Atlantic Council
MILLENNIUM LEADERSHIP PROGRAM

ISSUE BRIEF

Water Innovation in the Face of a Changing Climate

DECEMBER 2017 FIDAN KARIMOVA

Climate change is forcing people to prepare, adjust, and adapt to changes in the natural environment. These changes are affecting livelihoods—especially for those living on the coasts—due to rising sea levels, warming oceans, and acidifying water. World Water Day was established by the United Nations to shed light on the global water crisis. Population displacement, inadequate access to drinking water and sanitation systems, nutrient runoff into water systems, and resulting "dead zones" are just a few of the critical issues highlighted in observance of the day. However, while these challenges are often the key focus, there are several reasons to be hopeful about the future due to innovations in the treatment and reuse of water and novel approaches to solve water problems.

This paper highlights success stories from London, Rotterdam, and California in addressing water-related concerns and offers examples or possible remedies for other countries. In addition, it identifies organizations that are on the frontlines of innovative change, such as the Water Environment & Reuse Foundation (WE&RF) that works to disseminate applied research and technology advancement in the water industry.

Modernization in the water world

Many of the coastal cities in the European Union (EU) have experienced one-hundred-year floods[1] in the past few years—more frequently than at any time in recent history. These floods cause billions of dollars in damage and displace millions of people. In this article, we will look at two areas of the world—the Netherlands and the United Kingdom (UK)—to get a better picture of what is happening on the ground and how people are reacting.

California is on the opposite end of the spectrum. For the past four years, California has been in a state of drought, its worst in five hundred years. While the state received a record amount of rain and snow this year and Governor Jerry Brown recently declared the drought emergency over, groundwater levels remain critically low and "potable water is still being

1 One-hundred-year flood refers to the probability of such a flood occurring as approximately 1 percent per year.

The **Emerging Leaders in Energy and Environmental Policy** (ELEEP) Network is a joint project of the Atlantic Council's Millennium Leadership Program and the Ecologic Institute, an independent nonprofit think tank and applied research organization focused on environmental policy. The Millennium Leadership Program provides exceptional leaders aged thirty-five and under with unique opportunities to build a global network, engage directly with world leaders at flagship Atlantic Council events, develop key professional skills, and collaborate to have a global impact.

trucked to serve residents."[2] Groundwater aquifers require more time to recharge, sometimes taking years or decades. California has developed measures to ensure water access to the public, giving the state's inhabitants the ability to continue their daily lives.

Taken as separate crises along the water spectrum, these events required unique approaches and solutions. They each offer lessons for regions experiencing crises of their own.

Taming the Thames

On January 31, 1953, the United Kingdom experienced an unusually high spring tide and gale force winds that broke flood defenses as the water swept inland.[3] The five-hundred-year storm damaged over 1,600 km of coastline, breached sea walls, and forced over 30,000 people to evacuate their homes. The flood brought attention to the need for preventative steps to avoid similar incidents. While London has since taken preventative measures, the rising sea level does not bode well, as much of the city will be underwater according to current projections. More specifically, Westminster Abbey, the Tower of London, House of Parliament, 3.3 million homes, as well as other prominent areas of greater London would be affected.[4] Considering this, London officials constructed a sea wall called the Thames Barrier in 1982 at a cost of £534 million.[5] The wall protects the floodplain of all but the easternmost boroughs of greater London. During high tide, ten steel gates rotate upward to block the river. The barrier can hold back 9,000 tons of water when fully raised. Officials have closed the barrier 173 times since its opening. Every time the gates lock in place, they prevent the sea from filling the streets of the city and potentially displacing millions. The visual below, from the UK Environment Agency, highlights the effects of what would happen if the Thames Barrier were to break.[6]

Fortifying Rotterdam

Ninety percent of the city of Rotterdam, the second largest in the Netherlands, sits below sea level. Recognizing that rising sea levels could cause havoc in the country, the Dutch created the largest moving structure on Earth—the Maeslant Barrier—a storm-surge barrier installation that has protected the city of Rotterdam since 1997. A constantly monitored and updated automated system runs the 7,500-ton barrier by utilizing weather data.[7]

