

Colorado Water Conservation Board - Water Plan Grant

Final Progress Update

Prepared by: 10.10.10, a project of Colorado Nonprofit Development Center (CNDC)

Date: June 30, 2021

PO Number: POGG1, PDAA, 202100002361

PROJECT OVERVIEW

10.10.10, a project of Colorado Nonprofit Development Center (CNDC), develops and delivers unique programs presenting wicked problems to the public, volunteers, and successful serial entrepreneurs. 10 recruited, diverse, experienced entrepreneurs spend 10 days learning about 10 wicked problems in a specific sector. The wicked problems 10.10.10 targets are systemic problems requiring attention and solution, though not adequately addressed by government, large organizations or institutions. Serial entrepreneurs, validators (subject matter experts) and ninjas (temporary team members) focus on wicked problems through a developed and enhanced collaborative innovation ecosystem tackling wicked problems without the barriers of organizational silos.

PROJECT OBJECTIVES

1. Develop a robust understanding of the Wicked Problems related to water and climate in Colorado.
2. Draw upon the insight and expertise of stakeholders to both facilitate this understanding and support market-driven innovations in addressing the Wicked Problems.
3. Facilitate the creation of an engaged stakeholder network of experts and volunteers.

TASKS

Task 1 - Systems Mapping

Description:

- Convene validator/stakeholder advisory boards to map the complex system of water and the identified targeted Wicked Problems for the programs and beyond along with an initial network map that identifies the key actors and their attributes.

Method/Procedure:

- Meetings and discussions (virtual)
- Systems mapping

Deliverable:

- [List of stakeholders](#)
- [Systems map](#)
- [Outline of Wicked Problems](#)

Progress Update: The Director of Research created four system maps representing the following areas within water challenges and climate change:

1. Deteriorating Water Infrastructure
2. Water Scarcity and Supply
3. Water Quality and Safety
4. Extreme Climate Events (and their connection to water issues)

Various stakeholders participated in the data collection process used to construct the maps (see previous deliverable: List of Stakeholders).

In addition to maps, the Director of Research created data visualizations to further enhance the accessibility of water and climate issues to various audiences, including laypeople and the broader public. Those visualizations include timelines of significant events in the history of each of the four topic areas, contributing factors, and relevant agents and players. The creation of these additional research and communication assets arose out of a desire to more easily translate the complexities of the addressed water and climate wicked problems.

Task 2 - Identify Implementation Priorities

Description:

- Identify implementation priorities, policy needs, and individual enterprise implementation steps.

Method/Procedure:

- Research and explore policy needs
- Engage relevant stakeholders in discussing constraints and opportunities within policy
- Explore leverage points within Wicked Problems

Deliverable:

- [Outline of implementation priority area, policy needs with discussion of relevance to CWCB](#)

Progress Update: Wicked problem research included identification of relevant policies, players and agents within water and climate. A challenge arose in this area as the Water and Climate program kicked off shortly after President Biden took office and just as his administration was announcing policy commitments in climate and infrastructure. We addressed this challenge by updating components of our research briefs throughout the program and by noting news articles related to policy updates in our program slack channels.

Task 3 - Isolate Wicked Problems

Description:

- Isolate Wicked Problems that require entrepreneurs to develop new solutions

Method/Procedure:

- Using stakeholder discussions and systems mapping to identify and isolate Wicked Problems
- Frame problems for entrepreneurial development

Deliverable:

- [Presentation of Wicked Problems to CWCB](#)
- [Executive summary of Wicked Problems](#)

Progress Update: As outlined above, the Director of Research outlined the following categories for exploration relevant to water and climate: Deteriorating Water Infrastructure, Water Scarcity and Supply, Water Quality and Safety, Extreme Climate Events (and their connection to water issues). These categories were born from the entrepreneur problem identification and solution design process. The application of this process allows X Genesis to make a unique contribution to ongoing discussions about water and climate, even to the expertise represented by the Metro Roundtable and the CWCB. Rather than a lit review or traditional summation of issues, framing the water research in the lens of entrepreneurial discovery provides a fresh viewpoint and focus on topics such as market opportunity and resource

distribution, history and trends, and current approaches and workarounds. All of the above is delineated in the research briefs (roughly 25 pages each) addressing the four categories.

An issue to note: the matter of printing such extensive materials became a topic of ongoing discussion emerging from a desire to make materials as accessible as possible and a competing desire to align with sustainable environmental practices (such as avoiding printing in favor of digital distribution). In the end, COVID made this decision easy as people were not gathering to receive materials. All of our research assets are therefore available digitally. The digital assets provided a more interactive experience for our participants.

Task 4 - Recruit and Train Volunteers

Description:

- Recruit and train 30-50 volunteers focused on mapping the selected wicked problems and determining the opportunities with the prospective CEOs to create market based approaches to tackle the wicked problems

Method/Procedure:

- Conduct outreach among stakeholders for expertise sharing and volunteering
- Coach and train volunteers on participation
- Solicit feedback and perspective from volunteers regarding Wicked Problems and make any adjustments

Deliverable:

- [Systems maps & report of identified opportunities to create market based approaches](#)
- [Codex of volunteer names and bios for future possible engagements with CWCB](#)

Progress Update: The response to outreach and recruiting of volunteers (referred to as “specialists” in the context of our program) was strongly positive, with an eventual cohort of over 50 highly skilled professionals participating in the program. Each specialist contributes a unique perspective and area of expertise to the program, and works closely with our entrepreneurs as part of their temporary team to explore and vet opportunities connected to the wicked problem areas. The recruiting process included direct outreach via LinkedIn, referrals through our network, and outreach via other channels (i.e. email newsletters from partner organizations). Specialists were trained/on-boarded to the program via online content in Kajabi, an LMS (learning management system) used to house our learning content. The specialists participated in a number of sessions during the program designed to help them better understand the wicked problem areas, collaborate with each other and the prospective CEOs, and identify opportunities for market-based interventions.

As outlined in our deliverables for this task, we have compiled an online directory of all specialists in the program (also in Kajabi), which will be shared with CWCB. Upon completion of the program, we will provide an overview of the opportunities identified by participants in the program, focusing on those that are selected for further vetting and validation.

Task 5 - Recruit Subject Matter Experts

Description:

- Recruit and train 20-30 validators (subject matter experts) to ensure participants and validators understand the best ways to connect. Train validators on best practices to illuminate wicked problem areas, educate participants and invalidate or validate their ideas.

Method/Procedure:

- Conduct outreach among stakeholders for expertise and sharing
- onboarding

Deliverable:

- [20-30 validators on boarded](#)
- [Validator biographies compiled for participants](#)
- [Ask Me Anything panels](#)

Progress Update: Recruiting subject matter experts was truly one of the joys of the program and the grant funding experience. The virtual nature of the program allowed for recruitment of SMEs from across the nation and represented a range of experience and expertise in each of our 4 water and climate categories. In total, 30 validators served as SMEs for the program. Validators participated in Ask Me Anything (AMA) sessions and fielded questions from participating entrepreneurs.

Validator onboarding was conducted as asynchronous orientations and was a smooth process.

Finally, our SME recruitment also included recruitment of four problem advocates who shared their stories of dedication to each of our water and climate categories during the Big Reveal kickoff event. Obstacles emerged in recruiting these advocates, particularly as each is highly devoted to current water issues in the U.S. and in many parts of the country, including Texas and the South, ongoing water crises meant juggling schedules and shifting problems advocates. In the end, the Big Reveal was a tremendous success as the X Genesis team pulled together to accommodate our problem advocates.

Many of our validators have continued to work with our entrepreneurs after the program to continue to validate their business ideas.

Task 6 - Recruit CEOs

Description:

- Recruit and build/manage user experience for 10-15 prospective CEOs (entrepreneurs)

Method/Procedure:

- Digital marketing outreach
- Onboarding and training

Deliverable:

- [Recruit 10-15 entrepreneurs](#) and build an experience to aid their discovery of opportunities within wicked problem areas
- [Participant Biographies](#)
- [Program Calendar](#)

Progress Update: We engaged two contractors to support the recruitment of prospective CEOs, with the goal of recruiting a diverse and highly experienced group of entrepreneurs looking to start their next venture. One contractor focused on marketing strategy and outreach, while the other focused on interviews and user experience. We leveraged our existing network, which includes an email list of about 2200 supporters. Additionally, we engaged over 250 candidates via LinkedIn, and leveraged channel partners' email lists and direct introductions. After qualifying incoming leads, we interviewed 31 potential

candidates, for a final cohort of 13. Each of the 13 prospective CEOs are highly experienced entrepreneurs, and represent 5 different countries.

The prospective CEOs were trained/onboarded to the program via content housed in Kajabi, an LMS (learning management system). This includes access to the wicked problem research briefs and system maps, content related to opportunity discovery, program structure, expectations and deliverables, and more. We delivered an experience over four weeks that aided them in the discovery of opportunities and the development of business concepts. The experience included guided live learning sessions, Q&A sessions with domain experts, asynchronous communication with validators and specialist (via Slack), access to tools such as the “Opportunity Canvas”, and, the opportunity to work with a small team of dedicated specialists.

We currently have seven of the thirteen entrepreneurs working to validate new business ideas in the climate and water space.

An issue to note: Despite our focus on recruiting a diverse cohort, we failed to recruit any female entrepreneurs for the role of prospective CEO. Several female candidates moved on to the final round of interviews, and were extended invitations to the program, but none were able to commit at the time. Diversity is extremely important to us, and we view the lack of female pCEOs as a failure. We are committed to doing better and will be working with a DEI&B consultant to audit our internal processes and messaging. You can read more about our plans [here](#).

Additional Assets:

[Prospective CEO Videos & Training Sessions](#)

[Training Videos & Meetings - All Participants](#)

[Program Overview, Content, and Tools](#)

Task 1: List of Stakeholders

The following subject matter experts were engaged to map the complex system of water and the identified targeted Wicked Problems for the programs and beyond along with an initial network map that identifies the key actors and their attributes

Jim Ginley

<https://www.linkedin.com/in/jim-ginley-5389059/>

Utility management consultant, Jim Ginley Consulting LLC

I have more than 30 years in the water sector as a not-for-profit association professional, utility management consultant, regulatory compliance specialist, and active volunteer.

My areas of interest and expertise include:

- Training and Facilitation
- Strategic Planning
- Organizational Improvement
- Business Development

I have developed and implemented utility quality improvement programs, including organizational assessments, performance improvement programs, and benchmarking. I also specialize in workshop and session facilitation, strategic planning, and related training. I have served frequently as a workshop leader at professional conferences such as AWWA, WEFTEC and the Utility Management Conference. I have worked extensively with innovative technology companies and helped them get introduced to the municipal water sector.

David Greene

<https://www.linkedin.com/in/david-greene-8431647/>

Researcher & Analyst in Water Power, Water-Energy, and Blue Economy, National Renewable Energy Laboratory

David Greene has worked on water, energy and climate sustainability issues for over 25 years and joined NREL in 2019. For the decade before coming to NREL, he led the climate and resource sustainability efforts at the Austin (Texas) water and wastewater utility. Prior to that, he worked as an environmental consultant and on water and sanitation technology and development efforts internationally.

At NREL, David continues to work at the intersection of water and energy: as part of the Water Power team, his core work involves technoeconomic analyses of wave, tidal, and ocean current energy conversion devices at both the utility scale as well as in smaller, sector-specific applications through the DOE Powering the Blue Economy program. He supports NREL's work to promote hydropower and pumped storage at the municipal and regional level, and is one of the lab experts contributing to the National Alliance for Water Innovation ("Water Hub").

Lon Johnson

<https://www.linkedin.com/in/lon-johnson-66178535/>

CEO & Founder, WaterWorks Fund

For more than 20 years, Lon has served in critical strategic roles for national business, advocacy, and political organizations. Previous positions include Chairman of the Michigan Democratic Party, Vice President in a private equity firm, and senior staff roles for former Vice President Al Gore, U.S. Senator Debbie Stabenow, and Congressman John D. Dingell. Lon holds a BA from Arizona State University.

Javier Marti Canales

<https://www.linkedin.com/in/javiermarticanales/>

CEO and Founder, divirod - The Water Framework

Entrepreneur with strong experience in leading and delivering technically complex, multimillion projects, dealing with uncertainty, and managing teams with varied cultural and technical backgrounds. Forward thinker with the ability to see the very-big-picture, innovate and produce outcomes. Javier is a seasoned executive that brings together a unique combination of science, engineering and management. He has a sound experience in the design and construction of space instrumentation (SMOS, Envisat), space missions (Planck, Solar Orbiter), ground based astronomical observatories (ALMA, ELT) and the largest environmental observatory (NEON). His experience at the European Space Agency with soil moisture and ocean salinity fostered the original ideas behind divirod. Javier holds a PhD Summa Cum Laude in electromagnetic measurements from the Technical University of Delft, The Netherlands.

Ariel Miara

<https://www.linkedin.com/in/ariel-miara-7567332a/>

Energy, Water and Environment Research Analyst, National Renewable Energy Laboratory
Ariel Miara is a leading energy, water, and environment research analyst in the Resources and Sustainability Group within NREL's Strategic Energy Analysis Center.

As an energy-water nexus expert, Ariel leads research on a range of topics related to the interactions between energy systems, water resources, the environment, and policy. His modeling and analysis work includes integrating water resources and energy models to evaluate weather and climate impacts on electricity generation infrastructure.

As part of his cutting-edge energy-water nexus work, Ariel researches energy requirements for water infrastructure and innovative synergies between energy and water systems to maximize productivity and efficiency, under current and future conditions. His Thermoelectric Power and Thermal Pollution Model (TP2M) simulates power plant operations and water use, impacts on water resources and riverine ecosystems, and performance under environmental regulation and climate change.

Ariel holds a dual appointment with the City University of New York's Advanced Science Research Center, where he is a senior research associate. Ariel completed his PhD in Civil Engineering, with a focus on water resources and environmental engineering, at The City College of New York.

Bob Peters

<https://www.linkedin.com/in/bob-peters-2207b116/>

Water Resource Engineer, Denver Water

Bob Peters is a Water Resource Engineer at Denver Water. He has been involved with protecting, managing, and planning Denver's water resources for the last 25 years and is Denver Water's project manager for its Aquifer Storage Pilot Project. He attended Colorado State University where he earned Bachelors and Masters Degrees in Civil Engineering. He lives in southeast Denver with his wife and two children. He loves the outdoors and is an avid runner, biker, and skier.

Jayla Poppleton

<https://www.linkedin.com/in/jayla-poppleton-1a1a20b/>

Executive Director, Water Education Colorado

Jayla Poppleton is the Executive Director of Water Education Colorado. Prior to becoming Executive Director, Jayla oversaw Water Education Colorado's full suite of print and digital content programming. In that capacity she also served as the editor for Headwaters magazine, Water Education Colorado's flagship publication, for nine years. Through the duration of her career, she has been intent on communicating important science and policy issues with a human-interest lens. She has written extensively on all things Colorado water, and it continues to be the subject she is most passionate about. In addition to the Advisory Committee for TAP-IN, Jayla also serves on the Advisory Council for the One World One Water Center at Metro State University. Hailing from the outskirts of Chicago, her enthusiasm for outdoor adventure and the natural world led her to the field of natural resources—and to Colorado, where she earned a bachelor's degree in technical journalism with a specialization in natural resources management from Colorado State University. She fell in love with Colorado's rivers while guiding commercial rafts down the Cache la Poudre River. In addition to reading and traveling, she enjoys running, hiking, rafting, snowboarding, mountain biking and any other opportunity to be outside in the Colorado sunshine. She lives in Denver with her husband and three sons.

Joshua Sperling

<https://www.linkedin.com/in/joshua-sperling-0961289/>

Urban Futures and the Energy-X Nexus, New Concepts Incubator | Joint Institute for Strategic Energy, National Renewable Energy Laboratory

Josh Sperling is an 'Urban Futures and Energy-X Nexus' engineer and multi-disciplinary researcher at the National Renewable Energy Lab. He is a former Fulbright Scholar, holds a PhD from the interdisciplinary Sustainable Urban Infrastructure program at UC-Denver, and co-leads 'Urban Nexus Science & Innovation' to 'Smart Cities & Energy-X Nexus' thrusts in NSF and DOE consortiums, after joining the NREL's New Concepts Incubator, Joint Institute for Strategic Energy Analysis, Integrated Mobility Systems, International teams in 2015. He co-leads DOE and NYSERDA 'smart cities' work, strategic partnerships (including with universities), and supports various urban, behavioral, decision science and early career mentoring efforts at NREL and beyond.

Ari Kaufman

<https://www.linkedin.com/in/arikaufman/>

Chief Executive Officer, Spout

Ari Kaufman has led startups, turnarounds, and early-stage companies for 20 years. He has successfully raised private and institutional capital and has achieved successful exits, including two IPOs. His visionary leadership is complemented by his ability to attract and hire strong teams that execute.

Ari is the Founder and CEO of Spout, which is committed to safe water for everyone, everywhere. Spout is a smartphone-enabled device that identifies potential water contaminants - such as lead - in real-time for both the consumer and utilities via the cloud. Spout is working with water utilities to identify critical issues and prevent future catastrophic events like that which occurred in Flint, MI.

In 2012 Ari engineered the management buy-out of Placeable with the financial support of a private equity firm and most recently sold that company to a strategic acquirer. As the President of InfoNow-LocationInsight, he automated local search management. As founder, he successfully sold the interactive lead-generating advertising firm ThinkAcquisition to a global strategic agency. As General Manager for LookSmart, he managed the paid search platform responsible for \$250 million in revenue. As Chief Strategy Officer, he led PrecisionIR's IPO on the London Stock Exchange. He introduced first-party ad serving while at MatchLogic and as a founder of Zacks.com, he pioneered the online advertising industry with the first fully ad-supported web site in 1996.

Ari has proven that he builds winning cultures that promote ownership and accountability. His Own Your Shit mantra has received accolades from some of the most prestigious publications. Ari is considered a beacon for talent and a true nurturer of people.

Will Sarni

<https://www.linkedin.com/in/williamsarni/>

Founder and CEO, Water Foundry, LLC

Will is an internationally recognized thought leader on water strategy and innovation. He has authored numerous books and articles and presented on: the value of water, innovations in digital water technology, the circular economy, and the energy-water-food nexus.

He has been a water strategy advisor to private and public-sector enterprises and NGOs for his entire career. He has worked with multinational companies across a range of industry sectors in evaluating the technical viability and market potential of innovative water technologies, market entry strategies and M&A programs.

He is the author of: "Corporate Water Strategies" (Earthscan 2011, and in Chinese by Shanghai Jiao Tong University Press 2013); "Water Tech – A Guide to Investment, Innovation and Business Opportunities in the Water Sector" (Sarni, W. and Pechet, T., Routledge 2013); and "Beyond the Energy – Water – Food Nexus: New Strategies for 21st Century Growth" (Dō Sustainability 2015). He is currently working on the forthcoming books, "Water Stewardship and Business Value: Creating Abundance from Scarcity" (Sarni, W., and Grant, D., Earthscan 2018)

and “Creating 21st Century Abundance through Public Policy Innovation: Moving Beyond Business as Usual (Sarni, W. and Koch, G., Greenleaf Publishing 2018).

Will is a Board Member of 10.10.10 (www.101010.net) and ASSET (www.assetcampaign.org) and Founder of WetDATA.org. He was a 2016 X-PRIZE Bold Visioneer for the Safe Drinking Water Team and is on the: Scientific Program Committee for Stockholm World Water Week; Executive Council of NOAA’s National Integrated Drought Information System (NIDIS); Editorial Board of the Journal of Water Security; and a Technical Advisor for the Climate Bonds Initiative: Nature-Based Solutions for Climate and Water Resilience.

Barb Martin

<https://www.linkedin.com/in/barbara-martin-7448725/>

Director - Engineering & Technical Services, American Water Works Association

With over 20 years of experience in water and wastewater, Barbara Martin is currently Director of Engineering and Technical Services at the American Water Works Association, where she previously managed the Partnership water and wastewater optimization programs. She has a BA in chemistry from Boston University and an MS in geochemistry from Colorado School of Mines, where her thesis research focused on the effect of constructed wetlands on disinfection by-products and their formation. Barbara has an MBA from Colorado State University and is a licensed drinking water operator in the State of Colorado.

Christine Harada

<https://www.linkedin.com/in/christine-j-harada/>

Executive Council, Clean Energy for Biden

Member, Board Of Directors, Rekor Recognition Systems, Inc.

Partner, Sustainability Practice, RIDGE-LANE Limited Partners

Member, The Stimson Center - Loomis Council

Christine Harada is a climate and impact investor. Most recently, she was President of i(x) investments, a permanently capitalized holding company that invests in the critical areas of human need (renewable energy, green real estate development, affordable housing, gender equality, technology and information, waste reduction and food and agriculture) in a multi-strategy investment approach throughout the entire capital structure.

Christine has over 20 years of success in leading government and management consulting organizations. She has extensive expertise in business strategy and translating that into operational excellence. Most recently, she was a Partner with Ridge-Lane LP, a triple-bottom-line advisory that creates sustainable social value by bridging the gap that exists between private companies, investment capital, and government – across the Federal, State, and Local levels. She is also a Fellow with the Los Angeles CleanTech Incubator.

Before returning to the private sector, Ms. Harada served as the Federal Chief Sustainability Officer for the Obama administration. In this role, she provided oversight for all sustainability-related initiatives across the federal government in energy, fleet, and acquisitions-game-changing improvements that added to our nation’s clean energy future.

Prior to her White House role, Ms. Harada was the Acting Chief of Staff and U.S. General Services Administration. While at the GSA, Ms. Harada also served as Associate Administrator, Government-wide Policy and Chief Acquisition Officer responsible for transforming a "business model" to provide more proactive, evidence-based policies, and increased transparency at the agency.

Prior to joining the government, she was a management consultant to Fortune 500 and public sector clients to tackle their most pressing challenges. Christine has extensive expertise in business strategy, and translating that into operational excellence.

CWCB PRESENTATION

January 27, 2021

WATER & CLIMATE



Diagram illustrating four interconnected challenges in water and climate management, represented by four overlapping green circles arranged horizontally. The circles are labeled from left to right: Deteriorating Infrastructure, Supply & Scarcity, Quality & Safety, and Extreme Events.

