ARTICLES

Innovation Through Traditional Water Knowledge: An Approach to the Water Crisis

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ABSTRACT

Water supplies are being depleted and are further threatened by the impacts of climate change. The current water management systems are ill equipped to deal with the issue in significant part because they do not promote distributed water collection, water conservation, and water reuse. It is critical that water laws be reformed to encourage these practices. Fortunately, a combination of often forgotten traditional water practices and more recent innovations in water use and management can help resolve this growing water crisis. These include rainwater capture, black and grey water recycling and reuse, and new advanced technologies to purify water. Stepping up these solutions through legal and regulatory change will offer local officials and water managers a better chance to meet present demands and future needs in an increasingly water-constrained world.

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INTRODUCTION

The current model of water supply and distribution dates back to the nineteenth century's urban and industrial growth.[1] The need to provide increasing amounts of water to large and highly concentrated populations at the dawn of the Industrial Revolution led to the development of a centralized infrastructure that relies on electricity to pump and treat water. Generating electricity, in turn, requires large amounts of freshwater daily.[2] Cities routinely use potable water to satisfy a variety of different household, commercial, industrial and municipal needs.[3] After a single use, tap water is collected through the underground sewage system, treated again, and released back into rivers and oceans.[4] This once-through model well served sanitation needs and fostered economic activities, but it has grown increasingly inadequate to meet the water challenges of the twenty-first century. Today in the United States, the combined effect of urban development, increased climate variability and competition for water among agriculture, energy production, and municipal supply, coupled with an aging water infrastructure, puts tremendous pressure on already stretched surface and underground reservoirs and threatens the ability of local governments to deliver water to the populations they serve.[5] As more people move to urban areas and cities continue

1. JAMIE BENIDICKSON, THE CULTURE OF FLUSHING: A SOCIAL AND LEGAL HISTORY OF SEWAGE, 11 (2006); JAMES SALZMAN, DRINKING WATER: A HISTORY (Overlook Duckworth 2012).

2. KRISTEN AVERYT ET AL., FRESHWATER USE BY U.S. POWER PLANTS 12 (USC Publications 2012).

3. Potable water is water that is suitable for human consumption. Municipal needs include cleaning streets and other public spaces, extinguishing fires, filling up city fountains, and landscaping. *See* CHERYL A. DIETER AND MOLLY A. MAUPIN, PUBLIC SUPPLY AND DOMESTIC WATER USE IN THE UNITED STATES, 2015 4 (2017).

4. OFFICE OF WATER, U.S. ENVTL. PROT. AGENCY (EPA), PREMIER FOR MUNICIPAL WASTEWATER SYSTEMS 4 (2004). Municipal sewage is considered a point source of pollution under the Clean Water Act, and water treatment plants are required to obtain a state permit and treat sewage before discharge into watercourses. However, this is a relatively recent development.

5. See *infra* Part I.

to expand, preserving water is a critical issue for the future.[6]

This Article argues that there is an urgent need to revisit the present model of water supply and distribution to adapt to an increasingly water-constrained world. A mix of traditional water practices and more recent water technologies can help transition to a more diversified water infrastructure to better cope with a warming climate and degrading water conditions.[7] Historically, methods to access and supply water rested on sound hydrogeological, engineering, and ecological principles.[8] Current water supply techniques instead aim, for the most part, at realizing immediate results without respecting ecological boundaries.[9] Modern means to maximize the extraction and distribution of water often create the illusion of unlimited abundance, further contributing to the overexploitation of water sources and the destruction of vital ecosystems.[10] These shortcomings can be addressed by reclaiming the old wisdom of some traditional water supply methods and techniques, and by removing legal and non-legal barriers that hinder the adoption of new approaches and solutions.

Part I offers an overview of the precarious condition of the United States' water supply and water delivery systems and argues that a conservation-oriented approach to water law and management must become a priority. Part II introduces and discusses the notion of traditional water knowledge as knowledge derived from the observation of the environment and consisting of a system of practices, technologies, and adaptive strategies through which modern civilization can relearn how to sustainably manage water resources. Part III describes new local approaches to water management and conservation that are emerging in a piecemeal fashion today and provides specific examples of the most promising innovations in water use and management. It also discusses how, if stepped up, these innovations can deliver multiple benefits to individuals, water utilities, and communities. Part IV analyzes some of the main barriers and proposes ways in which these barriers can be overcome. Part V concludes by stressing the need for water administrators and policy makers to move towards a new model of water management that integrates development within the water cycle.

6. Total withdrawals for public supply were about 39,200 million gallons per day ("Mgal/d") in 2015. Sixty percent or almost 23,300 Mgal/d of the total public-supply withdrawals were delivered to domestic users. DIETER AND MAUPIN, *supra* note 3, at 2.

7. For instance, diverting and collecting water during heavy rains would help mitigate floods and increase supply. Also, there is no reason why the three R's of the conservation mantra "Reduce, Reuse, Recycle" shouldn't apply to water as well. These are just two clear examples of the lack of a comprehensive and coherent approach to deal with the water crisis that should inform the water policy debate at the national and state level. KATIE HIBBARD ET AL., THIRD NATIONAL CLIMATE ASSESSMENT, CHAPTER 10: ENERGY, WATER AND LAND USE 268 (2014).

8. LARRY W. MAYS, ANCIENT WATER TECHNOLOGIES (2010).

9. Troy L. Payne & Janet Neuman, *Remembering Rain*, 37 ENVTL. L. 105, 106 (2007).

10. *Id.* at 120.

I. THE WATER CHALLENGE IN THE UNITED STATES

In recent years, the rapid decline of the nation's freshwater resources has captured the attention of journalists, academics, and Hollywood celebrities, and generated a number of governmental studies. While events such as the drinking water contamination in Flint, Michigan, and the severe drought that hit California for three consecutive years have put the spotlight on the problem, those events remain, in the collective mindset, exceptional occurrences. After all, piped water in cities is rarely cut off. When such an inconvenience happens, it typically lasts only a few minutes or, in the worse cases, hours before plentiful water starts flowing again from the tap. The truth is that water insecurity is a growing concern not only in the most arid states or less privileged neighborhoods but also in places where water has been traditionally abundant and readily available. There are a few distinct drivers responsible for this water crisis, including widespread human alteration of the earth's water cycle and consequent, frightening, deterioration of water sources. Equally important, the current system of water delivery is proving increasingly inadequate to address present demands and future needs. If people fail to internalize this new reality and support corrective action, the lack of sufficient water will have devastating consequences for the United States' economy and its way of life. Water shortages are already causing grave damage in significant parts of the country.[11] While not all areas are suffering as severely, the vast majority of water sources are shared among a plurality of municipalities, counties, states, and regions. Therefore, achieving greater water conservation and water self-sufficiency is a common responsibility and will benefit all communities moving forward.

A. THE PRECARIOUS STATE OF WATER SUPPLY

1. Population Growth

The Unites States' population continues to grow due to both natural increase and international migration.[12] The country is also among those with the highest water consumption per capita.[13] The General Accounting Office ("GAO") conducted a nationwide survey on trends in freshwater availability and use for the first time in 2003.[14] The survey concluded that projected population growth

11. *See infra* Section I.A.2.

12. Press Release, U.S. Census Bureau, Nevada and Idaho Are the Nation's Fastest-Growing States (Dec. 19, 2018) https://perma.cc/MLZ3-B3UG.

13. ORG. ECON. COOPERATION AND DEV., OECD FACTBOOK 2014: ECONOMIC, ENVIRONMENTAL AND SOCIAL STATISTICS 169 (2014). Water abstraction (or withdrawal) refers to the amount of freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to the place of use.

14. U.S. GEN. ACCOUNTING OFFICE (GAO), FRESHWATER SUPPLY: STATES' VIEWS OF HOW FEDERAL AGENCIES COULD HELP THEM MEET THE CHALLENGES OF EXPECTED SHORTAGES 7 (2003). Overall, GAO found that the Nation's freshwater supply was reaching its limits with surface storage capacity strained and groundwater being depleted while population growth; pressures to keep water instream for

concentrating for the most part in urban centers would increase water demand, posing great challenges in states with already limited water supplies.[15] The survey pointed out that many of the states that were growing the most (California, Texas and Florida) or at the fastest rates (Arizona, Nevada and New Mexico) included areas already using water at the greatest daily rates in the nation.[16] In the Lower Colorado Basin, covering most of Arizona and significant parts of Nevada and New Mexico, consumptive use of water neared or exceeded the renewable supply (10.6 billion gallons consumed daily versus 10.3 billion gallons of renewable supply). The survey also highlighted that then-current water conservation efforts to lower per-capita use could not offset increases in public supply use directly linked to population growth.[17] Among the cities looking for ways to keep pace with water demand were Atlanta, Chicago, Tampa, Denver, and New York City. Already in the early years of 2000, New Jersey, Pennsylvania, Maryland, Maine, and New Hampshire all enacted water restrictions measures.[18]

GAO conducted a second survey on freshwater supply in 2014 that projected population growth would continue straining water resources.[19] The survey also underlines that population growth can stress freshwater supplies in areas that have not historically been concerned with limited water availability.[20] Over the next decade, in forty out of fifty states, water managers expect water shortages in some portions of their states under average conditions.[21] Shortages are also going to affect wider geographic areas reaching regional scale.[22] These trends make

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environmental, recreational, other purposes; and the potential effects of climate change all raised concerns about meeting future water needs.

15. *Id.* at 5.

16. *Id.* at 58.

17. *Id.* at 56.

18. *Id.* at 60.

19. U.S. GAO, FRESHWATER: SUPPLY CONCERNS CONTINUE, AND UNCERTAINTIES COMPLICATE PLANNING 14 (2014). In this survey, GAO found that that between 2000 and 2030, the United States population will continue to grow by approximately 29 percent. This growth will concentrate, for the most part, in urban and suburban areas. The western and southern regions will experience the greatest growth during this time—45.8 percent and 42.9 percent, respectively. Nevada and Arizona are the two states with the greatest projected growth where populations will more than double between 2000 and 2030. Both states, however, have historically received some of the lowest annual precipitation amounts in the nation and have among the highest water withdrawal rates in the United States.

20. *Id.* at 16–17. In certain parts of Maryland, for example, demand for water has increased exponentially in recent years due to a large number of people working in the Washington D.C. metropolitan area migrating to central and southern Maryland counties. Urban areas within central Maryland rely primarily on surface water reservoirs, and rural and exurban areas in the region rely on groundwater wells to meet their freshwater needs. According to local water managers surveyed by GAO, there is little chance of building new surface reservoirs in the long term because of their high costs and ecological impacts. Therefore, they expect increased groundwater use in this region; however, due to its geology, the region is not well suited for high production groundwater wells. These factors combined make it possible that some towns and small communities may have difficulty finding sufficient water supplies to meet the needs of the growing population.

21. *Id.* at 28.

22. *Id.* at 28–31.

freshwater management and planning increasingly difficult when factoring in water demand for industrial and agricultural users, ecosystems needs and climate variability.[23] The survey concludes that increasing water shortages in the future will lead to more service disruptions in urban areas and will continue to threaten local economic activities, damage the environment and aggravate local conflicts.[24]

2. Climate Variability

In addition to cities in the United States growing at unsustainable rates, climate variability is adding problems to water supply.[25] Warming temperatures are altering the earth's water cycle in multiple ways.[26] Changes in precipitation patterns, evapotranspiration rates and soil moisture affect regions in different ways. For instance, annual average precipitation has increased in wet regions in the Midwest, Great Plains, Northeast, and Alaska while it has decreased in arid or semi-arid parts of the Southeast and Southwest.[27] Moreover, heavy precipitation has become more frequent and dry spells longer.[28] Higher temperatures are responsible for snowpack losses and, therefore, diminished freshwater reserves; earlier snowpack releases in rivers and lakes threaten growing seasons and reduce water storage capacity during the summer; and sea level rise increases the probability of coastal flooding.[29] Higher temperatures also correspond to higher evapotranspiration rates that negatively impact surface and groundwater recharge.[30] Combined with decreasing soil moisture, greater rates of evapotranspiration amplify losses of land water to the atmosphere and contribute to more frequent and intense weather events.[31]

All these changes have catastrophic consequences for human activities and infrastructure. Extended droughts in the Southern and Mid-Western states are pushing ranchers and farmers out of business and imposing billions of dollars of costs on local economies.[32] At the opposite end of the spectrum, from 1981 to 2011, floods caused $8 billion in average losses per year, due to property and

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23. *Id*. at 42.
24. *Id*. at 67–73.
25. *Id*. at 20 (including climate change among the issues related to freshwater availability that have gained prominence between 2003 and 2014).
26. *See* ARIS GEORGAKAKOS ET AL., U.S. GLOB. CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT, CHAPTER 3: WATER RESOURCES 70-71 (2014) [hereinafter THIRD NATIONAL CLIMATE ASSESSMENT] (warming temperatures inevitably alter water's presence in the environment with consequences that are still under study).
27. *Id*. at 71.
28. *Id*. at 71.
29. *Id*. at 75.
30. *Id*. at 76–77.
31. *Id*. at 72–75.
32. *See*, *e.g*., SUSAN COMBS, TEXAS COMPTROLLER OF PUBLIC ACCOUNTS, THE IMPACTS OF THE 2011 DROUGHT AND BEYOND 6 (2012) (analyzing agricultural losses endured by Texas during the 2011-2012 drought, the future of water resources in the state, and possible solutions to solve the water crisis).

crop damages nationwide.[33] In 2012 alone, eleven weather disasters, including tornadoes, severe storms, wildfires, heat waves, and droughts, caused $115 billion dollars in total damages. In a single weather occurrence, Hurricane Sandy cost $65 billion and resulted in 159 deaths.[34] Over the past decade, erratic rains, dried-up soils, and sea level rise have ravaged agricultural lands as much as industrial, transport, and urban infrastructure all around the country.[35] Cities often face grave challenges during times of torrential floods or prolonged droughts such as temporary lack of potable water and electricity, extensive damage to houses and municipal infrastructure, and loss of business.[36]

These weather occurrences also complicate the management of freshwater resources. For example, increases in wildfires due to drier conditions result in loss of vegetation and forests. When combined with high-intensity rainfalls, steep and burned watersheds carry debris and other materials downstream, which in turn contribute to sedimentation in water reservoirs and the need for more chemical treatment for water supply.[37] Another detrimental consequence of climate-related events is the staggering loss of both surface and groundwater.[38] Since ground and surface water recharge each other, a diminished flow in surface water because of loss in snowpack or excessive withdrawal due to drier conditions amplifies losses in groundwater, and vice-versa.[39] Overall, less predictable precipitation patterns in both wet and arid regions will generate growing uncertainty in water supply.

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33. GEORGAKAKOS, *supra* note 26, at 80. In 2005, Hurricane Katrina alone was responsible for $148 billion in damages and over 1,800 deaths. U.S. GAO, *supra* note 19, at 22.

34. U.S. GAO, *supra* note 14, at 20.

35. GEORGAKAKOS, *supra* note 26, at 85–87. Floods frequently disrupt road, rail transportation and inland navigation.

36. SUSAN L. CUTTER ET AL., THIRD NATIONAL CLIMATE ASSESSMENT, CHAPTER 11: URBAN SYSTEMS, INFRASTRUCTURE AND VULNERABILITY 438 (2014); *see also* Dan Farber, *From the Wildfire Files*, BERKELEY LAW: LEGAL PLANET (Nov. 16, 2018), https://perma.cc/V77E-KAXS (highlighting how, in 2017 alone, wildfires in California burned 10 million acres in the Western United States, destroying 12,000 homes, killing 66, and resulting in $18 billion in damages); *Sinking Cities: A Four-Part Series on the Threat of Climate Change* (PBS television broadcast Oct. 31, 2018), https://perma.cc/HBJ6-MUUV (discussing how flooding is becoming a regular occurrence in all major coastal cities around the world, where local governments have begun to mobilize resources to study and implement innovative flood management solutions).

37. U.S. GAO, *supra* note 14, at 22–23.

38. Thanks to satellite data from NASA's Gravity Recovery and Climate Experiment (GRACE), it is possible to detect and calculate water losses and gains throughout the country. The country's greatest groundwater losses over the past decade were in the southern High Plains and Central Valley aquifers. Both of these reservoirs provide water supplies that are critical for crop and food production in the United States. They have also accounted for about 50 percent of groundwater depletion in the country since 1900. The amount of water lost in the Central Valley due to groundwater depletion from 2003-2010 was estimated to nearly equivalent to the capacity of Lake Mead, the largest reservoir in the United States. Under the current depletion rate, 35 percent of the southern High Plains may be unable to rely on groundwater irrigation within the next 30 years. James S. Famiglietti & Matthew Rodell, *Water in the Balance*, 340 SCIENCE 1300, 1300–01 (2013); Caitlyn Kennedy, *Groundwater Declines Across the U.S. South Over the Past Decade*, CLIMATE.GOV. 2 (Oct. 15, 2014), https://perma.cc/JV6S-EEB4.

39. U.S. GAO, *supra* note 14, at 24–25.

Given the complexities of climatology and how climate variability affects the water cycle, future impacts remain hard to predict with full accuracy, but the well-established trends cited above are creating new risks particularly to urban water supply systems.

3. Urbanization

Approximately 80.7 percent of Americans live in urban areas.[40] One of the consequences of urban development is the increase of impervious surfaces in the landscape. This affects the performance of the water cycle in various ways.[41] The most obvious is the reduction in vegetation to clear up space for construction and consequently the reduction in the natural process of transpiration performed by plants and trees through which water returns to the atmosphere. Cement and other similar materials used to pave streets, build parking lots and transportation systems, and lay buildings foundations also prevent water from percolating naturally into the soil to recharge water bodies and maintain the soil moisture. Less or zero percolation means that water stays at the surface and moves into streets gutters and other means of collection at relatively high speed, which in turn decreases natural evapotranspiration rates further diminishing the amount of water that returns into the atmosphere.

The higher the degree of urbanization, the greater the alteration experienced by the water cycle.[42] The most direct and detrimental impacts of imperviousness occur on local bodies of water.[43] On one hand, underground water reserves decrease drastically because of urbanization and urban sprawl (in addition to direct mechanical intake through water pumping, which can deplete aquifers and alter the natural chemical composition of water). On the other hand, during heavy rains and storms, surface waters (streams, lakes and coastal waters) receive enormous amounts of debris in the form of urban waste and other pollutants picked up and carried by uncontrolled and uncontained flows. Municipal discharges, sewage and urban-related runoff, and storm water consistently rank among the leading sources of water quality impairments in surface waters according to the Environmental Protection Agency (EPA)'s National Water Quality Inventory, preventing the achievement of water quality standards nationwide.[44] Pollution of beach waters by raw sewage from sanitary sewage overflows sickens 3.5 million

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40. U.S. CENSUS BUREAU, U.S. DEP'T OF COMMERCE, MEASURING AMERICA (2016), https://perma.cc/B7BF-Y63X.

41. OFFICE OF WATER, U.S. ENVTL. PROT. AGENCY ("EPA"), NATIONAL MANAGEMENT MEASURES GUIDANCE TO CONTROL NONPOINT SOURCE POLLUTION FROM URBAN AREAS 0-21 to 0-24 (2005).

42. *Id.* at 22, Fig. 0.4: "Impacts of urbanization on the water cycle."

43. For a complete assessment of how imperviousness affects streams and urban watersheds, see *id.* at 0-21 to 0-35.

44. U.S. EPA, NATIONAL WATER QUALITY INVENTORY: REPORT TO CONGRESS 24 (2017).

people each year and hurts coastal economies.[45]

Therefore, finding ways to mitigate urban development interference with the water cycle is of critical importance to reduce both groundwater depletion and pollution of surface bodies of water.

4. Overuse

Across the United States water consumption remains high while water resources are increasingly in short supply.[46] According to the latest estimates available by the United States Geological Service, in 2015 irrigated agriculture and thermoelectricity production were the two biggest users of water, representing respectively 42 percent and 34 percent of total freshwater withdrawals, followed by the municipal sector accounting for 14 percent.[47] However, there are important geographical variations to these percentages that, combined with other factors, exacerbate the competition for freshwater resources between energy production, agriculture, and urban supply in some areas more than others. For example, in seventeen Western and Midwestern states, irrigation accounts for more than half of the total freshwater withdrawals.[48] At the same time, some of these states (Nevada, Arizona, California, and Texas) are simultaneously experiencing among the highest rates of population growth and the harshest consequences of extended droughts.[49] Consequently, some of the fastest growing cities are struggling to find new sources of water supply to meet the needs of new development.[50] The recent surge in hydraulic fracturing to extract oil and natural gas also exacerbates competition among limited water resources and the risks of contaminating drinking water.[51] Its exponential rise is adding more pressure on already limited water supply, particularly in regions

45. MARC DORFMAN & ANGELA HAREN, NAT'L RES. DEF. COUNCIL, TESTING THE WATERS 2014, EXECUTIVE SUMMARY 4 (24th ed., 2014).

46. SUSAN J. MARKS, AQUA SHOCK: WATER IN CRISIS (Wiley & Sons, Inc., 2009); KRISTINA DONNELLY & HEATHER COOLEY, PAC. INST., WATER USE TRENDS IN THE UNITED STATES (2015).

47. CHERYL A. DIETER ET AL., U.S. GEOLOGICAL SERV. ("USGS"), ESTIMATED USE OF WATER IN THE UNITED STATES IN 2015, at 7 (2018).

48. *Id.* at 26–31.

49. KATIE HIBBARD ET AL., THIRD NATIONAL CLIMATE ASSESSMENT, CHAPTER 10: ENERGY, WATER AND LAND USE 259–260 (2014). In Texas, for example, during the heat waves of 2011 and 2012, demand for electricity spiked for air conditioning, which in turn corresponded to higher water withdrawals for electricity production. Since more than 16 percent of electricity production relied on cooling from water sources that were at historically low levels, water shortages threatened more than 3,000 megawatts of generating capacity (the equivalent to power one million homes). The resulting marginal cost for electricity reached $3,000 a megawatt per hour, three times the maximum amount that generators can charge in deregulated electricity markets in eastern United States.

50. ROBERT GLENNON, UNQUENCHABLE: AMERICA'S WATER CRISIS AND WHAT TO DO ABOUT IT 1–8, 17–18, 23–35 (2009).

51. OFFICE OF RESEARCH AND DEV., U.S. EPA, HYDRAULIC FRACTURING FOR OIL AND GAS: IMPACTS FROM THE HYDRAULIC FRACTURING WATER CYCLE ON DRINKING WATER RESOURCES IN THE UNITED STATES, ES-3–ES-4, 4-3–4-4, 4-21 (2016).

that experience drought conditions.[52]

The progressive decline of surface water due to over-allocation has led farmers, municipalities, and industries to turn to underground water to meet their needs.[53] Measurements conducted by National Aeronautics and Space Administration's Grace Mission[54] show that in all major aquifers in the United States water is being pumped at rates that produce long-term declines in the aquifers' levels and leave little if any chance of recovery if demand for water continues unabated. The over-pumping of underground aquifers—technically known as overdraft[55]—is causing groundwater depletion and increasing concerns in terms of water quality deterioration, further reducing water in streams and lakes, and land subsidence.[56] Land subsidence, in turn, is responsible for extensive infrastructural damages to bridges, roads, and buildings.[57] Overdraft is also causing numerous other water-related damages such as chemical alteration of groundwater, saltwater intrusion, and sea level rise.[58] It is affecting coastal regions in a unique way, with several municipal and private supply wells forced to close in Cape May County, New Jersey; southeastern Florida; and Monterrey, Ventura, Orange, and Los Angeles Counties in California.[59]

So far, water efficiency practices in food production, electricity generation, and municipal supply have achieved only limited results.[60] Keeping these

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52. MONIKA FREYMAN, CERES, HYDRAULIC FRACTURING AND WATER STRESS: WATER DEMAND BY THE NUMBERS, 6, 18–22 (2014).

