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Summary of Climate Change Impacts to Water and Sanitation for Frontline Communities in the United States

WATER, SANITATION, AND CLIMATE CHANGE IN THE UNITED STATES SERIES, PART 1

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EDITORS
Shannon McNeeley, Pacific Institute, Senior Researcher; Water and Climate Equity Lead
Morgan Shimabuku, Pacific Institute, Senior Researcher

CONTRIBUTING AUTHORS
Morgan Shimabuku, Pacific Institute
Shannon McNeeley, Pacific Institute
Nora Nelson, DigDeep
Antonia Sohns, independent contractor

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DEDICATION

We dedicate this report to the communities who
feel the impacts of climate change first and most strongly.

Water is life.

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Introduction: Intersection of Water, Sanitation, and Climate Change

Climate change is among the most urgent, wide-ranging crises we face. It poses significant challenges to water systems and is already severely impacting drinking water and sanitation access—both for those currently living without access and for communities where forces like drought, flooding, sea-level rise, wildfires, and intensifying storms threaten to degrade or strip basic services from people. Access to water and sanitation is a basic human right and essential for everyone's health, wellbeing, and prosperity. Without it, people cannot properly hydrate, clean, shower, and wash their hands, or safely dispose of their waste. They may have to travel long distances to obtain water, missing school or work, and be unable to adequately cool their homes. Water is life.

It is estimated that 2.2 million people in the United States live without access to running water or basic indoor plumbing, and even more live without access to sanitation (Roller et al. 2019). Furthermore, each year, 9–45 million people in the continental United States are potentially affected by unsafe water from community water systems with violations of health-based water-quality standards (Allaire et al. 2018). Those without access to water and sanitation in the United States are in what has been termed by DigDeep and the US Water Alliance as the "water access gap." Closing this gap is essential for achieving the human right to water and sanitation as recognized by the United Nations, but not by the US government (United Nations 2014; Gleick 2023).[1]

The impacts of climate change on water and sanitation are already evident and are expected to intensify as atmospheric greenhouse gas concentrations continue to rise. The Fifth US National Climate Assessment—the most recent available as of the writing of this report—found that climate change will continue to have profound impacts on the water cycle, altering precipitation, evapotranspiration, demand for groundwater, and snow cover and melt, posing many risks to people and nature (Payton et al. 2023). It also found that progress towards adaptation has been uneven; better data, decision-making, and cooperation has improved, but not all have adequate resources to adapt and some groups like Tribal and Indigenous communities are not fully represented in decision-

1 In this report, we use the term "Human Right to Water and Sanitation" to highlight the fundamental daily human need for clean, reliable water and sanitation access, and to build on the authors' decades of combined efforts to bring attention to this urgent issue. There are five essential components of water and sanitation services that must be met: water that is sufficient, safe, acceptable, physically accessible, and affordable. For definitions and references please see the full report: **pacinst.org/water-sanitation-climate-change-US-part-1/**.

making. Problems with critical water infrastructure, which is reaching the end of its design life in many parts of the United States, compound these climate risks (Lall et al. 2018).

Climate change will affect everyone, but not in the same way or to the same degree. Race, income, and age have been shown to increase vulnerability to the impacts of climate change, including floods, extreme temperature, and poor air quality (US EPA 2021b). Additionally, people without housing are extremely vulnerable to natural hazards while also lacking access to water and sanitation (Ramin and Svoboda 2009). All these factors compound stressors and strain resources for people and communities in the water access gap, further affecting their ability to manage and adapt to climate change and its impacts on water and sanitation systems. For those who have access but then loose it, we use the term "backsliding," which refers to the process by which a climate phenomenon causes a home or a community to lose access to water sanitation (centralized or decentralized), either temporarily or permanently. This builds on the way the term is used by DigDeep and US Water Alliance, who describe backsliding as a concerning trend of an increasing number of homes without water or sanitation access (Roller et al. 2019).

There is a growing body of literature on both the impacts of climate change on water *and* the gap in water and sanitation access. However, few studies address the intersection of these issues. The Pacific Institute partnered with DigDeep and the Center for Water Security and Cooperation to help fill this gap. In this report, the first in a series, we synthesize the literature on the effects of climate change on water and sanitation systems in the United States, especially for frontline communities. Here, we define frontline communities as those that experience the "first and worst" consequences of climate change on their water and sanitation systems, or on their access to water and sanitation.

Climate change will affect everyone, but not in the same way or to the same degree.