Water in the Netherlands has been the conduit of trade and inspired many water-related innovations such as the transformation of wastewater into drinking water and the creation of efficient new drip-irrigation methods for farms. According to Jan Peelen, attaché for Infrastructure and the Environment at the Embassy of the Kingdom of the Netherlands in Washington, DC, the country "has over 800 years of experience in water management, which makes us pretty capable to deal with climate change. We have the knowledge, the governance and the financial instruments to deal with climate adaptation."[8] A prominent example of a water-related innovation is the Delft University of Technology, which, along with consultants and engineers from six water authorities in the country, developed the Nereda technology that uses microorganisms to treat household wastewater four times faster than traditional technologies by forming sludge granules that sink to the bottom of treatment basins.[9]

Reusing Wastewater

While London and Rotterdam are trying to protect themselves from too much water, California is trying to grapple with having too little. With an increasing population and a recent drought, California has taken measures to reuse treated wastewater as potable water. Potable water reuse has two forms—Direct Potable Reuse (DPR) and Indirect Potable Reuse (IPR). DPR involves introducing highly treated wastewater into a municipal water supply system and eventually right to your faucet. IPR is the introduction of wastewater into an environmental buffer such as groundwater or surface

2 Brandon Miller, "A tale of two droughts in California," CNN, January 26, 2017, http://www.cnn.com/2017/01/26/us/weather-california-drought/index.html.

3 "Devastating power of 1953's tide," BBC News, November 9, 2007, http://news.bbc.co.uk/2/hi/uk_news/7086479.stm.

4 Dave Hill. "Beyond the Thames Barrier: how safe is London from another major flood?," Guardian, February 19, 2015, https://www.theguardian.com/cities/2015/feb/19/thames-barrier-how-safe-london-major-flood-at-risk.

5 Simon Parkin, "The great tide," Guardian, July 7, 2016, https://www.theguardian.com/world/2016/jul/07/great-tide-is-britain-equipped-cope-glbal-warming.

6 Tom de Castella, "How does the Thames Barrier stop London flooding?," BBC, February 11, 2014, http://www.bbc.com/news/magazine-26133660.

7 Daniel Grossman, "Battling sea change," GreenBiz, January 7, 2016, https://www.greenbiz.com/article/battling-sea-change-tale-two-northern-european-cities.

8 J. Peelen, Personal interview, May 3, 2017.

9 "Water Technology," Water and the Dutch, April 25, 2017, http://waterandthedutch.com/water/.

The DakAkker urban roof. *Photo credit:* Fidan Karimova.

water, and then treating it to meet drinking water standards.[10] There are benefits to using DPR over IPR, such as closely proximity of waste and drinking water treatment and related cost savings for municipalities, as well as a consequent decrease in energy use required in pumping water long distances to be further treated. In financial terms, it is a difference of A$616 million for a DPR system as opposed to A$1,287 million for an IPR system, according to a report by the Australian Academy of Technological Science and Engineering (ATSE).[11]

The Orange County Water District, which produces enough recycled water to meet the needs of 850,000 Orange County residents, currently utilizes IPR.[12] The district uses this water to replenish depleted groundwater by injecting it into wells. Plans are underway to further advance DPR. In partnership with WateReuse California, the Water Environment and Reuse Foundation (WE&RF)—an organization that conducts applied water research and technology demonstrations and disseminates results through research-based educational tools and technology exchange—launched a DPR initiative in June 2012 to conduct further research into the topic of DPR with the goal of examining and determining best practices. The initiative has raised over six million dollars to date and has funded two related demonstration projects.[13]

10 Jeffrey Mosher, "Framework for Direct Potable Reuse," (Virginia: WateReuse Research Foundation, 2015), 1

11 Laura Martin, "Direct Potable Reuse Vs. Indirect: Weighing the Pros and Cons, Water Online, November 4, 2013, https://www.wateronline.com/doc/direct-potable-reuse-vs-indirect-weighing-the-pros-and-cons-0001.

12 Aaron Orlowski, "Orange County's water recycling program expands," Orange County Register, June 27, 2015, http://www.ocregister.com/2015/06/27/orange-countys-water-recycling-program-expands/.

