policies, such as those requiring the sale of efficient fixtures and appliances, have successfully increased water efficiency without requiring enforcement in local communities. The CWCB anticipates seeing more of this type of policy to secure more water savings. Land use policy and water availability for new development offer an opportunity where states may be able to gain some ground. Kevin Reidy, State Water Conservation Specialist at the CWCB, noted that "To me that would be the most efficient way to do it because you can incorporate fixtures standards, landscaping standards, and other standards on a subdivision level of how you develop and what water footprint each new sub division is going to have" (K. Reidy, personal communication, January 24, 2018). States should consider a combination of elements to drive implementation, such as state-driven incentive and requirement-based elements, water pricing and rate structures that help enforce conservation signals to customers, and technical and financial assistance.

Conclusion

Water resources will be affected by climate change impacts in arid and water-scarce regions, as well as in more historically water-rich areas. As states and cities step up to fill the void left by the absence of federal planning for climate change, state plans that address potential impacts on water resources will become increasingly important. Municipal water efficiency is considered the most cost-effective, fair, and immediate means to building water security for public water supplies and is a valuable strategy for states with diverse contexts to consider.

As states consider how to build water resilience, efforts in other states, such as those examined through the case studies here, provide valuable examples and a potential framework for how to practically and effectively advance municipal water efficiency in diverse contexts. Bringing funding to the table and engaging utilities and peer agencies from the outset can help boost the likelihood of implementation, even when state directives are voluntary. Considering potential impacts to water providers, such as strains on finances and staff resources, and building in initiatives to help them navigate new challenges can help states more successfully convene support for state-wide goals. As constraints on water resources grow, driven by population growth, climate change impacts, and other factors, more mandatory water efficiency regulations and policies may become necessary to safeguard supplies. States with existing legislation-based approaches can serve as a helpful template, while policies that activate market forces can be an effective entry point.

By thoughtfully engaging with the diverse stakeholders involved in water management and considering practical ways to approach implementation, these state plans and efforts can offer a shared operating picture of sustainable water management in the face of climate change and stimulate further investment in water efficiency programs to build resilience.

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Appendix

Table 1. Overview of State Reports, Plans, and Policies

Relevant Plan(s) or Policies	Climate Change Impacts Cited	Water Efficiency Goals	WUE Strategies	Efficiency Targets	Responsible Parties	Enforcement/Compliance
California California Water Action Plan (2014) Making Water Conservation a California Way of Life Summary of Proposed Legislation (06/2017 Updates)	*"California's population of nearly 40 million people will continue to grow, and climate change is expected to make droughts more frequent and persistent, as warmer winter temperatures reduce water held in the Sierra Nevada and cause drier soil conditions."*	*"Executive Order B-37-16 outlined the objectives of using water more wisely, eliminating water waste, strengthening local drought resilience, and improving agricultural use efficiency and drought planning."*	Water Loss control, alternative sources, Residential WUE, Commercial WUE	DWR, the State Water Board, and other agencies will work together to develop methodology and Performance Measures for urban water suppliers to set targets for indoor use, outdoor irrigation, commercial, industrial, and institutional water use.	California Department of Water Resources, California State Water Resources Control Board, Regional Water Quality Control Boards, California Department of Food and Agriculture, Natural Resources Agency	Annual reporting required. Board may issue written notice or requirements of technical assistance or local enforcement for suppliers not meeting targets.
Colorado Colorado Climate Plan: State Level Policies and Strategies to Mitigate and Adapt (2015) State Water Plan (2016)	*"In the past 30 years Colorado has warmed substantially, bringing earlier snowmelt, shifting peak runoff by as much as a month, and increasing drought severity."*	*"Promote and encourage water efficiency and/or conservation at the local and state agency level." (CP) "Colorado must address projected gaps between future water needs and available water provisions from both the supply side and the demand side." (CWP)*	Residential WUE, Commercial WUE, Landscape Programs	"Colorado's Water Plan sets a measurable objective to achieve 400,000 acre-feet of municipal and industrial water conservation by 2050."	Colorado Water Conservation Board & DNR, Basin Roundtables, Water providers	"Water providers will be encouraged to do comprehensive, integrated water resource planning, geared toward implementing the best practices at the high customer participation levels, as defined in SWSI. This planning will be one of the components considered to achieve state support for projects, and financial assistance."