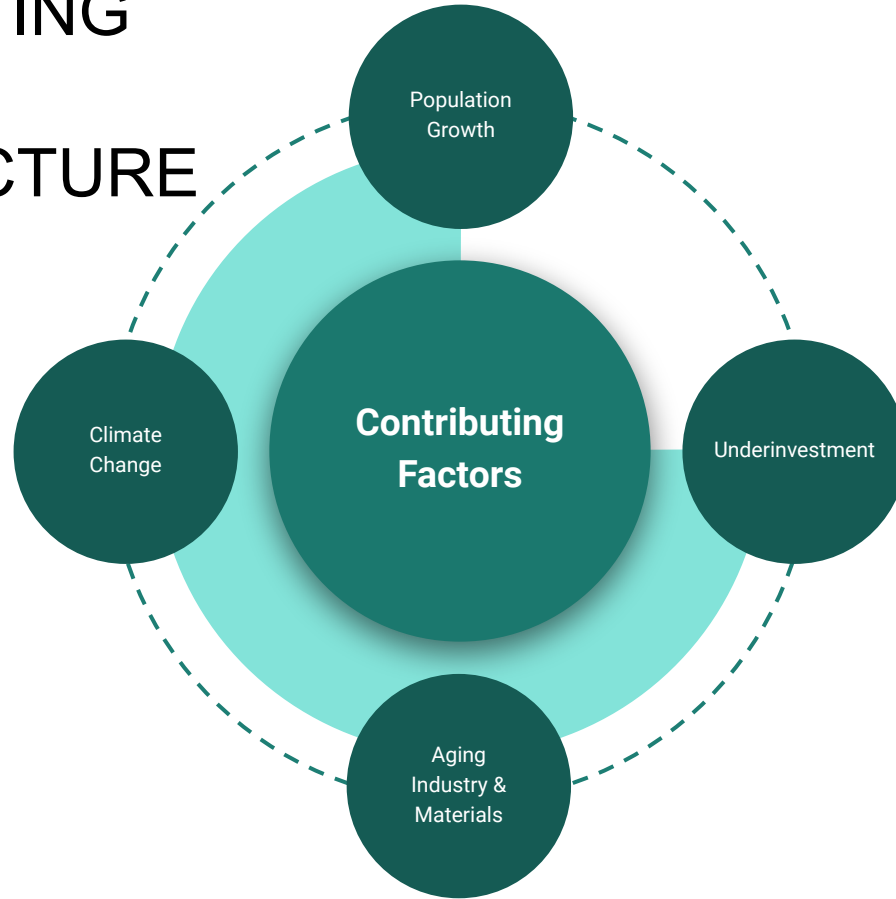
DETERIORATING
INFRASTRUCTURE

SUPPLY &
SCARCITY

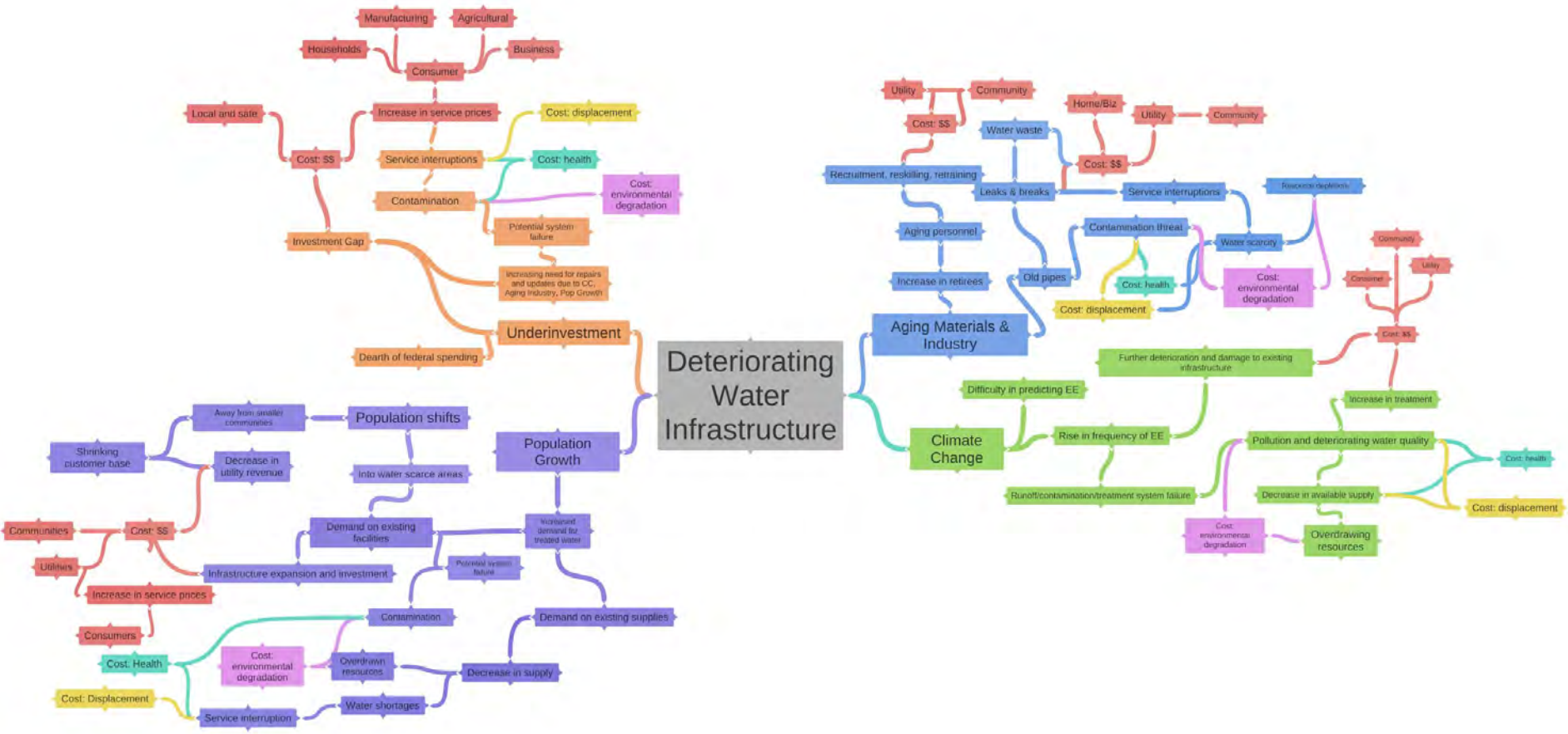
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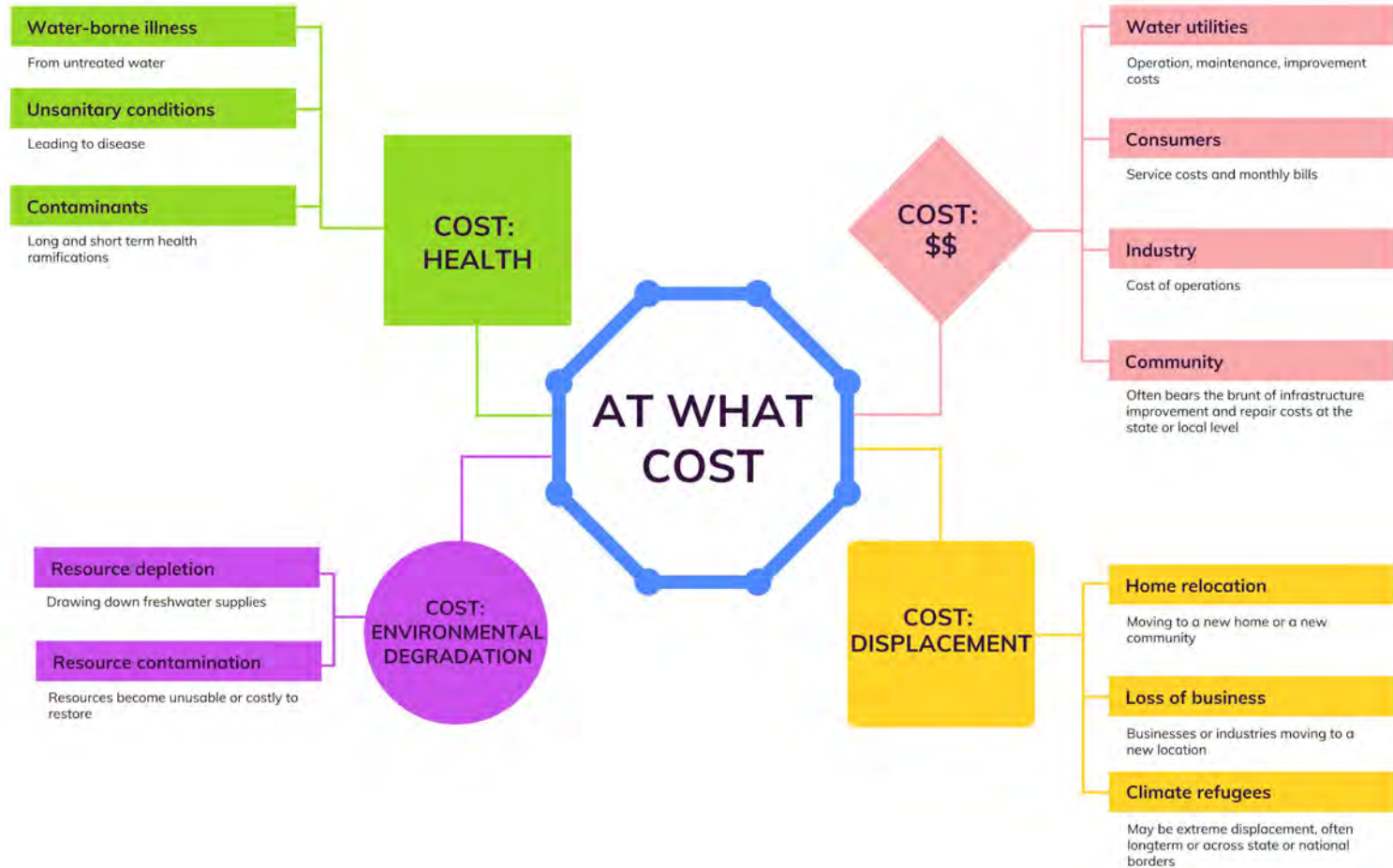
EXTREME EVENTS

DETERIORATING WATER INFRASTRUCTURE

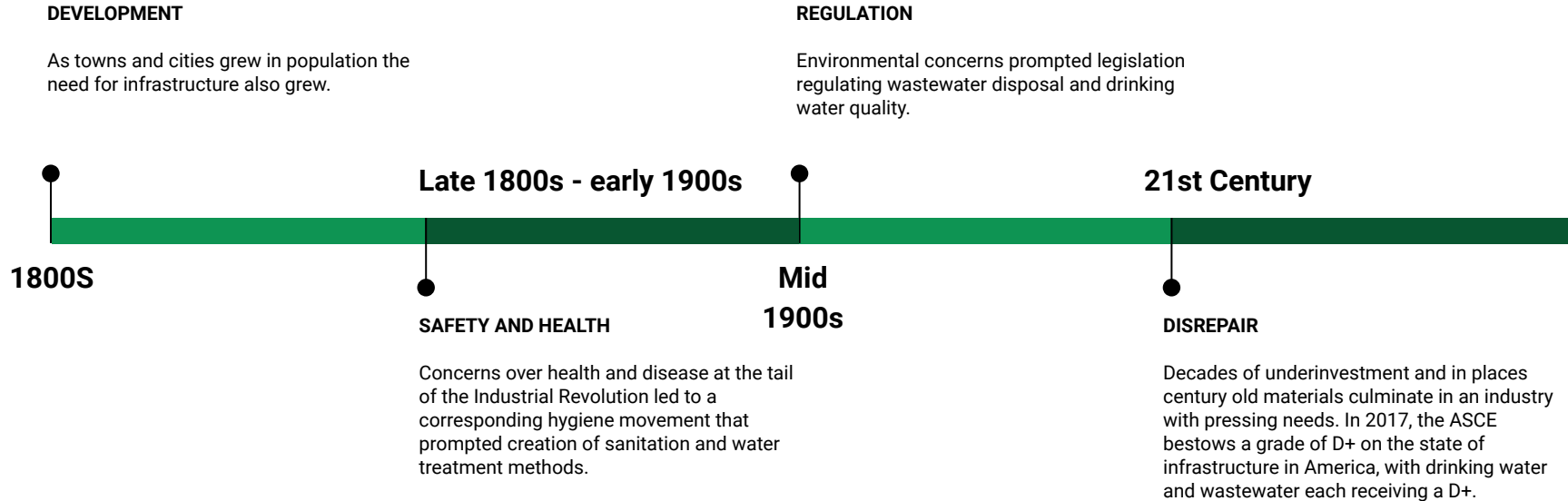


CONTRIBUTING FACTORS





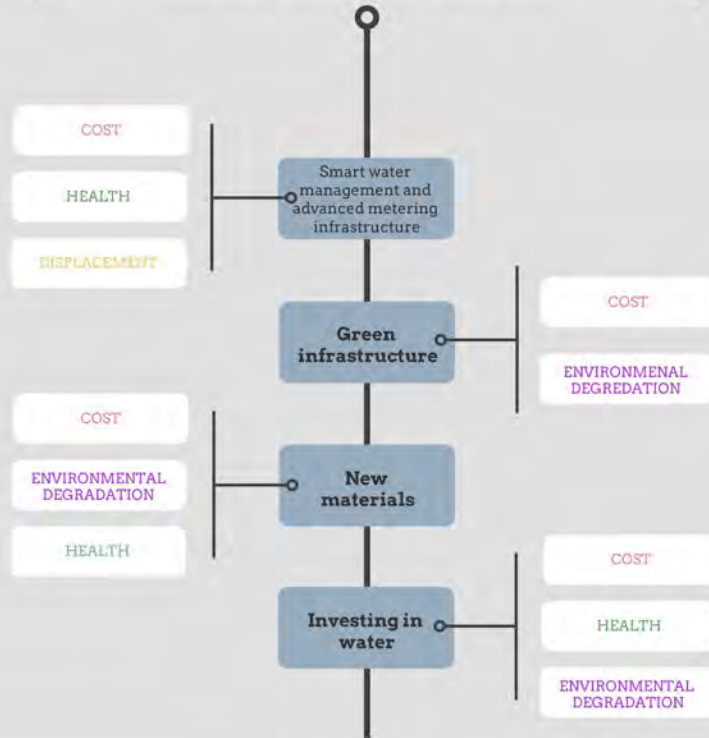
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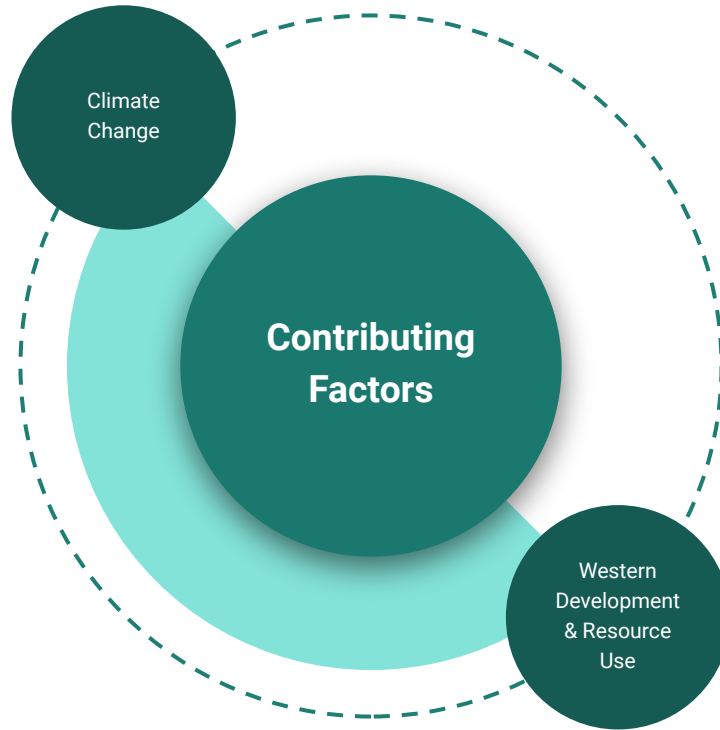




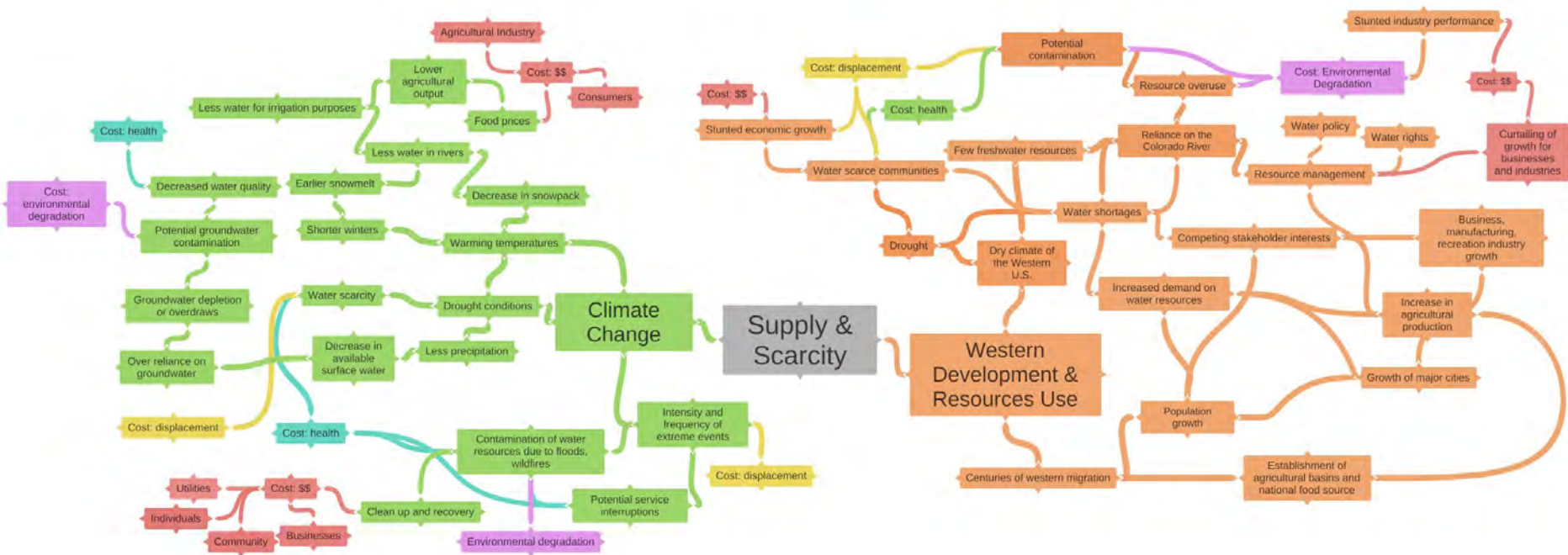
APPROACHES



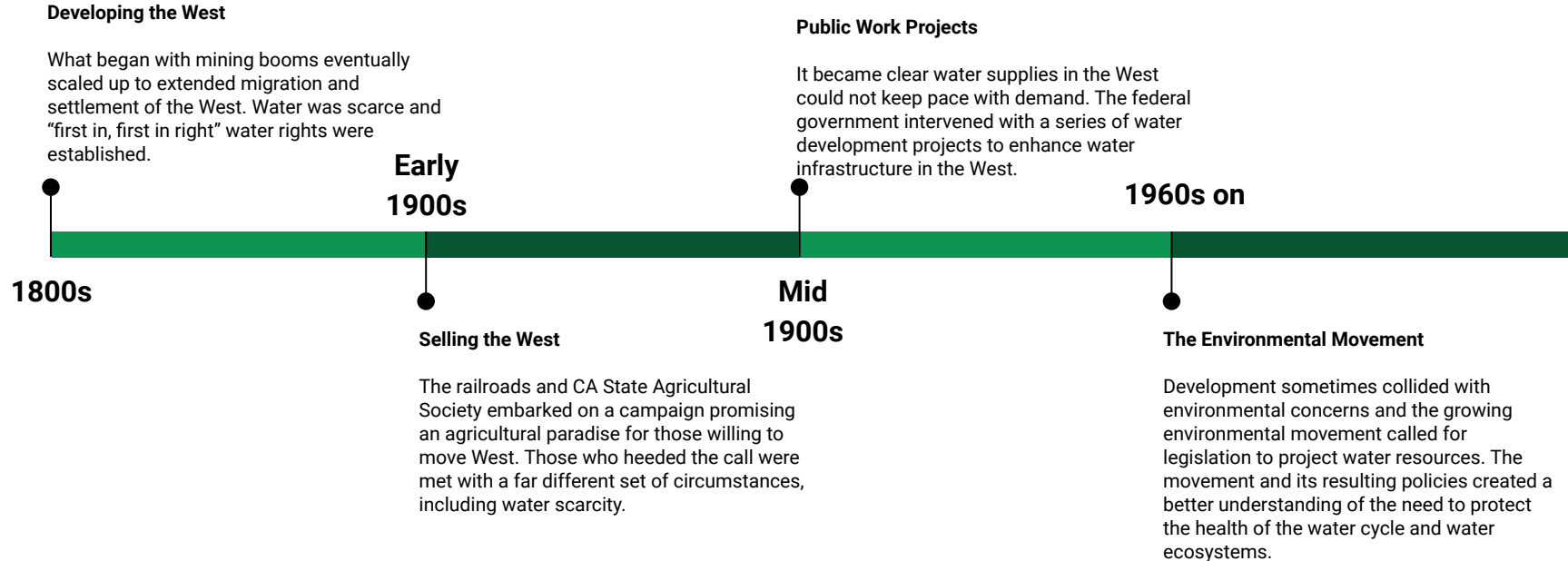
SUPPLY & SCARCITY



SUPPLY & SCARCITY



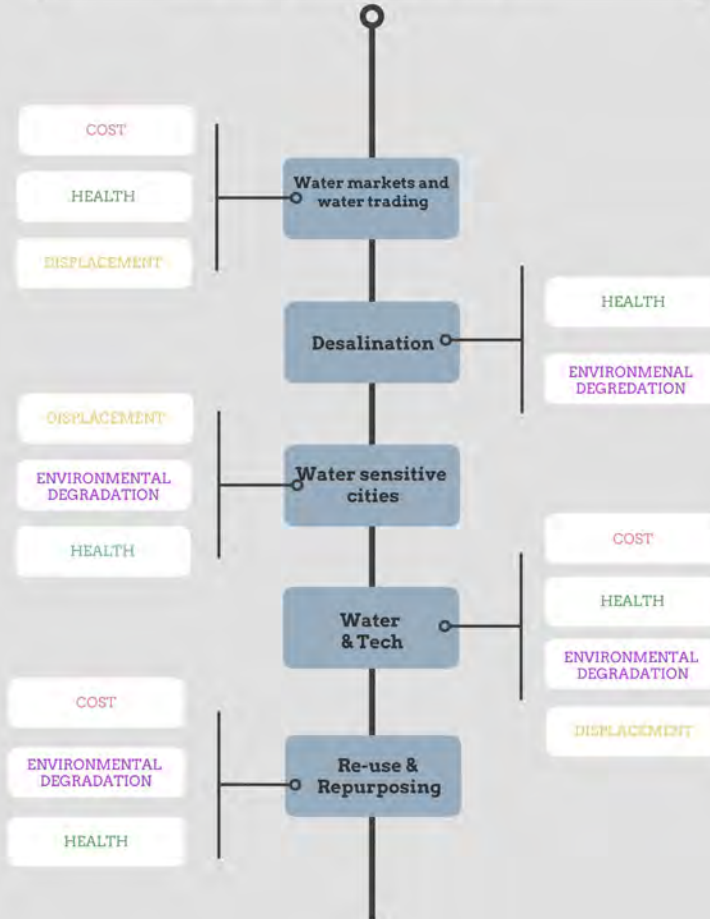
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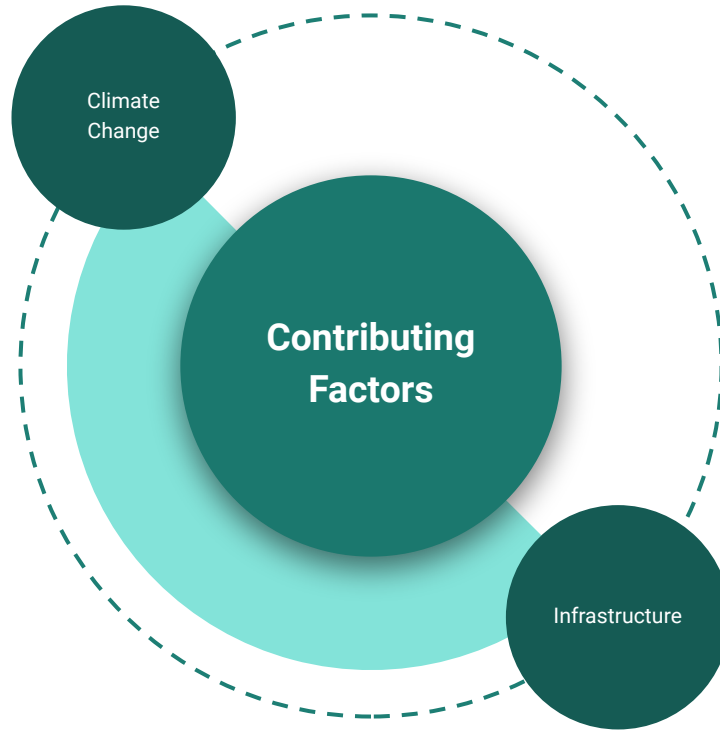




APPROACHES



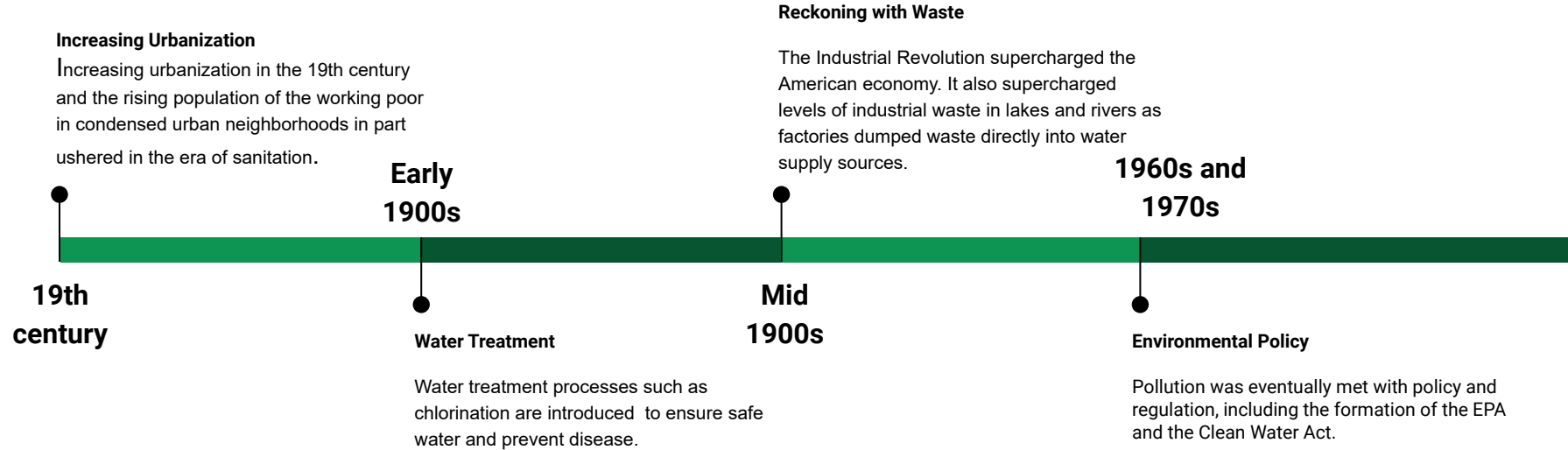
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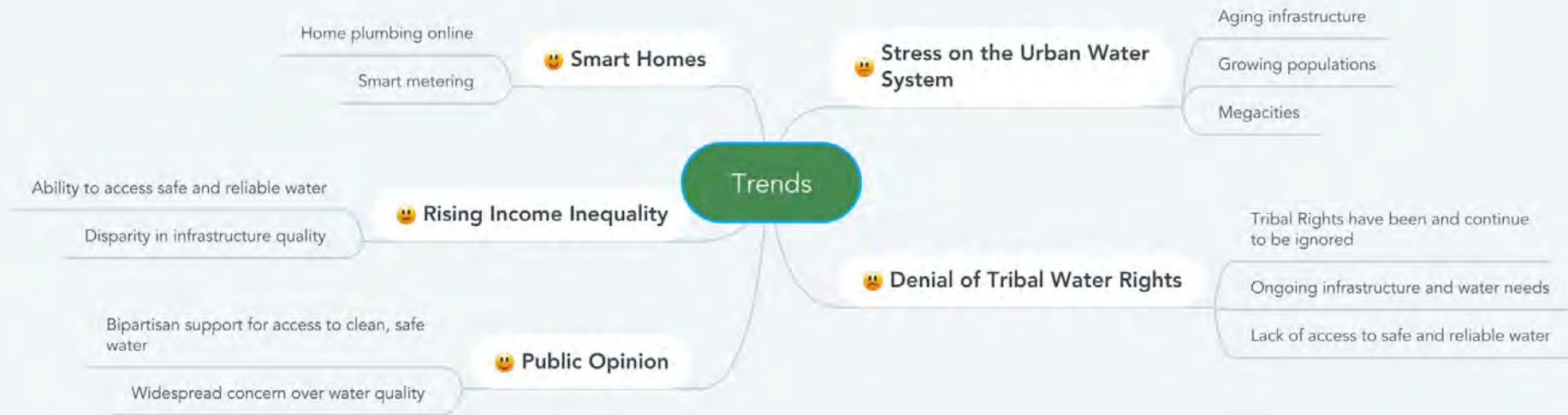


QUALITY & SAFETY



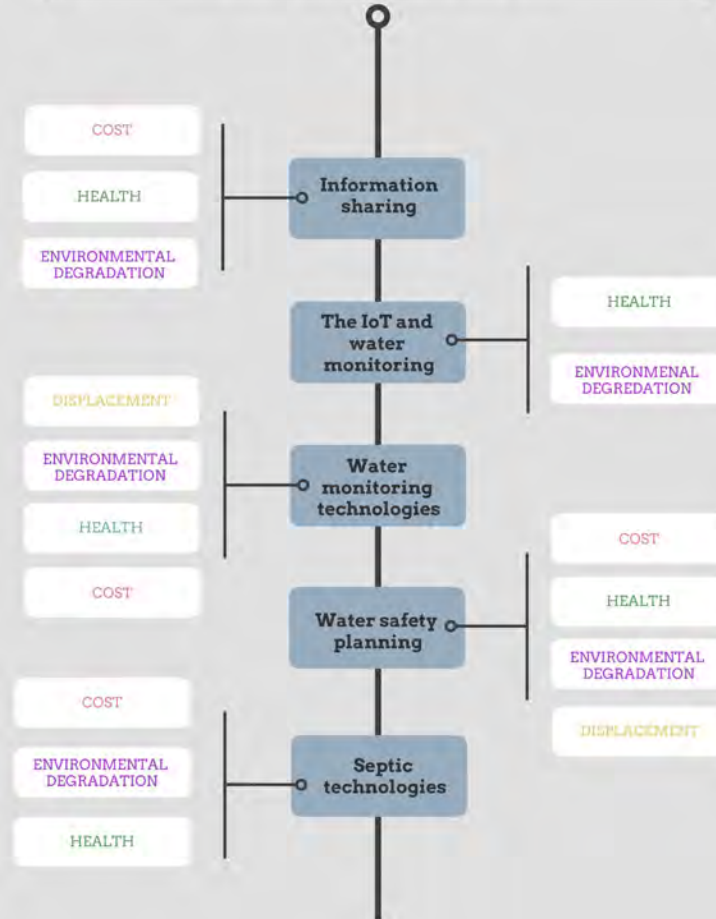
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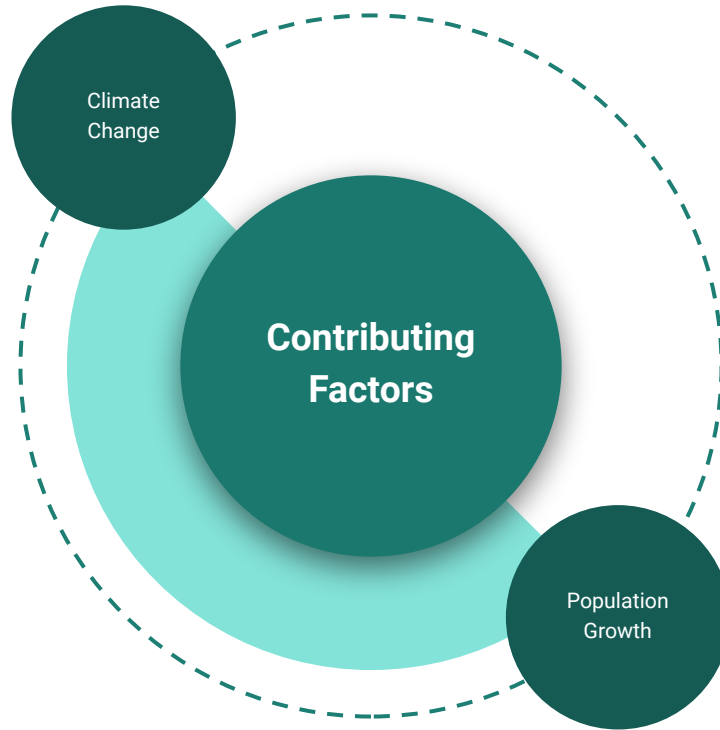




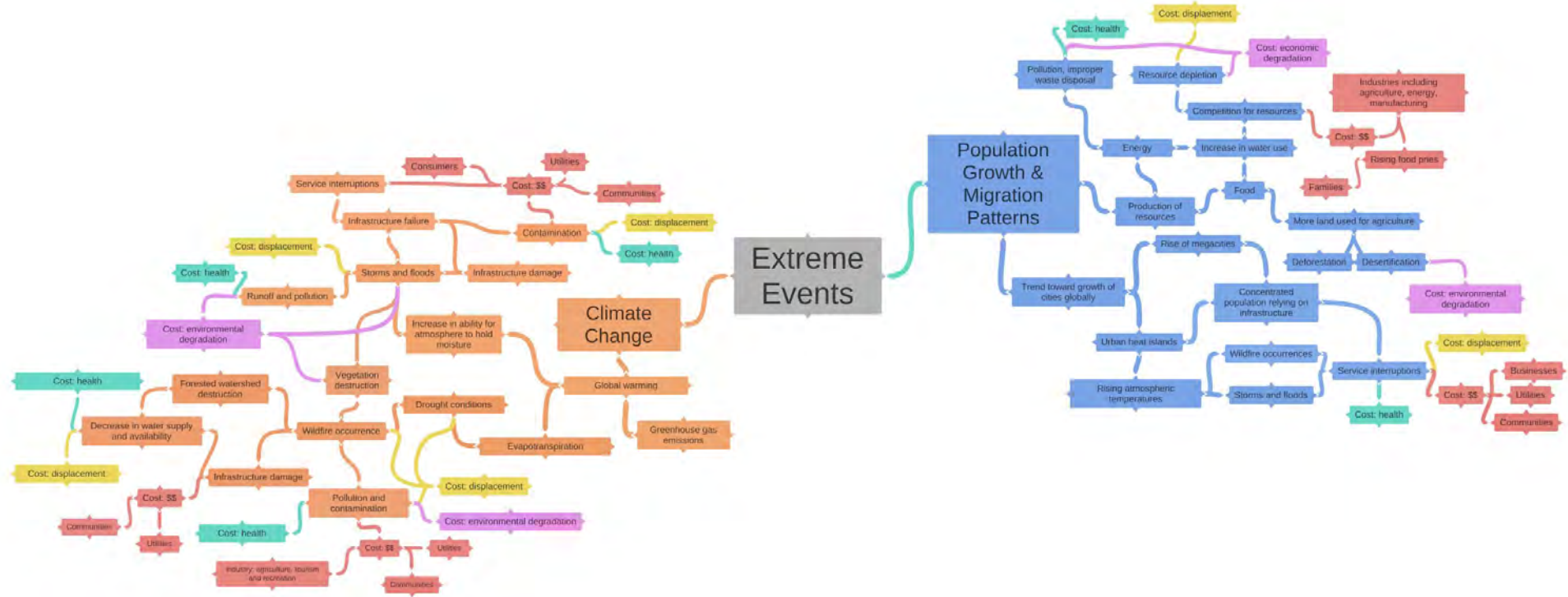
APPROACHES



EXTREME EVENTS



EXTREME EVENTS



HISTORY

Human Influence on Weather

The Dust Bowl of the 1930s is an example of human influence over extreme weather events. Caused in part by changes in land policy and agricultural practices.