With this synthesis, we hope to provide a foundation for understanding—and ultimately reducing—the impacts of climate change on these communities. Importantly, climate impacts on water and sanitation systems and water resources co-occur with other challenges facing the water sector and frontline communities. Consequently, closing the water access gap while increasing the resilience of frontline communities to the impacts of climate change will require innovative approaches that also address contributing barriers, such as institutional constraints, lack of integrated water resource management, and structural and systemic racism.

Here, we summarize the report entitled *Climate Change Impacts to Water and Sanitation for Frontline Communities in the United States*. This is the first report in a series on the myriad issues at the intersection of water and climate equity: ***Water, Sanitation, and Climate Change in the United States***. Forthcoming reports will focus on the laws and policies in the United States that govern the delivery of water and sanitation in the face of climate change; barriers to equitable, climate-resilient water and sanitation in the United States; and strategies and approaches for overcoming these barriers. Our hope is that this series will provide a foundation for the water, sanitation, and hygiene sector in the United States (US WASH) to incorporate and consider climate change in efforts to close the water access gap.

Six Climate Phenomena Affecting the Water and Sanitation Systems of Frontline Communities

Each region of the United States will face unique challenges due to, for example, climate, geography, and socio-political factors. This report examines six types of extreme climate impacts affecting water and sanitation systems and access in frontline communities: 1) extreme temperatures, 2) drought, 3) inland flooding, 4) sea level rise, 5) extreme storms, and 6) wildfires. This does not include all climate change impacts nor all the complex interdependencies affecting water and sanitation systems and water resources, such as energy dependence, resource tradeoffs, or environmental degradation. It is also important to state that not all examples used to demonstrate the challenges posed by these six climate phenomena are directly attributable to climate change. We do provide ample evidence of each phenomena's link to climate change and relevant future projection under Earth's increasingly altered climate system, but the importance of these examples is not in their direct or indirect attribution to climate change. Rather, it is in the profound and devastating ways that extreme weather and natural events can disrupt or destroy water resources and water and sanitation infrastructure, leaving people and communities without water or sanitation access for hours, days, weeks, months, and beyond. Importantly, while water-related climate risks are relatively well known, new information, better observations and data, and improvements in science continue to add to our understanding.

Here we provide a summary of our key findings on each of these six phenomena, including how each is expected to change in the future, the major known and projected impacts on water and sanitation, and, where available, information on any disproportionate impacts for frontline communities. While we have worked to be thorough in our investigation of each of these phenomena, we recognize that there may be additional impacts yet to be uncovered, and that different geographies and communities will experience impacts different than those presented here. We hope that this report can be updated and expanded as we learn more.

EXTREME TEMPERATURES

Climate change is driving an increase in the frequency, magnitude, and duration of heatwaves, and in some cases, of extreme cold events in mid-latitude regions of the Northern Hemisphere. Extreme heat events, also called heatwaves, can have direct and indirect impacts on water supply and water systems, disrupting water access. Direct impacts include evaporative losses in reservoirs and lakes and harmful cyanobacterial algal blooms, which can affect water access through reduced water sufficiency, physical accessibility, and safety. Indirectly, extreme heat can increase water use and demand, also challenging water systems' ability to ensure sufficient quantities of water. Extreme heat also contributes to conditions that create wildfires that affect water and sanitation infrastructure and access, also addressed in the Wildfire section below. Extreme heat can compound health risks in vulnerable populations, such as the elderly, outdoor laborers, or those experiencing homelessness, especially if these groups already have insufficient access to water.

Extreme cold events have caused major disruptions to water access due to freezing and rupturing of water pipes and power outages, challenging physical accessibility of water. When water pipes are ruptured, systems can experience pressure loss, which in turn puts the distribution system at risk of contamination, making water unsafe. Extreme cold events can impact septic drain systems that are not well insulated, even though they are below ground, leaving their owners without physical access to sanitation systems. Extreme cold events can contribute to poor water quality through disruptions to nutrient cycling and from application of road salts that eventually wash into and contaminate waterways, making water more expensive to treat and unsafe to drink.

DROUGHT

Climate change is increasing the frequency, severity, and duration of droughts, which impacts water and sanitation, especially in low-income and rural communities. Climate warming is progressing so-called "hot drought" and more arid conditions throughout an expanding area of the United States. Increases in water demand and competition from people and nature, as supplies diminish, can put pressure on water sufficiency and physical availability. Snow volumes across the Western United States are expected to decline approximately 25% by 2050, and low-to-no snow periods may become persistent within 35 to 60 years under a "business as usual" emissions scenario, reducing water availability (i.e., sufficiency) for downstream communities.