Connecticut Connecticut Climate Preparedness Plan (2011)	*"Droughts may increase in frequency, duration and intensity, Heatwaves may increase in frequency, duration and intensity."*	*"Adopt a water hierarchy that includes water conservation, capture and storage and water reuse, similar to the well known solid waste management „reduce, reuse and recycle‟ hierarchy"*	Smart meter technology, efficiency-oriented rate structures, plumbing code updates, alternative water sources, customer education	None referenced	Water Planning Council	None referenced
Florida Florida's Energy & Climate Change Action Plan (2008)	*"Prolonged drought affecting water supplies, agriculture, and habitat; Climate change may impact existing sources due to many factors including altered rainfall patterns and salt water intrusion into coastal aquifer systems."*	*"In order for Floridians to have adequate water supply available to meet their basic reasonable and beneficial needs while meeting the requirements of natural systems, state and local governments need to pursue intense conservation of all water uses and alternative water sources."*	None referenced	None referenced	None referenced	None referenced
Hawaii A Framework for Climate Change Adaptation in Hawaii (2009)	*"Climate change reduces aquifer recharge and available water supply: More frequent and severe drought, Changes in rainfall patterns, Higher evaporation due to higher global temperatures reduces recharge"*	*"In order to sustain and protect our water for future generations, we must strive to be as efficient as possible in all of our water uses."*	Water Loss Control, landscape programs, Fixtures and appliances, education and outreach, commercial efficiency	None referenced. Separately, Commission Dashboard states goal of 130 gallons per person per day.	County Water and Planning Departments; State Commission on Water Resource Management	Act 169, Session Laws of Hawaii, 2016: Requires water utilities to complete validated water audits annually
Idaho State Water Plan (2012)	*"It is expected that seasonal flows in snowmelt-fed rivers will occur earlier, summer and fall stream flows will be reduced, and water temperatures will increase. Increased*	*"Conservation and water efficiency practices should be implemented through voluntary, market-based programs, when economically feasible."*	No specific strategies: conservation guidelines, practices, partnerships encouraged	None referenced	Idaho Department of Water Resources, Idaho Water Resource Board	None referenced

	precipitation in the form of rain and fewer, but more intense, storm events are expected to result in more severe droughts and greater flooding."					
Kansas State Water Plan (2014) (Draft)	*"An emerging issue regarding water management strategies is climate change. Widely agreed upon models forecast even more variability in weather and climate resulting in more extreme droughts and floods."*	*"More opportunities exist to close the gap in meeting the goal of ensuring all Kansas citizens have a reliable water supply. Opportunities such as demand management, water reuse and the use of marginal supplies, artificial recharge and out-of-basin transfer will need to be evaluated and implemented where appropriate."*	Conservation plans, drought plans, water loss control	None referenced	Kansas Water Office, Water Suppliers	Many public water suppliers are required by statute to develop a state-approved water conservation plan (Kansas Water Appropriations Act: K.S.A. 82a-733. Conservation plans and practices)
Maryland MCCC Adaption & Response Working Group Action Plan (2016) Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change: Phase II (2014)	*"Precipitation is expected to become more variable, which may impact water quality and stress water supply infrastructure. More frequent and possibly more extreme summer drought, combined with increased population, will raise water demand and exacerbate problems associated with stressed resources."*	*ARWG Solution: "Ensure long-term safe and adequate water supply for humans and ecosystems. Water efficiency, conservation and managing demand are among the most cost-effective strategies for securing a long-term water supply. Homeowners should be encouraged to reduce water use within the home and in the landscape. "* *ARWG Goal: "Promote demand management and water conservation*	Utility conservation planning, efficiency-oriented rate structures, overall best practices, low impact development, rain barrels/cisterns, rain gardens and water conservation	None referenced	MDE, Partners: Water suppliers, Local govts, MDA, DNR, Business community	EO 01012007.07 or Code of MD Environment Article 5-5B, Md. ENVIRONMENT Code Ann. § 5-203 - (a) The Department has general supervisory power, regulation, and control over the water resources of the State within the boundaries of the tidal waters as provided in this article. (b) The Department shall exercise to the fullest extent possible the State's responsibility for its water resources by planning and supervising multiple purpose development and conservation of the waters of the State for the State's best interests and benefit.