More--and more extreme--extreme events

More frequent and intense extreme events also means a rise in cost. The annual average of billion dollar events from 1980-2019 is 6.6. As of October 7, 2020, the number of billion dollar extreme events in the U.S. was 16.

2020

1930s

1980s-
2019

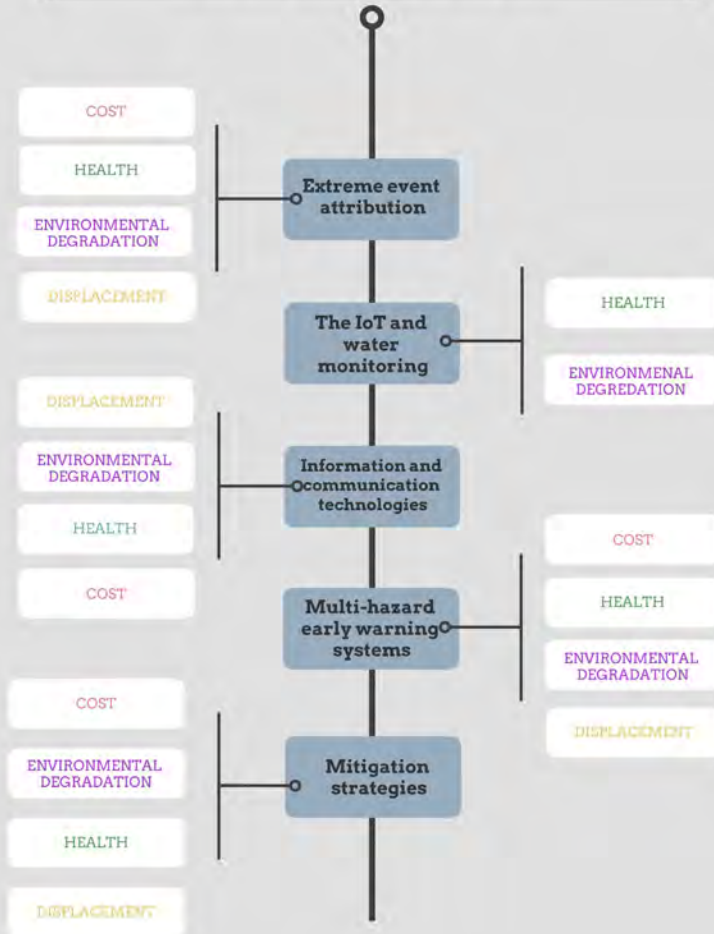
Another Record-Setting Wildfire Season

In 2020, there were 52,113 wildfires that burned 8,889,297 acres in 2020, roughly 2.3 million more acres burned than the 10-year average and almost double the acreage burned in the 2019 season.





APPROACHES



Task 3: Executive Summary of Wicked Problems

Extreme Events: Climate change is fueling the rising intensity and frequency of extreme weather and climate events such as drought, floods, wildfires, heat waves, and hurricanes. Attribution research names climate change a “threat multiplier” of extreme events and indicates human-caused climate change has played a role in the likely occurrence or severity of over 75% of extreme events in the past 20 years. Each year, these extreme events displace 20 million people globally as homes, and in some cases, entire communities are destroyed or made uninhabitable. The year 2019 broke records with 23.9 million people displaced due to weather-related disasters. The economic cost of extreme events is also staggering. In the U.S., the federal government has spent an estimated \$30 billion per year in the last 14 years on weather disaster assistance. Additional costs are borne by homeowners, farmers, ranchers, businesses, and local government. Both regionally and globally, women, children, and the poor are the populations most affected by extreme climate events resulting in compounded crises as extreme events exacerbate existing social inequities relating to health and safety, access to resources, and personal autonomy. Extreme climate events are wicked problems not only in the magnitude of their potential ramifications but in the difficulty to predict future events, particularly considering the uncertainty of climate change and the variability of regional landscapes, responses, and levels of preparedness.

Water Scarcity and Supply: According to the United Nations, water is “at the heart” of adaptation to climate change. Human-caused climate change, including the contributing factor of population growth, has resulted in less reliability in water supply resources as well as greater variability between water excesses and shortages. The result is growth in the frequency and intensity of water scarcity across the globe and escalating uncertainties concerning water supply. Over 748 million people around the world are without basic water access. That’s more than twice the population of the United States. As population growth continues--particularly in urban areas--so will instances of water supply scarcity. Almost *half the world’s population* will be living in areas of high water stress by 2030 and water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people. Climate change can significantly alter the water cycle, making predictions and planning for scarcity or water crisis events all the more challenging. As scarcity increases, attention to various sources and supplies of water, as well as more efficient water allocation and use, become essential for human survival and for economic growth. The estimated U.S. benefit of reducing agricultural water scarcity globally is \$94 billion a year. Source and supply issues become their own wicked problem spinoffs, however. Each water source--from groundwater, to sea water, to rivers, to rainfall, to reused water--includes climate change related challenges ranging from pollution and supply levels to consumer comfort and cost. Further, supply issues overlap with infrastructure and capacity limitations, technology considerations, and neglect of rural areas.

Infrastructure: The average age of water and sewage pipes in the U.S. is 45 years; in over 600 towns and cities in the U.S. the age of pipes is north of 100. These pipes--in some cases exceeding their intended life span by more than four decades--are not aging gracefully. A water main breaks in the U.S. every two minutes, resulting in a loss of 6 billion gallons per day and an

estimated cost of \$7.6 billion in treated water per year. Climate change worsens the conditions of aging infrastructure via an onslaught of extreme events such as storms or floods that stretch the limits of infrastructure resiliency. To combat the deluge in costs and face ongoing threats, local governments will spend an estimated \$300 billion on repairing and updating water and sewage pipes in the next ten years. These figures represent the deteriorating nature of much water infrastructure locally and globally. And it's not just pipes. Water infrastructure refers to the systems, including the workforce, the technology, and the processes related to the treatment, delivery, storage, supply, and resource management of drinking water, wastewater, and stormwater, increasing the complexity of infrastructure challenges. The American Society of Civil Engineers gave grades of D and D+, respectively, to the entire U.S. water and wastewater infrastructure systems. As these systems continue to age, the cost of operating and maintaining them will rise, exponentially increasing the cost of deteriorating infrastructure and further opening infrastructure to the threats of climate change, including rising water demands in response to heat waves, drought, and other extreme events. Not only is water infrastructure essential to individuals and households, entire industries from healthcare to manufacturing to mining rely on water and wastewater systems to function. Without significant investments to and changes in water infrastructure within the shifting reality of climate change, service disruptions could cost water-reliant businesses roughly \$250 billion by the year 2039 and costs to U.S. households could reach seven times that of current water costs. Finally, a deteriorating water infrastructure produces a multitude of health risks, be it metal seeping into the water from aging pipes as was the case in Flint, Michigan, to waterborne diseases resulting from sewage contamination. These risks threaten familial and community health and often occur in municipalities and neighborhoods with high levels of poverty, further complicating mitigation or innovation efforts.

Quality: More people die from unsafe water than from all forms of violence, including war. While surface water quality has improved in many parts of the developed world in recent decades, those improvements face threats from economic growth, population increases and shifts, and climate change. Climate change and its effects increase the possibility of compromised water quality in the U.S. and around the globe. A warming climate produces warmer water temperatures wherein harmful bacteria or algal toxins thrive, creating dangerous conditions for water use and water recreation. The growing frequency and intensity of extreme climate events such as storms and floods means more water runoff, eutrophication, and pollution of water sources and in coastal areas, salt-water contamination of freshwater sources poses a threat to water quality. Those living in poverty, in rural areas, and those who are members of vulnerable communities are disproportionately susceptible to unsafe water. Populations most at risk for lead exposure in drinking water, for example, are low-income, minority status, in urban areas, or residing in buildings constructed prior to 1978. Water quality is also tied to food production. Salinated water, resulting from runoff, poor irrigation systems in dry areas, and intrusion of sea water reduces global agricultural output each year by numbers equal to feeding 170 million people. Finally, water quality runs downstream. Literally. When the quality of a river is compromised, economic growth for areas downstream drops by roughly one-third due to water quality's central role in recreation and tourism, community health, agriculture, energy production, and manufacturing. Water quality is a wicked problem for many reasons. It is highly connected

to other wicked problems such as extreme climate events, infrastructure, and sanitation. It is highly susceptible to the various effects of climate change. Finally, there is a great deal of unknowns when it comes to measuring, understanding, and regulating water quality, including the potential harm of emerging pollutants like microplastics and pharmaceuticals. Despite these challenges, a concern over water quality tops public opinion on water issues throughout the U.S. and safe, accessible water is fundamental to human growth and development around the world.

Sanitation and Hygiene: Climate change creates a number of health concerns. Many of those are related to water and the spread of water-borne diseases due to poor sanitation--the safe separation of human waste from human contact--and hygiene--facilities and practices for the safe management of human excreta--worldwide. Conservative estimates attribute nearly 2 million preventable deaths worldwide to inadequate water and sanitation. Children, in particular, are at risk. Diseases related to unsafe water and poor sanitation kill more children under the age of five than malaria, measles, and AIDS combined. Climate change interacts with sanitation efforts in three primary ways: heightening the risk to sanitation systems via extreme events or changes to the hydrological cycle, an increase in uncertainties when planning for sanitation management in the face of climate change, and greater inequalities in access to sanitation as a result of climate change's role as a "poverty multiplier." Globally, 4.2 billion people lack access to basic sanitation services. Many homes, healthcare facilities, and schools lack the implements, such as water and soap, for handwashing. Infections associated with unclean births result in over 1 million deaths each year, including 26% of neonatal deaths and 11% of maternal deaths. In the U.S., over 2 million people live without access to drinking water and sanitation, including 1.4 million people in the U.S. who do not have access to indoor plumbing. Improving management of wastewater is one approach to sanitation and presents opportunity for resource retrieval and management in service to water, energy, nutrients, and other recoverable materials. Investments in sanitation yield return: for every dollar spent on improved sanitation the average global economic return is \$5.5. Sanitation and hygiene challenges are wicked problems in part because of their ties to infrastructure, water access and supply, and extreme climate events. Not to mention the increased import of sanitation and hygiene in the wake of global pandemics. Climate change is likely to slow progress related to water sanitation. We need adaptation measures to make sanitation facilities and processes more climate resilient.

CWCB PRESENTATION

January 27, 2021

WATER & CLIMATE



Diagram illustrating four interconnected challenges in water and climate management, represented by four overlapping green circles arranged horizontally. The circles overlap in a chain-like fashion, with each circle partially overlapping the one to its left and right.