Climate change, drought, and overexploitation of groundwater is resulting in reduced water availability, especially for rural communities dependent on shallow wells. This can lead to loss of water access due to lack of sufficiency, or in some cases, loss of physical accessibility. Climate change and drought are degrading both groundwater and surface water quality which can make water unsafe to use or drink. Drought impacts are not uniform and impact low-income communities and communities of color disproportionally. Drought worsened by climate change will likely disproportionately raise the cost of water for frontline communities, raising barriers to access due to affordability.

Photo provided by DigDeep

INLAND FLOODING

Flooding is the most damaging and costliest disaster in the United States, which climate change will make worse for disproportionately impacted rural communities and communities of color. Climate change makes the upkeep and maintenance of critical water infrastructure even more important to protect frontline communities from losing water and sanitation access from catastrophic failure (i.e., loss of physical accessibility) during floods. Flooding impacts water quality in all systems, and decentralized, onsite systems are often particularly vulnerable, especially in rural and low-income areas, making water unsafe.

Rain-on-snow events that result in flooding are becoming more common and increasingly impacting water infrastructure, such as dams. Compromised dams can cause loss of access due to displacement of downstream populations. Extreme precipitation and flooding combined with wildfire and natural resource extraction contribute to the destabilization of landscapes and flooding with deleterious impacts on water access for communities.

Major investment is needed in US water and sanitation infrastructure, and while recent investments are a step in that direction, estimates of needed investments far exceed those committed.

SEA LEVEL RISE

Climate-related rise in sea level is caused by thermal expansion of ocean waters and by melting of land-based ice, such as glaciers and ice sheets. The average sea level rise along US coastlines has been 28 cm (11 in.) from 1920–2020. Sea level rise affects surface water and groundwater quality through saltwater intrusion, increasing treatment requirements or, in some places, making water unsafe and unusable. Sea level rise can cause inundation of near-shore infrastructure, damaging facilities and property through corrosion and flooding. Wastewater systems and infrastructure that are located near the ocean are particularly vulnerable and, if taken offline, can cut sanitation access to entire communities due to loss of physical accessibility.

An assessment of the exposure of wastewater infrastructure to various sea level rise projections across the country found that as many as five times as many people will be impacted by wastewater system exposure than due to direct flooding of residences. Higher water tables in coastal aquifers from sea level rise can inundate wastewater treatment facilities, causing damage and loss of access due to physical accessibility. In parts of coastal Alaska, sea level rise has caused erosion, further exacerbating storm surges that have caused extreme flooding events and damage to water and wastewater infrastructure. More work is needed to understand the combined impacts of sea level rise and storm surges to coastal water and wastewater systems across the United States.

EXTREME STORMS

Extreme storms include a range of types of weather events, from tropical cyclones (hurricanes) and convective storms (tornadoes) to severe coastal winter storms. Hurricanes are increasing in intensity and frequency due to warming ocean temperatures, and rainfall associated with hurricanes is predicted to increase. Climate change is also causing extreme storms to occur in new geographies. Hurricanes along the Atlantic are reaching further northward and tornado risks appear to be increasing in Missouri, Arkansas, Louisiana, Mississippi, Alabama, and Tennessee.

High winds, heavy rainfall, and storm surges that knock out power and cause flooding, landslides, and severe erosion can lead to the destruction or disruption of water and wastewater systems, causing loss of access and water contamination from loss of physical accessibility and unsafe water. Widespread flooding from extreme storms has been associated with increased risk of exposure to bacterial and inorganic contaminates in water, harming human health. Severe winter storms in Alaska have been amplified by climate change due to reduced sea ice extent in space and time and rising seas; these storms have led to extensive flooding and damage to water and sanitation infrastructure in small, coastal communities. Research has shown that damage from natural disasters increased wealth inequality in the United States, and that race, education, and homeownership all influence the severity of climate risks and the ability to adapt or recover after disasters.

Photo provided by DigDeep

WILDFIRES

The potential for wildfires is increasing in frequency, geographic and temporal extent, and severity. Many of the most at-risk homes and communities exist along the wildland-urban interface, the zone where human development ends and transitions into wildland. Wildfires that burn houses and communities present a direct threat to water infrastructure during the fire and can place high demand on limited water resources to subdue and extinguish flames.