		practices. MDE should work with local jurisdictions and water suppliers (and provide funding or technical assistance where necessary) to promote water conservation, encourage the use of best management practices that reduce demand, and advance the use of water reuse technologies."				
Massachusetts Massachusetts Climate Adaptation Report (2011)	*"New England is expected to experience changes in the amount, frequency, and timing of precipitation. These changes in hydrologic cycles would have profound impacts on water resources, including increased flooding and polluted overflows from stormwater and wastewater systems during high periods of flow, and increased stress on surface and ground drinking water sources during periods of drought and low flow.....under the high emissions scenario, the occurrence of droughts lasting one to three months could go up by as much as 75% over existing conditions."*	*"Continue to Promote and Expand Conservation and Reuse Efforts. Enhance ongoing efforts to conserve potable drinking water, reduce wastewater discharge, and decrease stormwater runoff. Implement the Massachusetts Water Conservation Standards and advance the use of treated wastewater, especially in commercial and industrial settings"*	Plumbing Code, Alternative Water Sources	None referenced	None referenced	None referenced
Michigan	*"While Michigan's climate future is unclear, climate change can lead to*		Water loss control, conservation	By 2020, Increase by 20% the number of	MDEQ, MDARD, Office of the Great Lakes,	

Michigan's Water Strategy (2016)	*significant impacts to water resources, particularly through the variability and intensity of extreme weather (severe storm events and drought), more rapid runoff, greater flashiness in streams, sediment loadings, pollutants in runoff and flooding events."*	*"Optimize Efficient Use of Water in Business, Utilities, and Municipalities"*	plans, alternative water sources, CII efficiency	businesses, industries, and municipalities with water efficiency within their water management plans.	Interdepartmental Water Team	None referenced
Minnesota Adapting to Climate Change in Minnesota (2013)	*"When these same models are run with higher emissions scenarios, however, they depict Minnesota becoming more prone to dry periods. Combined with dramatic increases in hot days, these dry periods would increase Minnesota's short-term, and possibly even long-term drought risk, suggesting that drought indeed could become worse as a result of climate change. Drought impacts availability of water for community and industrial purposes, as well as for natural ecosystems."*	Specific high priority best practice areas recommended by MCAT for initial focus areas include: stormwater management best practices, water/wastewater reuse, and water conservation	Water Loss Control, Alternative Water Sources. (National Guard only)	None referenced	Minnesota Dept of Health, MNNG	None referenced
Montana Montana State Water Plan (2015)	*"Although annual stream flow volumes are expected to stay the same or increase, Montanans are likely to see a shift in the timing of runoff due to earlier snowmelt and an increase in rain as a percentage of*	*"Looking ahead, we must focus on innovative strategies to stretch supplies and promote water conservation while protecting against adverse effects to existing water users. Support the implementation of water*	No specific strategies referenced	None referenced	Dept of Natural Resources and Conservation	None referenced

	precipitation during late winter and early spring. Below average snowpack, early spring runoff, surface water shortages."	*conservation incentives and measures that are adaptable to the needs of local conditions, individual watersheds and municipalities. Drought preparedness."*				
New Hampshire Climate Change Resilience Plan, Resilience & Preparedness in State Government Project (2014)	*"These combined factors will result in more frequent low summer groundwater and surface water levels and, and more frequent short-term (1 to 3 months) and medium-term (3 to 6 month) droughts."*	*"Investigate alternative management procedures (such as reservoir operations, reuse of gray water and water conservation) to ensure adequate supply, especially for the summer months."*	Alternative water sources, home leak detection, education and outreach	None referenced	Water Systems, NHDES, Drinking Water & Groundwater Bureau	None referenced
New Mexico The Impact of Climate Change on New Mexico's Water Supply and Ability to Manage Water Resources (2006) New Mexico Drought Plan (2006)	*"Climate change, particularly long-term drought, can result in loss of water sources, as well as a rise in turbidity and in levels of contaminants regulated by the Safe Drinking Water Act (SDWA)"*	*"Enhanced demand management, conservation, and efficiency measures, with special attention to the water/energy nexus."*	Residential WUE, Commercial WUE, Metering, Plumbing Code Updates, Landscape Programs, water-energy optimization	None referenced	State Engineer, Interstate Stream Commission	House Joint Memorial 86 (adopted 2005) makes an appropriate rate structure a condition for state financing.
New York Climate Action Plan Interim Report (2010)	*"Less frequent summer rainfall is expected to result in additional and possibly longer summer dry periods, affecting water supply systems with limited storage. Reduced summer flows on large rivers and lowered*	(Not explicit, but implied): *"comprehensive statewide water management program to better regulate the use and consumption of the state's water resources, communities should*	Landscape programs, alternative water sources, drought planning	None referenced	No specific agencies referenced apart "communities"	None referenced