53. Over-allocation occurs when more water has been promised to competing users in the form of water rights according to the regime applicable in the region than what the local water source(s) can actually supply. U.S. GAO, MUNICIPAL FRESHWATER SCARCITY: USING TECHNOLOGY TO IMPROVE DISTRIBUTION SYSTEM EFFICIENCY AND TAP NON-TRADITIONAL WATER SOURCES 6 (2016).

54. The Gravity Recovery and Climate Experiment ("GRACE") is a joint U.S.-German satellite mission estimating from space how much water is missing from some of the biggest aquifers around the globe, and how their water storage is changing. NASA, *Tracking Groundwater Changes Around the World*, https://grace.jpl.nasa.gov/applications/groundwater/ (last visited Nov. 18, 2018).

55. Overdraft is a condition where the amount of water withdrawn from a groundwater basin by pumping exceeds the amount of water that recharges the basin over a period of years under average water supply conditions. Overdraft can be characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. U.S. GAO, *supra* note 53.

56. USGS, GROUND-WATER DEPLETION ACROSS THE NATION (2003).

57. Stanley A. Leake, *Land Subsidence from Ground-water Pumping*, USGS, https://perma.cc/9NND-LE45 (last visited Nov. 18, 2018).

58. *Id.*; U.S. GAO, *supra* note 53, at 7.

59. U.S. GAO, *supra* note 53, at 6–7.

60. Most of the water used in agriculture is consumptive water, meaning water that does not return to the watershed after its use. U.S. GAO, *supra* note 53, at 1. While the use of sprinklers and other water-saving methods have improved water efficiency in irrigated agriculture dramatically, achieving greater reductions would require planting different types of crops altogether or moving some crops to wetter areas of the country. Eco. Res. Serv., *Irrigation & Water Use*, FDA, https://perma.cc/FF5B-A48B (last visited Nov. 18, 2018). Most of the electricity produced in the United States comes from thermoelectric plants that burn fossil fuels and use large amounts of water in the process. Office of Research and Dev., U.S. EPA, *supra* note 51, at 4–1; U.S. Energy Info. Agency ("EIA"), *U.S. Energy Consumption by Energy Source 2017*, https://perma.cc/5JFN-D7BZ (last visited April 3, 2019); U.S. EPA, *Thermoelectric Water Use*, ENVIROATLAS, https://perma.cc/7CC2-N8RW (last accessed Set. 1, 2019).

consequences from worsening will require introducing more radical changes in all three sectors.

B. THE FAILING SYSTEM OF WATER DELIVERY

1. Declining Infrastructure

Today, several factors threaten the ability of local governments to supply water effectively to the populations they serve. The most immediate threat is the nation's water infrastructure that has neared the end of its useful life. A decade ago, the American Water Works Association (AWWA) surveyed 20 water systems in different cities and announced that significant investments will be required in the coming decades to maintain the level of water supply services that support the American way of life.[61] More recently, a second comprehensive study has brought the immensity of this challenge to light.[62] The study divides the country into four regions—Northeast, Midwest, West, and South—based on common demographic trends and water infrastructure history, and it classifies water systems by size and water pipes by age and category to determine their replacement time.[63] Assuming the pipes are actually replaced at the end of their useful life and the systems are expanded to meet the needs of growing urban populations, experts estimate that the overall investment needs for drinking water infrastructure total more than $1 trillion nationwide over the next twenty-five years.[64]

The AWWA study does not include in the cost estimates for the additional investments needed to repair and upgrade dams, reservoirs, water treatment plants, and storage tanks to meet drinking water quality standards. Furthermore, drinking water supply represents only one aspect of the water infrastructure. The sewage system is in urgent need of upgrades as well. In the Northeast, the Great

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There are also other limitations. Saline water, for example, cannot readily substitute for freshwater in this process because of its corrosive effect. Increasing the share of less water intensive energy sources such as wind and photovoltaic in the Nation's energy mix would require accelerating investments in smart grid technologies, supporting greater competition in the power sector through more distributed generation, and redirecting (at least a portion of) fossil fuels subsidies towards the financing of clean energy programs including those aimed at retraining workers. However, adopting a more comprehensive and coherent national energy policy sensitive to the energy-water nexus and the realization of water conservation goals is not a priority for the current Administration. Finally, significant opportunities to improve municipal supply remain largely untapped, though that is truer in some cities more than others. U.S. GAO, *supra* note 53, at 7–15; Peter A. Nelson, *Measuring Water From the Highmark: Defining Baselines for Water Efficiency in Green Buildings*, 11 N.Y.U. J. LEGIS. & PUB. POL'Y 105, 123–24 (2007).

61. AMERICAN WATER WORKS ASSOCIATION ("AWWA"), DAWN OF THE REPLACEMENT ERA: REINVESTING IN DRINKING WATER INFRASTRUCTURE 5 (2001).

62. AWWA, BURIED NO LONGER: CONFRONTING AMERICA'S WATER INFRASTRUCTURE CHALLENGE (2012).

63. *Id.* at 6–7.

64. *Id.* at 10. "Useful life" means the point in time when replacement or rehabilitation becomes less expensive going forward than the costs of numerous unscheduled breaks and associated emergency repairs. *Id.* at 8.

Lakes area, and the Pacific Northwest, an estimated 772 communities of about 40 million people total are still served today by combined sewer systems, which regularly experience overflows during heavy rains, impacting drinking and recreational waters.[65] Built over a century ago, these systems were designed to meet the flows of much smaller urban populations. In recent years, due to overflows, inadequate treatment systems, insufficient upgrades, and other issues, there has been an increase in the rate of emergency room visits for gastrointestinal illness in these regions compared to regions with separate systems for human waste, industrial waste, and storm water runoffs.[66] Such events will only occur more frequently with increasing extreme precipitations associated with climate variability.[67] Although no accurate estimate exists on the costs of wastewater and storm water upgrades, the EPA projects these costs to be similar to the costs of upgrading the drinking water system.[68]

Finding adequate means to finance critical water infrastructure can prove difficult given the current need for other pressing infrastructural investments as well as budgetary constraints.[69] At the same time, AWWA is warning that failing to invest in upgrades will result in degraded water quality with potentially dangerous health consequences, more service disruptions, and higher expenditures for sub-optimal emergency repairs over the long term, in addition to less water flows for fire-fighting and other important municipal uses.[70] At the local level, municipalities and water utilities can adopt different financing schemes. Water rate increases is the most common, but taxes and other emoluments are possible as well. However, not all municipalities have the same capacity to levy funds and balance budgets. Therefore, investing in water conservation measures is all the more essential at this particular juncture as it can also help free federal, state, and municipal resources for other critical needs.

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65. A combined sewer system (CSS) is a wastewater collection system that collects and transports sanitary wastewater (domestic sewage, commercial, and industrial wastewater) and storm water to a treatment plant in one pipe. During wet weather, when the capacity is exceeded, the system discharges untreated wastes directly to surface waters resulting in a combined sewer overflow ("CSO"). U.S. EPA, *Urbanization – Wastewater Inputs*, https://perma.cc/E9PK-SLVN (last visited Nov. 18, 2018); Mary Anna Evans, *Flushing the Toilet Has Never Been Riskier*, THE ATLANTIC (Sept. 17, 2015).

66. *See, e.g*., Jyotsna S. Jagai et. al., *Extreme Precipitation and Emergency Room Visits for Gastrointestinal Illness in Areas With and Without Combined Sewer Systems: An Analysis of Massachusetts Data, 2003–2007*, 123 ENVTL. HEALTH PERSP., 873–879 (2015).

67. As the study points out, in the United States since 1990, a large percentage of precipitation has come in the form of intense single day events. In the Northeast, single day heavy rainfall events are expected to increase, and the 99th percentile of rainfall events has increased by more than 1 inch for most of the region. This will trigger more CSO events because these systems are not designed to handle large volumes of water. Increases in overflow events will put more water systems, both drinking and recreational water, at an increased risk for pathogen contamination. *Id*. at 877.

68. OFFICE OF GROUND WATER AND DRINKING WATER, U.S. EPA, DRINKING WATER INFRASTRUCTURE NEEDS SURVEY AND ASSESSMENT: FIFTH REPORT TO CONGRESS 1–4 (2013).

69. WILLIAM D. EGGERS & TIFFANY DOVEY, CLOSING AMERICA'S INFRASTRUCTURE GAP: THE ROLE OF PUBLIC-PRIVATE PARTNERSHIPS 4 (2007).

70. AWWA, *supra* note 62, at 13.

2. The Rising Cost of Water

Regardless of which schemes state and local governments choose to finance their much-needed water infrastructure investments, residents will pay for the costs. This raises important affordability and cost distribution questions.[71] In the fast-growing South and West regions, the costs will be more than half the national total because of the need to repair and expand the current water distribution systems to serve incoming residents.[72] Prospective residents and builders are expected to pay for the expansions through impact fees or development fees, but established residents will still have to pay for the replacement of the existing infrastructure. In the Northeast and Midwest regions, growth will remain a relatively low component of the infrastructure costs, but as some localities see a decline in population, the remaining residents will have to bear a greater share of the costs for upgrades.[73] In some of the most affected communities, utility bills could triple (or increase as much as $550 per year for a three-person household) above current levels.[74] In large water supply systems with greater population density, the costs could still increase on average between $75 and $150 per year.[75] Furthermore, these costs will continue to grow steadily over time until all of the worn-out pipes have been replaced.[76]

Against this backdrop, water rates are already growing above inflation.[77] Since clean water is a necessity, low-income families carry most of the burden of the rising costs. Keeping water rates affordable is proving difficult for water managers around the country. Philadelphia recently created the first income-based water rate to cross-subsidize the cost of water delivery between rich and poor households.[78] Last year, Atlanta voted on an increase of one percent sales tax for

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71. A more recent survey shows even higher increases. Brett Walton, *Price of Water 2017: 30 Percent Increase in 30 Large U.S. Cities*, CIRCLE OF BLUE (May 18, 2017), https://perma.cc/LSA6-8QW7.

72. AWWA, *supra* note 62, at 11.

73. *Id.*

74. *Id.* at 10, 12.

75. *Id.* at 12.

76. This is because the pipes currently underground have aged at different rates depending on their material and time underground. The AWWA study calculates that the national level of investment will roughly double from about $13 billion a year in 2010 to almost $30 billion in annually in 2040. If growth were included, this would bring the costs up to $50 billion over the same period of time. *Id.*

77. Walton, *supra* note 71. According to the 2015 Circle of Blue survey: "The average monthly cost of water for a family of four using 100 gallons per day climbed six percent according to data from utilities collected in 30 major US cities. The median increase in 2015 was 4.5%. In comparison, the Consumer Price Index rose just 1.8% in the 12 months ending in March, not including the volatile energy and food sectors. Including these, prices fell by 0.1%." *Id.*

78. Under the program, a household earning less than 50 percent of the federal poverty line, or $12,300 for a family of four, will pay no more than 2 percent of their monthly income in water, sewer and storm water charges. The rate rises with income; a household earning between 100 percent and 150 percent of the poverty level will pay no more than 3 percent of income for those services. Brett Walton, *Philadelphia Water Rates Links Payments to Household Income*, CIRCLE OF BLUE (May 16, 2017), https://perma.cc/4Y25-RYWZ.

another four years to spread the cost of its monstrous water infrastructure bill beyond water consumers. In California, the state legislature is considering several schemes to overcome the state prohibition of cross-subsidization and guarantee the effectiveness and consistency of water utility lifeline rates for low-income users.[79] Water affordability is a particularly acute problem in California. Water service is provided by a conglomerate of over 3,000 entities between municipalities, counties, and mutual and private agencies, some of which are too small to afford discounted rates for their poorest customers. Moreover, since water rates are set locally, a patchwork of widely different programs has emerged to assist those most impacted by the sharp increases of water rates further aggravated by the ongoing drought.[80] The state is now evaluating options to deliver relief though a state-funded program, which is estimated to cost from $277 million to $619 per million year.[81] Together with the need for new water infrastructure, the rising costs of water makes the case for water conservation only more compelling both for governments and individuals.

3. Problems with Centralized Systems

Over the last two centuries, mechanized and hyper centralized water supply infrastructure has proven extremely effective to eliminate waterborne diseases and create a comfortable way of living. But it has also disconnected people and the industrial processes from the water cycle. Today, approximately 90 percent of Americans rely on public water supplies for their drinking water.[82] A water treatment plant (owned by a public or private water utility) withdraws water from a surface or underground source, treats that water with chemicals (chlorine or other type) and pumps it into the city's underground-piped network.[83] While this model undeniably has its advantages (as urban dwellers experience the convenience of turning the tap and getting drinkable water instantly), it also presents substantial

79. A lifeline rate is a special rate charged by a utility company for low income, disadvantaged, and senior citizens. These rates typically provide a discount for minimum necessary utility services such as electricity, telecommunication, and water. In California, a state law (Proposition 218 of 1996) prohibits charging more to high-income customers to fund rebates or subsidies for poorer residents. Michael Hiltzik, *The Next Crisis for California Will Be the Affordability of Water*, L.A. TIMES (Jul. 7, 2017, 2:20 PM), https://perma.cc/RMS2-5K35.

80. *Id.*

81. *Id.*

82. U.S. EPA, *Information about Public Water Systems*, https://www.epa.gov/dwreginfo/information-about-public-water-systems (last visited Nov. 26, 2018). A public water system provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year. A public water system may be publicly or privately owned. In 2010, approximately 14 percent of the population obtained drinking water from non-public water supplies. Non-public water supplies are often private water wells that supply drinking water to a residence. USGS, *Contamination in U.S. Private Wells*, https://perma.cc/9VG3-4P5F (last visited Sept. 4, 2019).

83. U.S. EPA, *Drinking Water Distribution Systems*, https://perma.cc/AK3Z-JG8L (last visited Nov. 26, 2018).

drawbacks. To begin with, it is subject to numerous structural vulnerabilities such as extensive and expensive maintenance, water losses due to long and complex distribution lines, and increasing risks to human health from worn-out pipes leaching lead or other harmful substances.[84] The bigger the system of water distribution, the harder it becomes to manage these vulnerabilities.[85] For instance, while the technology to detect water leaks is improving, it does not obviate the need to replace overused pipes.

Even without the urgency and magnitude of the cost to upgrade, this model is becoming increasingly obsolete to meet present and future water needs because it lacks any meaningful adaptation mechanism to cope with growing water supply challenges. Water utilities draw water from the same finite pool, such as a nearby river, lake or underground aquifer, shared with other competing users. Moreover, water supply and distribution systems are once-through systems. Once potable water reaches buildings and factories and on-site use takes place, the second step is to flush wastewater away through the sewage system to a water treatment plant where cleaning of wastewater occurs before discharge into coastal waters or inland locations.[86] Millions of gallons of highly treated water, particularly in coastal areas of the United States where most of the population resides, are lost to the oceans each day. While clear environmental considerations lie at the heart of water treatment, the process is energy intensive and results in the loss of water that could be re-utilized instead. Other methods of collecting water and increasing supply from non-conventional water sources such as rainfall capture and storage or water recycling and reuse are generally disregarded. As a result, there is no built-in backup in case the local point of water intake diminishes because of seasonal variation, extreme weather occurrences or depletion.

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84. The malicious introduction of harmful substances in the drinking water supply became a source of concern after the attacks on September 11, 2001, focusing the attention on the security of the nation's water infrastructure. As a result, Congress enacted the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, which requires larger water utilities to assess the vulnerability of their systems to terrorism and file those assessments with the EPA. For an account on the likelihood and viability of terrorist attacks targeting drinking water supply systems, see SALZMAN, *supra* note 1, at 140–58.

85. In many American cities, where municipalities struggle with budgetary constraints and tax levy limitations to address infrastructural failures and finance waterworks, the most vulnerable portions of the population (elderly and children) are the ones suffering the most from overexposure to lead and other chemicals increasingly present in their drinking water because of excessive leaching from worn-out pipes. The drinking water crisis that erupted in Flint, Michigan, between 2014-2015, for example, caused the death of 12 people—mostly elderly or with already weak immune systems; similarly, back in 2004 in the District of Columbia, the presence of amounts of lead in the water above the level prescribed by EPA due to a change in the treatment process that resulted in the corrosion of pipes, raised particular concerns for the safety of children. Kayla Ruble et al., *Five Years In, the Flint Water Crisis Continues Its Deadly Toll*, FRONTLINE (April 25, 2019), https://perma.cc/4S9Q-SGXP; Neal Augenstein, *Before Flint: D.C.'s Water Crisis Was Even Worse*, WTOP (April 4, 2016, 2:53 AM), https://perma.cc/C6XC-YNY5.

86. OFFICE OF WATER, U.S. EPA, *supra* note 4, at 6.

Finally, the present system of dams, reservoirs, and canals that collects and controls water flows within and between water basins works well under average climatic conditions, but it was not conceived to deal with more unpredictable and intense weather occurrences. It is a system that produces immediate results through powerful mechanized means of extraction, treatment, transportation, and distribution of water over long distances but does not incorporate elements of the natural process through which water circulates on Earth and replenishes freshwater reserves.

4. Problems with Water Management

Thus far, water managers have been following a quick-fix approach to water shortages such as looking to bring more water from other more distant reservoirs, or pumping underground water at deeper levels while transferring the costs of large water transportation projects or deeper wells on residents.[87] However, haphazardly pumping water out of surface (lake or river) or underground storage (aquifers) at rates and quantities that do not consider the natural rate of recharge of these storage systems perpetuates pockets of water deficit and exacerbates vulnerability to droughts. As water expert Peter Gleick has analogized, "it's like a bank account where more [water in this case] is going out than coming in. Pretty soon, your bank balance [or your reservoir level] dries up. You cannot operate the system for the long term if you are spending more than is coming in."[88]

With industrialization, water has progressively lost both its communal and local dimensions, and water rights have become subject to greater intrusion by the central state to accommodate the demands of multiple categories of users, regardless of whether these users (and their needs) are connected by tradition and physical medium to a particular watershed or among themselves.[89] Today, governments in charge of managing public water goods do so in the interest of large constituencies with often conflicting interests, privileging those water users and enterprises that can exercise the greater economic and political influence.[90] In light of increasing water scarcity due to climatic and development trends, scholars argue that water law has become obsolete to meet the needs of industrialized society.[91] In the United States specifically, individual water permits based on the

87. Noah Hall et al., *Climate Change and Freshwater Resources*, 22 NAT'L RES. & ENVT., no. 3, at 33 (2008) (stressing how water managers and utilities have been living by the notion that "there is always more water available from another source"); GLENNON, *supra* note 50, at 135–46. To try to meet both basic and luxurious demands for water, water managers have been looking at further, distant, improbable, and sometimes prohibitively expensive strategies. This is not a sound approach, sustainable in the long run, or capable of meeting increasing water needs. It is instead unavoidable to cut on certain uses or projects, put a limit on demand, and ultimately adapt to our new water conditions.

88. Marks, *supra* note 46, at 40.

89. *See infra* Part IV.

90. Joseph W. Dellapenna, *Global Climate Disruption and Water Law Reform in the United States*, *in* ENVIRONMENTAL GOVERNANCE AND SUSTAINABILITY 171, 178–79 (Paul Martin et al. eds. 2012).

91. *Id.* at 171–72.

doctrines of prior appropriation and reasonable uses of water often fail to maximize the social welfare.[92] Moreover, water laws and their judicial interpretation in the East, as in the West, discourage water conservation goals.[93] Indeed, these doctrines have grown increasingly inadequate to address the needs of ever-larger pools of users sharing the same finite watershed within the limits of water's natural ability to regenerate itself. Both obey to an anthropogenic definition of water allocation that privileges economic development over ecological balance and ends up delivering winners and losers in an increasingly water-constrained reality.[94]

For all these reasons, large, centralized once-through water supply and distribution systems are becoming untenable. At this juncture, it is crucial to rethink this model and find ways to promote distributed water collection, water conservation, and water reuse. In a growing number of places, this entails diversifying sources of water supply and reusing water more than once. Fortunately, traditional systems to manage and supply water offer several lessons that can help modern society rediscover and appreciate its dependence on the hydrologic cycle and inspire successful strategies. At the same time, new ideas and technological advancements are showing what is possible to improve water management today and best prepare for the future. Albeit not necessarily connected to past experiences, these more recent solutions share with traditional water knowledge some underlying principles.

II. WATER KNOWLEDGE: LESSONS FROM THE PAST

Although people's values, beliefs, and preferences have changed over the millennia permeating many aspects of society, water's physical characteristics and its behavior in the natural environment have not.[95] The hydrologic cycle is the natural process through which water moves continuously and consistently on Earth, changing between liquid, vapor, and ice states.[96] Water evaporates from the oceans and vegetation into the atmosphere where it condenses and falls back into the oceans or onto land in the form of precipitation. Some precipitation falls as snow and accumulates in glaciers and ice caps; some falls as rain and seeps into the ground to replenish aquifers or is absorbed by plants roots; some rainfall flows over the ground by gravity to enter rivers and lakes, and ultimately reaches the oceans again. Through this process, the planet produces only a limited amount of water that is fit for human consumption. Only 2.5 percent of the total amount

92. *Id.* at 177.

93. *Id.* at 177–89; Hall et al., *supra* note 87, at 34–35.

94. *Water Appropriation Systems*, UNDEERC, https://perma.cc/ML4Z-QALD (last visited Aug. 30, 2019).

95. DORA P. CROUCH, WATER MANAGEMENT IN ANCIENT GREEK CITIES 3 (1993).

96. See *Summary of the Water Cycle*, USGS, https://perma.cc/E7E4-HSHR (last visited Nov. 27, 2018), for a detailed description of the hydrologic cycle.

of the water found on the planet is freshwater (i.e. not saline).[97] Most of it is stored in glaciers, ice caps and underground aquifers. An even tinier fraction is surface water found in rivers, lakes, ground ice (or permafrost), swamps and marshes, soil moisture, and air humidity.[98] Although renewable, freshwater is not only limited, but also is unevenly distributed complicating its access and management.[99] However, because of water's unique and immutable properties, a historian ably described the study of water as "culture free" in that it allows people to rediscover, reuse, and readapt water management techniques over time.[100]

Historically, methods to access and supply water have rested on sound hydrogeological, engineering, and ecological principles.[101] Such solutions integrate local resources into their processes; in other words, they maximize the use of air, sun, land, and water in ways that are harmonized with the surrounding landscape and can sustain all forms of life including protecting humans from natural or human-caused disasters.[102] For example, creating small flat areas bordered by dry stone walls which sustain the ground (known as terracing) allows people to grow food in otherwise inhospitable surfaces by retaining rainwater while, at the same time, protecting the soil from erosion and downhill villagers from landslides.[103] Techniques such as terracing (in agriculture); collecting and storing rainwater in basins and cisterns; exploiting gravity to convey runoff into tunnels, underground drainages, and other catchment areas to avoid evaporation and replenish the local water table; and extracting water from air humidity by taking advantage of temperature differences between night and day to increase supply have enabled ancient civilizations to thrive and continue to be used to this day in many parts of the world. Their durability resides in their adaptation to the local natural conditions and the hydrologic cycle. Therefore, examining traditional methods to access, supply, and manage water is a useful exercise because it invites modern society to reflect on its relationship with this indispensable resource, evaluate present problems, and imagine future opportunities.