At the household scale, wildfires can melt and rupture water pipes and water meters. Domestic wells and household storage and distribution systems can also be damaged or destroyed. This causes loss of access due to water safety and can make it physically inaccessible. At the community scale, wildfires can cause adverse effects to water intake systems and water-treatment systems, and reduce reservoir lifespan by worsening erosion and sedimentation. This impacts water access by making it more challenging to treat, which makes it unsafe, and can leave an insufficient amount of water or make it physically inaccessible.

After a wildfire occurs, surface-water supplies in the affected watershed and water within damaged distribution systems can be contaminated and unsafe to drink. Additional treatment systems and processes to remediate the impacts of wildfire on water quality can be very costly, placing especially high burdens on low-income households who then may lose access due to affordability challenges. Drinking water supplies may be at risk for years to decades after a wildfire. Domestic wells can suffer many of the water quality challenges experienced by centralized drinking water systems post-fire. Yet these systems may not be able to recover as quickly as centralized systems, in part due to the high cost burden, meaning water access can be impeded due to affordability.

Photo provided by DigDeep

Conclusion

All of the impacts from the six climate phenomena—extreme temperatures, drought, inland flooding, sea level rise, extreme storms, and wildfires—directly affect water and sanitation access for frontline communities throughout the United States. The severity, frequency, and geographic and temporal extent of these phenomena are changing, affecting both water resources and the infrastructure essential for providing water and sanitation services. These impacts are disproportionately borne by frontline communities.

These climate phenomena are already affecting the sufficiency, safety, acceptability, physical accessibility, and affordability of water and sanitation, underscoring the direct connection between climate change and the challenges of closing the water access gap and achieving the human right to water.

For frontline communities that currently lack water and sanitation, more effort is needed to fulfill the human right to water and sanitation and to ensure that solutions and strategies to secure these services are resilient to climate change.

The full extent of climate change impacts on water and sanitation access, resources, infrastructure, and households in frontline communities is not fully understood. Nonetheless, we know that climate change is already having significant, harmful impacts on water and sanitation systems across the United States, and is expected to worsen and possibly lead to backsliding for frontline communities already suffering from the failure to provide water and sanitation for all. These communities often lack the resources and capacity to prepare for and recover from the impacts of climate change and the associated impacts on water systems. This disparity leaves those communities disproportionately vulnerable to the effects of water and sanitation system failures that cut access to drinking water and sanitation services, or in need of alternative water supplies post-disaster. For frontline communities that currently lack water and sanitation, more effort is needed to fulfill the human right to water and sanitation and to ensure that solutions and strategies to secure these services are resilient to climate change.

Here we focused primarily on a summary from documentation (from peer-reviewed and gray literature[2]) of the impacts of climate change on water resources, water and sanitation systems,

2 Gray literature refers to materials or research produced by governments, Tribal groups, or nonprofit organizations, as compared with peer-reviewed literature that is produced by academic and commercial publishing groups that have a standardized, peer-review process. However, some gray literature is peer reviewed, often noted in the front matter or described in the methods of the document.

and water access. This is only one dimension of the climate-related challenges faced by frontline communities. While large in scope, it is not comprehensive, nor localized enough, for uses beyond gaining an initial understanding of the major issues related to climate change, water, and sanitation in the United States. For the team of authors and our organizations, this will serve as a foundation for us to build and improve upon based on feedback and input from the broader community and experts in relevant fields (including the burgeoning US WASH Coalition). Future reports in this series will include a synthesis of US laws and policies that govern the delivery of water and sanitation in the face of climate change, an overview of challenges and barriers to equitable, climate-resilient water and sanitation in the United States, and a summary of documented strategies and approaches to overcome these barriers.

Some gaps in the broader series that we hope to address in future work include:

- Hygiene—i.e., the "H" in WASH—and specifically, climate change impacts to hygiene for individuals and households in frontline communities in the United States.
- Public health, which is the larger-scale lens through which hygiene at the individual and household level collectively impact society.
- Nexus issues, such as the energy-water-food nexus, have important ramifications for water, sanitation, and climate change.
- Other topics are missed that our partners and other stakeholders identify and highlight for us to review.

Ultimately, our hope is that this series will help to provide a foundation for the US WASH sector to incorporate and consider climate change in its work to close the water access gap.

Photo provided by DigDeep

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