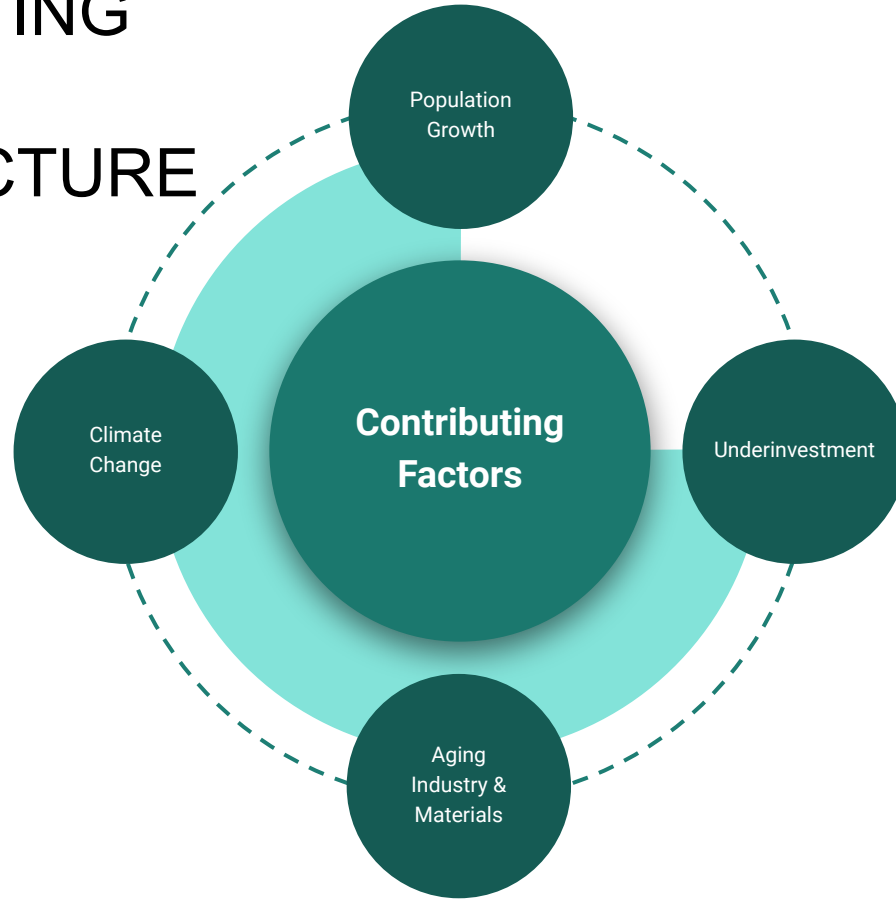
DETERIORATING
INFRASTRUCTURE

SUPPLY &
SCARCITY

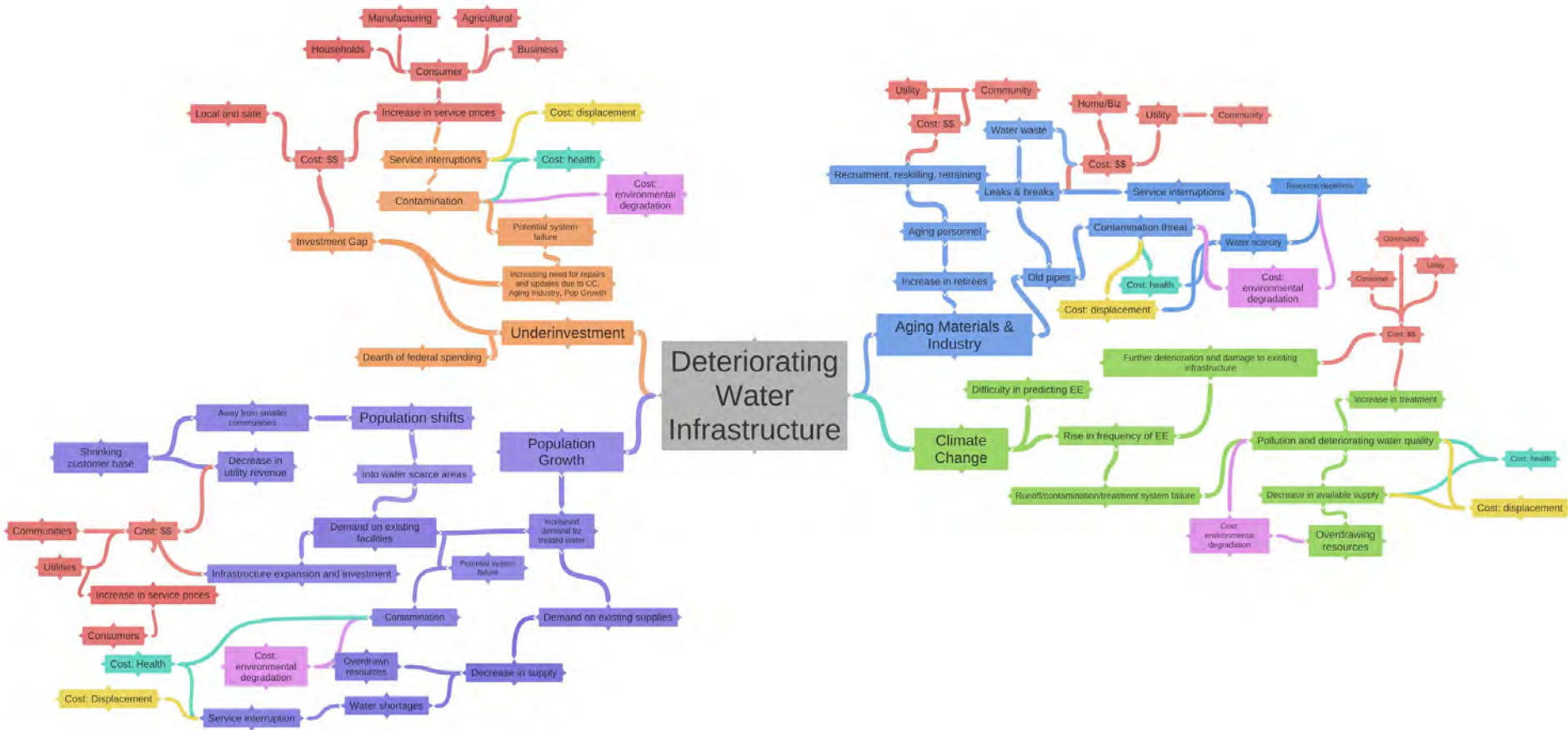
QUALITY & SAFETY

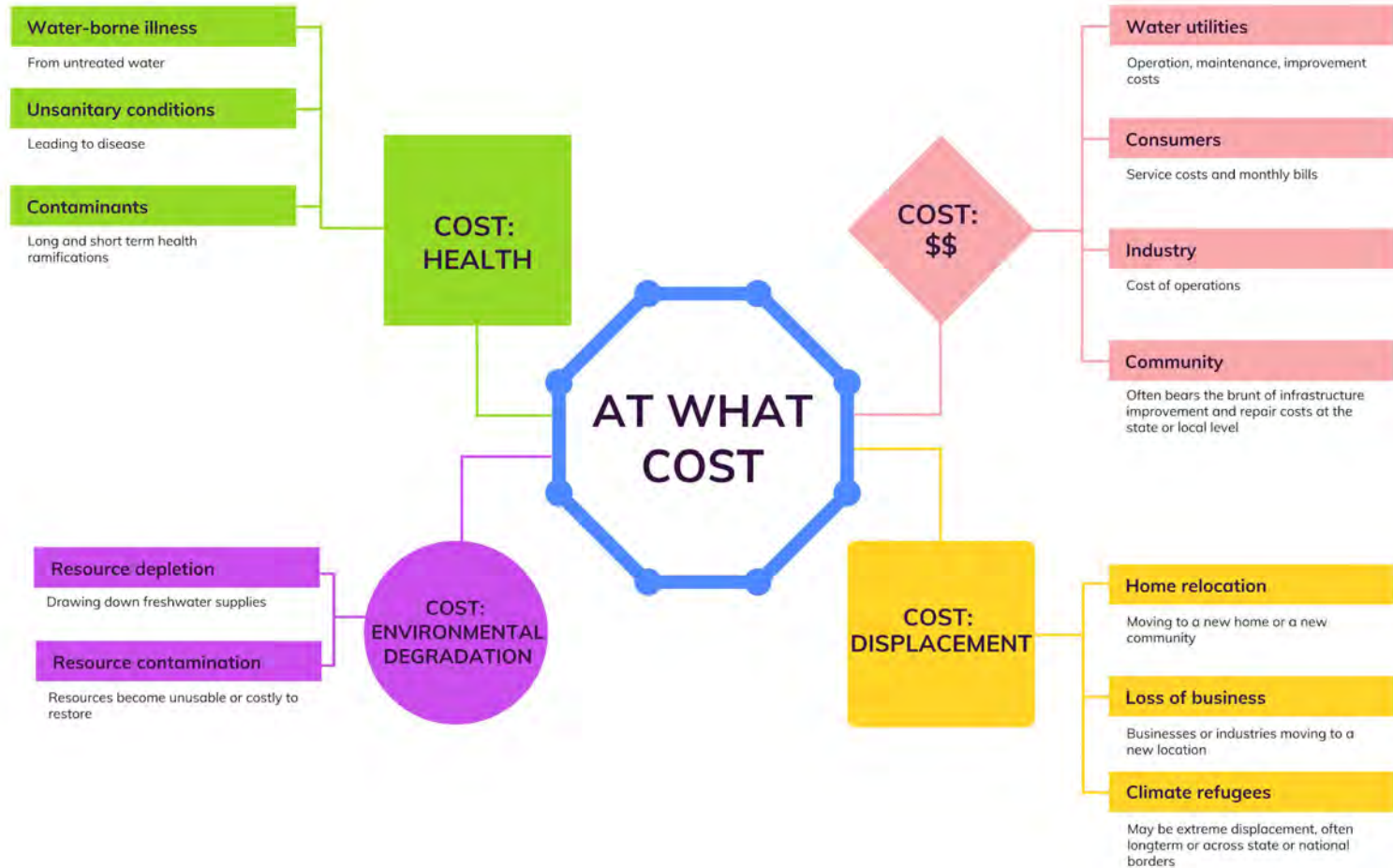
EXTREME EVENTS

DETERIORATING WATER INFRASTRUCTURE

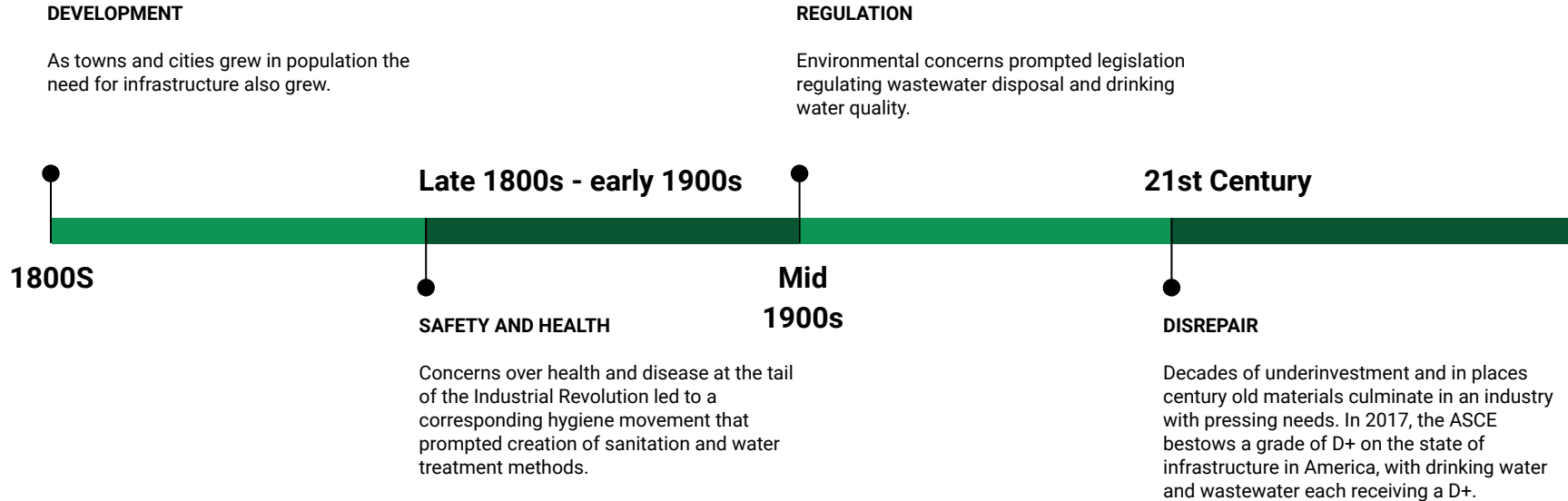


CONTRIBUTING FACTORS





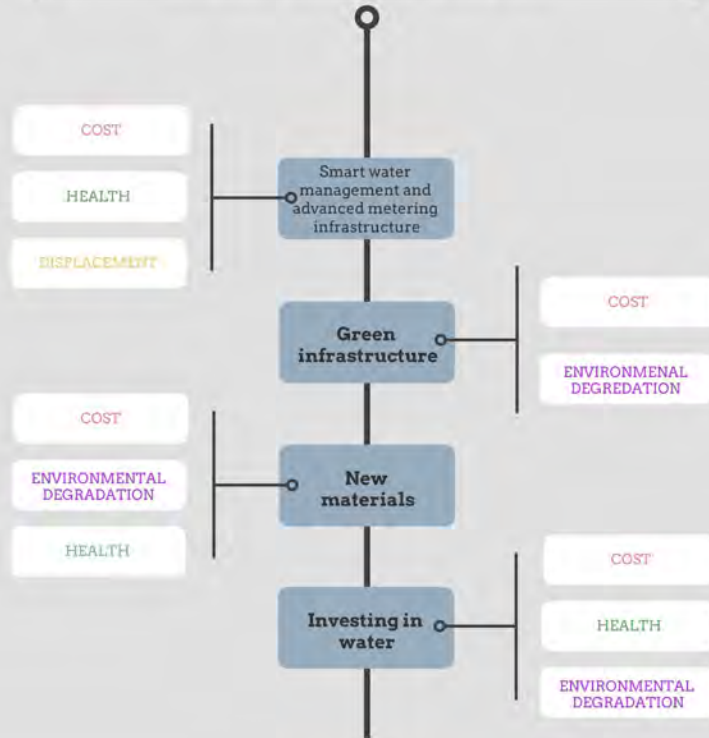
HISTORY



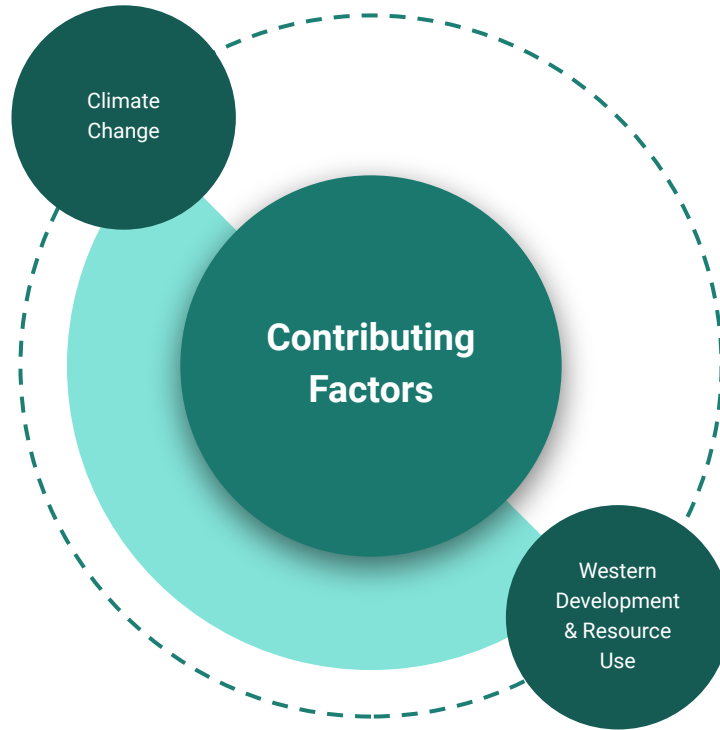




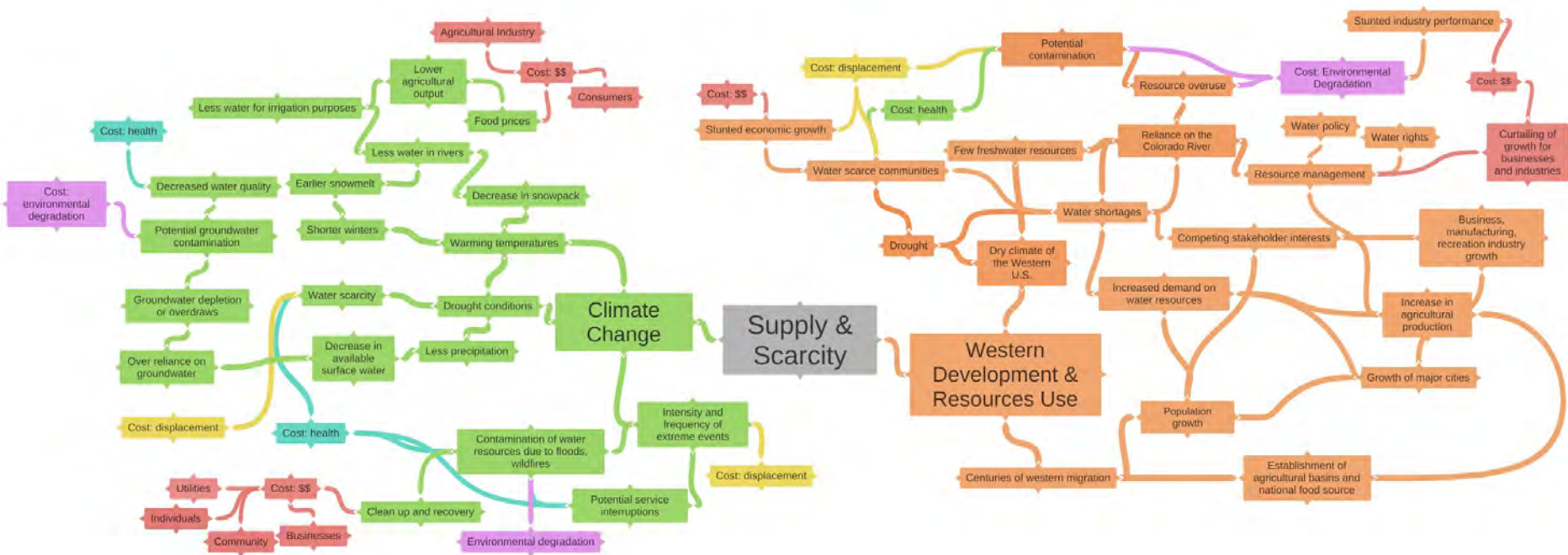
APPROACHES



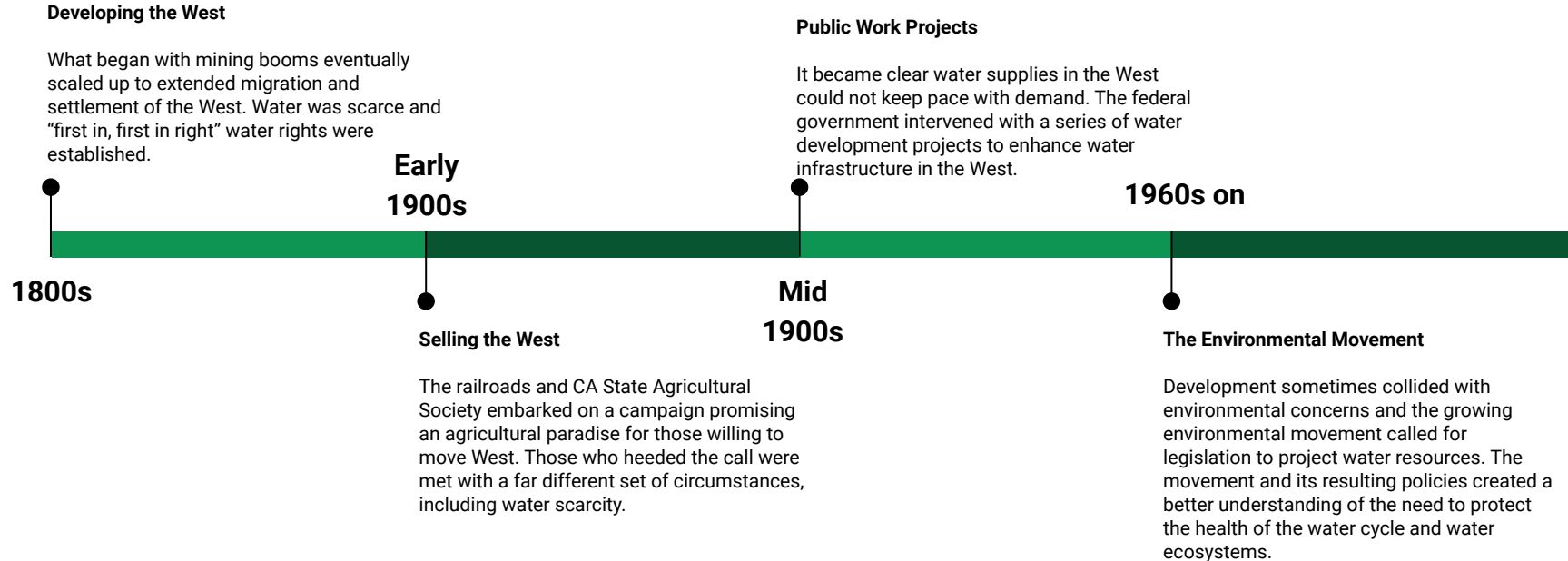
SUPPLY & SCARCITY



SUPPLY & SCARCITY



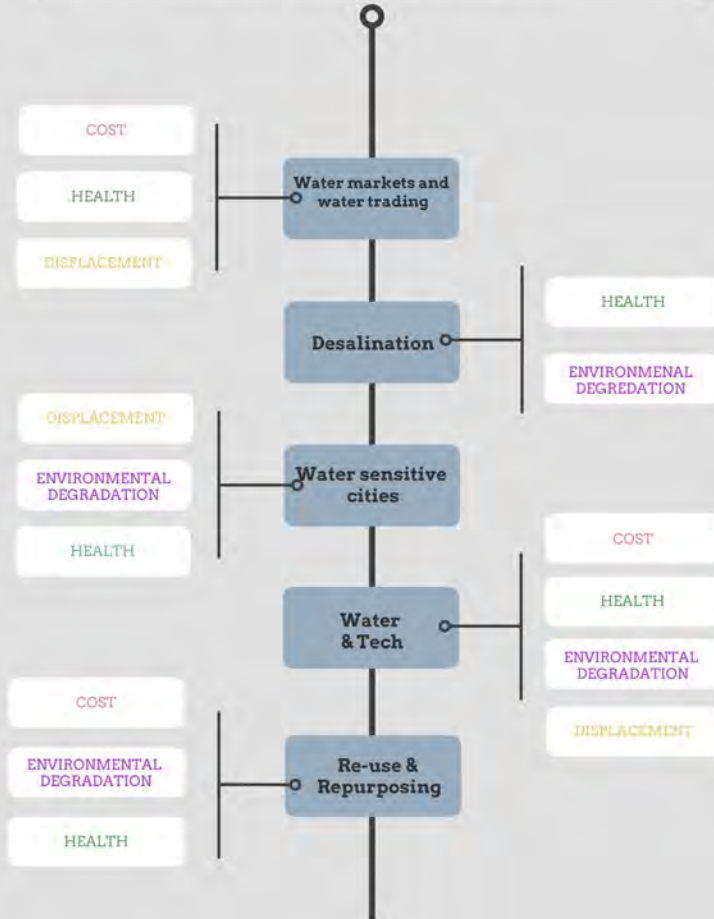
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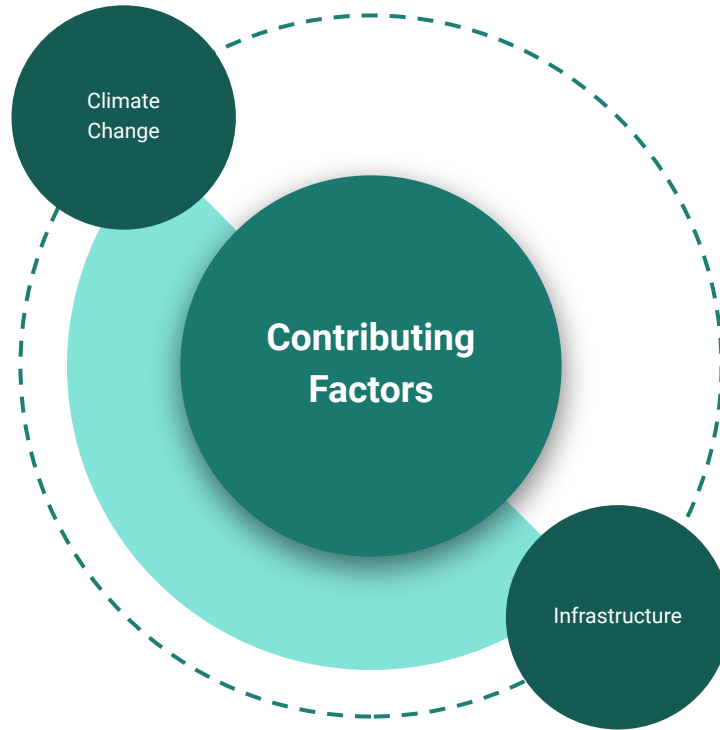




APPROACHES



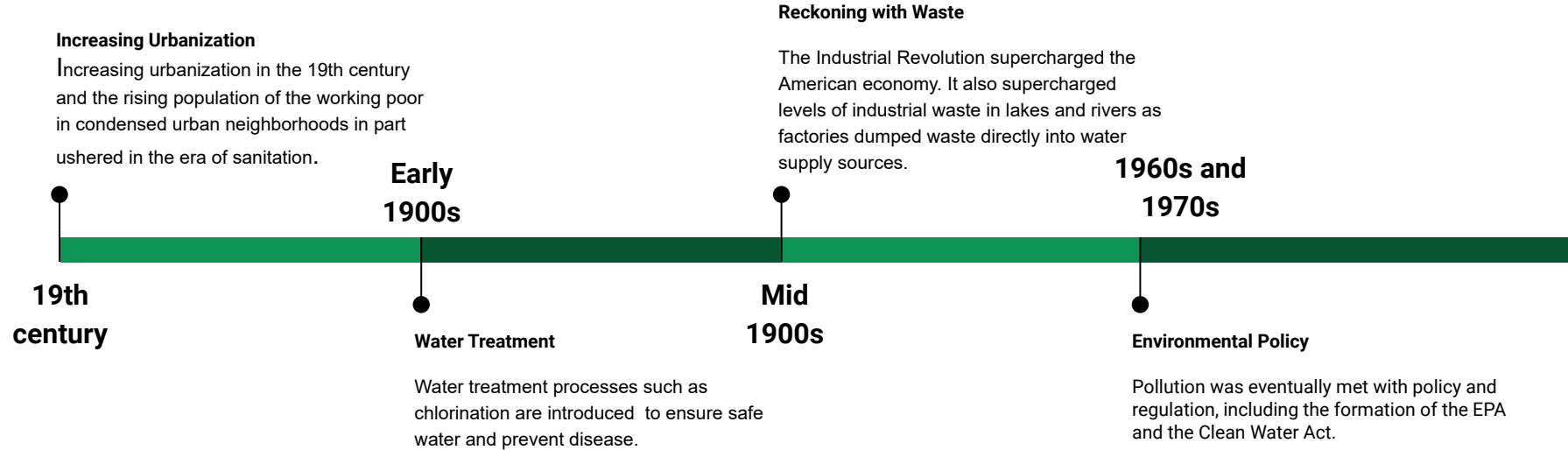
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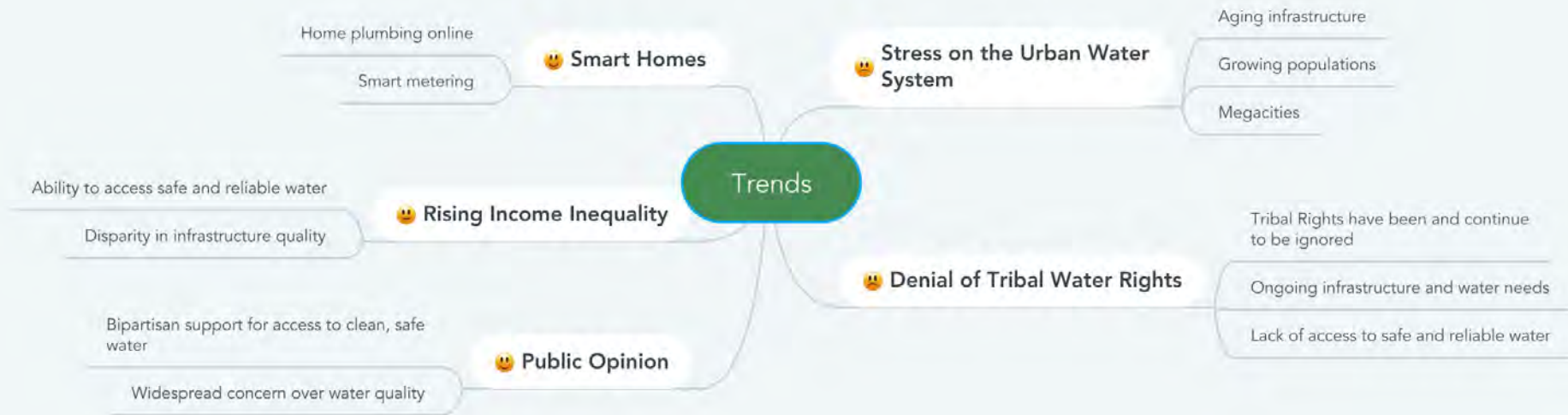


QUALITY & SAFETY



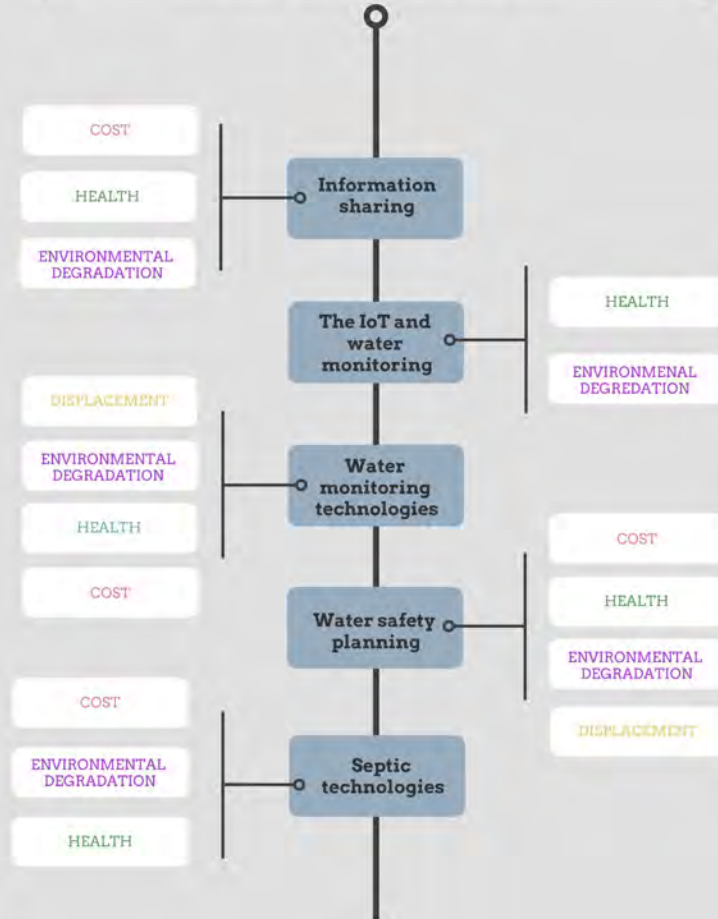
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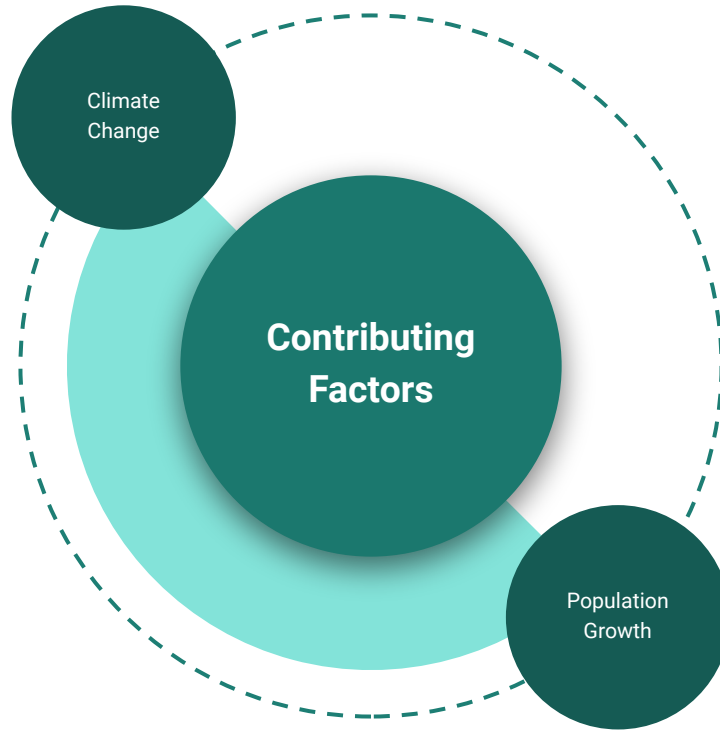




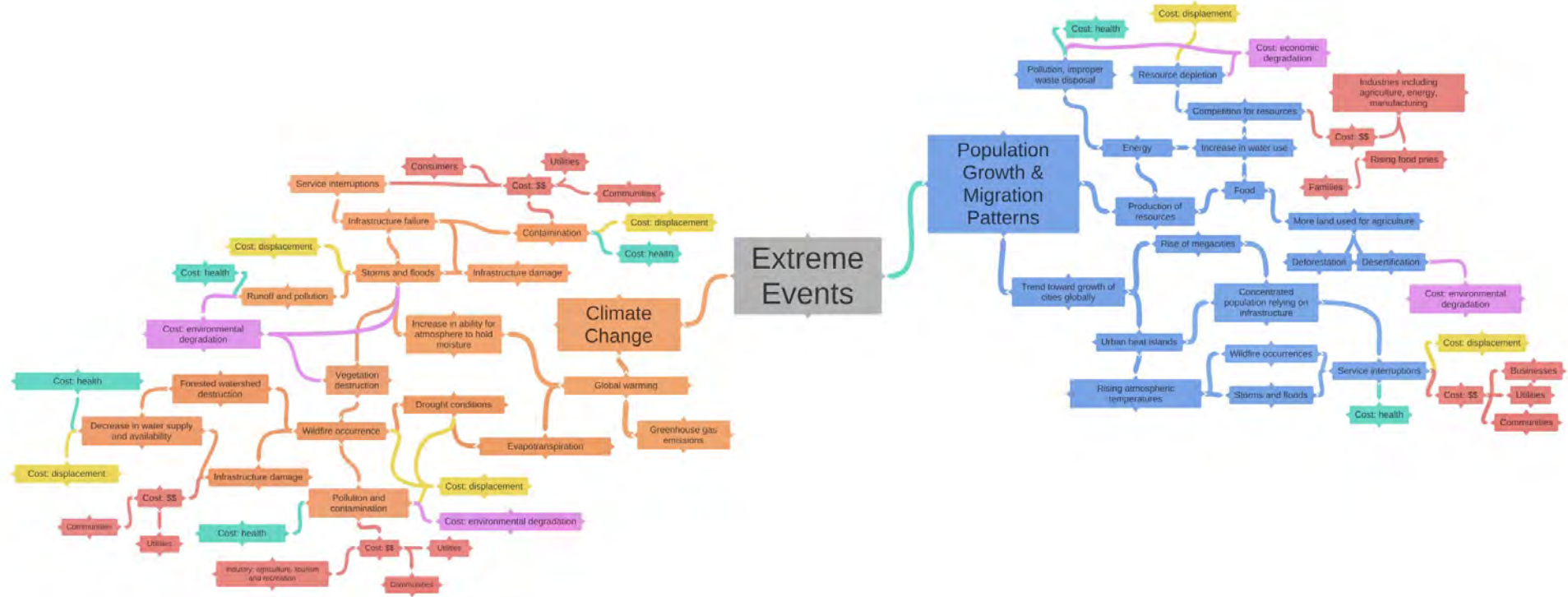
APPROACHES



EXTREME EVENTS



EXTREME EVENTS



HISTORY

Human Influence on Weather

The Dust Bowl of the 1930s is an example of human influence over extreme weather events. Caused in part by changes in land policy and agricultural practices.

More--and more extreme--extreme events

More frequent and intense extreme events also means a rise in cost. The annual average of billion dollar events from 1980-2019 is 6.6. As of October 7, 2020, the number of billion dollar extreme events in the U.S. was 16.

2020

1930s

1980s-
2019

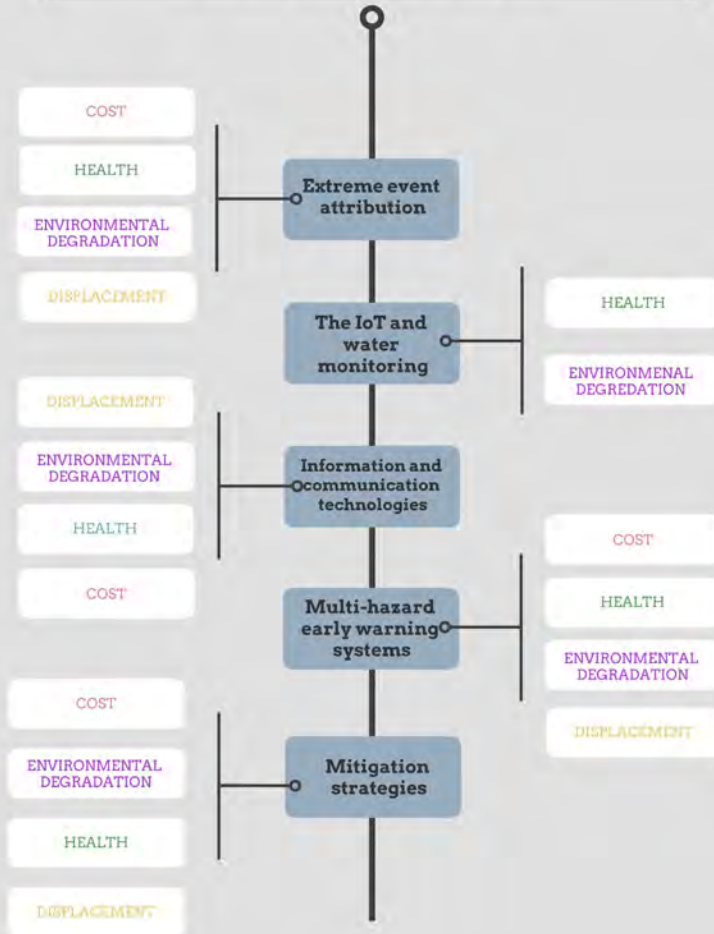
Another Record-Setting Wildfire Season

In 2020, there were 52,113 wildfires that burned 8,889,297 acres in 2020, roughly 2.3 million more acres burned than the 10-year average and almost double the acreage burned in the 2019 season.