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97. U.S. Geological Survey, *The World's Water*, https://perma.cc/VR9T-LYLE (last visited Nov. 27, 2018).

98. *Id.*

99. *Water: A Limited Resource*, FRESHWATERWATCH, https://perma.cc/325X-LT8L (last visited April 3, 2019).

100. CROUCH, *supra* note 95, at 21 ("[W]ater's behavior is consistent, but people forget and rediscover information about that behavior, and reinvent how to utilize water for their purposes."); *see generally* STEVEN SOLOMON, WATER: THE EPIC STRUGGLE FOR WEALTH, POWER AND CIVILIZATION (2010) (theorizing that water's initial conditions and human solutions to access sufficient water shaped civilization since the beginning of time and will continue to determine its destiny).

101. Mays, *supra* note 8.

102. Larry W. Mays, *Lessons from the Ancients on Water Resources Sustainability, in* ANCIENT WATER TECHNOLOGIES 219, 228 (Larry W. Mays ed., 2010).

103. *Water and Traditional Knowledge*, UNESCO, https://perma.cc/6LVJ-M6HH (last visited August 30, 2019).

A. HARNESSING TRADITIONAL KNOWLEDGE

1. The Value of Traditional Knowledge

At the World Conference on the Environment and Development held in Rio de Janeiro in 1992 (the "Earth Summit"), the United Nations officially recognized the fundamental contribution of traditional knowledge to building resilience against climate change and loss of biological and cultural diversity, conserving natural resources, and enhancing global sustainable development.[104] Traditional knowledge consists of practical (instrumental) and normative (enabling) knowledge about the ecological, socio-economic, and cultural environment.[105] It is people-centered (generated and passed on by people as knowledgeable, competent, and entitled actors), systemic (inter-sectorial and holistic), experimental (empirical and practical), transmitted from one generation to the next, and culturally valorized.[106] It supports diversity and both enhances and reproduces local (internal) resources. Traditional knowledge emanates from a community or group of communities, defines its identity, and sometimes provides ownership rights over its inventions and work products. In addition, it offers decision-makers a tool to assess the efficiency of a method of production in which both internal and external aspects are considered.[107] Although modern technologies aim at an immediate efficiency through highly specialized knowledge and means of production external to the environment (separation and specialization), traditional knowledge operates instead by integrating and connecting (holism and symbiosis).[108] It allowed ancient societies to keep ecosystems in balance and achieve local and environmental sustainability over the long term.[109] The same is true for indigenous and Native American communities.[110]

2. Borrowing from Traditional Knowledge

Sometimes modern cultures rediscover and acquire elements of ancient practices; other times original cultures borrow from modern and scientific developments, which they incorporate into their knowledge and techniques.[111] There are examples of both instances in different parts of the world and in different

104. Mays, *supra* note 102, at 227–228; *The Knowledge of Indigenous Peoples and Policies for Sustainable Development*, INTER-AGENCY SUPPORT GROUP ON INDIGENOUS PEOPLES' ISSUES 1-3 (June 2014), https://perma.cc/9EQF-35X3.

105. United Nations Convention to Combat Desertification ("UNCCD"), *Promotion of Traditional Knowledge* 50 (2005).

106. *Id*. at 51.

107. *Id*. at 12.

108. Mays, *supra* note 102, at 228.

109. Mays, *supra* note 102, at 228.

110. Anthony Moffa, *Traditional Ecological Rulemaking*, 35 STAN. ENVTL. L.J. 101, 102 (2016).

111. UNCCD, *supra* note 105, at 20.

contexts. One example of a traditional water supply technique is the *qanat*.[112] First developed in Persia in the third millennium B.C., a qanat is capable of conveying large amounts of water from long distances.[113] This water technology consists in an underground tunnel that uses gravity to convey water from a water table at higher elevation to the surface of lower lands to irrigate fields and supply water to villages.[114] The tunnel has a series of vertical shafts to provide for air, light, and convenient access for cleaning and maintenance.[115] Qanats rely on the simple concept of taking advantage of the difference in altitude and allow precipitation to naturally percolate in the terrain and recharge the water table. The technology spread extensively under Persian, Arab, and Roman spheres of political and cultural influence, and across trading routes reaching China and the New World.[116]

Qanat technology today exists with local variations in over thirty-five countries, but most functioning qanats are located in Iran, the region once occupied by the ancient Persian kingdom.[117] A qanat system offers several significant advantages over modern means of water transport and delivery because it is capable of extracting and supplying water in a controlled manner, with minimum losses and no use of pump energy.[118] In the late eighties, the city of London began putting the old qanat wisdom to good use by building an underground tunnel that forms a closed loop around the city's drinking water system from the point of water intake

112. *Qanat* means in the Semitic language "to dig." H. E. Wulff, *The Qanats of Iran*, 218 SCIENTIFIC AMERICAN 94, 94 (1968).

113. Larry W. Mays, *A Brief History of Water Technologies in Ancient Times Before the Romans*, *in* ANCIENT WATER TECHNOLOGIES 3–4 (Larry W. Mays ed., 2010). Digging qanats involves a considerable amount of work and sophisticated engineering skills. Hand-digging qanats used to be a traditional family job in Persia, where the technology originally developed, performed by highly skilled workers called "Muqanni."

114. *Id.*

115. See *Qanats*, WaterHistory.Org, https://perma.cc/RC86-N77K (last visited Feb. 12, 2019), for an additional graphic illustration of an original Persian qanat. Qanats are protected under the World Heritage Convention as "unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared" and "outstanding example[s] of a type of building, architectural[,] or technological ensemble illustrating [a] significant stage" in human history. *The Persian Qanat*, UNESCO, https://whc.unesco.org/en/list/1506 (last visited Feb. 12, 2019).

116. Mohsen Taghavi-Jeloudar et al., *Review of Ancient Wisdom of Qanat, and Suggestions for Future Water Management* 18 ENVTL. ENGINEERING RES. 57, 59 (2013).

117. *Id.*

118. *Id.* at 59–60. Qanats exploit groundwater as a renewable resource in contrast to a vertical mechanized well. The rate of flow in a qanat is always controlled by the level of the underground water table at the point of seepage. Thus, a qanat cannot withdraw excess water from the aquifer because its flow varies with the subsurface level of the water supply. If the level drops below the point of intake, water will stop flowing. Once the water table is recharged and the necessary level reestablished, water will start flowing again. Qanats offer a way to extract and use water that is self-sustainable and delivers several ancillary benefits such as decentralized water collection, natural water filtration, water storage and flood control during heavy rains. In addition, qanats systems can be employed for different productive uses, for example, running a water mill, cooling hot air and even operate as a fish farm.

in the Thames Valley to southwest London.[119] Today, twenty-one vertical shafts present all around the city transfer water from the ring beneath to the surface using only depth pressure and gravity. The system offers a decentralized way to distribute water that limits water losses compared to surface mains and saves energy and money at the same time.[120]

However, the reverse is also happening. Modern technology is currently being utilized to restore and modernize qanats with geotextile pipes and geomembranes that help protect the tunnel from erosion and better control flows. Geo-radar techniques, geographical information systems, and remote sensing instruments are also used to rapidly locate and operate repairs on qanats.[121] Likewise, the simple technique of extracting water through condensation, known and practiced for millennia, is currently being adopted in several countries using modern devices to help solve the problem of water access in poor rural areas with a vastly dispersed population.[122] These examples indicate that both modern and more traditional cultures are borrowing elements from each other and enhancing their respective knowledge to overcome their challenges.

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119. Construction of the London Water Ring Main took place between 1988 and 1993. Two extensions were added in the late 2000s and further extensions are planned through 2025. *Id.* at 62-63.

120. Thames News, *Thames Water Proposes Water Tunnel for London*, YOUTUBE (Jan. 15, 2015), https://perma.cc/5Z4A-NC5Y (highlighting how the project constitutes a better alternative than upgrading current surface mains, built in the last century, prone to frequent leaks and bursts and expensive to maintain).

121. *Id.*

122. *See, e.g.*, Newsy Tech, *Billboard in Peru Turns Air into Clean Water*, YOUTUBE (Mar. 23, 2013), https://perma.cc/G4VG-GQYK; Tuan C. Nugyen, *This Tower Pulls Drinking Water Out of Thin Air*, SMITHSONIAN.COM (Apr. 8, 2014), https://perma.cc/ST2X-CPK7; Joe Flaherty, *A Giant Basket that Uses Condensation to Gather Drinking Water*, WIRED.COM (Mar. 28, 2014, 6:30 AM), https://perma.cc/2DWW-F8RZ. Because condensation relies on the difference in temperature between nightfall and daybreak, the towers are proving successful even in the desert, where temperatures, in that time, can differ as much as 50 degrees Fahrenheit. In Ethiopia, for example, industrial designers Arturo Vittori and Andreas Vogler conceived a low-maintenance and low-cost structure capable of collecting twenty-five gallons of clean drinking water per day that mimics the Warka tree, a giant domed tree native to Ethiopia that sprouts figs and is used as a community gathering space. The structure uses the natural occurring process of condensation to convey water in a tower made of both natural materials, such as juncos and bamboos that grow locally, and a mesh of nylon textile, assembled without the need of any expensive machinery but only using bear hands and a team of five-six villagers. Drilling water wells on the rocky Ethiopian soil is difficult and very expensive. This system, in contrast, is a quickly deployable and inexpensive solution integrated within the natural and cultural context that can deliver immediate results but also meets the test of time. As noted by Vittori: "WarkaWater is designed to provide clean water as well as ensure long term environmental, financial and social sustainability. Once locals have the necessary know how, they will be able to teach others villages and communities to build the WarkaWater towers. Each tower costs approximately $550 and can be built in under a week with a four-person team and locally available materials." In Ethiopia, as in most of Africa, children usually spend hours collecting water from distant and unsanitary sources, instead of attending school. This technique will save women and children an average of six hours per day, or forty-eight billion hours per year, in gathering enough water for their basic needs.

3. Integrating Traditional Knowledge

After the Earth Summit, the Science and Technology Committee of the United Nations Convention to Combat Desertification further clarified that the inventory and classification of traditional knowledge does not serve the purpose of providing for miracle solutions directly applicable to the modern production system.[123] Instead, its value resides in the underlying logic of a model we can learn from and utilize again through means of modern technologies.[124] In this context, "traditional" does not mean old-fashioned, backward, or inappropriate; rather, the term indicates customary rules, institutions, and practices based on continuous observation and experimentation that evolve with people's needs, environmental conditions, and other socio-economic factors.[125] In other words, traditional knowledge has built-in mechanisms to renew and adapt itself. It incorporates innovation in a dynamic fashion.[126] Traditional knowledge does not become frozen in time, but consists of a system of practices, technologies, and strategies from which society can learn and develop new approaches to adapt to changing conditions.

The empirical observations of water's behavior in the environment together with the collective knowledge, norms, and practices that developed from such observations constitute traditional water knowledge. Ancient civilizations relied exclusively on the observation of geological, meteorological, and other natural phenomena to gain access to and manage water resources, and on basic principles of physics, such as gravity and pressure to carry water where they needed it the most and to remove human waste.[127] Nevertheless, they reached an astounding degree of advancement in hydraulic engineering.[128] In addition to developing an

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123. UNCCD, *supra* note 105, at 22.

124. *Id.*

125. *Id.* at 56.

126. Mays, *supra* note 102, at 228.

127. *See* CROUCH, *supra* note 95, at 19–31 (according to the author: "[Traditional knowledge is based on] millennia of observation that had enabled ancient people to become experts about many aspects of their environment"). The chapter offers a chronology of water knowledge in Ancient Greek cities based on the understanding of natural phenomena through geological and meteorological observations as well as social consensus and administrative organization. *See also* Larry W. Mays et al., *Urban Water Infrastructure: A Historical Perspective*, *in* URBAN WATER SUPPLY HANDBOOK (Larry W. Mays ed., 2002).

128. ROBERT E. KREBS & CAROLYN A. KREBS, GROUNDBREAKING SCIENTIFIC EXPERIMENTS, INVENTIONS AND DISCOVERIES OF THE ANCIENT WORLD 132–33, 146–47 (2003). The basis of all engineering derives from four simple machineries: the lever, the wheel and axle, the pulley, and the inclined plane our ancestors discovered thousands of years ago. The Hoover Dam, the Golden Gate Bridge, and the Superdome are only but a few examples of modern-day architectural marvels built upon inventions, innovations, and technological expertise such as the Persian and Roman aqueducts, the Chinese suspension bridges of the third century B.C., and the Amphitheater Flavio (Colosseum), which could host between 50,000 and 80,000 spectators and be flooded with water for mock sea battles. With respect to large-scale engineering waterworks, the Chinese surpassed all other civilizations. They championed river management through the unwearied application over centuries of water redirection, terracing and drainage techniques to control floods and irrigate fertile soils. With highly sophisticated

understanding of water's behavior based on repeated observations, they invented water control and delivery systems such as canals, dams, pumps, aqueducts, sewers, and water-lifting technologies that form the basis of today's hydraulic knowledge.[129] Some systems are still in use today, and others are being reclaimed and readapted because of their intrinsic value.[130] As illustrated by the example of the qanat, it is possible to draw principles and ideas from traditional methods to access and supply water and apply their logic to improve current water systems.

Three main techniques have fallen mostly out of use since industrialization began: rainwater capture and storage, reuse of degraded water for beneficial purposes, and cooperation between small and large water supply systems. Moreover, with modernization, water started losing its local and communal character. Water used to be a resource exploited and managed in common within the boundaries of a particular geographical and cultural context. The administration of water traditionally connected people among themselves and the landscape through a system

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engineering knowledge, they built canals that revolutionized China's hydrology and unified the country economically, politically and militarily. The skillful exploitation of water made China the "most precocious preindustrial civilization in world's history" and shaped its identity for the centuries to come. JOSEPH NEEDHAM & COLIN A. RONAN, THE SHORTER SCIENCE AND CIVILIZATION IN CHINA:5, at 172–94 (1995).

129. For an illustration of water technologies by early civilizations, see ANCIENT WATER TECHNOLOGIES (Larry W. Mays ed., 2010); *see also* EVOLUTION OF SANITATION AND WASTEWATER TECHNOLOGIES THROUGH THE CENTURIES 20 (Andreas N. Angelakis & Joan B. Rose eds., 2014). In the Third Century B.C., for example, Archimedes of Syracuse (287–212 B.C.)—the Greek mathematician, physicist, engineer, inventor, and astronomer generally considered to be one of the leading scientists in antiquity and greatest mathematicians of all time—invented the water screw: a device with a revolving screw-shaped blade inside a cylinder that can raise water efficiently and is still in use for pumping liquids and granulated solids such as coal and grains.

130. A well-known example of traditional water knowledge integration in the urban context is the "Sassi" of Matera. Located in the semi-arid region of Basilicata in southern Italy, Matera is today a town of about 60,000 people entirely built in deep fault fissures, ravines, rocks, and caves of a calcareous highland plateau alongside the border of a deep valley. Since the Paleolithic to the present day, given the very limited availability of surface water, its inhabitants have relied on rainwater catchment, distillation, and condensation as their main source of supply. During rainfall in the winter, the terraced structure of the dwellings and the water collection system protects the slopes from erosion. Water flows by gravity from the roof's edges (which never go beyond the walls) through canals in bell-shaped cisterns connected to each other by a vertical structure with up to ten levels of dwellings one on top of the other. During the dry summer period instead, hot humid air percolates in ample vaults carved from the rock where the cooler inside temperature of the inner wall transforms air in water droplets that fall in an underground cistern. At night, the process reverses: the exterior temperature is cooler and produces frost on the exterior walls that melts at the first sunrise and filters down inside the cavity where the water is collected again in the cistern. Thanks to funding from the Italian government, private dwellings, churches, monasteries, and other buildings have been restored and the oldest part of the city revitalized. These interventions have allowed the city to continue to rely on this traditional method of water supply, perfectly efficient and harmoniously integrated with the natural and hydrologic equilibrium that sustains it, with evident benefits for its people, the municipality, and the environment. Listed as a World Heritage Site since 1993 and described as "one of the most evocative landscapes of the Mediterranean," Matera is visited year-round by thousands of tourists from all over the world, boosting the local economy thanks to the unique role that human ingenuity coupled to water self-sufficiency have played in this particular site since time immemorial. *The Sassi and the Park of the Rupestrian Churches of Matera*, UNESCO, https://perma.cc/KGU3-LDX2 (last visited Nov. 27, 2018).

of water management rights that distributed risks and benefits equally.[131] Today, fair distribution and ecological considerations rarely guide water allocation decisions.[132] Together with water supply techniques, customary norms emerging from traditional collective practices hold important lessons to address the water crisis of today. Both are discussed in the sections below, after a brief description of the water supply infrastructure in early conglomerates.

B. WATER SUPPLY INFRASTRUCTURE AND URBANIZATION IN EARLY CONGLOMERATES

1. Water Supply Infrastructure

In the Bronze Age (third millennium before Christ) throughout China, Mesoamerica, Mesopotamia, and the Indus valley,[133] water engineering practices to collect, distribute, and use water in cities were comparable to modern standards.[134] For example, in the island of Crete near the Peloponnese in the east Mediterranean Sea, the Minoans enjoyed running water and flushing toilets.[135] Just a few centuries later, their successors began pumping spring water across valleys at high pressure using lead pipes and the inverted syphon to deliver water to their cities.[136] The Indus civilization stands out for its personal and communal sense of cleanliness and its conscious efforts to avoid water contamination.[137] In cities like Mohenjo-Daro, Dholavira, Lothal, and Harappa in the Indus Valley, households had bathrooms connected to the main street drain and street sewers were covered by loose bricks, flagstones, or wooden boards that were easy to remove by municipal workers for cleaning purposes.[138] Wells were usually

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131. *See* discussion *infra* Section III.C.3.

132. *See supra* text accompanying note 87.

133. The Mesoamerican civilization developed in parts of Mexico and Central America prior to Spanish exploration and conquest in the 16th century. Together with the Andean civilization farther south, this complex of indigenous cultures constituted the New World's counterpart of those of ancient Egypt, Mesopotamia, and China for its organization in kingdoms and empires, the sophistication of its monuments and cities, and the extent and refinement of its intellectual accomplishments. ENCYCLOPEDIA BRITANNICA, *Mesoamerican civilization*, https://perma.cc/L4QJ-T525 (last visited Nov. 28, 2018). Mesopotamia means "between rivers" in Greek, referring to the land between the Tigris and Euphrates rivers where the world's earliest civilization is known to have developed. The region includes the area that is now eastern Syria, southeastern Turkey, and most of Iraq. The region was the center of a culture whose influence extended throughout the Middle East and as far as the Indus valley, Egypt, and the Mediterranean. Richard N. Frye ET AL., *History of Mesopotamia*, ENCYCLOPEDIA BRITANNICA (updated Aug. 5, 2019), https://perma.cc/FQ34-4C6P.

134. In general, permanent settlements began some 10,000 years ago when hunter-gatherers discovered agriculture and formed the first farming villages. The first recorded settlement is history that can be classified as urban is Jericho (8000–7000 B.C.), located presumably near springs and other bodies of water in what is now modern Palestine. Mays et al., *supra* note 102, at 1.3–1.4.

135. CROUCH, *supra* note 95, at 20.

136. Mays, *supra* note 113, at 15.

137. Saifullah Khan, *Sanitation and wastewater technologies in Harappa/Indus Valley Civilization (ca. 2600 – 1900 B.C.), in* EVOLUTION OF SANITATION AND WASTEWATER TECHNOLOGIES THROUGH THE CENTURIES 31 (Andreas N. Angelakis & Joan B. Rose eds., 2014).

138. *Id.* at 31–32.

located at a safe distance from the street drains to prevent water contamination with human waste.[139] The Indus systematically collected solid waste and rubbish using septic tanks, grit chambers and wall chutes with bins at the street level emptied by scavengers.[140] This method in particular prevented waste accumulation and the risk of sewage overflows. Wooden screens at the end of the street drains also served as filters, and only liquid waste entered the main sewer and then the estuary.[141] Well before modern science could explain waterborne diseases, ancient civilizations were cognizant of the linkage between water and illness and had sanitation procedures in place to prevent them.[142]

2. Rainwater Harvest

For millennia, ancient civilizations successfully harvested rainwater to mitigate seasonal variations and meet both domestic and municipal needs. They primarily employed buildings' architecture and made extensive use of cisterns, both effective techniques. In Mohenjo-Daro, an elaborate system of canals, private and public wells, rock-cut tanks, massive cisterns, and reservoirs of impressive storage capacity collected and stored rainfall and diverted water from nearby streams.[143] The Minoans had flat roofs and open courts (forerunner of the Roman *impluvium*) that acted as catch basins to convey rainwater into storage areas and cisterns.[144] Since rainwater was generally of lesser quality than spring water, they invented a device made of terracotta and filled with burned wood to filter rainwater using a natural activated carbon process before it reached the sedimentation tank, where it was further cleared from sediments or suspended materials and finally conveyed through a small canal in the main household cistern.[145] Cisterns were also built outside the villages at the top (smaller one) and bottom (bigger one) of hills with vertical walls and rounded bottoms to take full advantage of the slope to help convey storm water inside, store water, and avoid soil erosion and

139. *Id.*

140. *Id.* Streets had public bins at convenient places.

141. *Id.* The main sewer was built out of bricks joined seamlessly and perfectly watertight, and it ran under the city, connecting sewers from north to south and east to west.

142. Some environmental scholars reject the idea that traditional knowledge is somehow inferior or suboptimal to modern science and technology. *See*, *e.g.*, Moffa, *supra* note 110, at 124–25.

143. According to historians and archeologists, these were deliberately planned cities characterized by a precise grid system and buildings made with same size baked bricks, wood, and stones placed on both sides of the lanes with doors rising above street level and stairs recessing at the front door. Ruins show a highly organized and flourishing culture based on commerce, trade, and agriculture. Khan, *supra* note 137, at 25, 29–30.

144. The palace of Knossos, for example, had pressurized terracotta pipes and open canals made of carved stone that distributed rainwater and water from the spring; in Phaistos, the water supply system depended entirely on rainwater collected from roofs and courtyards and stored for the dry season. Andreas N. Angelakis & Demetris Koutsoyiannis, *Urban Water Engineering and Management in Ancient Greek Times*, *in* ENCYCLOPEDIA OF WATER SCIENCE 999–1007, at 1000–1001 (Bob A. Stewart & Terry A. Howell, eds., 2003).