13 WE&RF, "Direct Potable Reuse Research Initiative," April 23, 2017, http://www.werf.org/c/KnowledgeAreas/WaterReuse/Potable_Reuse_Research.aspx.

Clean drinking water at the OCWD. *Photo credit:* Fidan Karimova.

Greening the grey

Storm water runoff occurs when there is rainfall or snowmelt. In many older cities with combined sewer systems, the water flowing off pavements and rooftops is mixed with wastewater in sewer pipes, overwhelming wastewater treatment plants and forcing the release of untreated sewage into streams and waterways. There are two ways to address this situation—green infrastructure or grey infrastructure. Grey infrastructure is a more traditional infrastructure solution, consisting of pipes, pumps, ditches, and other infrastructure to manage storm water. Green infrastructure consists of vegetation, soils, and other green environmental solutions that provide habitat and flood protection. Green infrastructure helps absorb rainwater while also enhancing social, economic, and environmental health. Recognizing the importance and value of green infrastructure, many cities have begun the move toward greening their grey infrastructure with positive results.

Building for Water

Rotterdam experiences dry spells that are quickly followed by heavy and unpredictable rainfalls, rapidly turning city streets into pools of water that could prove hazardous for residents. To better deal with climate change and potential extreme and unpredictable weather, the City of Rotterdam has designed and implemented a full-scale "water square" called Bethemplein.[14] The water square collects water in its three basins in case of severe storms; after the water drains, it serves as a basketball court and open space. The square is the culmination of a five-year collaboration among businesses, government, and scientific institutions.

14 "New innovative water square combines leisure and storm water storage in Rotterdam, the Netherlands," DutchWaterSector, December 8, 2013, http://www.dutchwatersector.com/news-events/news/8841-new-innovative-water-square-combines-leisure-and-storm-water-storage-in-rotterdam-the-netherlands.html.

This effort is part of Rotterdam's broader goal of becoming fully climate proof by 2025, as are the green roofs around the city. The DakAkker (roof farm) is the largest urban roof farm in all of Europe. The farm grows various vegetables and fruits and has six beehives. Environmentalists laud the garden for its local food production in the middle of the city, and it provides local produce for nearby restaurants. According to Jillian Benders, advisor for Urban Development & Management in the City of Rotterdam, "finding new ways for urban farming, reusing urban waste as coffee-grounds in greening and perhaps using our soon to be obsolete drainage systems for transporting materials offers a more Circular Next-Economy and Resilient future."[15]

Draining London

While London has less experience with dry spells, the city does experience occasional rainfall-induced flooding. However, measures taken by the city to deal with the finicky weather have significantly reduced the negative impacts of this flooding. To cope with the higher than normal water levels due to climate change, the Greater London Authority created the £3.2 million Drain London program that aims to identify, prioritize, and manage water flood risk.[16] To date, the program has delivered surface water flood risk maps and management plans, as well as studies on the vulnerability of critical infrastructure.

Although the Greater London Authority is leading the project, multiple partnerships have emerged around it. These partnerships allow participating organizations the opportunity to learn from each other and encourage collaboration amongst stakeholders. To date, the partnership has produced surface water flood risk maps and detailed risk analyses of vulnerable infrastructure, which can be mitigated through a series of demonstration projects that test and measure the effects of proposed changes. One example is the All London Green Grid (ALGG), a policy framework to promote the design and delivery of green infrastructure across London. A network of street trees and green roofs will also reduce flooding, enhance ecological resilience, and cool the urban environment.[17] The Big Green Fund—the Mayor of London's fund that is providing a £3 million investment to improve eleven areas of London—finances the ALGG.[18] Thus far, a number of projects have been completed, including a wetland enhancement, training of people to improve and manage spaces along the river corridors, easier access for bicyclists and pedestrians to city valleys and marshes, and more.