APPROACHES



First name	Last name	Email	LinkedIn URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Amir	Najian	amir.h.najian@gmail.com	https://www.linkedin.com/in/amirhajian/	Amir is a seasoned data scientist with more than 7 years of experience in applying data science and AI/ML in both startups and large corporations. He holds a Ph.D. in Geospatial Science and has more than 15 years of experience with location data and geospatial technologies. He also co-founded a consultancy where he built the core NLP solution for a RegTech startup that made a successful exit in 2020. Over the past 5 years, Amir has been a data scientist in the geospatial team at RMS. Currently, he is working on problems at the intersection of location data and NLP, most notably high-resolution address matching, address standardization and disambiguation, and statistical modeling of geocoding errors. Amir lives in San Francisco and he loves hiking and road trips along the Pacific coast.	prototyping/product development, other, leadership & management	6-10 years	2-5 Years
Ankur	Goel	ankurgoel@msn.com	https://www.linkedin.com/in/ankurgoel/	Ankur is a Washington-DC based attorney, with experience in all three branches of the federal government (including as counsel to Senator Biden back in the day), and in private practice. Most recently, he works primarily within the healthcare field, which itself is rife with "wicked problems" and complex structures and regulatory systems. He is particularly enjoys looking for challenges and the "levers" that might solve them. He has also served on several boards, including of the Asian American Justice Center .	compliance, leadership & management, vision and mission, other	20+ years	No experience
Anurag	Maloo	anurag@seedstars.com	https://www.linkedin.com/in/anuragmaloo/	Anurag is currently leading Seedstars in Asia-Pacific. Seedstars mission is to impact people's lives in emerging markets through technology and entrepreneurship with a focus on supporting impact entrepreneurs and investing in solutions achieving the global goals (UN SDGs). He focusses on building strategic partnerships for impact, new business development and sales, and manages the key accounts for Seedstars in Asia-Pacific. He has also launched UN Climate Innovation Labs/ Academy, and leading the Climate and Sustainability innovation programs at Seedstars. Featured as #ProfessionalsOfLinkedIn, Anurag is big on nurturing authentic and deep human connections through empathy and compassion. As a multicultural professional experienced in developing and operationalising innovation strategies in the non-profit, public and private sector, and in international development across India/ Asia, Anurag brings a depth of leadership experience in creating inclusive startup communities and vibrant entrepreneurship ecosystems across Asia-Pacific. He is also the Cofounder and Director of Green and Good Foundation. He is an entrepreneur, community builder, innovation and well-being coach and an ecosystem architect. Previously, he has worked with Techstars, the global platform for investment & innovation, as Regional Manager for 6 years, to grow, develop and catalyse the regional entrepreneurship ecosystems across APAC. He has been instrumental in launching Techstars India, and was the Happiness & Network Director for the first cohort of Techstars Bangalore Accelerator. He is also the Curator for Emerging Economies Startup Digest, and as a Global Facilitator, Community Leader & Mentor for Startup Weekend. Anurag is a former Teach For India fellow who was selected as 2041 Antarctic Youth Ambassador and was invited to join the polar explorer and environmental leader, Robert Swan (OBE, FRGS) on the 2041 Inspire International Antarctic Expedition in 2013. He is a former UNLEASH Global Talent 2018 and now involved as UNLEASH+ Specialist and UNLEASH Global Facilitator for SDG Innovation Labs since 2019. He is an alumna of the South East Asia Leadership Academy (SEALA) & a member of the Society of International Business Fellows (SIBF) network. An aspiring mountaineer, he hails from the hot deserts of Rajasthan, and before the world came to stillness, he has done impact journeys to over 58 countries across 6 continents. So far his journeys have taken him as far South to the cold & polar deserts of Antarctica to far North trekking to the Base of the World's highest mountain, MtEverest Basecamp, and in between travelling across high-altitude Himalayan Passes along the ancient trade cities on Silk Road to the vast, wild grasslands and virgin landscapes of nomadic Mongolia to the various conflict regions around Asia.	community engagement, customer discovery, go-to-market strategy, market research, sales, team culture, vision and mission, operations, product strategy	6-10 years	6-10 Years
Becca	Williams	becca@thoughtdistillery.com	https://www.linkedin.com/in/becca-williams/	Becca Williams is a pragmatic, creative technology consultant who glides between left and right-brained thinking and heart-centered practices. She has 10+ years of cross-industry and cross-functional experience leading globally-distributed and co-located software teams with a primary focus on B2B SaaS solutions. (And another 10 years in other areas including, but not limited to, classroom teaching, photojournalism, and non-profit work.) She has lots of opinions on remote work, having been fully remote for five+ years. Becca takes pride in being a generalist, loves helping teams find clarity in the midst of chaos, and completely nerds out about creating flow charts and collaborative canvases and writing really awesome user stories. Prior to starting Thought Distillery, Becca spent several years working for a Fortune 500 financial services organization and wore multiple hats for a boutique DevOps and Application Development consulting firm where she worked on cutting-edge solutions using Machine Learning and mission-critical systems for daily operations in the private and public sectors. She has invested significant time and energy into studying and applying Scrum, but she's not dogmatic about it. It's another tool in the toolbox. Becca's dot-connecting vantage point melds play, mindfulness, coaching, training, and social impact. She is passionate about her open-source research on reinventing K-12 education, diversity, equity, and inclusion in tech, companies leading the way in sustainability, and other resources for social enterprise founders. She is also working toward bringing her vision for Like Hearts Lab, a social enterprise campus in the forest, to fruition in rural Colorado.	customer discovery, market research, project management, team culture, vision and mission	10-20 years	2-5 Years
Ben	McConahey	bsmcconahey@gmail.com	https://www.linkedin.com/in/bsmcconahey/	Ben took the "typical" path towards a mission-driven career by playing professional golf coming out of college. After three years, two wrist surgeries, and seven months of physical therapy, he decided to challenge himself in new ways while striving to have a positive impact on community and the environment. That took Ben to Guatemala where he started and operated an agricultural export subsidiary for a company out of California. He spent two years building the company to over 100 employees, remodeling the processing facility, building a product procurement portfolio to meet buy-side contracts, and ultimately creating a joint venture with local business partners. With that experience the bar was set for how he wanted to contribute in life and what he wanted to get out of his career. Since Ben's time in Central America, he has been a founder or management team member of early-stage companies across the water, energy storage, and aerospace sectors; he managed a multi-million dollar water sourcing, storage, and delivery project; he developed comprehensive strategic plans for an \$800MM land conservation effort, and led strategic planning for a \$500MM ecological flow coalition; and, he raised a \$1.5 MM seed round and managed customer discovery and business development as a cofounder of a battery energy storage company that was part of the inaugural Techstars Sustainability Accelerator cohort. Ben identifies an Authentic Catalyzer, operating at the intersection of being an entrepreneur, intuitive leader, and humanist to drive value, optimize strategies, and positively impact lives. Brian is a serial entrepreneur focused on the intersection of food and climate. His first company, A&B American Style, was built to improve the way consumers relate to their food. It grew from a side project to the #1 hot sauce on Amazon and Oprah's Favorite Things List before selling to a PE-Backed artisan food platform. Brian started his career in corporate strategy with L.E.K. Later, he joined Citigroup and was a VP with Citi Holdings (aka The Bad Bank) at its creation during the financial crisis, Brian has no loyalty to outdated systems and companies. He left the corporate life to become as a line cook and learn the food business alongside some of the best operators in restaurants. He was The Worst employee on the line and struggled mightily to improve his skills and is forever thankful to the team who gave him the most important education of his life.	leadership & management, vision and mission, team culture, project management, customer discovery	10-20 years	6-10 Years
Brian	Ballan	brian@homebrewbrands.com	https://www.linkedin.com/in/brianballan/	Brian graduated twice from Columbia University with a BS in Engineering Management Systems and an MBA.	branding, customer discovery, fundraising, go-to-market strategy, marketing, market research, operations, product strategy, vision and mission	10-20 years	10-20 Years

First name	Last name	Email	Linkedin URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Bryan	Kimbell	bryan@ethikemarketing.com	https://www.linkedin.com/in/bryan-kimbell/	<p>Bryan is currently a fractional marketing executive with experience in brand development and integrated strategic marketing. Starting his marketing career in a sports branding agency, Bryan led brand strategy and marketing execution for professional and amateur sports teams (and one fantastic ski area). His first jump into startups was when he joined Brandfolder at the beginning of Techstars in 2013 as the head of marketing and sales. After an amazing experience in Techstars, and helping to grow Brandfolder, he was recruited to be the first Head of Cause Marketing for LifeStraw, a personal water filter brand with headquarters in Switzerland and Washington DC. Working out of the DC office, Bryan significantly expanded domestic and international marketing and sales for the brand, all in support of a core brand initiative to give back to the world by providing water purifiers to primary schools in developing countries, primarily in Western Kenya. It was through this experience that Bryan realized the true potential to use his marketing and sales skills to make the world a better place. Now focusing his efforts on social impact and ESG focused companies, Bryan leads a small but mighty consultancy, providing fractional marketing and brand leadership to small and medium sized businesses who are focused on solving the world's problems. Bryan has a bachelor's degree in Communications from the University of Arizona and a Masters Degree in Management from the University of Denver. Fun fact: Bryan was an ocean lifeguard and water polo player.</p> <p>Bryan is an ambitious and entrepreneurial individual with a multi-faceted skillset. He has been focusing primarily on growth capital investments in software companies for several years via his work at the Dallas based investment fund, Elm Park Capital. However, Bryan is currently in the process of making a career and geography change. He will be moving to the Denver / Boulder area in September of 2021 and is in the process of exploring job opportunities in Colorado.</p> <p>After evaluating and working closely with management teams at many small, entrepreneurial companies through his work at Elm Park, Bryan is keenly interested in sitting on the "other side of the table" and being an integral part of scaling a small software business as an operator. Having worked for several years at a firm with just 10 employees, Bryan is accustomed to wearing many hats, and as a result, his experience and skillset is wide ranging. Among other areas, he has particular experience and aptitude in strategy, financial modeling and analysis, business development and lead generation, negotiations and legal documentation, and management of junior staff. Additionally, the fact that he has evaluated literally hundreds of companies (primarily software businesses) means he has a unique, longitudinal understanding of best / worst practices, KPIs, and generally what makes businesses succeed (or fail).</p>	branding, community engagement, customer discovery, customer acquisition, go-to-market strategy, leadership & management, marketing, messaging & communications, metrics and KPIs, product strategy, vision and mission	10-20 years	6-10 Years
Bryan	Moynihan	bmoynihan3@gmail.com	www.linkedin.com/in/bryanmoynihan3	<p>Bryan has a degree in finance from the McCombs School of Business at the University of Texas at Austin. He is an avid outdoorsman and particularly enjoys rock climbing, skiing, and backpacking.</p> <p>Chad is an entrepreneur and startup advisor who supports sustainability and climate change focused founders go from idea to a successful MVP launch. You can think of him as a Chief Product Officer/CTO cofounder for hire. He has run a successful startup for the last ten years, has advised peers in the Boulder startup scene, and has researched the process of successful early stage companies in-depth. Through this experience, Chad is able to guide entrepreneurs through the maze of pitfalls and mistakes that most startups inevitably encounter, greatly increasing the chances of creating a successful business while saving both time and money. He also advises later stage startups as a fractional CTO, leveraging his skills to improve technical team culture, make DevOps processes more efficient, reduce infrastructure costs, and increase technical product performance.</p>	finance/accounting, fundraising, go-to-market strategy, sales, vision and mission	6-10 years	0-1 Year
Chad	McGimpsey	chad.mcgimpsey@gmail.com	https://www.linkedin.com/in/chadmcgimpsey/	<p>Chad is a mountain man at heart; his biggest passions are for adventure, nature, and technology. He's also a life-long learner and huge believer in self work and self awareness. In his spare time he enjoys doing pretty much anything in the mountains, sailing, photography, and optimizing everything he can.</p>	customer discovery, customer acquisition, go-to-market strategy, product strategy, prototyping/product development	10-20 years	10-20 Years
Christie	Brannon	cbrannon2196@gmail.com	https://www.linkedin.com/in/christiebrannon/	<p>Christie Brannon is a 2020 graduate from University of Houston's Wolff Center for Entrepreneurship, recently ranked #1 undergraduate entrepreneurship program by the Princeton Review. Since graduation, Christie has worked in small business and startups ranging from smart cities technology and general contracting to a YouTube channel for business education.</p> <p>Courtney was born and raised in Austin, Texas, her family means everything to her, and ethically-sourced, responsibly-farmed products are her jam. Having spent the last ten years building a career in the juxtaposition of marketing and community outreach, Courtney considers herself a social entrepreneur dedicated to leaving a positive and sustainable impact on the world. Education has been a major pillar in Courtney's journey, receiving her BBA in Marketing and Master's in Organizational Leadership from St. Edward's University and most recently an Executive Certificate in Corporate Social Responsibility from the Leeds School of Business, she has focused her studies on bridging the gap between business and society. Professionally, Courtney is a digital marketing and branding specialist, having thrived in every environment from small, local operations to large, global start-ups. She prides herself with her volunteerism having served on the board of her home chapter of the National Alzheimer's Association, and spending many a Saturday at local non-profits with Generation Serve families, introducing kiddos to the world of civic engagement. Early in her career, Courtney looks forward to the many opportunities still to come.</p>	branding, customer discovery, leadership & management, market research, vision and mission	2-5 years	2-5 Years
Courtney	Griffin	courtneygriffin512@gmail.com	https://www.linkedin.com/in/courtneygriffin512/	<p>Cy Megnin grew up in Bloomington Indiana and has been an entrepreneur, founder and advisor for the past two decades. Companies he has founded include Intel Capital portfolio company PrepFlash; an artificial intelligence company that uses natural language processing to automatically create flashcards from any content, and CloudCoreo a configuration management company that garnered investment from Microsoft and ultimately sold to VMware. He was in the 2014 class of 40 under 40 for Professional Remodeler Magazine at the helm of the long running real estate investment firm OPCS and was twice featured on TLC's hit TV show "Flip That House". After spending the last 15 years in Austin, Seattle and the Bay area he is currently back in his hometown of Bloomington, IN with his wife Andrea and son Jack. His role at Elevate Ventures is as an EIR for the Velocities region, which is a joint venture between the Columbus Chamber of Commerce and The Dimension Mill in Bloomington. He has a degree in Economics from Indiana University where he currently teaches an MBA course on entrepreneurship. He also has an MBA from Baylor University, where he is an executive judge for their annual MBA Ethics competition.</p>	branding, community engagement, customer discovery, fundraising, go-to-market strategy, marketing, messaging & communications, social media, team culture	6-10 years	2-5 Years
Cy	Megnin	cmegnin@elevateventures.com	https://www.linkedin.com/in/cymegnin/	<p>Daniel loves being outside. Whether hiking, biking, skiing, running, or just hanging out in the yard, he would much rather be outdoors than inside. That's just one of the reasons Daniel wants to apply his years of tech startup leadership experience to help founders tackle the big problems facing our planet. Daniel's current job is leading client operations at Neutrol, an AI startup focused on industrial automation. He has extensive SaaS experience and has helped build and scale operations at multiple startup companies. Daniel is very excited to meet and work with the founders and contributors at X-Genesis.</p>	community engagement, customer discovery, customer acquisition, executive coaching, fundraising, go-to-market strategy, leadership & management, marketing, messaging & communications, metrics and KPIs, operations, PR, sales, prototyping/product development, social media, user research, team culture, vision and mission	20+ years	20+ Years
Daniel	Glasser	dglasser13@gmail.com	https://www.linkedin.com/in/dglasser13/	<p>Dave Milliken is the founder of Greetly, Inc. Mr. Milliken founded Greetly to reduce wasteful administrative tasks. Mr. Milliken has held marketing leadership positions with Smashburger (Inc. 500), Louis Vuitton Moët Hennessy and MillerCoors. He has an MBA from New York University's Stern School of Business and a Bachelor's degree from Emory University.</p>	operations, metrics and KPIs, project management, leadership & management, product strategy	10-20 years	6-10 Years
Dave	Milliken	dave@greetly.com		<p>As a strategist, advisor, and educator who straddles the business and design worlds, Deborah serves as a thought partner to leaders navigating ambiguous futures, and has consulted with global corporate executives, non-profit leaders, and hundreds of inspiring entrepreneurs. A builder and systems thinker at heart, she's particularly drawn to opportunities to create new models that blur the line between purpose-driven and for-profit organizations.</p>	branding, marketing, project management, vision and mission	20+ years	6-10 Years
Deborah	Alden	deborahalden@gmail.com	https://www.linkedin.com/in/deborahalden/	<p>Both an intrapreneur and entrepreneur, she's led the design and development of five purposeful organizations including WeWork's global 'cultureOS' business, which drove revenue growth by helping C-Suite executives think and act differently about culture and the role it plays in their businesses, and the Brooklyn Fashion + Design Accelerator, which focused on sustainable and ethical businesses.</p> <p>Deborah loves sharing the stories of impact of the communities of which she is a part and is regularly invited to do so globally. She has taught human-centered design and research at SVA, IIT Institute of Design, CEDIM in Mexico, and Nanyang Technological University in Singapore, where she was the Inaugural Chair for the BFA in Visual Communication.</p>	team culture, product strategy, vision and mission, leadership & management, design (UX)	10-20 years	10-20 Years
Dick	Shuster	crudeminer@yahoo.com	https://www.linkedin.com/in/dickshuster/	<p>Able to assess a problem and develop a solution or direction to a solution. That being said, I look at my superpower, and can't decide whether it's being able to look directly at someone and ignore them' or 'the ability to develop a diverse group into a team that will exceed expectations'</p>	executive coaching, leadership & management, metrics and KPIs, operations, project management, vision and mission	20+ years	20+ Years
Dick	Shuster	crudeminer@yahoo.com		<p>Experience in building and rebuilding companies. Currently consulting in the oil industry and driving a bus part time.</p>	compliance, customer discovery, executive coaching, go-to-market strategy, leadership & management, messaging & communications, metrics and KPIs, product strategy, project management	20+ years	20+ Years

First name	Last name	Email	Linkedin URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it. Ean is a former scientist, turned unicorn startup innovator, turned consultant. Now, he runs a small startup consulting firm that specializes in early-stage startup architecture, helping clients to define their path forward and turning those plans into compelling, actionable pitch and due diligence materials. He loves coaching clients with targeted questions and drawing out what the founder truly visualizes for their business, then pressure testing the vision against the market and filling in any strategic gaps to create a complete picture. Ean fancies himself a bit of a PowerPoint guru and is similarly proficient in Excel modeling. He started his career in a commercial research lab, running microbiological and biochemical assays and managing collaborations with a partner Harvard lab. He then joined the innovation team at agtech unicorn startup Indigo Agriculture where he functioned as an internal entrepreneur, launching complementary business segments and driving technical due diligence on potential partners. He then helped design and launch Indigo's startup accelerator/challenge (Indigo Carbon Challenge) focused on innovations that support the emerging carbon market in agriculture. Most recently, he struck out on his own to found his startup consultancy which has served clients in agrifood tech, biotechnology, and clean energy. Ean lives with his wife and dog in Lakewood, CO, and loves hiking, birdwatching (aka "hiking with a purpose"), and dreaming with anyone about the next big market and/or climate disruptor. Franco is a UI/UX designer living in Lima with strong skills for Mobile app projects. He's got experience working with startups in remote mode and currently working with Series Code (a Denver company). Greg Payne is President and Principal Consultant at Emerging Market Enterprises, where he provides customer discovery, go-to-market, and fundraising support as well as leadership coaching for impact startups and social enterprises. His passion for this field stems from an early career in community development work and is fueled by research and studies in sociocultural anthropology, social entrepreneurship, and impact investing. Greg has over fifteen years of consulting and operational experience in the private, public, and non-profit sectors. He loves to travel (and can't wait until it's safe again to do so), and enjoys cooking and playing soccer. And - if you're a Chinese speaker willing to put up with him, he'd be honored to practice his "very" basic Chinese with you. Jenna Hartter is an end-to-end startup supply chain consultant & advisor. With a background in finance and sustainability, Jenna began her career at Unilever where she delivered efficiencies and cost savings across logistics, manufacturing, and procurement operations. Jenna went on to lead co-manufacturing strategy for one of the company's latest personal care acquisitions, including taking the portfolio through its integration with Unilever. It was there she fell in love with the startup environment and decided to bring her expertise to building new venture supply chains. She currently works for a boutique supply chain consulting firm, where she manages supply chain operations for a number of startup clients and advises others on strategy and process. Her current clients range from pre-launch to Series B and span personal care, food & beverage, apparel, fitness, and healthcare. Jenna is a sustainability enthusiast, bringing diverse experience from research, corporate sustainability, grassroots community organizations, and personal practice. She is always interested in a conversation about how to build resilient & sustainable supply chains to benefit people and the planet. When she's not traveling or finding some new hiking trail, Jenna lives in Denver, CO with her husband Ethan. Jennifer Chang is a startup veteran who has contributed to the success of dozens of early-stage companies as a cofounder, executive, advisor and marketing consultant. She specializes in go-to-market strategies and identifying product/market fit for venture-backed startups and new ventures. She has worked across a broad array of industries including digital media, logistics, healthcare, and deep tech. She has extensive experience in direct-to-consumer marketing for B2C companies, as well as built several enterprise sales teams for B2B companies. Jennifer received her bachelors in business administration at UC Berkeley Haas, master of arts in cultural and creative industries at King's College London, and MBA at USC Marshall. She volunteers her time with HBCU Heroes and the Network for Teaching Entrepreneurship (NFTE). Jennifer is a digital nomad who has traveled around the world twice, and as such, has built an extensive global network of entrepreneur friends. Jeremy is a recent graduate from CSU's Impact MBA which focused on entrepreneurship to find sustainable solutions for global problems. He founded Refill Alliance which provides organizations a turnkey fundraiser service and allowed members to refill their soap bottles to reduce single-use plastics. Jeremy is an agile and adaptable businessman and loves to network to learn what makes everyone tick. He likes to create power teams that play to individual strengths while creating a conducive environment to learn from one another. In his free time, Jeremy love to play outside with his new dog, Chaco. Jinchen has broad experience working on climate finance. She's an Associate at Pollination Group, a climate specialist advisory and investment platform. Prior to Pollination, Jinchen spent two and half years at McKinsey, working across public, private, and social sectors on strategy. Since the 2016 election, Jinchen's been trying to figure out how best fund climate solutions without an abundance of public support. In her time with Pollination and McKinsey, she's developed expertise in voluntary carbon markets, blended finance, philanthropic catalytic capital, and more to fund natural climate solutions and emerging climate technologies. She also has a strong business strategy toolkit and is excited to help folks think through and tinker with business models. Jinchen holds a BA on Economics and Global Affairs from Yale University, where she was very involved with the Tsai Center for Innovative Thinking. That is where the seeds of being an entrepreneur were planted. She has also previously worked at the US Treasury, USAID, and conducted fieldwork in the South Pacific and Ethiopia on climate migration. Jinchen is originally from Houston, TX, but currently resides in Boston. John works with entrepreneurs to build world-class software that brings awesome new products and services into existence. John has worked with global brands such as Hilton, Marriott, DirecTV, and Royal Caribbean Cruise Lines as well as amazing startups such as Speak Technologies, Focusloop, Muse, and Eleven Software. John uses his 25 years in software development to build software faster, cheaper, and better using small, autonomous teams of highly-engaged individuals from around the globe. John is CEO of Series Code, an organization that provides world-class software development with a financial model tailored to startups. Series Code focuses on long-term partnerships and builds scalable cloud applications that adhere to industry best practices and grow as you grow. They employ the Lean Startup process and Agile methodology to accelerate your software development and adapt to an environment of extreme uncertainty. John holds a JD from the University of Denver Sturm College of Law and a BS in Computer Science from the University of Maryland Global Campus. John earned both degrees while working full time. John was a member of DU's National Trial Team as well as the Denver Law Review. John lives in Denver with his wife and two kids, has his own WSOP Player Profile page, and loves to play doubles volleyball. Jose Flores is a first-generation from Long Beach, CA, who attended the U.S. Naval Academy and served aboard a submarine. After his time in the Navy, he attended the Darden School of Business at the University of Virginia. After graduate school, he worked in different roles and industries, from intel strategy in Seoul for Samsung to regional manager at a credit union to technical sales for a traffic management company. Jose and his family moved to Denver, CO, in 2018 for his wife's career. Today Jose is a transitioning stay-at-home dad. Jose values teamwork and thrives in a fast-paced environment.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Ean	Mullins	eswmullins@gmail.com	https://www.linkedin.com/in/eswmullins/	customer discovery, fundraising, go-to-market strategy, messaging & communications, vision and mission	6-10 years	2-5 Years	
Franco	Cueva	geueva8@gmail.com	https://www.linkedin.com/in/geueva8/	design (UX), design (UI)	2-5 years	2-5 Years	
Greg	Payne	gregory.e.payne@gmail.com	https://www.linkedin.com/in/gregoryepayne/	community engagement, customer discovery, customer acquisition, executive coaching, fundraising, go-to-market strategy, leadership & management, market research, team culture, vision and mission	6-10 years	6-10 Years	
Jenna	Harterter	jennaharterter@gmail.com	https://www.linkedin.com/in/jennaharterter/	operations, metrics and KPIs, project management, other	6-10 years	2-5 Years	
Jennifer	Chang	jennifer@techsparks.net	https://www.linkedin.com/in/jenniferchang/	customer acquisition, go-to-market strategy, fundraising, marketing, messaging & communications, sales, social media	10-20 years	10-20 Years	
Jeremy	Worrell	jeremyjworrell@gmail.com		community engagement, customer discovery, go-to-market strategy, leadership & management, metrics and KPIs, project management, prototyping/product development, sales, team culture, vision and mission	2-5 years	0-1 Year	
Jinchen	Zou	jinchenzou@gmail.com	https://www.linkedin.com/in/jinchenzou/	customer discovery, customer acquisition, go-to-market strategy, metrics and KPIs, market research, messaging & communications, product strategy, user research, prototyping/product development, project management, operations, sales, vision and mission, leadership & management, marketing	2-5 years	0-1 Year	
John	Steele	john@seriescode.com	https://www.linkedin.com/in/johnsteele/	prototyping/product development	20+ years	10-20 Years	
Jose	Flores	josesabinoflores@gmail.com		leadership & management, operations, project management, team culture, vision and mission, sales, customer acquisition	10-20 years	No experience	