145. Mays, *supra* note 113, at 7–10.

landslides—a technique that disappeared with modern urbanization.[146] Moreover, with the advent of mechanization and modern plumbing, the use of communal and household cisterns has also fallen out of use.[147] Nevertheless, in places such as dry-land farming regions in the Middle East or arid and semi-arid regions around the Mediterranean Sea, cisterns continue to be an essential feature of any well-designed water system to deal with limited water availability and successfully meet urban and agricultural needs.[148] Rainwater capture is an excellent water management method in wet climates as well to mitigate flash floods, enhance water self-sufficiency, and help preserve local water sources.[149]

3. Water Reuse

The progressive expansion of the urban population and increasing water demand prompted a systematic reuse of grey and black water and a separate use of potable and non-potable water, each for its intended beneficial uses.[150] This was common practice in Greek lavatories and Roman baths. In ancient Greece, lavatories in private houses, public buildings, and sanctuaries had bench-type seats with a keyhole opening and an underneath ditch connected to the sewage network. Ditches were flushed with reused water from other domestic (bath, kitchen) or communal (shrines, workshops, and public baths) activities in an effort to conserve limited water supply.[151] Greeks also made systematic use of black and grey water and storm runoff by collecting it in sewers and channeling it

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146. Mays et al., *History of Water Cisterns: Legacies and Lessons*, 5 WATER 1916–40, 1917 (2013). The first cisterns were simple holes of waterproof lime built in the house floors of the Neolithic Era. By the Bronze Age, they represented an essential element of emerging water techniques in dry rural lands and well-planned cities. Their technology kept evolving during the Archaic (750–480 B.C.), Classical (480–323 B.C.) and Hellenic periods (323 B.C.–death of Alexander the Great) up to present day where they still constitute an important water supply practice in Greece especially in rural areas.

147. *Id*. The authors stress how "[t]hroughout history, cisterns have been an essential part of water supply technology for human survival and well-being to obtain water resources sustainability . . . though their importance to modern-day supply purposes has vanished somewhat in developed parts of the world, despite having continued in many developing parts of the world." Yet, many historic buildings in Rome, including the one where I grew up, maintained and used water cisterns at least until the early 80's. These were typically located in the attic.

148. One great example of a water independent city is Venice, which massively relies on rainfall stored in cisterns due to its geographical location. *See* SALZMAN, *supra* note 1, at 111–12; Mays ET AL., *supra* note 126, at 1937.

149. Mohsen Taghavi-Jeloudar et al., *supra* note 116, at 61–62 (explaining how the qanat system can be used as a sustainable urban water management either in dry cities for water supply or in wet cities for flood control by capturing rainwater through the open series of shaft during heavy rain occurrences).

150. There are no universally accepted definitions for grey water and black water. Grey water generally indicates household wastewater (as from a sink or bath) that does not contain serious contaminants (as from a toilet or diapers) while black water is water containing fecal matter, untreated water, or sewage. Acceptable spellings for these terms include "grey water," "greywater," and "blackwater." *See* Roslynn Brain et al., *Defining Terms: Greywater, Blackwater and Clearwater*, https://perma.cc/MN65-5BXS (Jan. 2015).

151. Georgios P. Antoniou, *Ancient Greek Lavatories: Operation with Reused Water*, *in* ANCIENT WATER TECHNOLOGIES 80–81 (Larry W. Mays ed., 2010). Ditches were flushed using the natural flow of

outside the city using the force of gravity to fertilize and irrigate fields and provide water for local industries, reforesting, and naturally replenishing the water table.[152] This way they achieved a highly efficient closed loop system at a low cost to sustain their surrounding ecosystems. This method evidences the importance Greeks gave to an efficient use of water as well as their understanding of the water cycle.

The Italian peninsula, by contrast, benefitted from much more generous water endowments; therefore, the Romans preferred high quality water carried directly from a nearby spring for drinking and regular bathing.[153] However, contrary to modern day practice, they systematically matched water quality to its different purposes, using lower quality water for irrigation, gardening, cleaning, flushing, and latrines.[154] They used storm water to help drain and wash away waste on the side of the streets. Whenever possible, they made the most of rainwater through harvesting and storage rather than relying on underground water, particularly where water was not abundant, such as in southern parts of the peninsula or in the northern African colonies.[155]

In the past, water reuse was a non-wasteful, responsible way to make the most of the water already available and to satisfactorily meet multiple uses, without water undergoing extensive treatment. The same logic, if applied today to design water systems, could help save both energy and money, and conserve water resources.

4. Small and Large Scale Water Supply Systems

Greek and Roman cities used a multi-source decentralized hydraulic system to supply water to their cities. In Greece, to meet the growing water needs of an increasingly comfortable urban life, people used a combination of small-scale cisterns situated inside their residences and large-scale ones, such as the ones found in front of the Theater of Delos, or in Eleutherna, which had a remarkable capacity of 1000 cubic meters.[156] From an organizational perspective, this shows

water or taking advantage of the adjacent drainage at street level. Reuse of water also took place inside the lavatory.

152. CROUCH, *supra* note 95, at 153–54. Precipitation constituted the main source of drinking water supply in the Peloponnese due to its general lack of surface water. Therefore, the Hellenic people also made extensive use of sand filters and sedimentation tanks to treat rainfall water before it flowed into the cisterns and cleaned surfaces with special care in order to maintain water purity. Angelakis & Koutsoyiannis, *supra* note 144, at 1001; *Urban Water Engineering and Management in Ancient Greek Times*, *in* ENCYCLOPEDIA OF WATER SCIENCE 999–1007 (Bob A. Stewart & Terry A. Howell, eds., 2003).

153. Larry W. Mays, *A Brief History of Roman Water Technology*, *in* ANCIENT WATER TECHNOLOGIES 115 (Larry W. Mays ed., 2010).

154. Olfa Mahjoub & Mohamed Thameur Chaibi, *The Sanitary System in Ancient Roman Civilization: an Insight on Tunisia*, *in* EVOLUTION OF SANITATION AND WASTEWATER TECHNOLOGIES THROUGH THE CENTURIES 272 (Andreas N. Angelakis & Joan B. Rose eds., 2014).

155. *Id*. at 273.

156. Mays ET AL., *supra* note 126, at 1920–22.

how a mix of centralized and decentralized outlets both ensured water was continuously available where needed and improved the quality of life.[157] Cisterns were filled with a combination of rainwater, water from underground wells, and spring water brought by the aqueduct (a practice that continued with the Romans) to mitigate seasonal variation and manage water demand.[158] To this day, in many Greek islands, people fill private cisterns with rainwater and desalinized seawater provided by the municipality.[159]

In the Italian peninsula, before the advent of aqueducts and public large-scale water projects, cities like Ostia and Pompeii had relied on rainwater harvesting systems, cisterns, and wells for centuries.[160] Initially, in Ostia, water was supplied by underground wells disseminated around the city in public spaces for communal use and gathering (e.g., forum, temples and sanctuaries, cemetery, theater), along the main street crossing the city from east to west, in the military camp, and in private houses.[161] Archeological remains of both cisterns' and wells' design and structure reveal the ingenuous approach of filling them with water from different sources whenever available.[162] In private dwellings, cisterns were a functional element of the *impluvium*, i.e., the sunken part of the atrium floor where the water from the roof gathered and was then purified through a layer of gravel or

157. Nikos Mamassis & Demetris Koutsoyiannis, *A Web Based Information System for the Inspection of the Hydraulic Works*, *in* ANCIENT WATER TECHNOLOGIES 112 (Larry W. Mays ed., 2010); CROUCH, *supra* note 95, at 155. From a social perspective, cisterns also represented a way to economize the time and effort of women and girls inside the house (who would not have to gather it outside and bring it home for cooking and washing), as well as pooling and optimizing resources for the conduction of business in the agora and other locations reserved to men. We know that in ancient Greece women could participate in the political life, taking place in the agora. If we compare this with the time and effort women and girls currently spend in developing countries to collect water, sometimes kilometers away from their homes, it is striking to see how ancient wisdom can inform present time experiences serving as a model for possible solutions.

158. Angelakis & Koutsoyiannis, *supra* note 144.

159. Interview with Pietro Masci, Ph.D. in Public Policy, in Washington, D.C. (Sept. 15, 2017).

160. 1 MARIA A. RICCIARDI & VALNEA S.M. SCRINARI, LA CIVILTÀ DELL'ACQUA IN OSTIA ANTICA 15 (Fratelli Palombi ed., 1996). Marcus Vitruvius Pollio (born c. 80–70 BC and died after c. 15 BC) commonly known as Vitruvius, a Roman author, architect, civil engineer, and military engineer known for his multi-volume work entitled *De Architectura* describes various traditional methods used by early Roman settlers to find groundwater aquifers or springs: "One has to proceed as follows: dig a hole in the terrain five feet deep and three feet wide. At the sunset, deposit an oil lamp and light it on, then deposit one clean vase in bronze and one in clay, then cover the hole with branches and dirt. The day after, uncover it and if the lamp is without light, but has not consumed the oil, the bonze is oxidized and the clay is humid or crumbled apart, then water is in proximity. . . . Another sign is when a fleece is left on the terrain for some time and found humid; another is water vapor coming out of the terrain, then there is water" (translation from Italian to English by the author).

161. *Id.* at 10, 13. Ostia was founded in the Sixth Century B.C. by Anco Marcio, the fourth king of Rome. Situated in the Tiber's delta, Ostia started off as a small village and military camp inhabited by soldiers and workers in the nearby saline. It later developed into a heavy traffic center animated by the port of Trajan, on which Rome depended for its commercial activities with distant colonies, the proliferation of wealthy private villas along the western seaside, and the city's expansion—all supported by the aqueduct connecting Ostia to the inland hills of Acilia, rich in spring water.

162. *Id.* at 97.

sand before being stored in a chamber below ground.[163] This method helped ensure that water of excellent quality was always available and cooled by the inside temperature of the building. Although the topography of the city and its architecture evolved over time, Ostia consistently relied on rainwater as the basis of its water supply.[164] Pompeii, another prominent center at the time, drew water from a combination of wells reaching up to 110 feet below the surface, rainwater cisterns and other reservoirs, and spring water from the Serino located over sixty miles away and brought to the city by the aqueduct Augustus.[165] Households and public buildings had gutters along the eaves to collect rainwater and downspouts made of terracotta inside the walls to carry it to an underground reservoir.[166]

In Imperial Rome, increased reliance on aqueducts, while capable of moving huge quantities of water from afar, also meant frequent leaks, public officials' negligence, and illegal diversions, which resulted in large amounts of water loss, expenditures, and bureaucracy.[167] These are essentially the same issues facing current large-scale once-through water supply and distribution systems. The co-existence of large communal points of water intake with decentralized small-scale private reservoirs instead made Roman early municipal water systems not only less prone to abuse, but more affordable and effective in providing water to the urban population. The lesson here is that household self-sufficiency increases water availability and represents a valid solution when other alternatives fail. This practice, if rediscovered, would ease the consequences of water shortages and contribute lessening the pressure on the water distribution system.

C. WATER MANAGEMENT

1. Types of Water Resources

Roman water law principles have had a profound influence on the water legislation and administration of modern nations.[168] Under Roman law, there were

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163. *Id.* at 99.

164. *Id.* at 79. Based on her inspections and observations in Ostia, Professor Ricciardi points to several architectural elements in private and public buildings that lead her to believe that rainwater harvesting continued over time, even after the construction of the aqueduct, yet with some variations in the methods and systems used to fit in the structure of more luxurious and sophisticated homes.

165. Larry W. Mays, *A Brief History of Roman Water Technology*, *in* ANCIENT WATER TECHNOLOGIES 121 (Larry W. Mays ed., 2010). Water from the Serino spring, located in the region of Basilicata, served numerous cities (i.e., Pompeii, Herculaneum, Acerra, Atella, Nola, Pozzuoli, Miseno, Cuma and Baia) and private *villae*. It also alimented the most impressive and immense communal cistern ever built, the *Piscina Mirabilis* near Pozzuoli, in the bay of Naples, which supplied the Imperial fleet with water and had a capacity of 12,600 cubic meters.

166. *Id.* at 122–23.

167. *See* HARRY B. EVANS, WATER DISTRIBUTION IN ANCIENT ROME: THE EVIDENCE OF FRONTINUS (1993). Emperors, who had financed Rome's impressive water infrastructure with the spoils of war, began taxing citizens and requiring private gifts from rich families to pay for new constructions and repairs, but over the long term, Rome's magnificent aqueducts ultimately became unprofitable.

168. DANTE A. CAPONERA, PRINCIPLES OF WATER LAW AND ADMINISTRATION 59 (Marcella Nanni, 2nd ed., 2007).

three categories of water resources: waters common to everybody (*res comunis omnium*), public waters (*res publicae*), and private waters (*res sua*).[169] Waters common to everybody were waters not capable of any ownership status: no one could own these waters but, together with air and the seashore, in principle any man could make use of them.[170] This category applied to all flowing waters.[171] Public waters were waters owned by a community, municipality or other public institution with a legitimate title over them.[172] For example, all rivers and streams flowing on public land, springs feeding urban aqueducts at a mountain's foot, and mountain lakes and rainwater collected by natural mountain pools or artificial tanks were deemed public.[173] Accordingly, municipal authorities could allocate surplus public water to private uses.[174] Waters privately owned were typically rainwater, groundwater and small bodies of water found on private lands. A landowner had an exclusive right of use and abuse (*ius utendi et abutendi*) over these private waters, meaning that it was a right without restrictions, independent of the consequences it could cause to other neighboring landowners.[175] However, a landowner could suffer similar consequences by a neighboring landowner, presumably deterring abusive uses.[176]

The distinction between public waters and waters common to everybody was more theoretical than practical. Since the public or private nature of the water derived from the legal title of the land, flowing waters followed the public or private condition of the watercourse they belonged to.[177] However, the category of common waters underlined—already at that time—the vital importance of water and its key role as an enabler of social and economic development.

Today, both in civil law and common law countries, water resources are considered public goods that the state administers in the interest of its constituencies.[178] When there is a significantly large pool of users, as in the case of a river, a lake, or an underground aquifer that typically serves thousands if not hundreds of thousands of people and supports multiple economic activities, water administrators are confronted with two fundamental managerial issues: fairly allocating costs among users and finding ways to prevent overuse.[179] This is because natural resources including water are not unlimited but subject to exhaustion: after a

169. *Id*. at 60.

170. *Id*. at 32.

171. *Id*. at 60.

172. *Id*. at 28, 31. The legal status of the land directly influenced that of the water. For example, if the land was owned by the municipality, then the municipality also owned the water on that land.

173. *Id*. at 28.

174. *Id*. at 27.

175. *Id*. at 60.

176. *Id*. at 60.

177. *Id*. at 32.

178. *Id*. at 191.

179. Dellapenna, *supra* note 90, at 176. The author observes that very few true public goods exist in practice. If we take the internet or knowledge, these however are truly public in that they are inexhaustible despite some people may not have access to them because of social inequalities.

certain point, access by one or more additional polluting-users makes everybody worse off in their ability to enjoy them.[180] As a water scholar observed, rather than the qualities of the public goods themselves, what matters to manage them efficiently is "the social relations created or confirmed by the law regarding the rights to use the good."[181] In other words, the very function of water law is to achieve an optimal allocation of limited water resources among a variety of users in a manner that is sustainable and maximizes social welfare.

2. Customary Water Law

Customary uses of water, whether local, regional, or tribal, form an integral part of traditional water knowledge. Customs are unwritten rules of conduct observed by a group of people over a period of time under the conviction that they create legal obligations.[182] Customs originate from local traditions and shared interests within a community, are deeply rooted in spiritual values and religious beliefs that emerge from the land and its natural attributes, and inextricably link people, land, and water together.[183] Rather than becoming obsolete or irrelevant, customary water practices persist despite the introduction of modern water institutions and legal systems.[184] For this reason, they are hard to eradicate and replace with exogenous norms. Furthermore, statutory water rights often contradict, and even negate, customary water rights, as they tend to rely on different underlying principles emerging from formal bureaucratic structures rather than social interactions.

Current attempts in both the United States and Europe to reconcile these differences and integrate water customs into modern water legislation prove their

180. Some authors categorize natural resources as "common pool resources" to distinguish them from public goods. *See, e.g.*, *id.* at 178–79.

181. *Id.* at 176–79.

182. Two fundamental elements should be present to make customary practice a source of law: *diuturnitas* or *usus* (the practice is uniform, frequent, and consistent enough to prove its legal validity) and *opinio iuris ac necessitates* (the practice is understood to conform to a binding rule that serves the interests or needs of the collectivity). *See e.g.*, JOHN H. MERRYMAN & ROGELIO PÉREZ-PERDOMO, THE CIVIL LAW TRADITION: AN INTRODUCTION TO THE LEGAL SYSTEMS OF EUROPE AND LATIN AMERICA 24 (3d ed. 2007); Michael Wood (Special Rapporteur on the Identification of Customary International Law), *Second Rep. on the Identification of Customary International Law* 15, U.N. Doc. A/CN.4/672 (May 22, 2014).

183. Sanford D. Clark, *Tensions Between Water Legislation and Customary Rights*, 30 Nat. Res. J. 503, 505–07 (1990).

184. CAPONERA, *supra* note 168, at 60–61. According to the author, orally transmitted rules inspired by Islamic, Hindu, and Buddhist principles of law prevail among local water users over more recent codified norms in North Africa, the Middle East, and several Asian countries; so are traditional water management practices in rural China; water regulation and institutions deriving from the Inca or Maya traditions among large indigenous communities in Latin America; and customary water practices in Sub-Saharan Africa. In continental Europe, historic water institutions grounded in the Roman legal tradition have been formally incorporated in countries' water legislations and play an important role in water resources management. Some examples are the *consorzi di irrigazione* in Italy, the *comunidades de regantes* in Spain, and the *waterschappen* in the Netherlands.

enduring legitimacy.[185] Studies show that customary water practices can deliver enormous economic, ecological, and social benefits.[186] Customary water practices generally reflect local water management traditions based on the use of natural ecosystem elements of a specific local environment and collective human labor to harvest water. By relying on and taking advantage of the natural properties of the resources locally available *and specifically the ability of water, plants, and soil to renew themselves*, such practices do not destroy but rather integrate with the local ecosystem and even enhance it in the form of soil conservation and soil formation, increase in local water quality, reduced pollution from pesticides and other chemicals, agro-biodiversity, wildlife protection, microclimate regulation, preservation of cultural heritage, and landscape amenities (e.g., production of artisan goods, tourism, and other recreational services) which accrue to the local economies well beyond the mere community of water users.[187] Although customs' role as primary source of water law has receded with the progressive expansion of state power, their endurance is testimony to the fact that they create a system of water utilization and accompanying water rights that is rational, cooperative, self-governing, ecologically balanced, and self-sustaining over the long term.

First, customary water law creates symbiotic relationships between people and the environment. The progressive formation of uses, practices, and rituals consists of an internal process of connecting human behavior to nature and its biorhythm rather than of the imposition of an external rule of immediate convenience. As discussed in this section, for millennia before the advent of mechanization, the successful exploitation of water resources rested on a deep understanding of water's attributes and its behavior in the natural environment, allowing for water resources to be exploited within ecological boundaries. In contrast, when water managers in Colorado required the community of Hispano

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185. In the United States, the system of irrigation and water governance developed by the community of Hispano farmers of the Rio Culebra watershed of Southern Colorado in the headwaters of the Upper Rio Grande offers a similar example. Gregory A. Hicks & Devon G. Peña, *Customary Practice and Community Governance in Implementing the Human Right to Water – the Case of the Acequia Communities of Colorado's Rio Culebra Watershed*, 18 WILLAMETTE J. INT'L L. & DISP. RESOL. 185, 186–88 (2010). The premise for arguing greater pluralism in water law and institutions by way of integrating water customs into current water legislation rests on the fact that there is not, nor there should be, only one successful model of development (the western model rising out of means of mass production of the early twentieth century) but as many models as there are cultures and traditions. Moreover, when customary water norms are codified, water rights and obligations are clarified reducing the possibility of water conflicts.

186. *See supra* text accompanying note 130.

187. Gregory A. Hicks & Devon G. Peña, *Community Acequias in Colorado's Rio Culebra Watershed: A Customary Commons in the Domain of Prior Appropriation*, 74 U. COLO. L. REV. 387, 470–73 (2003). Here, the authors attempt to quantify the monetary value of the various benefits delivered by the *acequias*. At the same time, it is worth noting that many economists have begun to question whether wealth—expressed in monetary terms—is the best way to measure collective or individual wellbeing.

farmers of the Rio Culebra in the Upper Rio Grande to cover their earthen ditches with concrete on the grounds that it would prevent water from leaking and irrigate land more efficiently, they failed to understand that such intentional methods of water conveyance are crucial to ensure the good health of the *acequias*.[188] By letting water seep through the ground, underground aquifers are recharged and water is stored for drier years. At the same time, leaked water irrigates local wild vegetation between parcels of land, preventing soil erosion and sustaining the natural habitat of several animal and vegetal indigenous species. The benefits accrue to all *acequia* members in the form of preserving soil moisture, banking excess water, and growing medicinal plants and additional sources of food.[189]

Second, customary water law institutionalizes collaborative forms of living. Water customs establish a harmonious division of labor among members of a particular community who share gains (rights) and responsibilities (duties) in the administration of a communal asset.[190] This special relationship among people emerges from the collective waterworks endeavor and knowledge-sharing passed from generation to generation that makes water available to the community in the first place.[191] Under such models of governance, water is administered in common by those with individual land rights over an area served by the same source of water.[192] Customs do not give rise to individual or co-ownership rights over the water *per se*, but rather to *rights of use* connected to and dependent on each other according to a well-defined set of principles. First and foremost, the right to access and use water cannot be severed from the land; therefore, water rights cannot be sold to serve exogenous purposes outside the community of users. Moreover, individual uses of water exist in accordance with, and are instrumental to, the achievement of the common goals of the community. Finally, water rights among users are apportioned in a fair, equitable, and prioritized manner.[193] This means sharing water in times of scarcity, or "sharing the consequences of scarcity," by way of redistributing water, taking into account the needs of all

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188. The term "acequias" refers to the traditional water governance institutions and irrigations systems of the Culebra's Hispano farmers. *See supra* text accompanying note 185.

189. Hicks & Peña, *supra* note 187, at 471.

190. Hicks & Peña, *supra* note 187, at 452.

191. Hicks & Peña, *supra* note 187, at 400. Acequias members view water as an "asset-in-place," tied to the landscape and to the community economy it has created, rightfully belonging to the community that built the irrigations structures that first made water available. *See also* SOLOMON, *supra* note 100. Throughout his book, the author illustrates of how control of water sources for beneficial uses is an inherently collective endeavor, requiring people to pool together labor and resources, therefore shaping societies' structures and destinies since time immemorial.

192. In this respect, water customs are direct expression of the Roman law conceptualization of water as a *res comunis omnius*, i.e., a shared resource, which escapes the modern dichotomy of public and private property and, instead, reflects the possibility of a third category—that of a resource owned in common that generates usufructuary rights. As Hicks & Peña point out, in the system of acequias, water is "a situated resource, brought into being by shared labor for the good of a community and subject to claims of that community and of the watershed." Hicks & Peña, *supra* note 187, at 448.

193. Hicks & Peña, *supra* note 185, at 187.

participants, and prioritizing uses in accordance with the principle of mutual assistance.[194]

In sum, water customs create a fair and ecologically balanced system of water management by enhancing "the relationship of living beings (including humans) with one another and with their environment."[195] These elements are greatly influential in addressing the current water crisis.