	groundwater tables could lead to conflicts among competing water users."	*prepare for increased drought; water managers can implement certain no-regrets actions; water infrastructure updates should emphasize the use of smaller and more distributed systems operable under drought conditions."*				
North Carolina Climate Ready North Carolina (2012)	*"Hydrological drought is expected to increase across most of the country until at least 2050. Droughts impact many sectors of North Carolina's economy and therefore many of the state's residents. Reduced public and industrial water supplies can threaten public health, business continuity and employment."*	*"Water is a finite asset that should be utilized as efficiently as possible. The state needs to explore more efficient ways to use the water we have."*	Customer education; Alternative Water Supplies	None referenced	None referenced	2008 Drought Bill (SL 2008-143) contains initiatives for drought response that include registration and reporting requirements
Oklahoma Water for 2060 Act (2012) Oklahoma Comprehensive Water Plan Executive Report (2012)	*"Oklahoma could be considerably impacted by a changing climate—including reduced precipitation and higher temperatures—resulting in fundamental changes in water supplies, demand patterns, and availability."*	*"Provide assistance to communities or entities initiating water conservation plans, programs, and activities and to research and document the potential for improving water use efficiency through demonstration projects and other activities"*	Landscape programs, efficiency-oriented rates, plumbing codes, customer education, water loss control	Those indicate that fresh water use would need to be reduced by about 33% to meet the Water for 2060 goal	Oklahoma Water Resources Board, Water for 2060 Advisory Council	Plans to develop incentives and financial assistance to encourage communities to comply
Oregon	*"Changes in hydrologic patterns in some Oregon basins will affect supplies of water for all uses.*	*"Recommended Action 10.A*			Municipal providers	

The Oregon Climate Change Adaptation Framework (2010) Oregon Integrated Water Resources Strategy (Draft 2017) Governor's Executive Order on Resiliency to Drought 15-09 (2015)	*Reduced availability of water will affect junior irrigators, change water supply planning in many basins, and affect the quality and availability of water for some public drinking water systems. Drought conditions can also have a significant effect on the supply of drinking water.”*	*Improve Water-Use Efficiency and Water Conservation. Establish a water-use efficiency and conservation program that provides technical assistance to water users in all sectors, Expand participation in already-existing water-use efficiency and conservation programs.”*	Water-energy, efficiency-oriented rates, residential WUE, alternative sources	None referenced; 15% average reduction of non-essential water use by state agencies by December 31, 2020	(implicit), Oregon Water Resources Department	Annual reporting for state agencies against 15% goal. Water Resources Department requires water utilities to examine conservation-based rate structures as part of their Water Management and Conservation Plans.
Pennsylvania Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations (2014)	*“Other potential impacts are decreased water quality, urban flooding, and reduced water supplies for urban areas, and irrigation”*	*“Encourage statewide water conservation and water use efficiency, not just in time of drought but at all times, so that both conservation and efficient water use become routine to Pennsylvanians”*	General water use efficiency, landscape programs, green infrastructure, alternative sources	None referenced, but identified as low-cost, high priority	DEP, Dpt of Conservation and Natural Resources, Fish and Boat Commission, PENNVEST, Dept of Community and Econ Development, Water Suppliers	None referenced
Texas State Water Plan (2017)	*“The tree ring records, recent drought, and very wet episodes indicate that the climate of Texas is highly variable and droughts with durations and intensities exceeding the drought of record could occur in the future. A combination of warmer temperatures and decreased precipitation, as*	*“By 2070, about 30 percent of the total volume of these strategies would be in the form of demand management. Demand management refers to measures that reduce the need for additional water, such as conservation and drought management. Drought management includes*	Plumbing and fixture Updates, Efficiency-oriented rates, water loss control, landscape programs, CII efficiency programs	1.2 million acre-feet in municipal conservation, CII conservation and drought management	Water Providers, Regional Planning Groups, TWDB	Funding available only to projects consistent with or mentioned in State Water Plan