First name	Last name	Email	LinkedIn URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Julia	Zajac	julia@wemakewow.se	https://www.linkedin.com/in/julia-zajac/	<p>Julia Zajac is a Design Researcher, Service Designer and Strategist passionate about developing solutions to the complex challenges of our times.</p> <p>A voracious learner, curiosity and a sincere interest in people, society, and sustainability guides Julia's work. With a design thinking framework Julia helps founders, organizations and companies create strategies, services & designs based on insights from human-centered design research and analysis.</p> <p>Julia has worked in a variety of sectors (SMEs, startups, non-profits, arts & culture, education, public sector) throughout her career. A Circular Economy and Sustainable Business pioneer, Julia founded and ran an award-winning circular fashion brand in the early 2000s. Ze has worked with inclusiveness and diversity, and for improving artists' working conditions in arts & culture, and as an educator and mentor.</p> <p>Julia is excited to team up and tackle wicked Water & Climate challenges in this multi-talented environment and is looking forward to developing new ideas for positive social & environmental impact.</p> <p>With a daily motto to learn things she did not know yesterday, Komal is purpose-driven and committed to being a life long learner.</p>	customer discovery, design (UX), executive coaching, project management, product strategy, prototyping/product development, user research, vision and mission, go-to-market strategy, user testing, fundraising	6-10 years	2-5 Years
Komal	Sharma	komalravsharma@gmail.com	https://www.linkedin.com/in/komalravsharma/	<p>Komal graduated from University of California, Davis with a degree in Cognitive Science which sparked her curiosity in the intersection between artificial intelligence, neuroscience, and philosophy. She joined FTI Consulting as a Technology Consultant where she leveraged innovative technology to help Fortune 500 organizations better analyze and rapidly make sense of increasing amounts of complex data. Komal holds a great interest in mentoring the next generation of innovators and spends her free time serving as a mentor in various organizations such as the UN Youth Ambassador program, Teens in AI, and Dare 2B Digital, where she encourages the youth to explore careers in STEM.</p> <p>Komal's key objective is to contribute to a more just and equitable world and enjoys collaborating in creative thinking with a diverse group of people. She is particularly interested in the climate and water issues humankind collectively faces and has first hand witnessed climate impact in California during the drought and wildfires in recent years. She also has seen how the water crisis in India disproportionately impacts low-income communities. Komal seeks to employ her skills in project management, quantitative and qualitative analysis, and communication to help tackle the wicked problem of climate change through policy, innovative technology, science, and ethics.</p> <p>Kristen has many years of strategic, hands-on design experience with early-stage companies, notably at startup incubator Idealab in Pasadena CA where for 20+ years, she helped to brand, prototype, and launch dozens of startups before starting her own design practice in 2017. Kristen helps entrepreneurs develop an initial brand positioning and then clearly communicate that story across the company's visual identity, pitch decks, website, and digital product design. View samples of her work at kristending.myportfolio.com.</p> <p>Prior to Idealab, Kristen was the founding designer at Citysearch where she built and managed an in-house design team to launch one of the first city guides on the Internet. She has a double major in Psychology and Design from Stanford University and a BFA degree from Art Center College of Design in Pasadena CA.</p>	product strategy, prototyping/product development, vision and mission, user research, market research	2-5 years	0-1 Year
Kristen	Ding	kristending@gmail.com	https://www.linkedin.com/in/kristending/	<p>Kristen is based in sunny Southern California (and misses traveling to places both near and far!)</p> <p>Lian de Castro is a finance and business development professional with experience in the banking, infrastructure and energy sectors. Currently, he spends his days advising early-stage startups and learning about the latest climate tech: especially in carbon dioxide removal and electrification.</p> <p>Born and raised in Spain, studied law but started his career working in corporate finance at a global infrastructure / construction and after a Columbia MBA moved to the advisory side of Macquarie bank based in New York covering the US and Latam. From banking to renewables, and after a stint at Santander bank, back to renewables; where he worked at solar, geothermal and microgrid developers.</p> <p>The span of his 18 years career has taken place in Europe, Latam, Asia and the US, his final stop to date: the SF Bay Area. From his Bay Area den, he ventures to the wine region and the many national parks when wildfires allow.</p>	branding, design (UI), design (UX), prototyping/product development, other	20+ years	20+ Years
Lian	De Castro	lian.decastro@gmail.com	https://www.linkedin.com/in/liandecastro/	<p>Skills: strategy, M&A, corporate development, project finance and international business development. Superpower: raising money from non-VC investors.</p> <p>Marc identifies most fundamentally as a dot connector, the dots being the people, processes, technology, data, and institutions which can answer questions or solve problems in innovative ways. He looks for the complementary connections between disciplines which are not currently obvious.</p> <p>His past experience includes strategy and user research in building advanced applications and analytics for the financial markets, attempts to bring disruptive improvement to individual charitable giving and personal finance, and strong engagement with large, distributed engineering teams at the level of both functional specification and deep technical design. His background spans business and technical functions including engineering, data analysis, customer and technical research and support, strategic investment and partnership, and hiring and training.</p> <p>Most recently he has served as a consultant to smaller firms in the financial services ecosystem. His projects included developing sales and marketing plans for Google Cloud Platform's financial services offering, advising on distribution strategy for an alternative data vendor, research and design for workflow enhancements to those products, and authoring a technical whitepaper on a new data offering.</p>	finance/accounting, fundraising, vision and mission, other	10-20 years	2-5 Years
Marc	Milgrom	m.milgrom@icloud.com	https://www.linkedin.com/in/milgrom/	<p>Mehrad is a product-focused serial entrepreneur. His previous ventures spanned from bespoke D2C products, AdTech and EdTech. His expertise lies in product development and go-to-market strategy. After spending a decade abroad, he now resides in California and is currently involved in an initiative to support NGOs and corporates reduce their carbon footprint.</p> <p>Currently, Mirella works as a Sales Leader for a Berlin based circular tech startup offering a subscription model for the newest tech products. She also manages B2B marketing and has digital marketing experience as a freelancer where she managed the social media presence for various small businesses and artists. She cares about sustainability and making an impact</p> <p>Monica is a product strategist and operations maven working with start-ups and NGOs to solve big problems. She leverages her design education in building relationships, executive coaching, and leading teams. She is a Prehype alum and Parsons grad and is currently VP, Growth and Operations at a company that provides professional development opportunities for educators.</p>	design (UX), marketing, product strategy, operations, prototyping/product development	10-20 years	2-5 Years
Mehrad	Yaghmai	mehrad.yaghmai@gmail.com	https://www.linkedin.com/in/mehrad-yaghmai/	<p>Monica is a product strategist and operations maven working with start-ups and NGOs to solve big problems. She leverages her design education in building relationships, executive coaching, and leading teams. She is a Prehype alum and Parsons grad and is currently VP, Growth and Operations at a company that provides professional development opportunities for educators.</p> <p>Nick comes from an entrepreneur background, he has helped his own companies raise a few million over the course of his career. He has 10 years experience in the San Francisco/LA/NYC startup ecosystem and he's the former program director for the River Frontier Technology Accelerator program. The program has helped dozens of entrepreneurs build out their business and narrative skills to collectively achieve over 100M in follow-on financing.</p>	go-to-market strategy, product strategy, prototyping/product development, customer discovery, user research	6-10 years	6-10 Years
Mirella	Recchiuti	mirella.recchiuti@gmail.com	https://www.linkedin.com/in/mirella-recchiuti/	<p>Monica is a product strategist and operations maven working with start-ups and NGOs to solve big problems. She leverages her design education in building relationships, executive coaching, and leading teams. She is a Prehype alum and Parsons grad and is currently VP, Growth and Operations at a company that provides professional development opportunities for educators.</p> <p>Nick comes from an entrepreneur background, he has helped his own companies raise a few million over the course of his career. He has 10 years experience in the San Francisco/LA/NYC startup ecosystem and he's the former program director for the River Frontier Technology Accelerator program. The program has helped dozens of entrepreneurs build out their business and narrative skills to collectively achieve over 100M in follow-on financing.</p>	marketing, sales, social media	2-5 years	2-5 Years
Monica	Tinyo	monicatinyo@gmail.com	www.linkedin.com/in/monicatinyo/	<p>Monica is a product strategist and operations maven working with start-ups and NGOs to solve big problems. She leverages her design education in building relationships, executive coaching, and leading teams. She is a Prehype alum and Parsons grad and is currently VP, Growth and Operations at a company that provides professional development opportunities for educators.</p> <p>Nick comes from an entrepreneur background, he has helped his own companies raise a few million over the course of his career. He has 10 years experience in the San Francisco/LA/NYC startup ecosystem and he's the former program director for the River Frontier Technology Accelerator program. The program has helped dozens of entrepreneurs build out their business and narrative skills to collectively achieve over 100M in follow-on financing.</p>	community engagement, executive coaching, leadership & management, product strategy, project management, prototyping/product development, user research, user testing, team culture, vision and mission, operations	6-10 years	2-5 Years
Nicholas	Canafax	nicholascanafax@gmail.com	https://www.linkedin.com/in/nicholascanafax/	<p>Monica is a product strategist and operations maven working with start-ups and NGOs to solve big problems. She leverages her design education in building relationships, executive coaching, and leading teams. She is a Prehype alum and Parsons grad and is currently VP, Growth and Operations at a company that provides professional development opportunities for educators.</p> <p>Nick comes from an entrepreneur background, he has helped his own companies raise a few million over the course of his career. He has 10 years experience in the San Francisco/LA/NYC startup ecosystem and he's the former program director for the River Frontier Technology Accelerator program. The program has helped dozens of entrepreneurs build out their business and narrative skills to collectively achieve over 100M in follow-on financing.</p>	branding, community engagement, compliance, customer discovery, customer acquisition, executive coaching, finance/accounting, fundraising, go-to-market strategy, human resources, leadership & management, marketing, market research, messaging & communications, metrics and KPIs, operations, product strategy, project management, prototyping/product development, sales, social media, user research, user testing, team culture, vision and mission	6-10 years	10-20 Years

First name	Last name	Email	LinkedIn URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it. As a General Manager for a portfolio of 3 B2B SaaS technology companies, Nick has managed daily sales, customer, and technology operations, developed and installed SaaS sales training programs through Winning By Designed, restructured and managed company's teams and finances, and built various marketing campaigns through Google Ads and landing page testing. Besides coding, Nick has been able to learn various technology concepts such as Docker containers, messaging queues, and Grafana dashboards which has led to working with executives from enterprise companies to build their solutions. Nick has a passion for entrepreneurship, public speaking, and the outdoors. Every week, he volunteers his time hosting and organizing a weekly entrepreneur event and mentoring local entrepreneurs. In addition, he holds various leadership roles as a member of a weekly public speaking Toastmasters club. During his free time, he likes to ski, road bike, mountain bike, camp, hike, play volleyball, and tell puns. Competencies include SaaS Sales (Winning By Design), Google Ads, landing page testing, CRM, Google Analytics, Agile Development, Scrum, R, SQL, WordPress Development, Photoshop, and Microsoft Office 365.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Nick	Campion	nick.campion@gmail.com	https://www.linkedin.com/in/nickcampion/	Nikhil most recently was co-founder and chief product officer for Lima Hub, a company working to help small retailers in India with their procurement and to help them gain access to formal sources of credit. This experience in India made him more keenly aware of the need to address climate change and associated issues such as water scarcity and extreme heat. Prior to this experience as an entrepreneur, Nikhil has had roles both at large Fortune 100 companies such as Capital One and as a process engineer at a semiconductor company as well as at a nanotechnology startup trying to commercialize technology from Argonne National Labs. However, the common thread between these roles was the use of well-designed experiments and data analysis to inform strategy. At Capital One, Nikhil also added product management skills (leading diverse groups and driving the Paydown agenda) and used design thinking to better understand and serve the subprime customer. As an entrepreneur, Nikhil had to wear multiple hats, including customer research and building Lima Hub's go-to-market strategy. Nikhil is currently researching different approaches to addressing climate change including solutions from Project Drawdown as well as carbon removal technologies. He also advocates with different groups trying to advance climate policy (including advocating for the adoption of low carbon concrete) and is on his local city's climate working group. Outside of work, Nikhil is pretty busy with his family but he also enjoys hiking, trivia (Nikhil was once on Jeopardy!) and enjoys reading science fiction. Nuno is a life adventurer and an impact designer. When he's not thinking on a new expedition, he spends most of his time mentoring and consulting projects worldwide, focusing on emerging economies. He empowers people in achieving extraordinary things. Nuno advises in various fields, drawing from his experience as a serial entrepreneur, impact designer and responsible innovation specialist. He is passionate about bringing SDGs to cutting edge solutions and vice-versa by creating sustainable projects and engaging local communities.	marketing, sales, user research, operations, messaging & communications	10-20 years	0-1 Year
Nikhil	Neelakantan	nikhil.cy@gmail.com	https://www.linkedin.com/in/nikhilcy/	Nuno is an inspiring leader in everyday actions. He believes in the power of education and never stops learning and exploring this World. Oli is passionate about empowering people through the use of creativity and technology. His specialty is creating innovative cultures. He has earned two national awards in this arena. Oli became Executive Director at Arapahoe Libraries in January 2017. As Executive Director, he leads an organization whose primary goal is to empower its patrons. He works to create an innovative, empowering culture for the 300 plus talented staff that he oversees. Also, he has served on the Board of Directors at Early Excellence of Denver, located near Downtown Denver where he supports the mission of early childhood education by bringing innovative ideas and experience to their team. Oli's professional roots start in Hollywood, where he worked several years in the entertainment industry as an actor/filmmaker/coffee-fetcher/copy maker. Always wanting to work in a creative field, he became drawn to the possibilities that a career in technology would offer. Oli obtained a Master's Degree in Technology Management from the University of Denver in 2003. He spent many years working in technology leadership until his most recent position.	customer discovery, go-to-market strategy, market research, product strategy, metrics and KPIs	6-10 years	2-5 Years
Nuno	Veloso	nunoveloso18@gmail.com	https://www.linkedin.com/in/nunoveloso18/	I'm a highly energetic executive with international experience in Fortune 500, startups and not-for-profit environments. Driven by competitive and entrepreneurial spirit to develop and execute strategic B2B and B2C initiatives that result in ROI and revenue growth, increasing customer and member acquisition and retention. Experienced and certified in advanced Agile, Design Thinking, Project Management and Lean frameworks. Work closely with strategic partners, shareholders, board members, government and C-suite, translating reliable data analytics to produce actionable results. Leader and mentor.	other, finance/accounting, leadership & management, product strategy, team culture, prototyping/product development	10-20 years	6-10 Years
Oli	Sanidas	osanidas@gmail.com	www.linkedin.com/in/osanidas/	Renata is a strategic user experience leader with over 10 years of experience. She has focused on setting a UX vision for products and services for organizations. Renata has a proven ability leading international distributed teams in creating innovative solutions to complex problems. She is known for the strategic solving of complex business and user needs to create a lasting and meaningful impact. Also, known for passionate leadership, an appetite for learning, and dependability.	executive coaching, leadership & management, user testing, team culture, vision and mission	10-20 years	2-5 Years
Renata	Lerch	rebonetti@yahoo.com	https://www.linkedin.com/in/rebonetti/	Renata is currently at Apple as a lead strategic designer for AppleCare leading various projects including an internationalization project into Arabic. Before that she worked as a Lead UX Designer at Ascentis, which is a SAAS company delivering human resources applications. She led the design team overhauling applications from Windows software to cloud and mobile experiences across devices such as time clocks, mobile, and desktop. She has also spent time as a consultant often coming in having to quickly understand the market, business, users, and project needs, thinking on her feet, gathering requirements, collaborating with teams across the organizations and delivering design in short time frames ranging from several weeks to six months in length.	branding, customer discovery, marketing, community engagement, messaging & communications	20+ years	2-5 Years
Renata	Phillippi	rphillippi@gmail.com	https://www.linkedin.com/in/rphillippi/	Renata has broad experience across a number of industries: finance, insurance, entertainment, advertising, fortune 500, startups, software as a service, human resources, web, application design, and more from concept phase through to production – covering interface design, interaction, and UI design.	design (UX), user research, user testing, vision and mission, product strategy	10-20 years	2-5 Years
Robert	Wathua	robert.wathua@watson.is		Robert is graduate of Bsc. Business Administration With IT Finance option, an ACCA and CPA student too. Throughout his career life he has been majorly involved in socially impactful business in other words social entrepreneurship. During his campus life he led other young social entrepreneurs in converting water hyacinth which have been a menace to people living around Lake Victoria to fuel briquettes. He led the team as the finance director, this project got to win funds from Ford C3 an annual competition from Ford Fund, also won for 2 years consecutively at ENACTUS regional, national and world cup competitions. This project enabled him gain skills such as;finance management while managing the team funds, community involvement skills, leadership and management and product strategy. The water hyacinth was later upgraded into making of bio gas fuel but the project was left to another team to handle it. Robert has also been a community ford fund fellow 2019/2020, during this period he got intensive training on product design, design thinking and user research. He is also a Watson alumnus 2020 fall. Besides working as a social entrepreneur, he is also a full time banker working under credit department.	community engagement, customer discovery, finance/accounting, market research, prototyping/product development	2-5 years	2-5 Years
Ruba	Nemekh	rubanemekh@gmail.com	https://www.linkedin.com/in/rubanemekh/	Ruba is a business strategist with expertise in growth and project management. Her extensive experience includes product marketing, team leadership, community building and talent development. Ruba has been living and working in diverse countries such as Russia, Finland, India and Portugal. Her professional path has led her through NGOs, early-stage startups, SMEs, universities etc. Currently, Ruba is driving positive changes through advising, mentoring and consulting multiple startups, business founders and teams.	vision and mission, product strategy, marketing, leadership & management, customer discovery	10-20 years	2-5 Years
Sarah	Innocenzi	sarahinnocenzi@gmail.com	https://www.linkedin.com/in/sarahinnocenzi/	Ruba is good at transforming bottlenecks into opportunities through data capture and analysis. Her passion has always been helping people and companies to thrive and succeed. And to do so, she goes deep down into the heart of any project and company - hearing and understanding its people. Sarah has been working in scale-ups for the last 10 years. She's been in a variety of operational roles from HR Leadership, Business Operations, and as General Manager. She loves to collaborate, problem-solve, and think about turning big ideas into reality. She volunteers for a few non-profits in the animal welfare and climate space. She believes that the biggest issues our world faces today can be addressed through technology and innovation, which is why she's excited to be part of XGenesis.	executive coaching, go-to-market strategy, human resources, leadership & management, metrics and KPIs, operations, vision and mission, team culture, project management	6-10 years	0-1 Year

First name	Last name	Email	LinkedIn URL	Short Bio (250 word limit) Instructions: Written in 3rd person with a focus on past experience, general skills and current professional role, don't be afraid to be creative and put some personality into it.	Specialist experience and skillset (Check up to 5):	Years of professional experience (namely in the skills you checked above):	Experience working with or in early stage startups:
Sean	Matthews	seanmatthews@live.com	https://www.linkedin.com/in/seanmatthews/	Sean brings experience collaborating with clients in a number of spaces to evaluate and implement analytics solutions to support their growth and capabilities. These solutions range from KPI development to data management environment selection to AI strategy. He is currently supporting the evolution of DHI Group's marketplace and analytics maturation. Outside of work he enjoys spending time on the trails and following the rapidly proliferating climate tech solutions.	metrics and KPIs, other	6-10 years	0-1 Year
Sherry	Gui	sherryxgui@gmail.com	https://www.linkedin.com/in/sherryxgui/	Sherry Gui is a multifaceted product designer based in NYC. She holds a BA in Graphic Design (Interactive Design track) and a minor in Entrepreneurship from American University in Washington DC. Currently, she is serving as the Vice President & Manager of the Technology and Design Department at International Family Union, an NGO actively helping international students and their families with academic and mental support, legal resources, etc. Sherry specializes in design thinking, human-centered design, UX/UI and delivers creative solutions with the users and the business needs in mind. In the past few years, Sherry has actively participated in the AU Entrepreneurship Incubator and has worked with different startups across industries as a designer. She is a fast learner, adapts quickly, and can design for unfamiliar fields. Sherry believes that design is more than an aesthetic look but more about experiences, usability, and the impact delivered by communicating through design. With her international background, Sherry wants to serve as the bridge builder across cultures and between different stakeholders. She also believes in the power of storytelling and is always curious about learning from other people's stories. Outside of work, Sherry loves to explore new things and has various interests in digital and film photography, cooking, climbing up walls (aka. bouldering), and traveling. If you run into Sherry, you'll find her wandering around the city with her camera capturing unique moments and coming up with ideas to enhance people's lives.	design (UX), design (UI), user research, other, branding	2-5 years	2-5 Years
SJ	Maxted	sarahjanemaxted@gmail.com		SJ is a Principal at ADL Ventures, focused on energy venture development. She works with clients including National Grid Partners, Gates Ventures, XL Fleet, and NYSERDA. She volunteers her time with Energize CO as an Innovation Ecosystem Advisor and sits on the board of Exponential Impact, Forge, & Chain Reaction Innovations.	customer discovery, fundraising, go-to-market strategy, leadership & management, messaging & communications, metrics and KPIs, prototyping/product development	10-20 years	6-10 Years
Thomas	Knoll	thomas@innovatorsco.com	https://www.linkedin.com/in/thomasknoll/	Thomas Knoll is an entrepreneur and business owner with a track record of success in diverse environments. He has international business experience across multiple industries including corporate innovation management and consulting, technology, e-commerce, outdoor and sports equipment, apparel, sustainable and technical hard goods, and importing and distribution. Thomas is currently the Founder and CEO of The Innovators CoLab, a collaboration of Chief Innovation Officers and growth leaders from mid to large cap organizations. He helps innovation teams solve big innovation and growth challenges by facilitating and leading problem solving work sessions, sharing best practices, and using a set of services tailored for Chief Innovation Officers. Before iColab, Thomas was the Founder and President of Earthwerx, Ltd., an import and distribution business focused on the outdoor and active lifestyle markets. He partnered with leading manufacturers from Germany, Italy, Portugal, Canada, New Zealand, Asia, South Africa, U.K., France, Spain, India, Japan and South America.	executive coaching, go-to-market strategy, vision and mission, other, leadership & management	20+ years	10-20 Years
Tim	Wolters	tim@smartgarage.org	https://linkedin.com/in/timwolters/	Tim is currently working as a Product Owner for Giso in Boulder Colorado. His forte is understanding where the market meets product and providing a vision for getting there. Having grown up through the tech side and been both founding CEO and CTO in multiple startup companies he has pretty much done it all in the zero to one phase of a technology startup.	executive coaching, fundraising, go-to-market strategy, metrics and KPIs, product strategy, team culture, vision and mission	20+ years	10-20 Years
Toma	Bedolla	tbedolla@gmail.com	https://www.linkedin.com/in/tomabedolla/	Toma's experiences are as broad as life has allowed, moving from one adventure to the next. He has provided leadership and support as CEO of TravelSHARK, CEO of Approbatics, as Chief Technology Officer for Jason's Deli, studied physics at the Colorado School of Mines, climbed unnamed peaks in the Kunlun mountain range north of Tibet, played collegiate baseball and caddied full time on the PGA Tour. Toma strives to live his life to the fullest and to make the most of the opportunities as they have presented themselves. He aims to help others do the same and realize the potential that is in all of us. He spends his time exploring cross-pollinating entrepreneurship, advising and mentoring projects and individuals he believes in, getting to know his 2-year-old daughter, and exploring or tinkering with new ideas and perspectives every day.	community engagement, executive coaching, fundraising, go-to-market strategy, leadership & management, messaging & communications, metrics and KPIs, product strategy, PR, prototyping/product development, project management, vision and mission, team culture	10-20 years	10-20 Years
Tricia	O'Keefe	tricia.okeefe@maamuka.com	https://www.linkedin.com/in/triciaokeefe/	Toma's passion for House of Genius is helping communities around the world engage entrepreneurship more effectively while developing the strategies and platforms to integrate the global House of Genius community to make entrepreneurship fundamentally more effective. Occasionally you'll find him on Twitter @Toma_Bedolla Drawing from a background in both design and business, Tricia is an adept facilitator and researcher with a knack for distilling, synthesizing and translating ideas. She is entrepreneurial and collaborative by nature and works to pull folks together across the finish line of any project launch or engagement. Her curiosity spans a broad range of subjects. She is quick to understand the significance of new capabilities and technologies to the world around her and is keenly interested in how these might be leveraged for greater global good.	community engagement, go-to-market strategy, messaging & communications, product strategy, vision and mission, customer discovery	6-10 years	2-5 Years
Turab	Bajwa	tbajwa27@gmail.com	https://www.linkedin.com/in/turab-bajwa/	I'm a climate investor with operating, investing, auditing, banking, and advising experience across startups and multinationals, primarily in the energy and sustainability sectors. I'm currently an investor at Closed Loop Partners, investing in sustainable supply chains and the circular economy. I recently completed my MBA from Stanford.	finance/accounting, fundraising, go-to-market strategy, leadership & management, team culture, vision and mission	6-10 years	6-10 Years
Wendy	Bloechle	wendybloechle@gmail.com	https://www.linkedin.com/in/wendybloechle/	Wendy has over 25 years of marketing, sales, and product management experience and currently runs a marketing consulting company focused on helping companies grow through improving their go-to-market strategies, value propositions, and customer journeys. She has held several marketing leadership roles primarily with B2B SaaS companies including DHI Group, Extensis, Return Path, and E Source. Wendy has an MBA from the University of Colorado and a BS in Industrial Engineering from the University of Illinois. Wendy lives in Englewood, CO and loves all things food, wine, and travel related...and even went to chef school at night to learn classical French cooking techniques. To counterbalance this food obsession, Wendy relies on fitness and yoga to stay healthy. Her words to live by are from Mahatma Gandhi: "Live as if you were to die tomorrow. Learn as if you were to live forever."	marketing, go-to-market strategy, messaging & communications, customer acquisition, branding	20+ years	2-5 Years