D. INTEGRATING TRADITIONAL WATER KNOWLEDGE

Elements of traditional water knowledge are employed piecemeal today to deal with growing urban populations, the rapid deterioration of water quality from surface and underground sources, and accelerated demand for water. Sometimes traditional practices are rediscovered and integrated into current ones; other times, advanced technologies reclaim old-wisdom principles. In the Arab peninsula, where water shortages are becoming a significant constraint for socio-economic development and conventional sources—particularly groundwater—continue to deplete, governments are rediscovering elements of their cultural water traditions and are integrating them into current practices.[196] Rainfall, traditionally collected for agricultural purposes, is now conveyed and stored in dams, lakes, and other reservoirs to quench the thirst of fast-growing Arab cities.[197] At the opposite climatic spectrum, in the city-state of Singapore, a tropical island that possesses no rivers or underground aquifers but is home to almost five million people with some of the highest standards of living in the region, rainfall capture and wastewater recycling have become integral parts of a national strategy to diversify supply and lessen the country's dependence on water imports from its neighbors.[198] Even in places that have long enjoyed excellent water quality and

194. Hicks and Peña, *supra* note 187, at 411.

195. Moffa, *supra* note 110, at 106.

196. Abdelaziz Zaki et al., *Water Harvesting Techniques in the Arab Region* 139, 140–43, *in* UNESCO G-WADI MEETING ON WATER HARVESTING FINAL REPORT (Mike Edmunds & Claudine Cardona eds., 2006).

197. For example, in the United Arab Emirates, a country that receives less than four inches of rainfall per year, recent upgrades to the public water infrastructure have resulted in the collection of more than ninety-seven million gallons of rainwater from various dams and barriers across the country in a single heavy rainfall. *See Rainwater Collected in the United Arab Emirates*, WATER & WASTES DIGEST MAG. (Jan. 6, 2016), https://perma.cc/L28K-949Y; *see also* Derek Baldwin, *Rainwater Bounty Saved in UAE dams*, GULF NEWS (Jul. 22, 2015), https://perma.cc/PDK5-JSWX (reporting a rare downpour on July 14, 2015 that dumped 219,000 cubic meters of water, enough to fill 5,000 average backyard pools).

198. Envtl Goods & Serv., Asia-Pac. Eco. Coop. ("APEC"), *Environmental Technology Market in Singapore*, https://perma.cc/EKH3-JKB8 (last visited Dec. 3, 2018). Singapore plans to become completely water self-sufficient by 2060. Its state-of-the-art water recycling plant, NEWater, already produces 40 percent of Singapore's total water needs. Pub. Util. Bd., Sing. Nat'l Water Agency ("PUB"), *NEWater*, https://perma.cc/HN3L-J9N6 (last visited Aug. 31, 2019). Over the past decades, the Ministry of Environment and Water Resources has partnered with the private sector and invested heavily in new cutting-edge technologies such as membrane bioreactors and reverse osmosis processes to treat wastewater locally to reuse it for beneficial purposes. *See Singapore Water Story*, PUBLIC UTILITIES BOARD OF SINGAPORE (Nov. 14, 2018), https://perma.cc/39V9-F7GJ (last visited Aug. 31,

access, distributed water collection and storage complement the water supply and distribution system and deliver important ancillary services. One example is the round wooden water towers that lie on the top of many New York City buildings.[199] These structures, originally conceived to supply water to a building's higher floors by using the force of gravity (the main water infrastructure at the time the city was growing over a century ago could not handle the water pressure required to pump water above six stories or more), today serve multiple beneficial purposes including providing water for everyday use, extinguishing fires, and keeping a reserve of water always available against seasonal variations or other emergencies.[200]

These experiences are not surprising since traditional water knowledge consists of a system of adaptive strategies that evolve with people's needs, socioeconomic factors, and environmental conditions. However, to improve current water supply and distribution systems on a large scale, it is necessary to rethink the underlying logic of water administration which today by and large neglects the water cycle and does not promote sufficient distributed water collection, water conservation, or water reuse. Inclusiveness, self-sufficiency, and water stewardship stand out as three operational principles derived from water cultural traditions and practices that should guide water law reform. A more inclusive system of water governance is a system where adequate consideration is given to local water availability in the decision-making process that allocates water to users, who must share a proportionate burden of water restrictions for the restoration, maintenance, and preservation of water ecosystems, particularly in times of scarcity.[201] Self-sufficiency means that, to the maximum extent possible, all potential

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2019). In parallel, the Ministry launched a major public education campaign to bring people closer to water and instill in the citizenry a culture of water conservation. PUBLIC UTILITIES BOARD OF SINGAPORE, ACTIVE, BEAUTIFUL, CLEAN WATERS PROGRAMME, https://perma.cc/5J7P-N5E8 (last visited Aug. 31, 2019) (listing certified projects between 2010–2018 featuring various urban water designs and techniques ranging from green roofs to bio-retention swales implemented across the city).

199. FREE TOURS BY FOOT, *Water Towers in New York*, https://perma.cc/3JHM-2D7H (last visited Aug. 31, 2019). Water towers are built in twenty-four hours, take only two or three hours to fill (a float valve allows more water like in a toilet), use no sealants or chemicals (so not to contaminate water), and hold approximately 10,000 gallons each. Though most water towers are made of wood, some are made of steel, which is more expensive but also more resistant to weather in the long run. Therefore, they protect the water from external sources of contamination better. However, wood is a great insulator; it prevents water from freezing during the winter and is relatively inexpensive.

200. *Id*. One of the challenges is to ensure compliance with city's regulations regarding their appropriate maintenance since the water derived from the tanks is for residential uses and has to meet the Safe Drinking Water Act (SDWA) standards. A recent report by the New York Times reveals noticeable violations, *see* Frank G. Runyeon and Marie-Sophie Schwarzer, *Inside New York City's Water Towers*, New York Times (Jan. 27, 2014), https://perma.cc/7XJQ-NNMN. Compliance with SDWA is often a problem especially for small public water systems that struggle to keep up with clean water regulations due to lack of financial resources and human capital.

201. Dellapenna, *supra* note 90, at 188–89 (emphasizing the role of man-made physical and ecological transformation of water sources and lands as main drivers of the water crisis, and lamenting the lack of proper enforcement of regulated riparian rights by water agencies—under pressure from big water investors—in order to better protect public values).

sources of water are explored—including non-conventional ones—before transferring water from and to other localities. Systematic reuse of water and rainwater harvesting allow communities to increase their sources of supply without having to build expensive infrastructure to import more water from distant watersheds or rely on underground water. Water stewardship means using water efficiently in accordance with its intended uses and conserving water on site. Matching water quality to each intended use and storing water locally saves both water and electricity while reducing environmental impacts. Implementing these principles will lead to a more flexible, diversified, and ultimately fairer system of water allocation and distribution capable of better responding to present and future water shortages. Ideally, in any water governance system, whether local, regional, or global, vital uses of water for the sustenance of humans and the needs of water ecosystems are prioritized over all other uses and water rights are allocated after due consideration of the levels of demand and the type of uses that the local water cycle will have to sustain on the long term.

Historically, water resources have been shared and co-managed by communities with an understanding of water's regenerative attributes. Today, some localities are reclaiming the wisdom of traditional water governance and experimenting with new approaches. While infusing elements of traditional water knowledge is not without practical and legal challenges,[202] it will provide a better chance to meet present and future water needs.

III. NEW (LOCAL) APPROACHES TO WATER MANAGEMENT

As governments around the world increasingly look for ways to take advantage of all the water potentialities locally exploitable, these innovations raise ethical, practical, and legal questions: should municipal water users continue to access potable water for non-drinking uses? Can rainfall, grey water, and even black water represent viable safe alternatives to conventional water sources? Which uses should these non-conventional water sources primarily satisfy, and how can the public health be guaranteed? Should private individuals be allowed to tap into these water sources for domestic purposes?

Several pioneering groups of architects, government officials, water managers, and active citizens are experimenting with new approaches to water management and are pushing the bar higher in sustainable water practices, particularly at the local level. From water-independent buildings that harvest rainwater, treat and recycle their own grey and black water, and use non-flushing toilets to achieve complete water self-sufficiency; to municipal wastewater recycling to reduce the need to import water from depleted local sources; to bio-retention swales distributed throughout city pavements to prevent urban runoff and untreated sewage from contaminating the surrounding waterways; all these efforts challenge last

202. Moffa, *supra* note 110, at 124–53.

century's urban water management paradigm and are driving corresponding legislative changes to remove existing legal and regulatory barriers that inhibit their deployment. Rather than eccentricities advocated by environmental groups, these strategies represent common-sense, cost-effective solutions for urban water supply in the twenty-first century. They also demonstrate that meaningful progress is achievable without having to renounce the conveniences of the modern way of life. What constitute oddities today can become perfectly acceptable and desirable solutions tomorrow. For example, non-flushing toilets can be made completely safe, modern looking, and as functional as flushing ones. At its core, embracing the goals of water conservation and greater water self-sufficiency requires keeping an open mind about the meaning of culture, development, and modernity. Simultaneously, reclaiming elements of traditional water knowledge and integrating them into current practices with modern means can save municipalities considerable resources when compared to the costs of other interventions, contribute to keep water rates affordable for everyday consumers, and restore vital watersheds and ecosystems.

The next sections take a deeper look at some of the most promising innovative approaches to water management and their many benefits for individuals, the collectivity and water utilities.

A. UTILITY SCALE APPROACHES TO WATER MANAGEMENT

1. Recycling Wastewater

a. Approach

The practice of water recycling has been rediscovered only in the past fifteen years to cope with increasing demand for water and the simultaneous shrinking of conventional water sources.[203] The EPA defines water recycling as reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater basin (referred to as ground water recharge).[204] The purpose is to tailor wastewater treatment to match the water quality requirements of a particular reuse. For example, recycled water for landscape irrigation requires less treatment than recycled water for drinking water.[205] Matching wastewater treatment to the intended use is both resource-effective, as no new raw water needs to be extracted from a nearby reservoir, and cost-effective because treating water to a lesser standard for non-drinking uses requires less electricity and chemicals.

Beginning in the mid-1990s, water utilities in Southwestern states (California, Texas, Nevada, and New Mexico) began promoting, financing, and implementing

203. U.S. EPA, *Water Reuse and Recycling: Community and Environmental Benefits* (last visited Aug. 31, 2019), https://perma.cc/ZF4V-XB6U.

204. *Id.*

205. *Id.*

water recycling projects.[206] These projects mostly involve non-potable purposes, such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for such facilities as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing, and artificial lakes.[207] In more recent years, however, a growing number of water utilities' investments include indirect potable uses in the form of recharging ground water aquifers and augmenting surface water reservoirs with recycled water.[208] This has been possible due to advances in wastewater treatment technology and health studies of indirect potable reuse indicating no human health problems due to contact with recycled water treated according to standards developed by the EPA and state agencies.[209]

At the cutting edge of water recycling strategies, sewage-to-drinking water is emerging as an important model for water utilities for a number of reasons. Sewage-to-drinking is the ability to purify already highly treated wastewater at the end of the life cycle of a water utility plant and before discharge into the ocean or a river to the standards of quality required for drinking.[210] The concept is based on the idea of a closed loop water cycle rather than discharging one-time used and highly treated water to the ocean. This technology opens up enormous opportunities for securing new local and reliable sources of water supply for citizens and business with added environmental, long-term savings, and water security benefits.

b. Application

These early and more recent applications demonstrate that wastewater—just like other more conventional sources of water—with the appropriate and targeted level of treatment can serve multiple needs.[211] More importantly, evidence suggests that city-scale recycling of waste and grey water requires far less energy than treating saltwater using a desalination system or treating and transporting water from a greater distance.[212] San Diego, California is at the forefront of this

206. *Id.*

207. *Id.*

208. Press Release, Sustainable Water Initiative for Tomorrow, HRSD Launches Sustainable Water Initiative for Tomorrow (Sept. 15, 2016), https://perma.cc/E87P-WA7S.

209. U.S. EPA, *supra* note 82.

210. WAVY TV10, *Treatment Process Turns Wastewater Into Drinking Water*, YOUTUBE (Sept. 15, 2016), https://perma.cc/52HE-L22F.

211. Any source of water today, including raw water from an underground aquifer or a surface lake, can potentially contain and carry with it disease-causing organisms or other contaminants that—if not properly treated—can threaten human health, especially when considering current pollution levels. *See Risks of Drinking Untreated Water*, NATIONAL TRIBAL WATER CENTER, https://perma.cc/7ZKH-SWHW (last visited Sept. 4, 2019).

212. In Orange County, for example, indirect potable reuse costs $800–$850 to produce enough recycled water for two families of four for a year. Desalinating an equal amount of seawater would

practice with one demonstration facility already built and operating at a capacity of one million gallons of pure recycled water per day (MGD).[213] The Pure Water San Diego project offers a local alternative to increase supply without having to import water from out of state and northern California reservoirs.[214] This solution makes the city less vulnerable to climate variability, natural disasters, and rising imported water costs from wholesalers while increasing water reliability for residents and business activities.[215] At the same time, the project is a cost-attractive option to manage wastewater environmental impacts in an innovative way. Instead of upgrading the aging Point Loma treatment plant to meet federal clean water standards before discharge into the ocean, the city decided to use the money to build two additional water-recycling facilities, the Central Area Facility and South Bay Facility (Phase 2 providing fifty-three MGD by 2035).[216] Together with the North City Facility (Phase 1 will provide thirty MGD by 2021), once completed, these three facilities will divert about 100 million gallons of the current 140 million gallons processed each day at the Point Loma.[217] The city was able to gather unanimous support for the project from environmental groups, provided that Pure Water treats all the wastewater in the future.[218]

San Diegans will inevitably see a hefty increase in their water rates to pay for the necessary upgrades in their water supply infrastructure. However, the estimated costs of water recycling are lower than desalinization and cost-competitive with importing water.[219] This option gives them a more dependable, localized, and conservation-minded water supply system that reduces reliance on water imports and lessens demand on strained water sources in the region. The project also demonstrates that broad acceptance to black water reuse for potable uses is achievable and that, when the public has access to enough information, it is possible to overcome psychological barriers to this type of water reuse.[220] A recent poll showed that more than 70 percent of the county's residents now support the concept compared to the strong opposition the city faced when it first proposed the idea back in the 1990s.[221]

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require $1,200–$1,800 because of the amount of energy needed. Renee Cho, *From Wastewater to Drinking Water*, EARTH INST., COLUM. U. BLOG (Apr. 4, 2011), https://perma.cc/V6S3-6ZZE.

213. Purewatersd, *City of San Diego's Pure Water Program*, YouTube (Oct. 27, 2016), https://perma.cc/8R36-DFPX.

214. *Id.*

215. *Id.*

216. *Id.*

217. Joshua E. Smith, *San Diego Will Recycle Sewage into Drinking Water, Mayor Declares*, SAN DIEGO UNION TRIB. (May 10, 2017), https://perma.cc/XX9A-A2HT.

218. *Id.* Environmental groups gave the green light to this alternative as long as Pure Water treats all the wastewater in the future.

219. Purewatersd, *supra* note 213.

220. For more information on outreach activities, *see Pure Water San Diego*, CITY OF SAN DIEGO, https://perma.cc/Y3N6-Z6FF (last visited Sept. 1, 2019).

221. Smith, *supra* note 217.

At the utility level, advanced water purifying technologies are proving safe and cost-effective in solving local water shortages. This model, when replicated in other communities and reaching larger scale, would make an appreciable impact in mitigating water depletion trends. Just as ancient societies made extensive use of water reuse to adapt to water scarce conditions, modern society can relearn how to take advantage of the water locally available, prevent wasteful uses, and preserve hydrologic balance.

2. Separating Rainwater from the Sewage System

a. Approach

In today's urban centers, characterized by impervious surfaces and high population density, rainwater is become a nuisance.[222] With increases in the frequency of more erratic and heavier rain events, municipalities are confronted with new storm water management challenges, especially in the Northeast where sanitary wastewater (domestic sewage, commercial, and industrial wastewater) and storm water are both collected and transported to a treatment plant in one underground pipe.[223] Under wet weather conditions, the capacity of the sewage system is regularly exceeded, and untreated sewage and pavement wastes carried away through the city's drains are discharged directly into surface waters. In addition to contaminating drinking water sources, torrential rains causing storm water overflows can suddenly inundate streets, roads, and bridges, creating traffic disruptions and in some cases even putting pedestrians and vehicles in immediate danger, especially when in proximity to overgrown bodies of water.[224]

To avoid these consequences and comply with more stringent standards under the Clean Water Act, cities such as Chicago and the District of Columbia have

222. For example, Virginia applies a modified common law rule to surface water. At common law, "[s]urface water is defined as water 'diffused over the surface of the ground . . . until it reaches some well-defined channel.'" *Mullins v. Greer*, 311 S.E.2d 110, 111–12 (1984) (quoting *Howlett v. South Norfolk*, 69 S.E.2d 346, 348 (1952)). Under the modified common law rule, "surface water is a common enemy, and each landowner may fight it off as best he can, 'provided he does so reasonably and in good faith and not wantonly, unnecessarily or carelessly.'" *Id.* at 112 (quoting *McCauley v. Phillips*, 219 S. E.2d 854, 858 (1975)). Therefore, a plaintiff in Virginia alleging sufficient facts to support that a neighbor wantonly, recklessly, or carelessly developed their property resulting in the discharge of additional surface water that prevents him the "use and enjoyment of his land" may have a cause of action for nuisance (among others); *see also* Neil Stalter, *When it Rains, It Pours: The Effects of Stormwater Runoffs*, 222: EARTH INST., COLUM. U. BLOG (Apr. 3, 2018), https://perma.cc/9N8C-VHTQ (pointing at urban infrastructure as one of the major causes of water pollution from nutrient-rich storm water runoff and analyzing it detrimental effects on water ecosystems).

223. OFFICE OF WATER, U.S. EPA, REPORT TO CONGRESS: IMPACTS AND CONTROLS OF CSOs AND SSOs, 2.1-2.3 (2004). This is, for example, the case in Chicago, Boston, Philadelphia, and the District of Columbia.

224. *See* Sharon T. Ashley & Walker S. Ashley, *Flood Fatalities in the United States*, 47 J. of APPLIED METEOROLOGY AND CLIMATOLOGY 805 at 815 (2008) (concluding that floods are the second-deadliest U.S. weather-related hazard and that between 1959 and 2005 a majority of fatalities occurred in vehicles (63 percent)).

opted to conduct sewer renovation of their underground pipes and drainage systems to transition from a one-pipe system (i.e., storm water drains and sewage from households and business converging into one underground pipe) to a two-pipe system to separate rainwater drainage from sewers.[225] A dedicated pipe for wastewater optimizes the performance of wastewater treatment plants by preventing the commingling of sewage with other exogenous materials such as tree roots, branches, sleeves, garbage, or other debris that can end up in the city's drain.[226] Furthermore, this is creating new business opportunities for companies specializing in storm water management solutions to improve sewage system performance.[227] For example, old concrete pipes are now being replaced with new products made of special fibers, such as basalt and polypropylene, resistant to high temperatures and pressure; manholes and other water tanks and chambers are being installed along the sewage transportation system to allow for quick and easy inspections, just like it was common practice to maintain sewage systems and manage storm water in ancient cities.[228] From an environmental standpoint, separating rainwater from sewage mitigates urban flooding and prevents water pollution, and, in the long term, storm water capture and diversion can also contribute to naturally restoring local rivers flows and ecosystems, increasing reservoirs' capacity, recharging underground aquifers without altering their chemical composition, meet landscaping needs, and saving water for other uses.[229]

b. Application

There are some setbacks associated with the transition to a two-pipe system. First, separating sewage from storm water drains requires unearthing miles of pipes at great cost and labor, especially where the sewage system dates back to the early nineteenth century.[230] Some municipalities have proceeded on a neighborhood-by-neighborhood basis or have relied on less expensive and disruptive methods such as close fit lining the old pipes.[231] Second, it does not address all the risks

225. *Tunnel and Reservoir Plan*, METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO https://perma.cc/MZ2U-WU29 (last visited Sept. 1, 2019).

226. *See, e.g., Separating Sewage from Rainwater*, CITY OF VANCOUVER, https://perma.cc/PPG5-FNL6 (last visited Sept. 1, 2019).

227. *See, e.g., Solution for Sewer*, WAVIN, https://perma.cc/6R3Z-BSBH (last visited Sept. 1, 2019). Wavin is one of the biggest producers of plastic pipes and connections worldwide and one of the largest petrochemical companies in Latin America. Wavin is present in more than 25 countries and has about 30 manufacturing facilities mostly located in Europe. *About Wavin*, WAVIN, https://perma.cc/7BUJ-LLY6 (last visited Sept. 1, 2019); *Company Profile*, WAVIN, https://perma.cc/YQ3E-J5P5 (last visited Sept. 1, 2019).

228. *See, e.g., Recent Innovations*, WAVIN, https://perma.cc/VCG7-3CMH (last visited Sept. 1, 2019).

229. *See, e.g., Ghelamcho Arena – Vision and Sustainability*, WAVIN, https://perma.cc/C8GC-TY3N (last visited Sept. 1, 2019).

230. U.S. EPA, *supra* note 223.

231. The District of Columbia Water Authority has opted for a wide range of solutions, including a bold and expensive project consisting of building an underground tunnel to prevent runoff into

associated with untreated surface rainwater diverted directly to the rivers and other nearby water bodies. Nevertheless, there are also several ways to help address these shortcomings. For example, in the District of Columbia, campaigns to inform the public about the need to responsibly handle city waste have ranged from stickers on street drainages holes warning pedestrians "No Dumping–Drains to the Potomac River," to imposing a five-cent tax on all plastic bags sold in business and supermarkets to disincentive their use, to inviting citizens to take part in the cleanup efforts of the Chesapeake Bay which would bring to the regional and local economy an estimated $22 billion annually.[232] Initiatives like these educate the public about the fundamental role of water in the local economy and promote civic engagement in the preservation of local water resources, which are the first steps to stimulate change in people's mindset and build a culture of water conservation rather than waste.

3. Green Storm Water Infrastructure

a. Approach

In the early 1990s, a few pioneering local governments and municipalities began to revive the practice of allowing water to soak into the ground to help control and divert river flows, keep adequate soil moisture, recharge underground water, and mitigate seasonal variations.[233] This traditional method of water management, referred today as green storm water infrastructure, is now trending in a growing number of cities in the United States, Europe, and Asia to prevent runoff from overwhelming sewers and polluting waterways.[234] Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural

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Anacostia River. *See Anacostia River Tunnel Project*, DC WATER AND SEWER AUTHORITY, https://perma.cc/46DN-4HL5 (last visited Sept. 1, 2019). Using compact pipe technology offers the rehabilitation of a defective system by close fit lining with a standard PE100 pipe. *See* WAVIN, *supra* note 227.

232. *Economic Benefits of Cleaning Up the Chesapeake*, CHESAPEAKE BAY FOUND, https://perma.cc/LSU4-PWL9 (last visited Sept. 1, 2019); *How You Can Help Save the Bay*, CHESAPEAKE BAY FOUND., https://perma.cc/3P3N-4GBC (last visited Sept. 1, 2019); Darryl Fears, *The Chesapeake Bay Hasn't Been This Healthy In 33 Years, Scientists Say*, WASH. POST (Jun. 15, 2018), https://perma.cc/EX2J-LDYF (reporting that "studies have shown that cutting such pollution—nitrogen and phosphorous from human activities, as well as sediment from dusty building sites—has reduced the size and number of 'dead zones' where fish, oysters and other creatures die in oxygen-depleted water").

233. *See*, *e.g.*, *Downspout Disconnection Program*, CITY OF PORTLAND, https://perma.cc/R4C6-PBN9 (last visited Sept. 1, 2019).