	experienced during the 2011 drought, enhances the risk of Texas experiencing extreme droughts".	*activities that temporarily restrict water use for certain types of activities and businesses."*				
Utah Recommended State Water Strategy (2017)	*"This challenge is magnified by climate projections from the State Climatologist that show a significant decrease in Utah's snowpack, which presently provides more annual water storage capacity than all of Utah's human-made reservoirs combined"*	*"Utah needs to strengthen conservation and efficiency goals by refining them regionally and revising them on a more frequent and continual basis. Implementation by all communities and throughout all sectors of water use—including agricultural, residential, commercial, industrial, institutional, and secondary municipal uses6—is needed to reach and achieve these goals."*	Efficiency-oriented rates, community plans, education, Residential WUE, CII WUE, landscape programs, water loss control, land use planning	No - Recommends new targets be set to update Governor's conservation goal of 25% reduction by 2025	Water providers	"Utah Code 73-10-32: Retail water providers with over 500 service connections must have a water conservation plan that is adopted by the governing body of that community, submitted to the Division of Water Resources, and updated no less than every 5 years. Plans must include benchmarks for improvement in conservation programs, conservation targets, a timeline for action, and an evaluation process to measure progress"
Virginia Final Report: A Climate Change Action Plan (2008) Virginia Water Resources Plan (2015)	*"With 16% of streams predicted to see greater than 5% reduction in Drought of Record flows based on anticipated increases in use, drought related impacts are likely to be more severe and last longer."*	*"DEQ should incorporate assessment of the current and potential impact of climate change on instream flow into the state water resources plan. From Water Resources Plan: - Recommendation 7.1: DEQ will encourage localities and regions to place more emphasis on conservation efforts to reduce demand in their water supply plans."*	Water Loss control, drought management	None referenced	DEQ/SWCB/ Localities	None referenced
Washington Preparing for a Changing Climate: Washington	*"The quantity and quality of water available for communities, irrigation, fish, hydropower generation, recreation,*	*"Implement water conservation and efficiency programs to reduce the amount of water needed for*	Landscape programs, Codes and standards, efficiency-	None referenced	Dept of Ecology, water providers	"Several state water laws and programs are aimed at improving water management by seeking out new water supplies for both instream and

State's Integrated Climate Response Strategy (2012)	*and other uses will be affected by declining snowpack, changes in seasonal streamflow, and increases in summer demand for water."*	*irrigation, municipal, and industrial users and to improve basin-wide water supply."*	oriented rates, landscape programs, land use planning, water-energy, alternative sources			out-of-stream uses; funding and incentivizing conservation, water use efficiency, reclaimed water, and shallow aquifer recharge; and enhancing water resources data and information."
West Virginia West Virginia Water Resources Management Plan (2013)	*"If the climatic conditions reverted to what we experienced in the 1930's through the 1960's, our state would have significantly less available water than we currently have. "*	*"Improving water use efficiency through implementation of use reduction methods or equipment"*	efficiency-oriented rates, CII efficiency, residential efficiency, customer education, water loss control, alternative sources	None referenced	None referenced	None referenced
Wisconsin Wisconsin's Changing Climate: Impacts and Adaptation (2011)	*"Groundwater withdrawals by municipal water systems would also be expected to increase with elevated summer temperatures and greater demand for water."*	*"Encourage water conservation (rural and urban) through incentives and regulation."*	None referenced	None referenced	None referenced	None referenced

Interview Questions for State Agency Representatives

Development of Strategy:

1. What was the driver for developing a climate change adaptation plan?
2. What is the primary climate change related driver for inclusion of water efficiency in the climate plan?
3. What agencies were involved in development of the water efficiency recommendation/strategy?
4. Were water or wastewater utilities consulted in the development of this strategy?
    a. If yes, how?
5. Is there a target for the water efficiency goal in the State Plan? (if not explicitly mentioned)
    a. If yes, how was this target determined?
    b. If no, did the agency consider determining a target? Why was one not selected?

Implementation:

6. What entities or agencies are responsible for implementing this strategy?
7. How does the agency engage water utilities around this strategy?
8. Have water utilities been supportive of this strategy?
9. What has been implemented in support of this strategy?
10. In implementing this strategy (strategies), what has been working well?
11. What has not been working well?

Enforcement of strategy:

12. How is success for this strategy measured?

13. Is implementation required?? How?
14. If not required, is the agency incentivizing implementation in some way?
15. Is there any legal basis to require these agencies to comply?

Funding and resources

16. Has your agency determined what kind of funding is necessary to achieve the goal?
17. What resources have been allocated by the agency to achieve this goal?
18. Is there dedicated funding to support water efficiency goals in the plan?

Evolution:

19. What elements or changes would help make this strategy successful?
20. Does the agency plan to revise this goal in the next update of the plan?
    a. If yes, how?

Interview Questions for Water Utilities

1. Is your utility aware that the state climate change plan includes a water efficiency strategy?
    a. If no, (explain state plan and requirement)
2. Does your utility have an explicit role in achieving this goal or implementing this strategy?
    a. If not aware of this, do you think there's a role for your utility in implementing this strategy?
3. Is your utility taking any steps to achieve this goal?
    a. If yes, what?
    b. If no, what has prevented investments in conservation?
4. What resources would your utility need to implement this goal?
5. What might prevent your utility from implementing this goal?
6. Outside of this plan, is your utility addressing climate change impacts?
    a. If yes, how?
7. Outside of this plan, is your utility implementing water efficiency strategies.
    a. If yes, which ones?