Email	First name	Last name	LinkedIn URL	<p>Please include a short bio (limit 250 words)</p> <p>As the Director of Water Innovation, Kim works directly with Elemental Excelsior's water portfolio companies and partners. With over a decade of experience in launching and growing technology and organizational platforms rooted in sustainable impact, she helps Elemental's portfolio companies co-design and implement successful projects, as well as scale their solutions.</p> <p>In addition to guiding portfolio companies, Kim works alongside municipalities, corporates, and investors in the water sector, expanding Elemental's work in the sector through collaboration with multi-dimensional stakeholders and fundraising and acquisition opportunities for Elemental's portfolio companies. Kim launched and led a fast-growing drinking water product line for a growth-stage company that was acquired by UGSI Solutions. She co-founded a venture in industrial wastewater treatment, completing multiple capital raises and winning awards on behalf of the company. Before becoming an entrepreneur, Kim was a consultant on a variety of public-sector projects including the expansion of citywide Green Business Programs, energy transmission projects in San Francisco, and early adoption of California's Greenhouse Gas reporting initiative. Kim's formal education includes an MBA in Sustainable Management and a BS in Environmental Engineering.</p> <p>Cesar is a former Naval officer whose professional career has been a diverse and dynamic path, from being a defense analyst for Department of Defense, to managing the development of cutting edge technology while working in the research and development field, and now a co-founder of a flood risk analytics start-up, Ceres Engineering.</p> <p>Prior to moving to starting Ceres Engineering, Cesar and his wife embarked on a seminal road trip, driving from Washington DC, down the PanAmerican Highway through Central and South America, down to Patagonia, Argentina.</p> <p>The people and places encountered during this trip has helped shape Cesar's views and motivations in applying innovative data driven technologies to the climate based risks emerging today.</p> <p>Will is an internationally recognized thought leader on water strategy and innovation. He was ranked as a Key Player Pressuring Businesses to Care About Water and one of the Top 15 Interviews In Smart Water Magazine 2019. He has been a water strategy advisor to multinationals, water technology companies, investors and NGO's for his entire career. Will works with multinationals on water strategies, technology innovation and market entry strategies. His work with technology companies is in a strategy advisor and investor.</p> <p>Will has written numerous books and articles and presents on the value of water, innovations, the circular economy, and the energy-water-food nexus. He is currently working on "Digital Water: New Technologies for a More Resilient, Secure and Equitable Water Future" (Routledge, 2021).</p> <p>He is a Board Member of Flowwater, Silver Bullet and Project WET; Chairman of the Scientific Advisory Board for the WAITRO Global Water Innovation Summit; the Editorial Board of the Journal of Water Security and a Technical Advisor for the Climate Bonds Initiative. He was an Advisor to the 2020 XPRIZE Safe Drinking Water Team and on the Scientific Program Committee for Stockholm World Water Week from 2013 - 2019.</p> <p>Karin Wadsack is a program manager for the National Renewable Energy Laboratory, where she leads multiple third renewable energy projects and performs applied analysis for energy system decarbonization and resilience projects around the world. She has over a decade of experience working with tribes across the United States on energy analysis, policy, and project development. Her background includes experience in international development, business management, and more than 20 years developing and executing projects.</p> <p>Education: Karin holds a PhD in Engineering Sustainable Systems, a certificate in Applied Statistics, master's degrees in Environmental Science & Policy and Journalism, and a bachelor's degree in Government.</p> <p>Her dissertation research focused on the implications for air quality regulation of power system modeling of high-renewables-and-storage scenarios considering the reduced hydroelectric effects of climate change in the American Southwest.</p> <p>Kristin Leigh Campbell is an Environmental and Climate Justice Research and Policy Consultant for the National Associate for the Advancement of Colored People (NAACP). Prior to joining this role with the NAACP, Kristin served as the Science and Policy Analyst for the Institute for Governance and Sustainable development, focusing on incorporating scientific research on short-lived climate pollutants and near-term climate change impacts into policies centered around fast-action mitigation. She has served as an Expert Reviewer for numerous Intergovernmental Panel on Climate Change (IPCC) reports, including the three special reports – the 1.5°C of warning, the ocean and cryosphere, and the land-use reports – as well as the first drafts of all three Working Groups of the upcoming Sixth Assessment Report. Kristin has a Juris Doctor and Master's of Environmental Law and Policy from Vermont Law School, a Master of Arts in Climate and Society from Columbia University, and Bachelor of Science in Meteorology from Florida State University.</p> <p>Brian began his career as an environmental consultant in Washington, DC, working with companies and organizations around the world on a wide range of sustainability issues. The work focused heavily on climate change and sustainable product design, and included developing GHG offset projects for the Chicago Climate Exchange, designing a tool for the World Bank to help them evaluate the sustainability of their investments, and partnering with NIST to develop life cycle environmental data for their BIEES green building design tool.</p> <p>In 2006, he left consulting and joined Cisco to create a program to manage the environmental performance of its \$10B supply chain. One of the first programs of its kind, it has won awards and praise from outside groups. He then moved to NetApp to lead the company's corporate sustainability activities, where he worked across functions to quantify and reduce the company's energy footprint, implement a water management plan to address the California drought and revamped the company's global e-waste program, reducing waste and saving the company \$500k annually. Most recently, he was at Nutanix, a cloud software company, where he designed a first-of-its-kind supply chain security management program, launched the company's first Business Continuity program and led a hackathon team to develop an energy-carbon tracking application that could be integrated into the company's software platform.</p> <p>Brian is a Master's in Environmental Science and a Master's in Public Affairs from Indiana University and lives in Hall Moon Bay, California with his family and a very energetic German Shepherd Pointer.</p> <p>As CEO of The Water Research Foundation (WRF), Peter Grevatt, Ph.D. directs the world's leading water research cooperative. WRF oversees research and promotes innovation across all aspects of the water sector – in pursuit of ensuring the highest water quality and improving water services to communities across the globe. With approximately 1,200 subscriber members in the U.S. and abroad, the Foundation has over \$130 million of contracted research and innovation activities currently underway.</p> <p>Dr. Grevat has dedicated over 30 years to the implementation of public health and environmental protection programs, including significant national leadership experience in the water sector. He previously served as Director of EPA's Office of Ground Water and Drinking Water (OGWDW) where he was responsible for ensuring the safety of the nation's drinking water supply. Dr. Grevat also served as Senior Advisor to EPA's Administrator for Children's Environmental Health and has held leadership roles in EPA's water quality and national hazardous waste cleanup programs.</p> <p>Dr. Grevat is a graduate of New York University Medical Center with M.S. and Ph.D. degrees in Basic Medical Sciences. He earned his bachelor's degree in Biology from Earlham College in Richmond, Indiana.</p> <p>Ariel Mira is a leading energy, water, and environmental research analyst at the National Renewable Energy Laboratory. As an energy-water nexus expert, Ariel leads research on a range of topics related to the intersections between energy systems, water resources, the environment, and policy. His modeling and analysis work includes integrating water resources and energy models to evaluate water risk, weather, and climate impacts on electricity generation infrastructure. His cutting-edge energy-water nexus work includes researching energy requirements for water infrastructure and innovative synergies between energy and water systems to maximize productivity and efficiency, under current and future conditions. As part of the National Alliance for Water Innovation team, he leads the model development of the WaterEPA/PA techno-economic model that evaluates the cost and performance of water treatment systems. Ariel completed his PhD in Civil Engineering, with a focus on environmental and environmental engineering, at The City College of New York.</p> <p>My passion lies in using science and technology to tackle urgent and important problems in health and the environment. I am a self-driven, focused and result-oriented bioinformatics scientist/computational biologist who is an accomplished leader of technical and scientific teams. With >14 years of experience in pharmaceutical and diagnostic Product Research and Development, I have expertise in digital display PCR (ddPCR) and next-generation sequence (NGS) analysis. My area of specialty is cancer and infectious disease genomics and epigenomics, spanning machine learning, biomarker identification, multivariate regression, survival analysis, and protein structural and dynamics modeling. As a recent example, my team and I were responsible for the data analyses and algorithm behind Bio-Rad's SARS-CoV-2 ddPCR kits, which received Emergency Use Authorization from the US FDA in May 2020. (https://www.bio-rad.com/en-us/products/bio-rad-2-ddpcr-digital-pcr-bio-rad-2-ppk-09K9K8RTK09).</p> <p>Mike has a degree in resource economics from UC Berkeley, and has had a long career as an entrepreneur and managing engineering and Big Data groups at companies such as eBay, Appiqe, and BNY Mellon (one of the largest global banks). Mike has been involved in digitization of industries as diverse as retail, fashion, toys, and others. In 2017 Mike founded Aqiaq, an impact startup, to try to help bring water and water infrastructure projects of all types. The Aqiaq Software platform automates the processes of financing for resilience infrastructure, and enables new finance instruments such as green bonds, environmental credits, and social impact bonds.</p> <p>Jessica Brody joined Denver Water as General Counsel in August 2018. Previously, she served as the lead environmental attorney for the City and County of Denver (2013 – 2016) and then as an Assistant Director (2016 – 2018) in the Denver City Attorney's Office.</p> <p>A 2003 graduate of The Yale Law School, Jessica started her career as an environmental attorney at Arnold & Porter LLP, an international law firm. Jessica has always had a passion for public service. She was a member of the AmeriCorps program inaugural class and was selected as a Harry S. Truman Scholar in 1998.</p> <p>In her spare time, she serves as President of the board of a Denver public charter school. She is also a member of the Colorado Bar Association Environmental Law Section Advisory Council.</p> <p>Lauren Schmeisser is an engineer and scientist with comprehensive expertise in environmental challenges. Lauren has formal education in water, earth, and atmospheric sciences, with an emphasis on climate change. She solves complex systemic problems with a spectrum of tools and techniques ranging from data analysis to field work to models. She is well versed in environmental datasets, including satellite, reanalysis, in-situ data, and primarily programs in Python in order to investigate science questions using these datasets. Lauren knows her way around the global climate model database and is passionate about analyzing model output to learn more about what a potential future climate will look like here on earth. Applied projects with intersection between climate science, engineering, and business are of particular interest to her. Lauren holds a PhD in Atmospheric Science from the University of Washington's MSE in Earth Sciences from the University of Amsterdam, and a BS MS in Environmental Engineering from the University of Colorado Boulder. She is currently a postdoctoral researcher at the Cooperative Institute for Research in Environmental Sciences at the University of Colorado and NOAA in Boulder. When not working on science, Lauren enjoys teaching yoga, hiking, and seeking new recipes!</p> <p>Sam Stein (he/him) is a Program Manager in the Water Supply Planning department at the Colorado Water Conservation Board. He is also the CWCB's liaison to the Basin Roundtables where he engages local regional stakeholders to further and inform the Colorado Water Plan. Prior to joining the CWCB, Sam served as a Demand Planner for Denver Water where he modeled long-term municipal water demands by considering both a changing climate and changing population. Sam holds a bachelor's degree in Economics from Goucher College, and a master's degree in Natural Resource and Environmental Economics from Colorado State University.</p> <p>John R. (Grizz) Deal is Executive Chairman & CEO of XPower Clean Water, Inc.</p> <p>John R. (Grizz) Deal has nearly thirty years of experience in technology commercialization, tech-based startups, fast-growing ventures, and product development.</p> <p>Grizz was CEO and a co-founder of Hyperion Power Generation, a Los Alamos National Laboratory (LANL) spinout developing a Small Modular Reactor (SMR). He has also served as the chief marketing officer for Space Imaging and was the founder and CEO of LinnTech, one of the more successful LANL spinouts. Additionally, Grizz has served as Entrepreneur in Residence for the U.S. Department of Energy (DOE) National Nuclear Security Administration (NNSA) at Technology Ventures Corporation and as a Visiting Entrepreneur at Los Alamos National Laboratory. Grizz founded seven firms based on U.S. DOE technologies and holds graduate and undergraduate science degrees in geography from Texas A&M University.</p> <p>Grizz is on the Board of the Riggs Innovation Center (RIC) in Latvia, the former Product Development Service for CIVA Launch Curns in Russia and Kazakhstan, a former adjunct faculty member at the Moscow School of Management Skolkovo, a member of the Texas A&M University College of Geosciences Advisory Council, a Mentor at the University of Northern Colorado Hartzell Collaborative, and a Steering Committee member of the JetCo Energy Action Project.</p> <p>James Salzman holds joint appointments at the UCLA School of Law and at the UCSD School of the Environment. In thirteen books and more than 100 articles and book chapters, his broad-ranging scholarship has addressed topics spanning drinking water, policy instrument design, and creating markets for ecosystem services. A national expert on drinking water, he formerly served on EPA's drinking water advisory council. Author of Drinking Water: A History, he is a frequent media commentator on water issues.</p> <p>Eric has over 30 years of experience in water, wastewater, and stormwater utility financial and strategic planning. His recent projects include supporting the City of Atlanta Watershed Management Department's capital financing program, and as co-author of the report: "Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector".</p> <p>Previously, Eric served on the Michigan Governor's Flint Water Advisory Task Force, and as a program manager for establishment of the Great Lakes Water Authority. For the Detroit Water and Sewerage Department, he chaired the Blue Ribbon Panel on Affordability and led initial implementation of its impervious area based drainage fee. He was Jefferson County, AL's rate consultant and municipal advisor for financing related to the County's bankruptcy and issuance of \$1.7 billion in sewer warrants. Eric prepared the City of Atlanta's Financial Capability-Based Schedule Extension Report. For several permittees (Atlanta, Akron, ERMUD, Honolulu, Guam, NEORSD, St. Louis), Eric provided strategic and financial consulting and negotiation support services on financial capability assessment and low-income affordability issues.</p> <p>Eric is a member of the USEPA Environmental Finance Advisory Board, an MSRB registered Municipal Advisor, and a contributing author of the WEF Financing and Charges for Wastewater Systems and AWWA Principles of Water Rates, Fees and Related Charges Manual of Practice.</p> <p>Education MA, Economics, University of California-Davis; AB, Economics & History, Ripon College, Ripon WI</p> <p>Javier is an entrepreneur with strong international experience in anything from utilities to state-of-the-art instrumentation for big data, ground based, distributed operations. Since 2016 he is the CEO of David addressing water risk problems.</p> <p>Josh Sperling is a Urban Futures and Energy-X Nexus Engineer, working at the nexus of rapidly changing urban environments, water, energy, and complex decision systems. He is a former Fulbright Scholar, holds a PhD from the interdisciplinary Sustainable Urban Infrastructure program at UC-Denver, and co-leads threats focused on smart cities, infrastructure and urban-design sciences. In NSF, DOE, to State Dept-funded consortiums, he is focused on a fusion of integrated systems and service transformations for improving quality of life, infrastructure, and with emphasis on addressing priority goals of diverse stakeholders. He joined NREL's New Concepts Incubator, Joint Institute for Strategic Energy Analysis, Urban Science, International, and National Alliance for Water Innovation teams in 2015. He also co-leads multi-disciplinary, cross-sector initiatives for DOE/NREL strategic and global partnerships (including with universities) and supports early-career mentoring at NREL and beyond.</p>	<p>In what program topic areas are you comfortable offering your expertise? (Check all that apply)</p> <p>Water Scarcity and Supply, Water Quality and Safety, Deteriorating Infrastructure</p> <p>Extreme Events</p> <p>Water Quality and Safety, Water Scarcity and Supply, Deteriorating Infrastructure</p> <p>Extreme Events, Water Scarcity and Supply</p> <p>Extreme Events</p> <p>Extreme Events, Water Scarcity and Supply, Deteriorating Infrastructure</p> <p>Extreme Events, Deteriorating Infrastructure, Water Scarcity and Supply, Water Quality and Safety</p> <p>Water Quality and Safety, Extreme Events</p> <p>Water Quality and Safety</p> <p>Deteriorating Infrastructure, Water Scarcity and Supply, Water Quality and Safety</p> <p>Extreme Events</p> <p>Water Scarcity and Supply, Extreme Events</p> <p>Water Quality and Safety, Water Scarcity and Supply</p> <p>Water Scarcity and Supply, Water Quality and Safety</p> <p>Deteriorating Infrastructure, Water Scarcity and Supply</p> <p>Water Scarcity and Supply, Extreme Events</p> <p>Extreme Events, Deteriorating Infrastructure, Water Scarcity and Supply</p>	<p>How would you generally identify yourself or your organization? (Check all that apply)</p> <p>Technology Experts: Water and Climate related AI, Data, Hardware, Software, Other</p> <p>Technology Experts: Water and Climate related AI, Data, Hardware, Software</p> <p>Industry Experts: large corporations, utilities, etc., Technology Experts: Water and Climate related AI, Data, Hardware, Software, Environmentalists</p> <p>Scientists</p> <p>Scientists, Environmentalists, Legal Experts: policy makers, lawyers, human rights advocates</p> <p>Environmentalists, Technology Experts: Water and Climate related AI, Data, Hardware, Software, Industry Experts: large corporations, utilities, etc.</p> <p>Scientists, Environmentalists, Conservationists, Technology Experts: Water and Climate related AI, Data, Hardware, Software, Industry Experts: large corporations, utilities, etc.</p> <p>Scientists, Technology Experts: Water and Climate related AI, Data, Hardware, Software</p> <p>Scientists, Economists, Environmentalists, Technology Experts: Water and Climate related AI, Data, Hardware, Software, Industry Experts: large corporations, utilities, etc.</p> <p>Legal Experts: policy makers, lawyers, human rights advocates</p> <p>Scientists</p> <p>Economists, Environmentalists, Conservationists, Industry Experts: large corporations, utilities, etc.</p> <p>Scientists, Economists, Environmentalists, Conservationists, Technology Experts: Water and Climate related AI, Data, Hardware, Software</p> <p>Legal Experts: policy makers, lawyers, human rights advocates</p> <p>Economists, Environmentalists, Conservationists</p> <p>Scientists, Economists, Environmentalists, Technology Experts: Water and Climate related AI, Data, Hardware, Software, Other</p>
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joshua.sperling@nrel.gov	Josh	Sperling	https://www.linkedin.com/in/joshuasperling/			

				<p>James is co-founder and CEO of Ekland Haulan, LLC, a water law and policy firm. As Director of the Colorado Water Conservation Board, James was the architect of Colorado's first strategic water plan and is regularly consulted in implementing what has become the "gold standard" of water plans in the Western US. During his tenure as director, he quickly built a reputation as a leader in negotiation and diplomacy - bringing together multiple stake holders with opposing goals in order to collaboratively craft binding solutions to common problems.</p> <p>James also served as Colorado's Colorado River Commissioner. James had the honor of negotiating and signing the first management plan for the Colorado River that recognizes climate change and will be the foundation for all future management decisions on a river that serves 40 million people, seven of the United States, and the Republics of Mexico. In near recent time, he successfully helped craft and shepherd critical Colorado River legislation through the US Congress and testified in the House of Representatives in support of the bill that was ultimately signed into law.</p> <p>Recently, while at the international law firm Squire Patton Boggs, James led firm's global water and climate change practices. He also previously served as legal counsel to the Governor of the state of Colorado and as Assistant Attorney General for Colorado specializing on interstate and international water issues.</p> <p>James also currently teaches graduate environmental classes at the University of Denver and is a frequent presenter on water and climate change issues. His favorite endangered species is the Ranezabach Sucker (he thinks of himself as sharp but gillible at times).</p> <p>Before a career in business, I was a Mechanical Engineer in a variety of applications. Recently, my experience includes entrepreneurship, sustainability projects with a water focus, impact finance, forest health, and the infrastructure surrounding these problem areas. Looking forward, my interests include becoming more adept and involved with international projects, finance, technology (software), sustainability, and entrepreneurial ventures that have a triple bottom line focus. I hope while on this journey to find new solutions for emerging markets and ways to create positive effects for the stakeholders involved.</p> <p>Daniel has 12 years of experience serving as an innovator and he has been bringing new equipment to market for CPO companies for the past 9 years. After graduating from Manhattan College with a Master of Science in Mechanical Engineering, he began his career designing defense systems for government contractors like Lockheed Martin and ITT Exiles. He then moved into the Food & Beverage industry by joining PepsiCo as an Associate Principal Engineer, where he led the development of new vending machine and vis-cooker innovations. He is now a Sr. Manager of Innovation with Nestle Waters USA, leading the end-to-end development of new dispensing equipment and delivery services. Outside of his career, Daniel has always been passionate about the environment and the anthropogenic impact on it. He loves traveling around the world to explore the diversity of our planet, and enjoys experiencing nature everywhere he goes. One of the most inspirational experiences of his lifetime was camping in the Okavango Delta of Botswana, where he experienced nature in its complete ecological balance, nearly unaltered by humans. This has inspired him to take a more proactive role in driving sustainability efforts forward. He is extremely excited to join X Genesis as a Validator and is looking forward to the program.</p> <p>Rachel Brown is a Senior Policy Advisor in the Native American and International Affairs Office at the Bureau of Reclamation. In her current role, she works primarily on Indian water rights settlements and water resource issues in the western United States, and on projects with foreign countries seeking technical expertise from the Bureau. Prior to joining Reclamation, she worked for the National Park Service in the American Indian Liaison Office. In her position with NPS, she worked on negotiations to create the first Tribal National Park and advised the Park Service on issues relating to cultural and natural resource protection. Prior to joining the Department of the Interior, she worked for the Senate Homeland Security and Governmental Affairs Committee Subcommittee on Disaster Recovery where her portfolio included Gulf Coast recovery following hurricanes Katrina and Rita, and the federal disaster response to the Deepwater Horizon oil spill and the 2010 earthquake in Haiti. She has a spent her career working in the areas of federal policy making and federal appropriations with a focus on water resource development, infrastructure, western water rights, climate change, and disaster response and recovery. Rachel a Presidential Management Fellow (class of 2012), and 2020 Presidential Leadership Scholar.</p> <p>Griffin Hale is an Environmental Control and Life Support (ECLSS) Engineer, hardware entrepreneur and outdoor enthusiast. He received his masters degree in aerospace engineering from the University of Colorado with a focus in Bioastronautics and a minor in Biosciences. He has worked with multiple life support systems and had successfully taken concepts from paper to functional prototypes. He is now able to get his hands dirty and enjoys both researching new technology and running experiments in the lab. During his time as a lab manager, he performed a multitude of tasks including: writing procedures, calibrating instruments, performing data analysis and developing sampling techniques. Griffin also helped pioneer a water reclamation system that transformed urine to drinking water. The novel process took him salt from urine and transformed them into chlorine species that then oxidized organic waste. Griffin is also the founder of Full Body Sound and has created technology that allows users to feel music, and audio. The tech has the potential to increase accessibility as well as create a more immersive experience for everyone. When Griffin is not working, he loves to adventure and is passionate about the outdoors. He and his amazing wife - co-founder Allison can be found hiking, biking or leading art expeditions down the Grand Canyon.</p> <p>Jerry Timanow is the proprietor of Western Urban Sustainability Advisors, LLC. WeatUrb advises local governments on the creation and improvement of sustainability plans and programs. WeatUrb also assists businesses that offer sustainability-related products and services to local governments. WeatUrb's work is based on his service as Denver's first Chief Sustainability Officer (2013-19). He worked with all departments in Denver's 1,100-employee city-county government on programs across a wide variety of disciplines, including climate change and water. During his tenure Denver was Platinum-level certification under the U.S. Green Building Council's LEED for Cities and Communities program, one of only five U.S. cities to reach that level. Denver met its ambitious 2020 greenhouse gas reduction goal in 2018, two years ahead of schedule. Denver was put on the "A-List" of top-performing climate change programs worldwide by CDP (formerly known as the Climate Disclosure Project). Jerry was the 2018 winner of the Wirth Chair Sustainability Award given by the University of Colorado, based on his role in creating Denver's climate change plan.</p> <p>Prior to his work in Denver, Jerry was a national officer for both the Sierra Club and the National Audubon Society. He also served as the director of the Center for Energy and Environment at the Mid-Ohio Regional Planning Commission, an attorney by training. Jerry was a partner and commercial trial attorney in a two large law firms. Jerry received his undergraduate degree in International Affairs and his law degree from the George Washington University.</p> <p>The CEO of Atargis Energy Corporation, the first company with the technology to product low-cost, utility-scale electricity from ocean waves. Has been the President/CEO of four other startups in photonics, real-time big data analytics, cancer therapy and semiconductor testing. Retired Navy Captain, USNR, BS US Naval Academy, MIT University, Rochester.</p> <p>Eric has over 30 years of experience in water, wastewater, and stormwater utility financial and strategic planning. Eric is a member of the USEPA Environmental Finance Advisory Board, an MSRB registered Municipal Advisor, and contributing author of the AWWA and WEF rebranding Manuals of Practices.</p> <p>Barbara Martin is Director of Engineering & Technical Services at AWWA. She has worked for global water service providers, including business development for a private process treatment technology company. She has a BA in Architecture from Boston University, an MS in geomechanics from Colorado School of Mines, and an MBA from Colorado State University.</p> <p>James is co-founder and CEO of Ekland Haulan, LLC, a water law and policy firm based in Colorado. As Director of the Colorado Water Conservation Board, James was the architect of Colorado's first strategic water plan and is regularly consulted in implementing what has become the "gold standard" of water plans in the Western US. During his tenure as director, he quickly built a reputation as a leader in negotiation and diplomacy - bringing together multiple stake holders with opposing goals in order to collaboratively craft binding solutions to common problems.</p> <p>In 2014, James was appointed by Governor John Hickenlooper to serve as the Colorado River Commissioner for the state of Colorado. James fought fiercely to protect Colorado's rights to water on the river, but also worked collaboratively with downstream states in order to ensure a good outcome for all 40 million people who rely on the Colorado River for their health and well-being.</p> <p>To do this, James negotiated and signed ground-breaking agreements binding the seven basin states, the Republic of Mexico and the US federal government. In near recent time, James successfully helped craft and shepherd critical Colorado River legislation through the US Congress and testified in the House of Representatives in support of the bill that was ultimately signed into law by the US President. He, along with other state representatives, later signed the Drought Contingency Plan which ensures the near-term sustainability of the Colorado River.</p> <p>Recently, while at the international law firm Squire Patton Boggs, James led the global water and climate change practices. He also previously served as legal counsel to the Governor of the state of Colorado and as Assistant Attorney General for Colorado specializing on interstate and international water issues.</p> <p>James also currently teaches graduate environmental classes at the University of Denver and is a frequent presenter on water and climate change issues.</p> <p>More at EklandHaulan.com</p> <p>Lumbie is a mother, wife, graduate from Indiana University South Bend and Texas Woman's University, UNIA Women member, a 2019 UN Global Leadership Award Recipient, a Global Goodwill Ambassador, and an active advocate for Clean Water and Empowerment of Women and Youth. She was born in Zimbabwe, but moved to the USA in 1985. She currently resides in Dallas, Texas with her family (2 sons JB and Sam Jr and her husband Sam of 32 years).</p> <p>Lumbie is the President & CEO of JB Dondolo, Inc. (https://jbdondolo.org), a nonprofit which helps underserved and impoverished communities who struggle with the lack of clean water. Her organization removes barriers of access to clean water, sanitation, and hygiene in underserved and impoverished communities to reduce poverty and promote gender equity.</p> <p>Josh Dorfman is a mission-driven entrepreneur. He was CEO of The Collier, an innovation center for climate change resilience solutions. He was Managing Director of Asheville Angels, an early-stage angel investment group. He is currently co-founder of Simbly, a modern sustainable furniture startup.</p> <p>I am an engineer with a diverse 12-year career extending from research (high-temperature solar processes, off-grid sanitation) to spacecraft testing (contamination control and thermal-vacuum testing) to consulting in water resources and water rights. I am a registered Professional Engineer in the State of Colorado.</p> <p>Dr. Tolu Oyejumu (MD, MPH) rich background spans across various fields including medicine, research (scientifically published), epidemiology, disease prevention, clinical trials, regulatory affairs, innovation, and startup advisory. She leverages her supervisor of empathy to solve complex healthcare and social problems.</p> <p>I have spent more than 30 years in the water sector as a not-for-profit association professional, utility management and technology consultant. My areas of expertise include strategic planning, organizational assessments, and benchmarking, as well as workshop facilitation and training. I have led or facilitated dozens of sessions/workshops that engaged hundreds of utility sector professionals, including senior executives, appointed and elected officials, top managers and supervisors, and front-line staff. I helped build and launch the AWWA QualityServe program and Utility Best-Practices effort, as well as the series of AWWA/ANSI Utility Management Standards. I helped build the nationally known and multi-association sponsored Effective Utility Management (EUM) framework (2007, 2008) and I have been trained by AWWA to build and present the revised version of EUM, which has been delivered across the US since 2017. I also teach a one-day version of the updated EUM framework as a subcontractor to the US EPA. I am a frequent presenter and facilitator at professional conferences such as AWWA, WEFTEC and the Utility Management Conference. I have been published in Journal AWWA, co-authored an AWWA guide book on the AWWA/ANSI Utility Management System Standard (G-400), and authored a chapter in an award-winning water sector anthology, "Damned if We Don't: Ideas for Accelerating Change around Water."</p> <p>I am listed as the author for AWWA's MS Manual on Utility Management (because I chaired the committee of a dozen people who contribute) and authored a chapter on strategic planning. I am a member of the AWWA Strategic Management Practices Committee, the AWWA Utility Benchmarking Advisory Committee, the WEF Utility Management Committee, and I am the founder and co-chair of the Rocky Mountain Utility Management Committee.</p>			
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toluohbbie@gmail.com	Tolu	Oyejumu	www.linkedinfo.com	Water Quality and Safety, Extreme Events, Water Security and Supply	Scientists, Legal Experts: policy makers, lawyers, human rights advocates, Other		
jim.ginsley2@gmail.com	Jim	Ginsley	https://www.linkedin.com/in/jimginsley2/	Deteriorating Infrastructure, Water Security and Supply, Water Quality and Safety	Industry Experts:large corporations, utilities, etc.		

First name	Last name	Email (please enter the same email address you used when you signed up to participate in the program)	Linkedin URL	Short Bio (written in 3rd person with a focus on past experience, 250 word limit)
Damon	Waters	damonwaters@gmail.com	http://www.linkedin.com	Damon's work background is mostly in science startups. He co-founded a software company back in Austin during the dot-com days but since then have preferred to pursue clean tech opportunities. Damon has experience with things like biofuels, algae, clean coal, batteries, and water treatment. His most recent project was a chemistry company that I started about in 2013 and evolved into a water treatment service company in the energy sector. That company is now owned by PE.
Majid	Boroujerdi	majid436@gmail.com	www.linkedin.com	Majid has over a decade of experience at Procter and Gamble launching 20 products that delivered over \$200M in revenue on brands such as Pampers, Crest and Downy. His experience at P&G includes being tasked with developing disruptive business models in healthcare that can achieve \$1B in revenue, one of which included a personal genetics service.
Jermaine	Watkins	jermainewatkins@gmail.com	https://www.linkedin.com	He also owned the P&L for a \$400M+ brand in Bounce laundry care before leaving to successfully start a digital behavior change company in Gain Life. He has since worked in a variety of categories leading both marketing and product innovation. This includes online higher education, CBD, outdoor adventure and weight loss services.
Gerald	Best	geraldbest1@gmail.com	www.linkedin.com	Jermaine is a seasoned CTO with 20+ years of experience creating complex, web-based applications and e-commerce applications. Proven ability to lead software development teams. Strong understanding of AI, machine learning, server-less, and distributed systems.
Ned	Harvey	nedharvey1197@gmail.com	https://www.linkedin.com	Jermaine is a serial entrepreneur with successful exits, a pioneering technologist with 10+ years of executive-level experience. Jermaine identifies, qualifies, and builds consensus around implementing technologies and enterprise systems to facilitate key business processes and strategic objectives.
John-Paul	Maxfield	jpmxfield@gmail.com	http://linkedin.com	Gerald Best is an experienced operations professional with over 27 years of experience turning around under performing business units, consistently optimizing operational efficiency and making significant contributions to immediate and long-term business profitability. Gerald has extensive experience in Lean operations, environmental health and safety, Six Sigma program development, union negotiations, team leadership and business development.
Nigel	Wylie	nigelwylie@gmail.com	https://www.linkedin.com	Ned Harvey recently completed a 12-year tenure as a Managing Director at RMI where, most recently, he led the creation of its global Climate Intelligence Program focused on improving emissions transparency and developing the data and insight tools required to support climate aligned decision making in policy, finance, and emission intensive sectors. In his role before this, Ned led RMI's work with global industries with initiatives focused on aviation, trucking, freight, Materials, and oil and gas.
Tim	Falls	tsfalls@gmail.com	https://www.linkedin.com	During his time at RMI, Ned served in diverse roles, including the institute's Chief Operating Officer, Program Director for the Solar Market Transformation Program, and Head of Development. He also led the institute's acquisition of the Carbon War Room.
Daniel	Hoyos	danielhoyosg@gmail.com	https://www.linkedin.com	Before RMI, Ned founded and led several Renewable Energy Development companies and served as an executive for a global consultancy. In his early career, Ned spent eight years as an officer in the United States Navy, serving aboard nuclear submarines and the Tomahawk cruise missile program office.
Aaron	Benshabat	aaronb999@gmail.com	https://www.linkedin.com	Ned received an MBA from Harvard Business School and a B.S. in Electrical Engineering from the University of California at San Diego. Ned serves on the boards for the Harvard Business School Club of Colorado and the Colorado Clean Tech Industry Association.
				John-Paul Maxfield is the Founder of Waste Farmers. The Company started in 2009 with \$9,000 and a belief that idealism and capitalism can coexist. Waste Farmers is a regenerative holding company twice named to the RL100 top Impact Companies.
				John-Paul was named as one of 5280's 2013 Top of the Town Personalities in the Environmentalist category; highlighted as one of the "Fifty for the Future" by the Colorado Statesman and selected as one of the Denver Business Journals' "40 Under 40" in 2011.
				Little known fact: John-Paul has had to run from charging African elephants- more than once- which says more about his personality than it does elephants.
				Nigel Wylie is an experienced entrepreneur in the water and wastewater industry. Driven by scaling novel solutions in water, waste and climate, he takes pride in providing practical and real ROI to his clients. Nigel has founded businesses in the water treatment, manufacturing, construction, and aerial data industries with a focus on the protection and regeneration of natural resources from a market-based perspective. He also served as the Managing Director of Asia for EDI, Inc., a global wastewater treatment technology and manufacturing company, leading their regional expansion. His delivered services and products are currently treating industrial wastewater in China, Southeast Asia (Thrive Water, EDI Asia) and the United States (Aerowater). As a water tech advisor, Nigel has evaluated over 150+ novel water and wastewater treatment technologies for organizations, investors and entrepreneurs.
				Tim has worked in tech startups since 2009 and small business since 2005.
				As an early employee, senior leader, cultural steward, team-builder, and community strategist, he has worn lots of proverbial hats and supported companies from inception to exit. His journey has followed the ups of IPOs and acquisitions and the downs of layoffs and fire sales, creating a spectrum of experiences to inform his perspective as a prospective CEO.
				Tim's greatest accomplishments are the genuine, lasting relationships with coworkers and community members. Through authentic leadership and human-centric values, he builds trust with others, cultivates supportive team environments, and empowers individual self-actualization that ultimately propels organizational excellence.
				Tim also serves as a strategic advisor, independent board member, mentor, and friend to founders of for- and non-profit organizations around the planet, from San Francisco to South Africa.
				In the realm of climate, Tim completed a fellowship with Terra.do in 2020 and co-leads community strategy at ClimateChangemakers.org.
				Serial entrepreneur. Founding partner of a Fintech company (acquired). With a deep sense of ethical principles and values. Able to provide and contribute to the solution of problems in business and technology fields. Mentor, Jury and Advisor from well-known entrepreneur programs from Colombia. Book lover, tennis player, swimmer (once in a while).
				Aaron Benshabat has spent the majority of his career as the CEO of a company in the university and standardized exam prep market. He founded the company in 2005 during his undergrad and by 2019 it was responsible for the exam prep services of over 20,000 students annually, across multiple subject matters. During his time as CEO, Aaron grew the business across all major Canadian markets, either through organic growth or agreements with local/national partners. This past year he accepted an offer for the company in the hopes of focusing his entrepreneurial spirit on what he believes is the biggest challenge for humanity: facing the existential threat posed by the rising impact of climate change. Now he hopes to bring all the skills and experience that have contributed to his prior business success to this cause.
				Aaron's academic background is in finance and has prior work experience in corporate finance and business consulting. On a personal note, he contributes to philanthropic causes in his community, including sitting on the board of directors of the local community center.