234. Cities that started experimenting with green infrastructure in the Nineties in small locales and with small budgets, such as sc in Maryland, Philadelphia, Portland, Seattle, and Milwaukee, have now considerably expanded their efforts. *See e.g.*, PRINCE GEORGE COUNTY, https://perma.cc/MA2F-SCZA (last visited Aug. 30, 2019); PORTLAND, https://perma.cc/G6FT-M4CP (last visited Aug. 30, 2019); PHILADELPHIA, https://perma.cc/2MVH-7A4S (last visited Aug. 30, 2019); Milwaukee, https://perma.cc/R62U-2VFN (last visited Aug. 30, 2019); SEATTLE, https://perma.cc/9KWJ-HBNE (last visited Aug. 30, 2019). The same is true in European and Asian cities. *See*, *e.g.*, *China's Sponge Cities Aim to Re-Use 70% of Rainwater – Here is How*, THE CONVERSATION (Sept. 5, 2017), https://perma.cc/3FQK-BGBN.

processes required to manage water and create healthier urban environments.[235] One immediate goal of green infrastructure is to mitigate the detrimental effects of impervious land surfaces by recreating, in the urban streetscape, Earth's natural hydrologic regime using a patchwork of natural areas made of rain gardens, planter boxes, bio swales, permeable pavements, and trees (e.g., canopy) woven into sidewalks, streets, alleys, and parking lots that collect, store, infiltrate, evaporate, and transpire runoff.

In addition to flood protection, this particular method of storm water control contributes to the restoration of natural habitat, cleaner air and water, reduction of the urban heat island effect, and more pleasant and walkable neighborhoods and downtown areas.[236] Moreover, through land conservation, particularly near riparian areas, wetlands, and steep hillsides in or adjacent to cities, storm water can be collected and used to create recreational opportunities for urban residents and increase the aesthetics of a locality as well as property values.[237] Another advantage of green infrastructure is that it contributes to alleviating some unhealthy aspects of urban living. Glass and steel skyscrapers growing out of concrete were the symbol of American modernity in the last century, but they have resulted in smog, traffic noise, and lack of access to natural light for prolonged hours, which all affect people's health to different degrees.[238] A growing body of scientific literature linking the environment to human health suggests that spending more time in contact with nature can boost creativity, intellectual productivity, and reduce stress and aggressiveness.[239] Therefore, introducing natural elements in the built environment not only leads to healthier and happier urban living conditions, but can also help rethink the very idea of modernity and bring nature back into the development paradigm.

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235. Green infrastructure is an environment-oriented method of managing storm water runoff. *See* U.S. EPA, *What is Green Infrastructure?*, https://perma.cc/WQK5-XY6L (last visited Dec. 3, 2018).

236. *Id.*

237. Land conservation for example is another tool in the arsenal of communities and city planners that the EPA includes in green water infrastructure.

238. The World Health Organization ("WHO") defines health as "not merely the absence of disease or infirmity," but more broadly as "a state of complete physical, mental and social well-being." *See* WHO & UN-HABITAT, HIDDEN CITIES: UNMASKING AND OVERCOMING HEALTH INEQUITIES IN URBAN SETTINGS, CHAPTER 2: HEALTH IN AN URBAN CONTEXT (2010). Compelling scientific evidence today shows that physical, mental, and social health and well-being are interwoven and deeply interdependent, and that health is influenced by a wide range of factors beyond the health sector. While living in cities has many positives, there can be several physical and mental detrimental consequences such as exposure to air pollution—which can cause respiratory diseases and, in the worst cases, even death—or crowding, light, and noise—which can affect sleep and generate stress. Health determinants in cities vary widely. For a comprehensive assessment, see *id.*

239. *See, e.g.*, FLORENCE WILLIAMS, THE NATURE FIX: WHY NATURE MAKES US HAPPIER, HEALTHIER AND MORE CREATIVE (2017); Jenny Roe, *Cities, Green Space and Mental Health*, OXFORD RES. ENCYCLOPEDIA OF ENVTL. SCI. (2016); WHO REGIONAL OFFICE FOR EUROPE, URBAN GREEN SPACES AND HEALTH: A REVIEW OF EVIDENCE (2016).

b. Application

With its "green makeover" under way, Philadelphia perfectly illustrates the numerous economic, social, and environmental benefits that green infrastructure can deliver at the municipal scale.[240] Rather than committing to an estimate of $9.6 billion dollar for the construction of an underground tunnel to handle storm water flows and prevent their discharge in the Schuylkill and Delaware rivers to meet its obligations under the Clean Water Act, starting in 2011, the city began investing $2.4 billion on green infrastructure projects and partnering with the private sector to help solve its storm water problem.[241] The Philadelphia Department of Water is measuring progress using the concept of "greened acre."[242] It has calculated that each urban acre in Philadelphia receives roughly one million gallons of rainfall annually.[243] Once "greened," an acre starts managing runoff and reducing pollution.[244] So far, the 1,100 greened acres already built have cut storm water overflows volumes by 1.7 billion gallons, three times the Department's original projections.[245] The Department expects to add another 1,300 acres in the next three years and reach the 10,000 acres target by 2030, thereby creating the largest green storm water infrastructure in the United States and reducing storm water pollution entering the waterways by 85 percent.[246]

From an economic standpoint, this approach is saving the municipality an estimate of $7.2 billion when compared to the underground infrastructure tunnel originally considered, which would have required to torn apart streets and parks across the city. Greened acres, instead, are smaller in scale but immediately effective in absorbing water and removing chemicals and other pollutants through soil filtration.[247] Moreover, they come with additional social benefits, such as the beautification of neighborhoods and the creation of places where residents can gather, engage in communal activities such as gardening, and learn about water ecosystems and the importance of preserving water resources.[248] Since a greened

240. Bruce Stutz, *With a Green Makeover, Philadelphia is Tackling its Stormwater Problem*, YALE E360 (Mar. 29, 2018), https://perma.cc/3MRP-4VNT.

241. The tunnel would have taken fifteen to twenty years to complete, and many more would have passed before residents would have been able to repay it. *Id.*

242. *Id.*

243. *Id.*

244. *Id.*

245. *Id.*

246. *Id.*

247. Green acres come in different shapes and forms and are helping the city avoid water contamination by letting rainwater seep into various porous surfaces: from strips of land running nearside public highways, to vacant lots transformed into community gardens, to the creation of "blue" and "green" roofs on top of public buildings. For an overview, watch the video: "With a Green Makeover, Philadelphia is Tackling its Stormwater Problem," made available by YaleE360 at https://perma.cc/YBS3-CTTN (last visited Apr. 3, 2019); *see also* PHILADELPHIA WATER DEP'T, *Green Stormwater Infrastructure Tools*, https://perma.cc/3XLR-PFRS (last visited Apr. 3, 2019).

248. PHILADELPHIA WATER DEP'T, *Community Partnerships*, https://perma.cc/6NZC-5AYM (last visited Apr. 3, 2019).

acre costs and functions the same way regardless of where it is built, Philadelphia is strategically using such spaces in marginalized areas to improve neighborhood amenities (such as transforming vacant lots in playgrounds and public parks) and reduce criminal activity.[249] Over the years, and in the aggregate, green acres are creating new job opportunities and restoring the local water ecosystem balance.[250]

B. BUILDING-SCALE APPROACHES TO WATER MANAGEMENT

1. Living Buildings

a. Approach

The novelty of the Living Building Challenge (LBC), the most rigorous green building benchmark available today, is the idea of conceiving buildings as if they were "living structures" reconciled with the natural environment, not simply doing less harm to it.[251] According to this vision, to be considered truly "green" a building should imitate the biological process of a plant or a tree, for example producing its own energy, treating its own waste, and taking full advantage of the air, light, water, materials, landscape, and cultural meaning of the place where it is built.[252] The result is buildings that serve our need for shelter and comfort while contributing to the restoration of nature instead of its spoliation.[253]

The LBC takes the traditional green building "whole-building approach" to a more radical level in each area of consideration. Specifically, in the area of water, "the intent . . . is to realign how people use water and to redefine 'waste' in the built environment so that water is respected as a precious resource."[254] To meet the LBC certification, a building would have to become water self-sufficient or a water-independent structure, for example, by harvesting rainwater and recycling wastewater for reuse, thereby eliminating the need for imported municipal water and exported sewage or storm water.[255] This entails capturing storm water, filtering it, and treating all the water on site to minimize pollution and the detrimental

249. *See* Stutz *supra* note 240.

250. PHILADELPHIA WATER DEP'T, *Green City, Clean Waters*, https://perma.cc/2MVH-7A4S (last visited Apr. 3, 2019).

251. THE LIVING BUILDING CHALLENGE ("LBC"), https://perma.cc/LBF4-3C8B (last visited Dec. 4, 2018).

252. *Id.*

253. This new way of conceiving buildings is also referred as "regenerative construction" or "regenerative design."

254. LBC, *Water Petal Intent*, https://perma.cc/QVK9-V9WD (last visited Dec. 4, 2018).

255. To meet the certification standard for water, "one hundred percent of the project's water needs must be supplied by captured precipitation or other natural closed-loop water systems, and/or by recycling used project water, and must be purified as needed without the use of chemicals. All storm water and water discharge, including grey and black water, must be treated onsite and managed either through reuse, a closed loop system, or infiltration. Excess storm water can be released onto adjacent sites under certain conditions." *Id.*

impacts on local water resources. Moreover, each project receives the LBC certification based on actual, rather than anticipated performance, after twelve consecutive months of the building's operation.[256]

b. Application

The Bullitt Center is a six-story, 52,000 square foot office building located at the northern edge of the Central District neighborhood, near Capitol Hill, in Seattle, Washington.[257] There are two main water saving technologies that the Bullitt Center incorporates to reach its water self-sufficiency goal. The first is rainwater collection from the photovoltaic ("PV") rooftop array.[258] Rainwater landing on the PV array trickles through the openings between the solar panels onto a membrane located underneath, is channeled to drains, screened and filtered, then carried by downspouts to a 56,000 gallons cistern in the basement. From the cistern, it is withdrawn and sent to different filtration and purification routes (including a UV light disinfection system and a carbon activated filter) on its way to a 500-gallon potable water tank.[259] From there, potable water will be used to feed sinks, showers, and potable fountains.[260] Instead of relying on the city's municipal water, once approved, the building's exclusive source of water will be rainwater for all its occupants' water needs.

The second technology is micro-flushing toilets and composting.[261] Currently, only two to three tablespoons of treated rainwater create a biodegradable soap-foam transport medium for human waste in each toilet.[262] These toilets sense a

256. This has been one distinctive difference between LBC and the Leadership in Energy and Environmental Design ("LEED") green building certifications. LEED was the first voluntary green building accreditation process adopted in the United States in 1998 and made available to developers for the purpose of promoting human health and resources efficiency while minimizing the environmental impact of buildings on the environment. LEED has undergone several revisions and additions and is now in its fourth edition ("LEED v4"). However, the basic rating approach remains unchanged in that it allows developers to gain points by choosing which strategies and technologies they want to implement within a range of eight different categories: location and transportation ("LT"); sustainable sites ("SS"); water efficiency ("WE"); energy and atmosphere ("EA"); materials and resources ("MT"); indoor environmental quality ("EQ'); innovation ("IN") and regional priority ("RP"). LEED v4 continues to allocate three times as many possible points to energy efficiency than water conservation measures, thereby incentivizing project teams to focus most of their efforts on achieving energy points. U.S. GREEN BUILDING COUNCIL, *Leadership in Energy and Environmental Design*, https://perma.cc/2E2V-5873 (last visited Apr. 4, 2019).

257. The Bullitt Center is located in 1501 East Madison Street, a high-density residential neighborhood just a few minutes away from downtown Seattle. It opened on Earth Day 2013 as "the greenest commercial building in the world." Owned by the Bullitt Foundation, the building is home to seven tenant-organizations, including the University of Washington Center for Integrated Design and the Foundation itself, and the building has an additional co-working desk space available for rent. *See* BULLITT CTR., https://perma.cc/BAS3-RT2C (last visited Dec. 4, 2018).

258. Rob Pena & Nina Smith-Gardiner, *Rainwater Collection and Use at the Bullitt Center*, BULLITT CTR. (Aug. 8, 2012), https://perma.cc/7XUD-SUKR.

259. *Id.*

260. *Id.*

261. BULLITT CTR, *Waterless Waste*, https://perma.cc/7K3C-PN2G (last visited Dec. 4, 2018).

262. *Id.*

user and begin to emit foam. The foam slides down a vertical tube (versus a S shaped drain commonly used in conventional toilets) creating a low-friction lining to ensure all the waste makes the journey down to the composters. Air circulation between the vertical pipe and the receiving composters located in the basement eliminates odors and contributes to the aerobic process of decomposition.[263] Once waste reaches the basement, ten Phoenix Composting Systems, each about the size of a Fiat 500 (84" tall x 40" wide x 61" deep), process it and the resulting bio solids are sent to a facility to become fertilizers.[264]

Beyond water saving technologies, the Bullitt Center takes wastewater use in the building a step further. A third strategy consists of implementing a grey water treatment system through which the building contributes to the restoration of the local hydrologic cycle.[265] In its approach, LBC's core philosophy is to change drastically a building's conceptual design and operation so it can imitate those functions performed by a living tree. With respect to water, in the words of the Bullitt Center leading architect, Denis Hayes, the goal is to "realign how we use water" to its historical and biological relationship with the site, once covered by the Douglas fir forest.[266] Water from sinks, showers, and floor drains (grey water) cleans itself in a green roof filled with porous soils and gravels and returns to the water ecosystem through ground filtration or in the form of evapotranspiration.[267] The green roof also acts as a storm water drain during and after rain events, mitigating water runoff and consequently the negative impact of non-point sources of water pollution in local watersheds.[268] Today, the Bullitt Center is showing what is achievable by pushing the bar further in green building practices.[269] The building meets the goals of the LBC certification (version 2.0)

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263. *Id*. Each toilet acts as a point of air intake from where air is drawn down the waterless pipe.

264. BULLITT CTR, *Waste Not . . .*, https://perma.cc/UFR2-VZ3E (last visited Dec. 4, 2018). Using bio-solids and compost from soil conditioners in fertilizers, gardens, and landscape increases plant growth, improves soil quality, and returns nutrients to the soil in an endless renewable cycle that dramatically reduces human carbon footprint. Questions have been raised regarding the amounts of chemicals from pharmaceuticals and personal care products that end up in the treatment process. Following EPA's risks assessment methodology, companies such as Northwest Biosolids and Loop, have determined that risks of exposure to compost is infinitesimally small compared to every day household products that contain harmful chemicals. *See, e.g.*, NORTHWEST BIOSOLIDS, *What are Biosolids?*, https://perma.cc/NZ72-5NWM (last visited Dec. 4, 2018).

265. BULLITT CTR, *Wastewater Use*, https://perma.cc/7R8M-K3ZU (last visited Dec. 4, 2018).

266. *Id*.

267. *Id*.

268. Non-point source pollution is any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. Simply stated, it is pollution that unlike industrial discharges and sewage treatment plants—which are spatially confined and clearly identifiable sources of pollution—comes from many diffuse sources such as rainfall and snowmelts moving over through the ground, picking up and carrying away debris that end up contaminating water sources. *See* U.S. EPA, *Basic Information about Non-Point Source (NPS) Pollution*, https://perma.cc/QT4B-PG6S (last visited Dec. 4, 2018).

269. *See* Denis Haynes, *Better, Faster, More*, BULLITT CTR, https://perma.cc/T8TL-XT8Q (last visited Dec. 4, 2018).

created and promoted by the International Living Building Institute. Once the Seattle Public Utilities (SPU) and the State Department of Health (SDH) approve the Bullitt Center water features, it will be able to achieve complete water self-sufficiency.[270]

C. BENEFITS OF WATER INNOVATION

1. Individual Level

For commercial and residential building owners, water conservation strategies represent an economic opportunity. Over the last ten years, power and water rates have increased significantly in the United States, and they will continue to rise.[271] In the vast majority of cites, raising water rates is the only means by which local water utilities can meet their infrastructural challenges.[272] At the same time, mitigating utility bills has become a necessity for many medium and low-income families who are the most exposed to these increases.[273] For example, raising water rates were the principal reason why in 2007 Central City Concern ("CCC"), a non-profit and social housing provider based in Portland, Oregon, decided to embrace a bolder and more innovative construction standard (the first version of the LBC) and achieve water independence in their newest multi-family project under development in the Pearl District.[274] CCC was particularly sensitive to the potential water savings that a water independent building could realize

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270. *Rainwater-to-Potable Water System is Live*, BULLITT CTR, https://perma.cc/ZW2F-2TWM (last visited Dec. 4, 2018). The system was finally approved after five years from the beginning of the building's operations, allowing it to achieve 95 percent reduction in water use (or one gallon per square foot per year). An average commercial building in the U.S. uses twenty gallons per square foot per year. However, the Bullitt Center team did not receive approval to waive the use of chlorine to treat rainwater for drinking purposes. Chlorine, a chemical that the International Living Future Institute includes in its "Red List," is a disinfectant statutorily required for the provision of potable water to prevent bacterial growth that could harm the public health. However, chlorination is only one possible method to purify water. *See* Jeremiah Castelo, *How to Purify Water for Drinking: 8 proven Methods Everyone Should Know*, WORLD WATER RESERVE (May 29, 2018), https://perma.cc/HLQ4-BHXP.

271. Walton, *supra* note 71.

272. *See* FOOD AND WATER WATCHERS, AMERICA'S SECRET WATER CRISIS: NATIONAL WATER SHUTOFF SURVEY REVEALS WATER AFFORDABILITY EMERGENCY IS AFFECTING MILLIONS (2018) (highlighting how the federal government has been steadily cutting back funding for water systems since the late 1970s, effectively shifting the burden of paying for infrastructural upgrades onto local ratepayers).

273. *See* MARINA ECONOMIDOU, OVERCOMING THE SPLIT INCENTIVE BARRIER IN THE BUILDING SECTOR 16 (2014).

274. *See* CENT. CITY CONCERN, *Achieving Water Independence in Buildings* (2009), https://perma.cc/QR82-CW24. The project's comprehensive vision was to provide a high-rise development neighborhood with vital family amenities, namely affordable housing, childcare, and a community center. In the words of Ben Gates, one of its leading architects: "Today, cities are being built for singles and empty nesters, while family needs are largely ignored, especially the needs of working families. Our urban family development in Portland is an opportunity to show how American cities can be truly livable by attracting and retaining children and families." According to Gates, engaging the community at the outset of each project and raising the bar in sustainable construction practices are essential to achieve better outcomes. Telephone Interview with Ben Gates, Development and Sustainability Director, REDSIDE (July 30, 2013).

over the long term.[275] This economic advantage gave the team the input and stimulus to look for innovative solutions. Moreover, as a socially- and community-oriented organization operating in the housing market, CCC immediately realized the positive impact that implementing LBC goals could have for the average Portland household with regard to water-related utility costs and the reduction of economic hardship on low-income families.[276] At the time, an average household was spending over $800 annually on water and sewer utility costs, including storm water and other fees.[277] Today, with water and sewer rates forecast to continue rise exponentially in Portland and elsewhere, faster than household income, the case for water conservation and self-sufficiency is compelling.[278]

2. Collective Level

At a collective level, utilizing the goal of water independence should move a community—and, on a broader scale a nation—to explore what is possible and implement strategies in accordance with their unique water situation. Particularly in urban areas, rainfall capture constitutes a valid method to provide for an additional source of water supply, improve public health, build resilience against climate change, and move a community towards a more harmonious state of balance with the ecological boundaries of its local water endowment and ecosystem. The total volume of rain falling on rooftops in the United States is tremendous, including in small and mid-sized cities.[279] In a study conducted in 2012, the Natural Resources Defense Council ("NRDC") estimated that total rooftop rainfall for eight major United States cities, if captured in its entirety, would be enough to meet the water supply needs of between 21 percent and 75 percent of that city's population each year.[280]

Under scenarios that are more conservative, rainwater capture could still meet the needs of thousands of people per year in each of the eight cities under study.[281] Translated into potential water saving costs, each city could save millions of dollars. For example, for the District of Columbia, in a scenario where only 50 percent of the rooftop surface collects rainwater and only the first inch of that water is recycled for limited uses, NRDC calculated that the District would

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275. CENT. CITY CONCERN, *supra* note 274, at 7–9.

276. *Id.* at 7.

277. *Id.* at 9. For a family earning minimum wage, this represented more than 5 percent of their disposable income.

278. *Id.* at 7.

279. NAT. RES. DEF. COUNCIL, CAPTURING RAINWATER FROM ROOFTOPS: AN EFFICIENT WATER RESOURCE STRATEGY THAT INCREASES SUPPLY AND REDUCES POLLUTION 12 (2011).

280. *Id.* at 12. The eight cities under study are: Atlanta, Austin, Chicago, Denver, Fort Myers, Kansas City, Madison, and Washington, D.C.

281. *See id.* at 13–14 (by limiting, for example, the amount of water captured to the first inch of rainfall from each storm event, and further limiting the use of that water, e.g., only for outdoors irrigation in residential buildings or only for flushing toilets in non-residential buildings).

save $14,325,000 at the water rates that were effective in 2009.[282] This is without factoring in the cost of electricity that each municipality spends to treat water to potable standards each year.[283] Less electricity also means less carbon emissions output per gallon of drinking water supplied, which varies depending on the type of fuel used to produce such electricity.[284] The NRDC study also found that by 2030, at the current rate of development, redevelopment, and retrofitting projects in the United States, 50 percent of a city's rooftop area could successfully implement rainwater capture.[285]

Modern society has forgotten rain at a great cost.[286] Rediscovering ways to collect and use rainwater offers citizens and municipalities an opportunity to take advantage of the earth's natural ability to produce freshwater, to save resources, and help to mitigate some of the negative effects of urban development.

3. Utility Level

Water utilities play an indispensable role in providing the expertise and services needed to smoothly integrate emerging water conservation technologies within the municipality's infrastructure. In a more independent and decentralized system of water supply, some of these services could consist of monitoring compliance with health and environmental standards before buildings release water back into the municipal system, managing water pressure in the municipal pipes, and educating consumers about the social and economic benefits of water conservation. Particularly in the case of water regenerative buildings, the approach does not suggest that the building should completely secede from the municipal water and sewage infrastructure. Instead, there could be a two-way interaction between localized water loads or points of water intake and the main water supply infrastructure connected to a reservoir or other large storage system. In such a decentralized model, one can imagine that municipal water could serve as backup during a particularly dry season while under normal weather conditions, individual buildings could send treated water back to the municipal system for additional supply, storage, and reuse. This would achieve two results: first, it would reduce domestic water demand and increase local water availability and storage capacity

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282. *Id.* at 15.

283. *Id.* at 6. 270 billion gallons of water are used each week—a significant portion of it potable—to water 23 million acres of lawn in the United States. This watering bill costs $40 billion annually. In addition, more than 11 percent of drinking water delivered to households—an estimated 6 billion gallons of water each day or more than 2 trillion each year—and 25 percent of drinking water delivered to commercial buildings is flushed directly down the toilet, and along with it the money and energy used to treat and deliver the water. Considering that in 2016 residential and commercial buildings represented about 40 percent (39 quadrillion British Thermal Units) of total U.S. energy consumption, clear synergies could be achieved between water conservation and energy production. *Frequently Asked Questions*, U.S. ENERGY INFO. ADMIN., https://perma.cc/VZU8-6RKG (last visited Dec. 3, 2018).