SIWMing to Success

Green infrastructure is only one type of solution to address storm water surges and the resultant polluted water entering waterways. The Santa Monica Urban Runoff Recycling Facility (SMURRF)was created in response to public complaints about polluted storm water in Santa Monica, California. The facility eliminates the pollution of Santa Monica Bay caused by urban runoff during the dry season, such as water from excessive irrigation, car washes, and construction sites, which used to go directly into the bay through storm drains.[19] Upon treatment at the SMURRF facility, the water meets California's requirement for safe water and can be reused by farmers for landscape irrigation and dual-plumbed systems. A key component of the SMURRF is public education, as it is located at one of the most attractive tourist destinations in Los Angeles. This provides facility staff with a forum to teach people about pollution prevention and control.

On a municipal and utility scale, WE&RF has a Sustainable Integrated Water Management (SIWM) research program that takes a holistic view of wastewater, storm water, drinking water, and reclaimed water. WE&RF has been leading the International Stormwater Best Management Practices (BMP) Database, a publicly accessible online resource of scientifically sound information on storm water management BMPs, in partnership with the American Public Works Association (APWA), the Environmental and Water Resources Institute (EWRI), and the Federal Highway Administration (FHWA). The database includes over 200 Green Stormwater Infrastructure studies and over 400,000 storm water quality records. Harry Zhang,

15 J. Benders, Personal interview, May 5, 2017.

16 Fiona Fletcher-Smith, "Drain London Programme 2014-16," Greater London Authority, London.gov, August 8, 2014, https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/DD1250%20Drain_London%202014%202016%20PDF.pdf.

17 "All London Green Grid," London.gov, March 10, 2017, https://www.london.gov.uk/WHAT-WE-DO/environment/parks-green-spaces-and-biodiversity/all-london-green-grid.

18 "Big Green Fund," London.gov. November 28, 2017, https://www.london.gov.uk/what-we-do/environment/smart-london-and-innovation/big-green-fund.

19 "SMURRF: Santa Monica Urban Runoff Recycling Facility," Santa Monica Public Works, March 12, 2017, https://www.smgov.net/Departments/PublicWorks/ContentCivEng.aspx?id=7796.

program director at WE&RF, states that a more diverse storm water and green infrastructure portfolio "...of centralized and decentralized systems, a mix of gray and green infrastructure, along with climate impacts on water quantity and quality ...[would] enable better decision making for sustainable water management at utilities and municipalities." [20]

Conclusion

These examples illustrate the need for cities to think outside the box. Creative solutions go hand in hand with partnerships between different stakeholders to achieve lasting change. The European Union has a European Innovation Partnerships (EIP) on water, formed in 2015, which provides the latest information on water innovation in the European Union. In the United States, WE&RF, in partnership with the Water Environment Federation (WEF), has a Leaders Innovation Forum for Technology (LIFT) program that works with key water sector stakeholders to accelerate the innovation and adoption of new water technologies to improve treatment processes, reduce costs, and protect the environment. Following completion of the platform for innovation, the challenge is to continue fostering a culture of innovation in a traditionally conservative and risk averse water industry and to provide the tools and resources to support it. Programs such as LIFT and EIP make major contributions toward this goal.

The innovative solutions discussed above all have one important connecting thread—they all respect water as a valuable resource. As Melissa Meeker, chief executive officer of WE&RF, stated, "As we face more intense weather patterns, diversifying our water supplies and thinking about water holistically will be key to maintaining economic diversity and the quality of life we have come to expect."[21]

Fidan Karimova is the Water Technology Collaboration Manager at WE&RF, in charge of bridging the gap between the utility subscriber needs and available technologies in the market. She graduated from University of Maryland with a Bachelor's degree in International Business and a Master's degree in Environmental Management. She received a Water Management Certification program from Delft University of Technology.

20 H. Zhang, Personal interview, April 27, 2017.

21 M. Meeker, Personal interview, April 27, 2017.

Atlantic Council Board of Directors

Atlantic Council

The Atlantic Council is a nonpartisan organization that promotes constructive US leadership and engagement in international affairs based on the central role of the Atlantic community in meeting today's global challenges.

Atlantic Council

1030 15th Street, NW, 12th Floor,
Washington, DC 20005

(202) 463-7226, www.AtlanticCouncil.org