284. NAT. RES. DEF. COUNCIL, *supra* note 279, at 7.

285. NAT. RES. DEF. COUNCIL, *supra* note 279, at 15.

286. Payne & Neuman, *supra* note 9, at 106–07.

without the need for municipal pharaoh infrastructural projects to bring more water from distant sources. Second, it would make communities more resilient to weather events, water scarcity, and pollution.

In San Diego, multiple water independent buildings could connect to the Pure Water San Diego plant and become part of its close-loop system, thus contributing to the water recycling function. Instead of sending sewage for treatment, living buildings could return water that is already partially treated or fully treated and suited for human consumption, thereby saving the utility water and electricity. As illustrated by the Pure Water San Diego project, acting at utility-scale, with water recycling solutions—on the supply side—can generate multiple benefits. Implementing similar strategies at the building scale—on the demand side—can capture even additional benefits both at individual and collective levels.

IV. REGULATING FOR THE FUTURE

The present regulation of water use was conceived with centralized control over water access, supply, and distribution in mind and at a time when water resources were abundant relative to the local population. The advent of large-scale sanitation and drinking water systems in European and North American cities during the nineteenth and twentieth centuries marked the beginning of modern plumbing.[287] The idea of using running bodies of water as natural sinks to help remove domestic and industrial wastes away from urban conglomerates was born, and it has endured in the collective mindset of the affluent of the world ever since.[288] While a growing number of people today are willing to try recycled water, many find harvesting rainwater or reusing water from a kitchen sink or a bathtub repulsive or believe it is unsafe.[289] Similarly, people believe that flushing toilets are the greatest invention of modern civilization, and by default non-flushing ones are a second-best solution suitable for developing countries.[290] The irony, however, is that at the current pace of surface and underground water withdrawals, very soon the developed world will not be able to afford its flushing toilets unless radical changes are implemented to reverse depletion trends.

In industrialized countries, even in places where water is scarce, continuous and readily available access to "too cheap to meter" water for decades has contributed to a false perception of water abundance and a sense of entitlement when it comes to clean water from the tap.[291] Water is routinely treated to potable standards for uses that may only require grey water or no water at all, wasting

287. SOLOMON, *supra* note 100, at 249–65.
288. BENIDICKSON, *supra* note 1, at 4–5.
289. Marcus Woo, *Why We All Need to Start Drinking Toilet Water*, BBC (Jan. 6, 2016), https://perma.cc/MS5F-UKQE.
290. GLENNON, *supra* note 50, at 206–07.
291. Payne & Neuman, *supra* note 9, at 106.

great amounts of electricity, chemicals, and water itself.[292] Thanks to the many conveniences brought by municipal water infrastructure and household plumbing, people do not have to give a second thought to where their water comes from and where their waste is taken. They rely on local governments to provide drinking and sanitation services in exchange for a reasonable fee and take their daily access to tap water for granted. Under this model of urban water supply and distribution, peoples' consciousness of how water regenerates itself in the environment and humans' vital connection to this process easily gets lost, further incentivizing wasteful uses.

In addition to this generalized mindset, most of the innovation in water supply and distribution systems remains a largely unexplored opportunity because of institutional barriers that complicate, slow down, and sometimes even forbid pursuing rainwater collection, water recycling, and reuse strategies outside the more conventional and regulated practices.[293] Unfortunately, many of the solutions described in this Article find their biggest impediments in outdated laws as well as in the absence of a comprehensive regulatory framework that adequately supports their deployment, therefore hindering their widespread adoption. In fact, only a handful of states have engaged in serious efforts to educate and develop support around water reuse opportunities and appropriately reviewed legislation to permit rainwater harvesting and grey and black water reuse for beneficial uses that include potable water.[294] While the water crisis is not as severe in all states, water shortages are a growing global issue with potential far-reaching consequences for peace, development, and prosperity.[295] This underscores the need for public policy to take a long-term view and accelerate the spreading of innovative solutions that promote distributed water collection, water conservation, and water reuse. It also highlights the need for wider support of bold and progressive initiatives that too often find resistance from industry coupled with government inertia.

The main barriers to water innovation lie at the building scale, particularly in outdated building codes and green building practices that are not ambitious enough. However, significant problems also exist with current water laws. The

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292. The average American family uses 300 gallons of water per day at home. Around 70 percent of this use occurs indoor, with the biggest share of that water used for toilet flushing (24 percent). While nationally, outdoor water consumption accounts for 30 percent of household use, it can be much higher in drier parts of the country where more water-intense landscaping irrigation occurs. For example, the arid West has some of the highest per capita residential water use because of landscape irrigation. *How We Use Water*, U.S. EPA, https://perma.cc/7XQD-MZQY (last visited Aug. 31, 2019).

293. More conventional practices generally include using rainwater and runoff for outdoors uses such as irrigating gardens and golf courses. *See discussion infra* Sections A.2, and B.

294. For an overview on grey water regulatory efforts*, see Gray Water Policy Center*, OASIS DESIGN, https://perma.cc/CHK6-3LXY (Apr. 4, 2019). For a discussion on black water reuse for potable purposes, *see infra* Section IV.B.

295. Kangen Water Boise, *Water–Blue Gold World Water Wars*, VIMEO (Mar. 16, 2017), https://perma.cc/VT6G-VZYF.

next two sections identify these main barriers and propose ways to overcome them.

A. ECONOMIC AND REGULATORY BARRIERS

1. Economic

a. Suboptimal Use of Space

When it comes to integrating innovative approaches to water efficiency that provide greater economic, health, and environmental benefits, developers tend to exercise their negotiating power with third-party certification organizations by supporting green building standards that are sub-optimal or under-performing rather than pushing the bar higher.[296] This is in part because some water solutions come with additional costs and can diminish the profitability of construction projects.[297] Especially in a commercial or high-rise residential building, a developer would want to maximize the Floor Area Ratio (FAR); the relationship between the total amount of usable floor area that a building has or that the developer can build under a permit, known as Gross Rentable Area (GRA); and the total area of the lot in which the building stands.[298] The bigger the project is, the bigger the capacity of the water tanks, cisterns, filtration systems, and bio digesters to meet the occupants' demand. These systems need more space than conventional plumbing. They are typically located in basements or in other common areas of the building such as equipment rooms.[299] This means that they occupy otherwise usable square feet. Although basements or garages generally are not included in the FAR, in dense urbanized areas these spaces are highly valued and marketable.

b. Operation and Maintenance Costs

As opposed to conventional plumbing, innovative collection and filtration systems require a much higher degree of specialization and monitoring for their correct installation and functioning, raising their operation and maintenance costs. A survey conducted by the American Council for an Energy-Efficient Economy (ACEEE) on the 2004-2005 California Multifamily Rebate Program for energy efficiency equipment revealed that the main reason why property managers and owners were not implementing energy efficiency measures on their own is because of the lack of maintenance staff and installation expertise.[300] This is even

296. Interview with Victoria Kiechel, Architect and Professional Lecturer, American University School of International Service, in Washington, D.C., (Sept. 25, 2017).
297. *Id.*
298. *Id.*
299. *Id.*
300. CHRISTOPHER DYSON & CAROLINE CHEN, AM. COUNCIL. FOR AN ENERGY-EFFICIENT ECO., THE SPLIT INCENTIVE BARRIER: THEORY OR PRACTICE IN THE MULTIFAMILY SECTOR? Table. 5, at 7–71 (2010).

truer for systems that use UV filtration, bio digesters, and other processes, which fall outside the typical expertise of a professional plumber or a Leadership in Energy and Environmental Design (LEED) certified building manager.[301] In sum, rainwater harvest and grey water systems have represented an unattractive option so far, as they add more capital expenditures and require greater expertise both at the beginning and throughout the life cycle of the building. This discourages building owners from embracing bolder water conservation strategies.

c. Split Incentives

The split incentive barrier is another way building owners are discouraged from incorporating innovative water equipment. The many benefits of high-performing buildings, such as increased level of health, happiness, productivity, and lower operating costs generally do not accrue to the building owner or the property manager who sustains the higher costs for incorporating green features. Instead, the tenants enjoy these benefits. In the literature, "split incentive" is the term used to describe this problem usually in the context of building-related energy efficiency upgrades.[302] Examples of these upgrades include the acquisition and installation of a solar water heater, contracting an energy services company to perform an energy survey and procure better insulation, and replacing lights bulbs with more efficient ones, all of which are equipment expenses capable of generating significant savings that translate into lower electricity bills. However, unless the owner is also a long-term occupier of the building, such savings will not accrue to the investor to offset the initial expenditures. The same is true for water efficiency upgrades, including installing toilets or fixtures and more so for more expensive water cisterns that capture rainwater and UV water filtration systems.[303]

One way to deal with this issue is to allow a building owner to collect a fee from the tenant to recoup the investment costs that lead to a reduced or complete lack of an energy or water bill in the case of high-performing or zero energy

301. Walter Labitzky, Head of the Office of Facilities Management, American University Washington College of Law, during a Q&A session after a guided tour in January 2016 of the school's newly inaugurated campus. Often referred as the "Tenley Campus" given its proximity to AU-Tenleytown Metro Station, the property is an 8.5 acres LEED Gold certified facility. *See* Am. U. Wash. C. of L., *Our Campus*, https://perma.cc/U3LA-FHC5 (last visited Sept. 26, 2019).

302. *Id*. at 65 ("Misplaced, or split, incentives are transactions or exchanges where the economic benefits of energy conservation do not accrue to the person who is willing to conserve.").

303. Several mechanisms have been experimented with in various countries around the world to more fairly allocate these costs between building owners and tenants, whether through regulatory measures or by contractual means. For an overview of current practices both in the social housing and commercial sectors, see ECONOMIDOU, *supra* note 273. Moreover, a developer may be able to capitalize in "building greener" by incorporating its upfront costs in higher rents. The reputation incentive to implement green building practices, however, is the strongest among academic institutions, banks, social housing providers with big real estate portfolios, which typically don't face this problem.

building.[304] Such an approach has recently been introduced in the Netherlands, where legislation provides for the circumstances under which such a fee can be collected, the standards that are relevant for its calculation, and the limits to the fee that can be collected.[305]

2. Regulatory

In addition to misaligned economic incentives, overly restrictive laws and outdated building codes for both commercial and residential buildings prevent the adoption of many water conservation strategies.[306] These legal and regulatory barriers also contribute to inhibit greater progress in sustainable construction practices and design by developers.[307] For example, when in 2007 Portland's social housing provider decided to embrace the LBC certification and achieve water independence in their newest multi-family project in the Pearl District, the team of architects and engineers discovered that many proven water conservation strategies, such as harvesting and treating rainwater for landscape irrigation, washing machines, cooling and heating appliances, or reutilizing wastewater from a shower or bathtub for toilet flushing, were not allowed under Oregon's building code provisions.[308] To implement the LBC requirements and build a structure that could potentially reach water self-sufficiency, the team would have to apply for a permit or obtain special approval from the state or the local authority or sometimes both, depending on the classification of the building and on the type of water conservation system they proposed to integrate in their design.[309] Successfully navigating the local regulatory environment proved a daunting task. First, there was great confusion between overlapping state, city, and county authority requirements.[310] For example, reusing grey water from a shower drain was regulated by the plumbing code, but if the water was discharged outside for irrigation purposes, it would fall under the jurisdiction of the Oregon Department

304. Lee Paddock & Caitlin McCoy, *Deep Decarbonization of New Buildings*, 48 ENVTL. L. REP. 2 at 10143 (2018).

305. *Id.*

306. Kim Slowey, *Snarl of Codes and Regulations Ultimate Inhibitor to Going Green*, CONSTRUCTION DIVE (Apr. 20, 2016), https://perma.cc/7TC2-Q4MS.

307. According to Kiechel, unless a local government specifically mandates developers to implement bolder water conservation features (as in the case of the redevelopment of Battery Park in New York City, where the Battery Park City Authority required developers to incorporate more advanced water reuse objectives than LEED in their projects) or unless developers receive extra certification points through LEED regional chapters, for example, incremental water saving improvements won't be pursued. However, LEED regional chapters have not involved water efficiency measures thus far.

308. CENT. CITY CONCERN, *supra* note 274, at 22–23.

309. CCC's Pearl Family Development is a mixed-use building designed to host up to 175 affordable family apartments, a childcare facility and a community center. It is categorized as a commercial building under Oregon's regulations. Different requirements apply for commercial or residential buildings whether recycling water for potable or non-potable water uses and whether water would be used inside or outside the building. *See id.* at 7–8.

310. *Id.* at 7.

of Environmental Quality.[311] Similarly, rainwater harvesting was regulated by the plumbing code, but if it was captured for potable uses, it would require approval by Oregon's Department of Health Services and Human and the Department of Environmental Quality.[312] Second, compliance with health and safety requirements was in some instances unduly restrictive and overburdening.[313] At the time, there was not a law in place defining grey water and black water for reuse in a building. Instead, grey water and black water would fall under the category of "sewage" *tout court*, which complicated the prospect of their recycle.[314] Regulatory agencies in Oregon would apply sewage standards to the proposed systems, which meant that CCC would have to obtain a Water Pollution Control Facility permit—the same permit of a sewage treatment facility.[315] Third, all approvals were granted on a 'building-by-building' basis.[316]

Overcoming these regulatory hurdles at the outset of the project would help bring soft costs down for building owners by standardizing construction practices and spur larger support down the construction supply chain.[317]

a. Regulation of Non-Conventional Water Sources

Federal, state, and local laws all participate in regulating the use of water in buildings. Rainwater and on-site recycled wastewater are sources of water supply that are non-conventional in the sense that the water comes from a different source than the municipality. This begs the question of how authorities regulate them when used for beneficial purposes inside a building or within its perimeter, which includes gardens, backyards, courtyards, and other appendices.

There are two main categories of beneficial uses of water involving a building: potable uses (drinking, cooking, dishwashing, bathing, showering, and maintaining oral hygiene) and non-potable uses (laundering, toilet flushing, and irrigation).[318] A conventional building uses municipal potable water without distinguishing among the above uses.[319] Moreover, through the plumbing system, potable water becomes wastewater after a one-time use and then flushes back to the municipal sewage

311. *Id.* at 20.
312. *Id.*
313. *Id.* at 11.
314. *Id.* at 20.
315. *Id.* at 21.
316. *Id.*
317. Soft-costs and hard-costs are terms of art in the construction business. Hard-costs are the cost of materials and labor. Soft-costs generally refer to additional architectural and engineering fees, business income or loss of rent due to delayed project completions and other similar costs associated with what Denis Hayes, refers to as "the cost of doing things for the first time." Hayes, *supra* note 269.
318. Alexandra Dapolito Dunn, *Water Use and Management in Buildings*, *in* THE LAW OF GREEN BUILDINGS: REGULATORY AND LEGAL ISSUES IN DESIGN, CONSTRUCTION, OPERATIONS AND FINANCING 250–56 (J. Cullen Howe et al. eds., 2010).
319. *Id.* at 250.

system.[320] In addition, in conventional buildings, gutters and other similar fixtures make rainwater flow outside its perimeter and to the storm water system, which in most cities also joins the sewage system.[321] Due to today's industrialized activities, rainwater can contain chemicals or other substances that may be present in the atmosphere raising concerns regarding drinking suitability.[322] Wastewater can also contain chemical or biological residues that, depending on their concentration, may pose risks to human health. However, the law generally does not distinguish between black and grey water, even though these two could pose widely different threats to human health.[323] Finally, both rainwater and grey water create lesser safety concerns when it comes to beneficial uses than water contaminated with raw sewage.[324]

To increase water efficiency, one must match the level of water treatment to each of its intended uses better. This way it is possible to use water that is safe for human consumption only for potable-uses while tapping into water that meets sub-potable standards for all the other needs that do not require the same level of treatment. As mentioned above, this is both resource-efficient because it requires less electricity, chemicals, municipal staff, and equipment to treat water, and it preserves freshwater resources. Using non-drinkable water for non-potable uses generally does not encounter impediments in the law. For example, states allow and, in some cases, even encourage homeowners to install rainwater barrels on their property for irrigation purposes to save drinkable water and lower water utility bills.[325] It would be a completely different issue, however, to install a rainwater catchment system on the roof of a high-rise residential or a commercial building to utilize that water for domestic or other uses inside the building. Under the Safe Drinking Water Act (SDWA) of 1974, such a system—if providing water for human consumption through pipes or other constructed conveyances to at least fifteen service connections or regularly serving at least twenty-five individuals—would meet the definition of a public water system.[326] Public water systems are subject to stringent and costly EPA standards.[327] The EPA has issued maximum permissible levels for more than ninety contaminants, including regulations setting new standards for drinking water disinfectants, their byproducts,

320. J. Cullen Howe, *Overview of Green Buildings*, *in* THE LAW OF GREEN BUILDINGS. REGULATORY AND LEGAL ISSUES IN DESIGN, CONSTRUCTION, OPERATIONS AND FINANCING 8 (J. Cullen Howe et al. eds., 2010).

321. *Id.*

322. Payne & Neuman, *supra* note 9, at 110; Kiechel, *supra* note 296.

323. CENT. CITY CONCERN, *supra* note 274, at 13.

324. OASIS DESIGN, *supra* note 294.

325. *See also*, CITY OF SAN DIEGO, *Rainwater Harvesting Rebates*, https://perma.cc/P9V2-LN86 (last visited Oct. 7, 2019); LAS VEGAS VALLEY WATER DIST., *Drought and Conservation Measures*, https://perma.cc/G4ST-5HKE (last visited Nov. 27, 2018); Nat'l Conference of State Legislatures, *State Rainwater Harvesting Laws and Legislation*, *in* MASON'S MANUEL OF LEGISLATIVE PROCEDURE (2018).

326. The Safe Drinking Water Act of 1974, 42 U.S.C. § 300f (West 2016).

327. MARY TIEMANN, CONG. RESEARCH SERV., IB10118, SAFE DRINKING WATER ACT: IMPLEMENTATION AND ISSUES 2 (2006).

and for microbial contaminants, including one regulation on uranium and one on arsenic.[328] Water supply systems must monitor, detect, and treat all these substances according to the best technologies, treatment techniques, or other means available as determined by the EPA.[329] Alternatively, water systems could qualify for technology variances and exemptions, but the requirements set by the EPA to grant those are tight.[330] Finally, SDWA requires public water systems to report monitoring results to the states on a regular basis.[331]

A rainwater harvest system such as the one described in section III.B.1.b that was implemented in the Bullitt Center in Seattle, Washington, can meet the EPA's drinking water standards through well tested UV light disinfection and carbonized filtration techniques because the level of contamination of rainwater is generally lower than the level found in local rivers, underground aquifers, and regional basins.[332] Nonetheless, it took over five years after the inauguration of the building in 2013 for state authorities to review and approve (with special restrictions) this alternative source of water supply for uses in the building.[333]

Long administrative procedures with uncertain outcomes can discourage developers and buildings owners from pursuing less conventional water supply methods in their construction or retrofitting projects. Instead, the EPA and monitoring state authorities should move swiftly to legalize innovative rainwater and grey water purifying technologies as protective of the public health as more established ones to allow them to reach greater scale.

b. Wastewater Regulation

In addition to the SDWA requirements, a different set of laws and regulations applies to wastewater, adding another layer of complexity for building developers and owners who intend to achieve water self-sufficiency in their construction projects. The common way to dispose of sewage is for buildings to send their wastewater (both grey and black water) to a municipal wastewater collection

328. MARY TIEMANN, CONG. RESEARCH SERV., A SUMMARY OF THE ACT AND ITS MAJOR REQUIREMENTS 5 (2008).

329. *Id*. at 6.

330. MARY TIEMANN, CONG. RESEARCH SERV., IB10118, SAFE DRINKING WATER ACT: IMPLEMENTATION AND ISSUES 11–12 (2006).

331. MARY TIEMANN, CONG. RESEARCH SERV., RL30853, A SUMMARY OF THE ACT AND ITS MAJOR REQUIREMENTS 7 (2014). General variances, small system variances, and exemptions are granted to water systems only under special conditions. When treated water cannot comply with the maximum contaminant levels established by the agency, there are no public water services restructuring options, there are no other sources of water, and there is no affordable technology, the state may grant a small system a variance. An exemption may only be granted if the system agrees to undergo capital improvements that may take an extended amount of time to be completed so that the treated water will meet the MCL requirement. For more information, see EPA, *Drinking Water Requirements for States and Public Water Systems*, *Variances and Exemptions*, https://perma.cc/AEK7-EUAD (last visited May 16, 2019).

332. Payne & Neuman, *supra* note 9, at 110.

333. *See supra* text accompanying note 270.

system.[334] Under the Clean Water Act (CWA) of 1972, these systems are subject to technology-based standards for treatment and must comply with a National Pollutant Discharge Elimination System (NPDES) permit issued by either the EPA or a qualified state agency.[335] The purpose of the permit system is to control the amount of pollutants both from municipal and industrial discharges that enter the nation's waters each year.[336]

If a commercial or high-rise residential building intends to implement its own wastewater collection system on-site rather than relying on the municipal wastewater treatment plant, it must determine whether it needs a permit similar to a publicly owned municipal sewage treatment plant in order to operate. The EPA considers a wastewater system small if "it serves a community with a population of 10,000 or fewer people and an average daily wastewater flow of less than one million gallons per day."[337] An example of such a facility is the Center for Health and Healing at Oregon Health Science University. The Center was able to achieve a 56 percent reduction in potable water use by harvesting rainwater and treating 100 percent of wastewater onsite for use in toilets and irrigation.[338] A membrane bioreactor captures, treats, and reuses all of the building's estimated 15,000 gallons of daily wastewater for toilet flushing, cooling tower makeup, and irrigation—virtually eliminating the building's wastewater contribution to the municipal sewer system.[339] However, it had to obtain a Water Pollution Facility Permit from the State's Department of Environmental Quality, which is the same permit required to a large-scale sewage treatment plant.[340] In its report to Portland, the construction team pointed out that navigating state and local permits, as well as building code issues with the membrane bioreactor with respect to sludge discharges into the city's sewer and reduction in sewer discharge fees were among the most challenging issues it faced.[341]

As discussed in Part I.A.3, buildings and their annexes, including parking lots and paved streets, contribute significantly to the impairment of streams, lakes, rivers, and coastal waters through pavement runoffs and sewage outpours during heavy rains.[342] Congress decided to regulate nonpoint sources of water pollution linked to land use activities such as agriculture, timber harvesting, mining, and

334. OFFICE OF WATER, U.S. EPA, *supra* note 4, at 6.

335. ROBERT GLICKSMAN ET AL., ENVIRONMENTAL PROTECTION LAW AND POLICY 642 (8th ed. 2019).

336. *See id*. Clean Water Act jurisdiction extends to discharges that enter *navigable waters*.

337. U.S. EPA, *Small Wastewater Systems Research*, https://perma.cc/EQ9V-DPMB (last visited Dec. 3, 2018).

338. PORTLAND OFFICE OF SUSTAINABLE DEV., GREEN INVESTMENT FUND: GRANTEE FINAL REPORT 3 (Jan. 13, 2005) (unpublished manuscript) (on file with author and Portland Bureau of Planning and Sustainability). The building sends only 400 gallons daily to the municipal sewer.

339. *Id*.

340. *Id*.

341. *Id*. at 7.

342. Michael Byrne, *Greening Runoff: The Unsolved Nonpoint Source Pollution Problem, and Green Buildings as a Solution*, 11 N.Y.U. J. LEGIS. & PUB. POL'Y 145, 154–59 (2007).

construction through a much less aggressive approach than industrial and municipal discharges. Instead, Congress has states develop and submit management plans, procedures, and methods to the EPA in order to control pollution from these sources to the extent feasible.[343] The approach proved less effective, and with growing urban development, nonpoint sources have become the crux of the nation's waters quality. Revisiting the regulation of water uses at the building scale to allow for well-proven rainwater harvest and wastewater reuse systems would help state and local governments dramatically in meeting the CWA standards.

c. Building Codes

States regulate construction through the adoption of building codes. A building code is a collection of laws, regulations, ordinances, or other regulatory requirements issued by a state or a local government legislative authority involved with the physical structure and healthful conditions for occupants of buildings.[344] The purpose of a building code is to establish the minimum acceptable requirements necessary for protecting the public health, safety, and welfare in the built environment.[345] The term building code generally refers to four principal coordinated documents: a building code, a plumbing code, a mechanical code, and an electrical code.[346] The plumbing code is the set of specifications that apply to water supply and distribution piping, water heaters, fixtures and fittings, sanitary drainage and venting, storm drainage, and, in synthesis, all materials, systems, and components that convey water in and out of a building.[347] States adopt their building codes based on Model Codes developed by three main regional organizations, which appeared in the United States between the 1920s and 1940s, and the International Code Council, formed in 1994 as an umbrella organization to support common code development with a view on harmonization given increased global economic trends.[348] States tend to amend Model Codes to reflect their local practices and conditions; therefore, building codes can vary considerably from one jurisdiction to another. This is not necessarily a negative aspect because it allows states to impose requirements on the construction industry that take into consideration its specific needs such as, seismic activity.

343. GLICKSMAN, *supra* note 335, at 590, 637–42, 684–685.
344. COUNCIL OF AM. BLDG. OFFICIALS, AN INTRODUCTION TO MODEL CODES 2 (1997).
345. *Id.*
346. *Id.*
347. *Int'l Plumbing Code*, INT'L CODE COUNCIL, https://perma.cc/BY3Y-CK6Q (last visited Dec. 3, 2018).
348. COUNCIL OF AM. BLDG. OFFICIALS, *supra* note 344, at 3–5, 18.

Unfortunately, none of these model codes foresee the possibility to use rainwater for potable uses but limit it to non-potable uses.[349] It is the states (or local governments authorities when there is no state preemption) that ultimately set the standards that each category of building within a particular jurisdiction will have to follow. Sometimes, local building codes forbid grey water systems or omit specifications for new water technologies, adding another barrier for the implementation of these systems. In Maryland, for example, many local governments that adopted the National Standard Plumbing Code or the International Plumbing Code amended them and inadvertently removed the provisions that authorized the reuse of grey water.[350] This shows the importance of adequate expertise in sustainability and innovation among local legislative bodies. To rectify these missteps, the state legislature in 2010 passed a law stating, "A county may not adopt or enforce a provision of a local plumbing code that prohibits a grey water recycling system".[351] Maryland state law now preempts any local government's authority to enact a building code that would inhibit the installation of grey water recycling systems.

Overall, greater coordination among federal, state, and local water authorities would ensure a more coherent and enabling regulatory framework for non-conventional sources of water supply and their technologies.

B. PROPOSED REFORMS

1. Updating Building Codes and Zoning Requirements

State building codes generally do not allow even the most basic water conservation strategies, such as harvesting and treating rainwater for landscape irrigation, washing machines, cooling and heating appliances, or reutilizing wastewater from a shower or bathtub for toilet flushing.[352] Removing these impediments must become a priority in every state to allow new water approaches and technologies to set foot and reach meaningful scale.

In Oregon, local administrators are at the forefront of rethinking water regulation at the state and local level. Already in 2008, Oregon's Building Code Division approved a series of Alternate Method Rulings to allow the adoption of rainwater harvesting systems for potable uses in low-rise residential buildings and non-potable uses (for flushing toilets and urinals) in commercial and residential buildings.[353] It also allowed wastewater conservation systems for flushing toilets and urinals in commercial buildings and for industrial

349. ALL. FOR WATER EFFICIENCY, THE STATUS OF LEGISLATION, REGULATION, CODES & STANDARDS ON INDOOR PLUMBING WATER EFFICIENCY 4–6 (2016), https://perma.cc/7CRL-WTKV.

350. *Id.*; Stuart Kaplow, *Can Green Building Law Save The Planet?*, 3 U. BALT. J. LAND & DEV. 131, 145 (2014) (quoting H.B. 604, 2010 Gen. Assembly, Reg. Sess. (Md. 2010)).

351. H.B. 604, 2010 Gen. Assembly, Reg. Sess. (Md. 2010).

352. *See* discussion *supra* Sections III.A.2.a–b.

353. CENT. CITY CONCERN, *supra* note 274, at 26.

applications.[354] These rulings ensure that the plumbing systems that harvest rainwater and recycle water from bathtubs, showers, bathrooms wash basins, clothes-washers, and laundry tubs follow certain specifications and are consistent statewide. Previously, no consistent installation standard existed throughout the state for rainwater catchment and plumbing systems, obliging developers and construction teams to propose a site-specific method and file a building appeal to the local authority.[355] These changes provide consistent standards and appropriate guidance to local jurisdictions for approving harvesting and reuse systems statewide as alternate methods to those addressed in the local building codes, thus, facilitating their proposal and construction.

However, more progress needs to be made. To that end, the Seattle Department of Construction and Inspection has recently launched a new pilot program to promote the construction and operation of buildings that meet the highest green standards and enhance environmental quality like in the case of the Bullitt Center.[356] The goal is to study the impacts of high performing buildings and develop permanent green construction standards in the Land Use Code.[357] To incentivize more green construction, the city is experimenting with zoning variances.[358] Projects that qualify under the program have to meet demanding energy, water, and transportation standards set out in Seattle's 2030 District Strategic Plan.[359] In return, these projects receive special zoning allowances in the form of additional floor area and structure height, and more specifically:

> 25 percent more FAR than allowed in the zone, with an allowance for space occupied by mechanical equipment;[360] thirty more FAR than allowed in the zone if the project includes renovation of an unreinforced masonry building (i.e., a building particularly vulnerable to earthquakes); additional height for residential buildings–12.5 feet for zones under eighty-five feet in height, and twenty-five feet for zones with a height limit greater than 85 feet; additional height for non-residential buildings–fifteen feet for zones with a height limit under 85 feet, and 30 feet for zones with a height limit greater than eighty-five feet.[361]

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354. *Id.*

355. *Id.* at 22–23.

356. Seattle Dep't of Constr. & Inspections, *2030 Challenge Pilot: What & Why*, https://perma.cc/AQM8-F63D (last visited Dec. 3, 2018).

357. *Id.*

358. Council Ordinance 125612, CITY OF SEATTLE, WASH. (June 25, 2018).

359. For existing buildings, the goal is to reduce the use of energy, water, and transportation by 50 percent by 2030. For new construction, the goal is to reduce energy use by 70 percent now and become carbon neutral by 2030; for water and transportation, the goal is to reduce them by 50 percent by 2030. For more information on Seattle's 2030 District Plan, *see* Seattle 2030 District, *About Us*, https://perma.cc/M6JQ-LSPJ (last visited May 15, 2019).

360. "For example, a Heat Recovery Ventilation System can take up 150 square foot on each floor that they are needed, which takes up chargeable FAR." SEATTLE SDCI, *Seattle 2030 Challenge Pilot SEPA: SEPA Environmental Checklist*, https://perma.cc/N82Z-XLML (last visited Sept. 2, 2019).

361. CITY OF SEATTLE, *supra* note 358, at 2.

These zoning allowances remove the extra costs typically associated with integrating high-performing energy and water efficiency features in existing buildings and new constructions, and they reward construction teams for engaging in more innovative building design and advanced technologies to achieve greater environmental sustainability.

Beyond individual buildings, the city's pilot program is taking a broader approach by providing the opportunity for district-wide heat recovery, distributed generation, and other district energy efficiencies that can reduce the demand for resources.[362] Together with more modern and updated building codes now in place, Seattle's 2030 Challenge Pilot in effect since June 2018 constitutes a trailblazer model for other cities and regions to accelerate the deployment of high performing green buildings. With clear and determined environmental goals embraced at the district level, the Program is setting new standards to reimagine the future of the built environment.[363]

2. Matching Water Use and Treatment

Not all uses of water require the same level of treatment. Water that enters into contact with the human body, through direct ingestion or otherwise, must be made safe: federal legislation requires that organic and non-organic compounds that are or may be present in a particular source of water and pose a hazard to human health shall be removed or reduced to non-threatening levels.[364] All other uses of water that do not directly involve contact with the human body, such as non-potable uses, can be met without water having to clear the same strict requirements. Because most water needs are currently met with water treated to potable standards, better matching of the level of water treatment to each intended use opens new supply possibilities and saves resources. However, implementing this approach implies that regulatory health and safety requirements would have to differentiate between alternative sources of water and type of uses. For example, a hospital's grey water as potential source of water for on-

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362. "The 2030 District Network is an interdisciplinary public-private partnership initiative working to create a groundbreaking high-performance building district in downtown Seattle." "With the Architecture 2030 Challenge for Planning" providing their performance goals, they "seek to develop realistic, measurable, and innovative strategies to assist district property owners, managers, and tenants in meeting aggressive goals that reduce environmental impacts of the construction and operations of buildings." For example, "the 2030 District provides members a roadmap to own, manage, and develop high performance buildings by leveraging existing market resources and by creating new tools and partnerships to overcome current market barriers." For more information, see SEATTLE 2030 DISTRICT, *About Seattle 2030 District*, https://perma.cc/98BJ-UWNJ (last visited May 15, 2019).

363. *Id.*

364. The Safe Drinking Water Act of 1974, Title XIV of the Public Health Service Act, 42 U.S.C. § 300f-300j-26, is the key federal law for protecting public water supplies from harmful contaminants. However, as highlighted by Professor Salzman in his book, this is more an ideal than a realizable goal; even with today's powerful means to treat water, it is impossible to remove all contaminants. Therefore, a certain level of risk acceptance is inevitably incorporated in EPA's decision-making. *See* SALZMAN, *supra* note 1, at 124–26.

site treatment and reuse is not of the same quality as the grey water produced by a school or a business, and different filtration and treatment processes could be envisioned to address specific needs.

In 2009, Oregon's state legislative body adopted a bill amending several sections of Title 36 Public Health and Safety of the Oregon Statute.[365] These amendments introduced some important new water administration principles and rules that could be implemented in other states to more efficiently match water use with water treatment. First, section 468B.015 in Chapter 468B – Water Quality now declares, "It is the public policy of the state: (1) to conserve the waters of the state through innovative approaches, including but not limited to the appropriate reuse of water and wastes". Secondly, section 454.607 in Chapter 454 Sewage Treatment and Disposal now reads:

> It is the public policy of the state to encourage: (1) Improvements to, maintenance of and innovative technology for subsurface and alternative sewage disposal systems and non water-carried sewage disposal facilities consistent with the protection of the public health and safety and the quality of water of this state; and (2) The appropriate reuse of grey water for beneficial uses.

At the same time, the legislature introduced a formal definition for grey water that reads as follows: "Grey water means shower and bath wastewater, bathroom sink wastewater, kitchen sink wastewater and laundry wastewater. . . . Grey water does not mean toilet, garbage, or wastewater contaminated by soiled diapers;"[366] and the legislature mandated the state's Environmental Quality Commission to create a more expeditious permitting process for the beneficial use of this type of wastewater. Now, section 454.610 (1) reads, as revised:

> A person may not construct, install or operate a grey water reuse and disposal system without first obtaining a permit from the Department of Environmental Quality. [. . .]. The Environmental Quality Commission shall adopt rules for permits issued under this section. In adopting the rules, the commission shall:
>
> (a) {. . .}
>
> (b) Minimize the burden of permit requirements on property owners; and
>
> (c) Prescribe requirements that allow for separate systems for the treatment, disposal or reuse of greywater.

Oregon's Environmental Quality Commission adopted such rules in 2011.[367] Oregon's Administrative Rules Chapter 340, Division 53 titled "Gr[e]ywater

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365. H. B. 2080, 2009 Gen. Assembly, Reg. Sess. (Or. 2009).

366. OR. REV. STAT. §454.605(7)(a)–(b) (2017). Grey water and black water require different levels and methods of treatment to make their reuse safe since each presents different types of contaminants.

367. OR. ADMIN. R. 340-053-0050 to 340-053-0110 (2011). These rules prescribe requirements for the permitting of grey water reuse and disposal systems. Or. Dep't of Envtl. Quality, https://perma.cc/P2CT-CG42 (last visited May 15, 2019).

Reuse and Disposal Systems" begins by stating: "It is the policy of the Commission to encourage the use of greywater for beneficial purposes not requiring potable water because it reduces demand on drinking water sources and may conserve groundwater and stream flows by reducing withdrawal," acknowledging—at the outset—that non-conventional sources of water and the practice of water reuse can preserve the state's water resources. The regulation is applicable to all grey water produced by any residential dwelling or commercial facility with very few exceptions.[368] The rules distinguish between three main types of grey water and each type of grey water can be used only for the approved purposes.[369] This leaves open the possibility for property owners to propose other beneficial uses of grey water subject to preliminary approval by the Commission.[370] All grey water collection systems must follow certain design and construction standards. For example, all pipes, valves, and other plumbing appurtenances must comply with the Oregon Plumbing Specialty Code; for Type 2 and 3 Greywater, a person must choose a product that bears the seal of approval from either the American National Standard Institute (ANSI), the International Association of Plumbing and Mechanical Officials (IAPMO), the Canadian Standards Association (CSA), or any other standard setting body recognized by the Department of Environmental Quality and the Oregon Building Code Division, and so forth.[371]

Oregon's grey water reuse and disposal systems for commercial, residential, and industrial uses offer an excellent example of light-handed regulation, replicable in other states, that distinguishes between grey water applications and

368. OR. ADMIN. R. 340-053-0060 (2011).

369. Type 1 is "greywater that contains dissolved oxygen and may have passed through primary greywater treatment [a physical process to remove a portion of the grease, floatable and settable solids from greywater] but has not passed secondary greywater treatment [a chemical or biological process to remove a portion of the dissolved or suspended biodegradable organic matter and other suspended solids];" Type 2 is "greywater that is oxidized and has passed through secondary greywater treatment;" and Type 3 is "greywater that is oxidized and has been disinfected following secondary greywater treatment." Type 1 Greywater can generally be used for subsurface irrigation of lawns, landscaping plants, gardens, vegetated roofs, and subsurface irrigation of certain types of crops and compost; Type 2 Greywater can be used for the landscaping purposes authorized for Type 1, plus landscape ponds not intended for human contact such as fish ponds, water gardens and golf courses, surface irrigation of gardens, lawns, living walls, greenhouses, and landscaping plants; Type 3 Greywater can be used for all the beneficial purposes authorized for Type 2, plus surface landscaping using sprinkler irrigation, wash water for mechanical cleaning of equipment, cars, sidewalks and streets, industrial cooling, rock crushing, aggregate washing, mixing concrete and dust control, fire suppression systems in commercial and residential buildings, toilet and urinals flushing, and floor draining trap priming. OR. ADMIN. R. 340-053-0090 (2011).

370. "A person may request an alternative beneficial purpose not specified in this rule and must demonstrate to the department's satisfaction that the public health and the environment would be adequately protected. The department, in a permit . . . will include limitations or conditions or both necessary to protect human health and the environment." OR. ADMIN. R. 340-053-0090 (2011).

371. OR. ADMIN. R. 340-053-0100 (2011).

provides developers with sufficiently standardized procedures for the construction, operation, and maintenance of these systems.

3. Streamlining Permits

Streamlining permits for grey water systems and other similar applications would help bring down soft-costs for developers and make building owners and tenants more willing to pursue innovative urban water supply strategies.[372] A nationwide survey conducted by the National Association of Industrial and Office Properties in 2007 revealed that faster permit processing would go a long way in promoting green building practices going forward according to developers.[373] Some commentators further propose mandatory instead of voluntary green constructions standards that, without imposing a specific certification rating system, establish water conservation goals and types of technologies capable to push the bar higher in green building practices.[374] This would create a healthy competitive environment for third-party certification organizations, as well as companies specializing in water technology innovation, and facilitate the promotion of bolder green standards and water conservation goals.

4. Targeted Incentives

Targeted grants and other monetary incentives for water conservation to support and scale decentralization of water supplies and treatment strategies are necessary. At the federal level, more funds should be appropriated to support state and local government water modernization efforts.[375] At the local level, one way to engage private building owners and developers in pursuing more ambitious green building strategies could be through the reduction or waiver of water fees. Instead of levying storm water fees on commercial and high-rise residential buildings to cover the costs of handling runoff, water departments could consider

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372. In a recent interview with Crosscut, Denis Hayes said: "Living buildings are harder to finance, despite our excellent financial performance at Bullitt. They face greater regulatory challenges, especially from local officials. They require creative architects, engineers, and contractors who will work together as a team—not 'starchitects.' And they require developers who are willing to take calculated risks. For all these things to come together also probably requires tenants who demand excellence—not just some additional insulation and some LEDs." Hallie Golden, *Bullitt Center Innovations Haven't Caught On – But Seattle Wants to Change That*, CROSSCUT (July 23, 2018), https://perma.cc/78LL-U49C.

373. Yudelson Associates, *Green Building Incentives that Work: A Look at How Local Governments are Incentiving Green Development*, NAT'L ASS'N OF INDUS. AND OFFICE PROPERTIES RESEARCH FOUND 16 (2007).

374. KAPLOW, *supra* note 350, at 177.

375. Trump's infrastructure plan has already generated a fair amount of criticism among environmental groups in that it does not seem to provide the amount of federal investment necessary to help cash-stripped state and local governments, putting much hope on the private sector to "foot the bill." Becky Hammer, *Trump's Infrastructure Plan Underinvests in Water*, NAT. RES. DEF. COUNCIL BLOG (Feb. 14, 2018), https://perma.cc/7YJR-DTJK; WFM Staff, *What's in Trump's Infrastructure Plan?*, WATER FIN. & MGMT. (Feb. 13, 2018), https://perma.cc/W8M5-3FFJ.

waving such fees in exchange for owners to green retrofit and redevelop their properties. This is an example of a well-targeted incentive that has already proven to work in cities with aggressive green infrastructure targets, such as Philadelphia (discussed above).[376] The advantages of this type of incentives are multiple: first, it consists in a fee waiver rather than an outright expenditure for which the city would have to find avenues for finance; second, the city can easily plan, budget, and monitor results without having to directly engage in the construction, thus multiplying efforts without having to outsource more contractors; third, it frees municipal resources for other needs.

5. Educating the Public

Educating the public about the importance of conserving water is as important as facilitating innovative strategies through legal and regulatory change. The recent water crisis in California is particularly telling of people's general lack of receptivity with respect to water shortages. Since 2011, California has experienced the worst persistent drought ever recorded in history, with 66 percent of the state under "extreme drought" conditions at its highest point in 2014.[377] As reported by the Weather Channel in April 2015, the Sierra snowpack, which accounts for 30 percent of the state freshwater supply, was at 5 percent of its average level, the lowest since recording started in 1950, and Lake Tahoe has been consistently below its natural rim since October 2014.[378] Despite 94 percent of Californians agreeing on the seriousness of the drought, when Governor Brown first attempted to reduce water consumption by 20 percent through voluntary restrictions, the State Water Resources Board reported only 8.8 percent participation in urban water reductions as of January 2015.[379] Some argue that this failure is attributable to a combination of past uses, such as municipal and household landscaping and ornamental uses like fountains and gardening that have not stopped even under drought conditions. A widespread sentiment among water city managers is that the burden should fall on farmers (who account for 80 percent of water use in California) rather than urban dwellers.[380] However, once the restrictions became mandatory, big water users like the University of California Los Angeles finally began looking into retrofitting and upgrading water fixtures. This indicates that even the most basic water saving technologies will remain unutilized and unimplemented unless mandatory water conservation goals are put in place.[381]

376. *See* discussion supra Section III.A.3.b.
377. *Drought in California*, U.S. DROUGHT PORTAL, https://perma.cc/3VP2-3TJ6 (last visited Nov. 27, 2018).
378. Jon Erdman, *California's Snowpack at Record Early-April Low; Sierra Snow Survey Finds Bare Ground*, WEATHER.COM (April 2, 2015), https://perma.cc/U9L7-UTB8.
379. Jessica Glenza, *California Water Restrictions Have Not Stopped Sprinklers from Flowing*, THE GUARDIAN (April 6, 2015), https://perma.cc/D5YK-3YQG.
380. *Id.*
381. *Id.*

Business as usual is no longer an option. Providing adequate information to the public about the safety and multiple benefits of emerging water saving technologies can go a long way in ensuring broad support and cooperation on the part of local stakeholders. Residents' involvement and support are crucial for any water conservation and reuse strategy to succeed. This is well illustrated by the sewage-to-tap campaign deployed by San Diego to grow public acceptance to their multi-year multi-phase program, Pure Water San Diego, aiming at producing one third of San Diego's drinking water needs from local wastewater recycling by 2035.[382] Since 2011, the municipality has organized free tours of its demonstration facility at the North City Water Reclamation plant, published online videos and other materials (such as detailed factsheets) that explain the process of water purification in a clear and comprehensible way, including kid-friendly packages, and offered individualized presentations at request.[383] Without these outreach efforts, the city would have experienced stronger push-back from local residents with respect to proposed water rates increases and, ultimately, would not have been able to finance the program.

Water is a common, indispensable asset for social and economic development. The vast majority of water sources in the United States are shared among a plurality of states, counties, and municipalities that increasingly compete to access a resource growing scarcer by the day. People need to embrace the goals of water conservation and water self-sufficiency, and together with water managers and lawmakers, make possible that there will be sufficient water for all going forward.

CONCLUSION

Pursuing distributed water collection, water conservation, and water reuse strategies will increase the chances to meet present and future water demand in a context of increased competition for freshwater resources among agriculture, thermoelectric production, and municipal supply exacerbated by a changing climate. Given the need of urgent upgrades to the current water infrastructure, integrating solutions such as regenerative construction, wastewater recycling programs, and green municipal infrastructure, hold great promise to reach greater water self-sufficiency and achieve a more ecologically sound exploitation of water. This article has identified some specific areas of intervention in the United States to correct regulatory shortcomings that inhibit meaningful strategies. More broadly, it has outlined a working framework to rethink water administration using principles derived from traditional water knowledge common to humanity that each nation can adapt to their specific water situation and cultural traditions.

382. *Pure Water San Diego*, CITY OF SAN DIEGO, https://perma.cc/D7J3-7KLH (last visited Apr. 4, 2019).

383. Marsi A. Steirer, *City Opens Doors to Water Purification Demonstration Program*, WATERWORLD (Oct. 1, 2011) https://perma.cc/M4LK-VZRA.

Traditional water knowledge should guide water administrators and policy makers to move towards a system of water supply and distribution that integrates development within the water cycle. Only by preserving water resources and conserving water, governments will be able to keep water available and affordable to their communities. Much progress remains to be made to foster a culture of water conservation, particularly in the United States. At this juncture, it is critical for people to understand how precarious the state of the nation's water resources has become and support corrective actions. Public officials bear the responsibility to bring needed changes in the laws and regulations to transition to more decentralized and conservation-oriented means to meet water supply demand and support human adaptation to the new regional and local water realities.