Extreme Climate Events



Credit: [David McNew Getty Images](#)

Climate change is fueling the rising intensity and frequency of extreme weather and climate events such as drought, floods, wildfires, heat waves, extreme cold, and hurricanes. Attribution research names climate change a “threat multiplier” of extreme events and indicates human-caused climate change has played a role in the likely occurrence or severity of over 75% of extreme events in the past 20 years. Each year, these extreme events displace 20 million people globally as homes, and in some cases, entire communities are destroyed or made uninhabitable. The year 2019 broke records with 23.9 million people displaced due to weather-related disasters. The economic cost of extreme events is also staggering. In the U.S., the federal government has spent an estimated \$30 billion per year in the last 14 years on weather disaster assistance. Additional costs are borne by homeowners, farmers, ranchers, businesses, and local government. Both regionally and globally, women, children, and the poor are the populations most affected by extreme climate events resulting in compounded crises as extreme events exacerbate existing social inequities relating to health and safety, access to resources, and personal autonomy. Extreme climate events are wicked problems not only in the magnitude of their potential ramifications but in the difficulty to predict future events, particularly considering the uncertainty of climate change and the variability of regional landscapes, responses, and levels of preparedness.

Focusing Question: How might we reduce the harm and disruption caused by extreme events?

Contributing Factors	
Climate change (GGE, global warming, anthropogenic CO2 emissions) Population growth (rise in megacities, migration and climate refugees) Pre-existing water vulnerabilities (infrastructure, supply, quality, sanitation and hygiene) Land use and soil health	
History & Trends	
History Human influence on weather More--and more extreme--events	Trends Worsening wildfires Strategic approaches to wildfires Wildfire budgeting Extreme heat Intense drought More hurricanes
Populations & Agents	
Populations Vulnerable populations	Agents Water utilities Elected officials Communities/users Government agencies Industry sectors
Existing Approaches & Workarounds	
Approaches Disaster risk reduction Mitigation strategies Multi-hazard early warning systems	Workarounds Urban development and structural measures Reducing emissions Substitutions for oil

Information and communication technologies Extreme event attribution	Human response to risk
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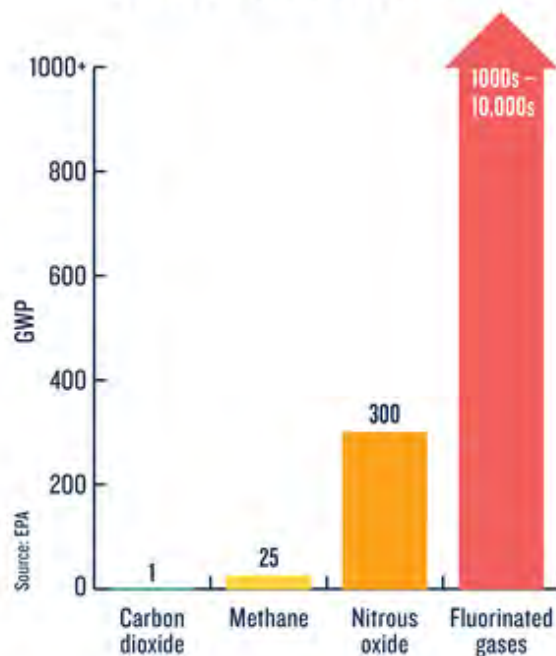
Contributing Factors

Climate change. [Extreme event attribution](#) is a field of study noting the connections between human activity, climate change, and extreme weather.

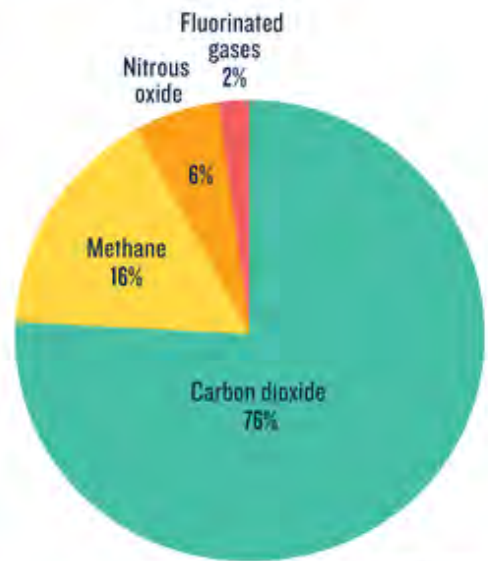
→ In particular, **global warming**, due to an increase in the amount of [greenhouse gases](#) released into the atmosphere, specifically carbon dioxide, contributes to extreme weather (see Figure ____). Greenhouse gases trap heat in the atmosphere, creating a warming effect across the globe (see Figure ____). And a warming atmosphere produces more volatile weather. Higher temperatures lead to [evapotranspiration](#), the process by which water evaporates from the soil and transpires plant matter, facilitating drought and dry conditions suitable for wildfires. In other parts of the U.S. and the globe, rising temperatures increase the air's ability to hold moisture, creating rain and storm events such as hurricanes and floods. In sum, climate change enhances the frequency and severity of extreme weather events. It also means [dry areas become drier and wet areas become wetter](#), with implications for water use as well as overall safety and economic security.

An important note is the [distinction between climate and weather](#). While weather refers to what we may experience in terms of temperature and precipitation day to day, climate is a more long term view of weather patterns over decades. The difference between climate and weather helps explain [differing views](#) on the February 2021 extreme cold event and snowstorm in Texas. In general, however, an increased frequency of any extreme events, be they droughts or snowstorms, is a sign of a [transitioning climate](#).

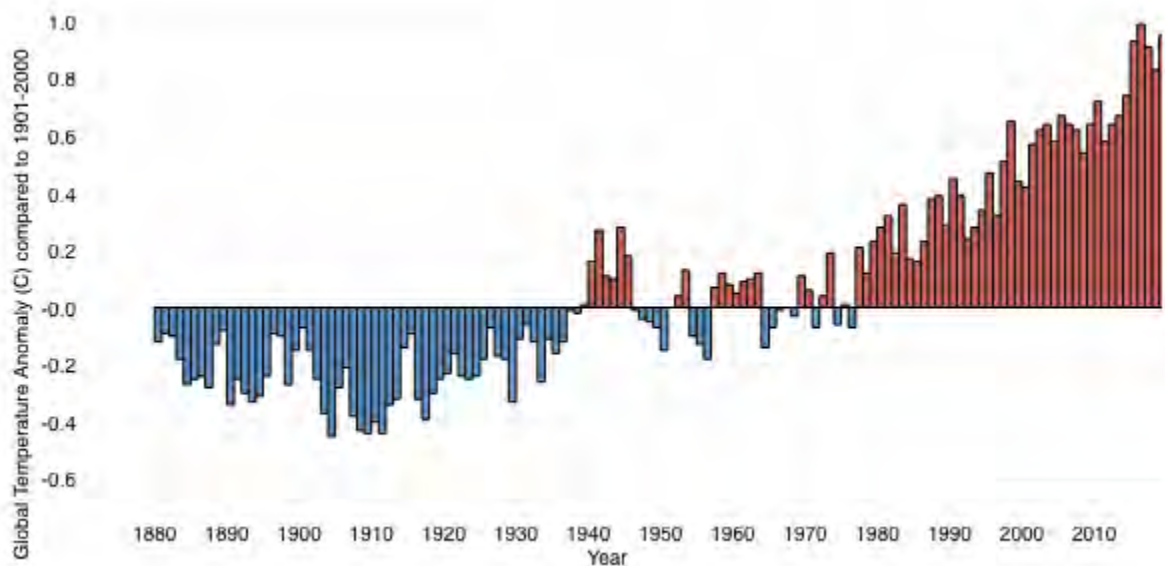
HOW GREENHOUSE GASES WARM OUR PLANET



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.

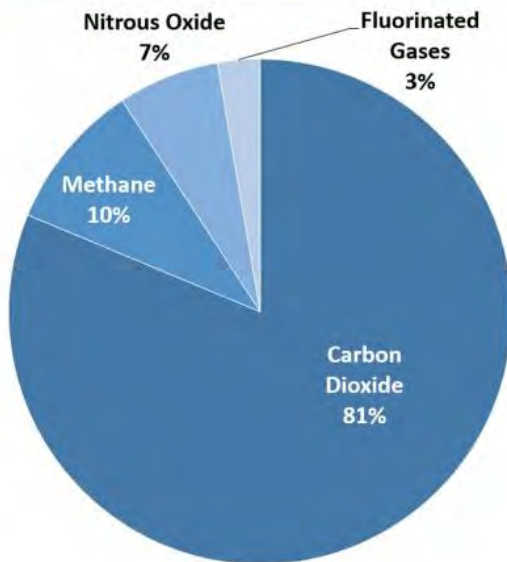


How much each human-caused greenhouse gas contributes to total emissions around the globe.



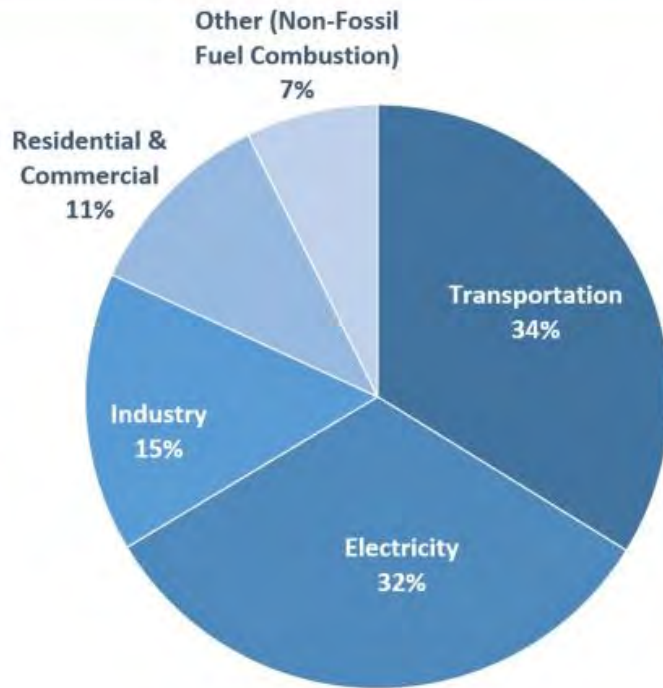
→ **Anthropogenic carbon dioxide (CO₂) emissions** increase the greenhouse gas in the atmosphere and drive global warming. Those emissions primarily stem from the combustion of [fossil fuels](#) for [heat](#), energy, [electricity](#), and transportation. Figures ___ and ___ below illustrate greenhouse gas emissions by type of gas and related industry. For more information on the topic of U.S. CO₂ emissions, see page ES-4 to ES-15 of the executive summary to the expansive [Inventory of U.S. Greenhouse Gas Emissions and Sinks \(1990-2018\)](#).

Overview of Greenhouse Gas Emissions in 2018



Caption: Total U.S. GHG emissions in 2018 = 6,677 [Million Metric Tons of CO₂ equivalent](#). Percentages may not add up to 100% due to independent rounding.

2018 U.S. Carbon Dioxide Emissions, By Source

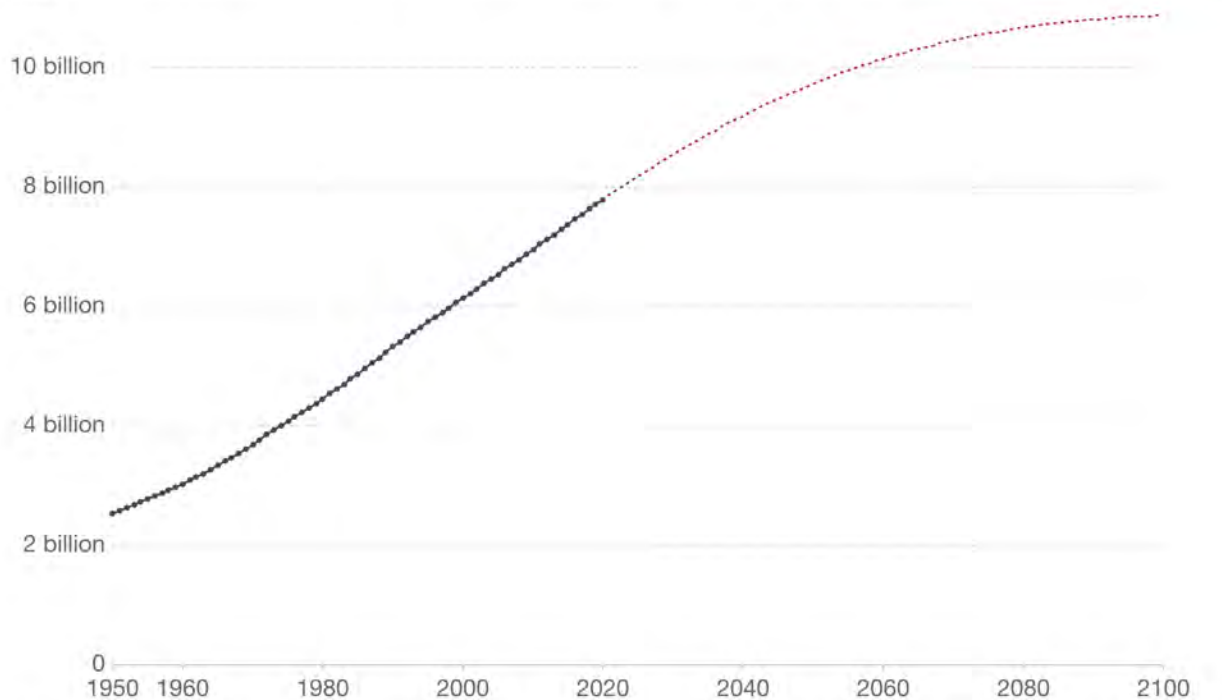


Population growth. The current [global population](#) is 7.79 billion--a product of exponential growth over the past decades and one expected to continue in the decades to follow until we reach a "leveling off" around the year 2100 as the population nears the 10 billion mark (see Figure ____). One way to think about the rise in population and the corresponding draw on earth's resources is [Earth Overshoot Day](#). This is the day in a calendar year wherein the human population's demand on the planet's resources exceeds what the earth can regenerate in a year. In 2020, Earth Overshoot Day fell on August 22, meaning in only 234 days, humans had used up the earth's resources for the year.

Population projection by the UN, World, 1950 to 2100

Shown is the total population since 1950 and the Medium Variant projections by the UN Population Division until 2100.

Our World
in Data



Source: United Nations – Population Division (2019 Revision)

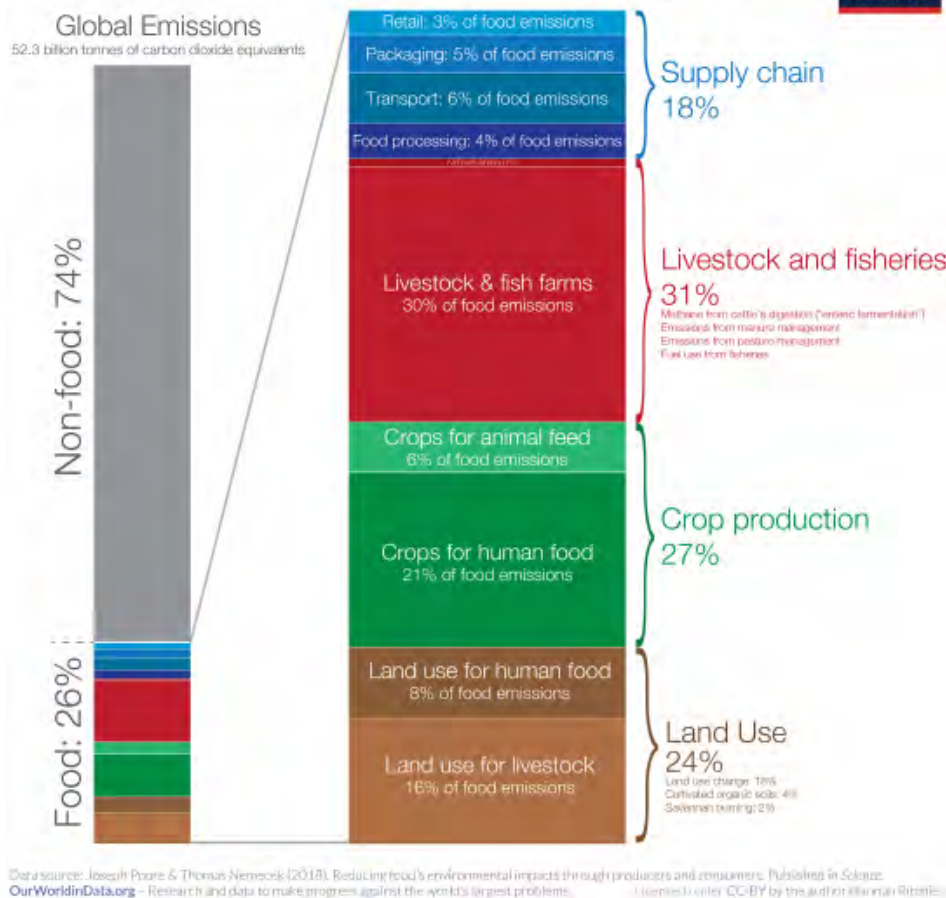
OurWorldInData.org/future-population-growth/ - CC BY

[EOD [video](#)]

Growth in the global population [creates strain on the planet](#). Such strain is felt primarily in two areas, each in turn accelerating climate change: one is the production of resources such as [energy](#) and [food](#) (see Figure ___ for more information on the components of food production creating GGH emissions) and the second is the concentration of population in specific geographic areas like [megacities](#). While these trends contribute to climate change, they also exacerbate vulnerability to extreme climate events.

Global greenhouse gas emissions from food production

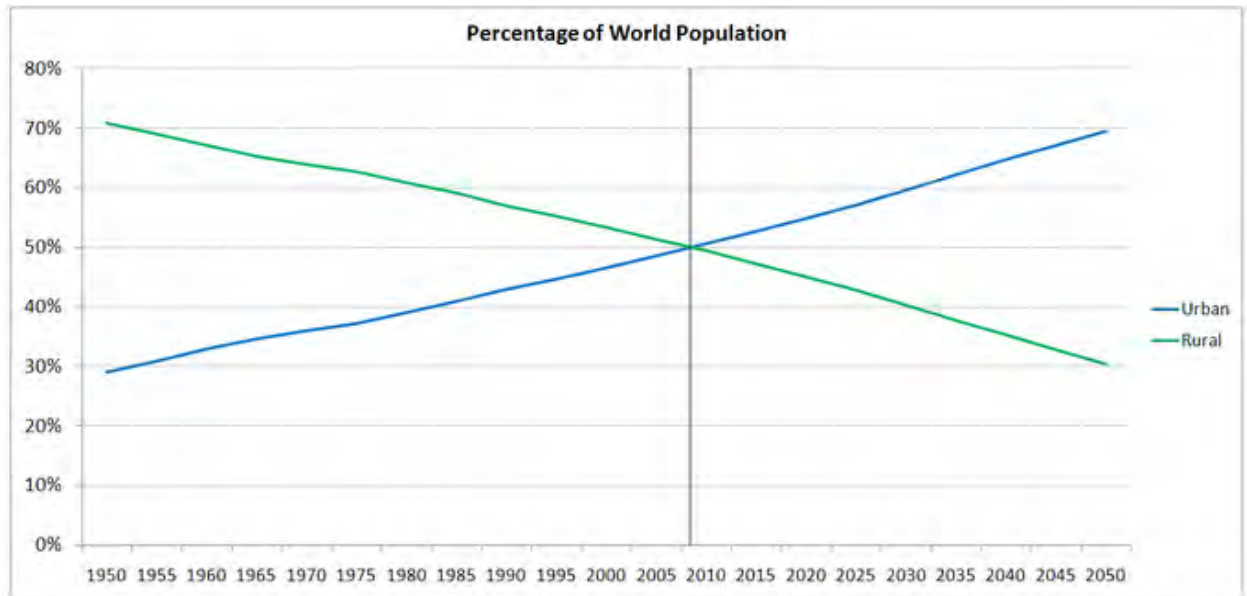
Our World
in Data



→ **Increased food production.** From 1961 to 1970, land use for food production (cereal crops) [increased by 240%](#). The increase in production not only contributes to GGE; the change in land use for agricultural purposes also leads to degradation and desertification (see Land and Water Use section below).

→ **The rise and shift of megacities.** As more of the earth's population becomes concentrated in [urban areas](#) (see Figure __) and megacities, those cities become increasingly vulnerable to adverse effects on water systems and sources due to extreme events. Megacities are urban areas wherein the population exceeds 10 million (see Figure __ for a list of the 38 megacities in the year 2019). Increasingly, the earth's population concentrated in megacities will be outside the high-income world. Predictions indicate the urban area of New York (including New Jersey and Connecticut), for example, will fall off the list of largest urban areas--those with populations above 10 million--in the coming decade as other cities, particularly those in Asia and Africa, grow at faster rates. For in-depth information related to trends in demography in urban areas, see the [Demographia World Urban Areas report](#) from 2020.

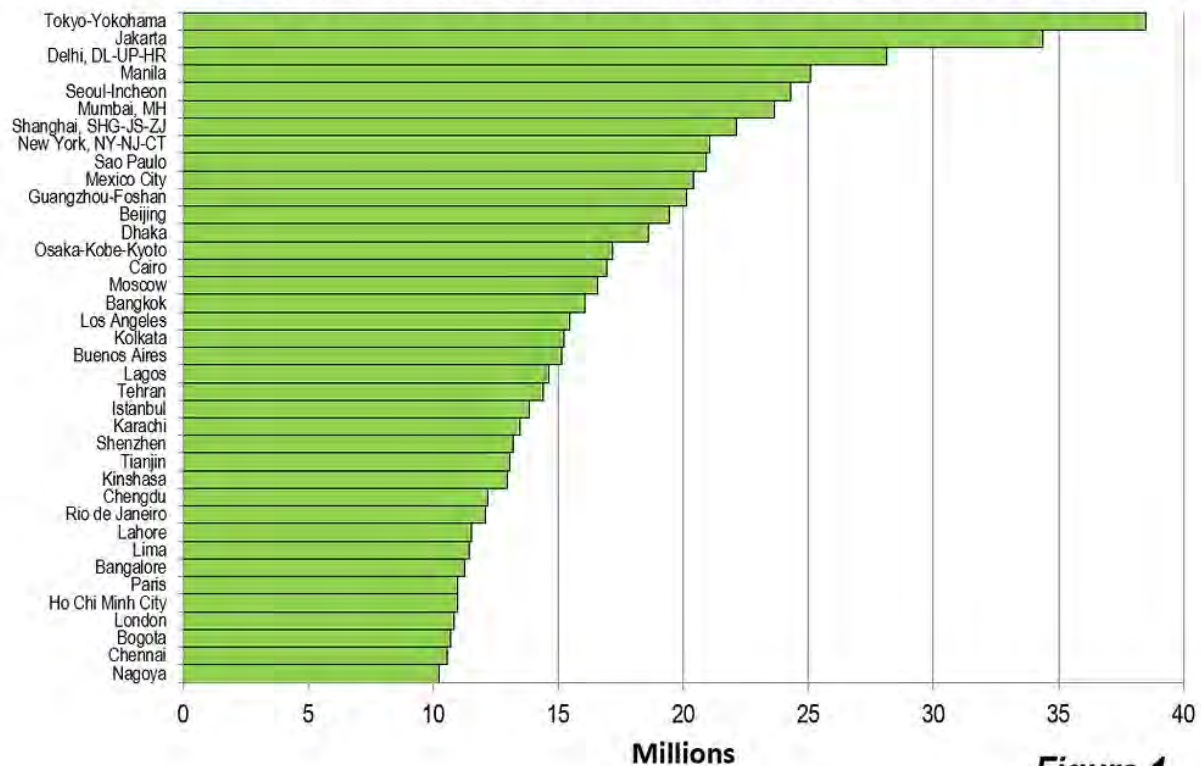
The growth in urban population is also relevant to the western United States. According to [2020 U.S. Census Bureau data](#), the western U.S. experienced rapid population growth since 2010. Denver, Los Angeles, San Diego, Seattle, and Phoenix are five of the fifteen fastest growing cities in U.S. in the past decade.



Data Source: United Nations, <http://esa.un.org/unup/p2k0data.asp>

The 38 Megacities (2019)

URBAN AREAS WITH MORE THAN 10 MILLION POPULATION



→ **Vulnerability to system disruption.** Megacities, particularly those in the low-income world, are vulnerable to disruptions in services providing necessary resources such as water, food, and power. A single extreme event such as a hurricane or severe drought has the potential to create a wide breakdown in a city's infrastructure. Yet such an event is difficult to plan for and predict. [Researchers note](#) baseline information for predicting and preparing for droughts is grounded in historical data and trends largely insufficient in the face of climate change. And while water utilities recognize the need to make shifts in water policies and practices, representatives from these facilities [also acknowledge](#) the need for better response and intervention mechanisms to address drought, floods, wildfires, and other extreme events.

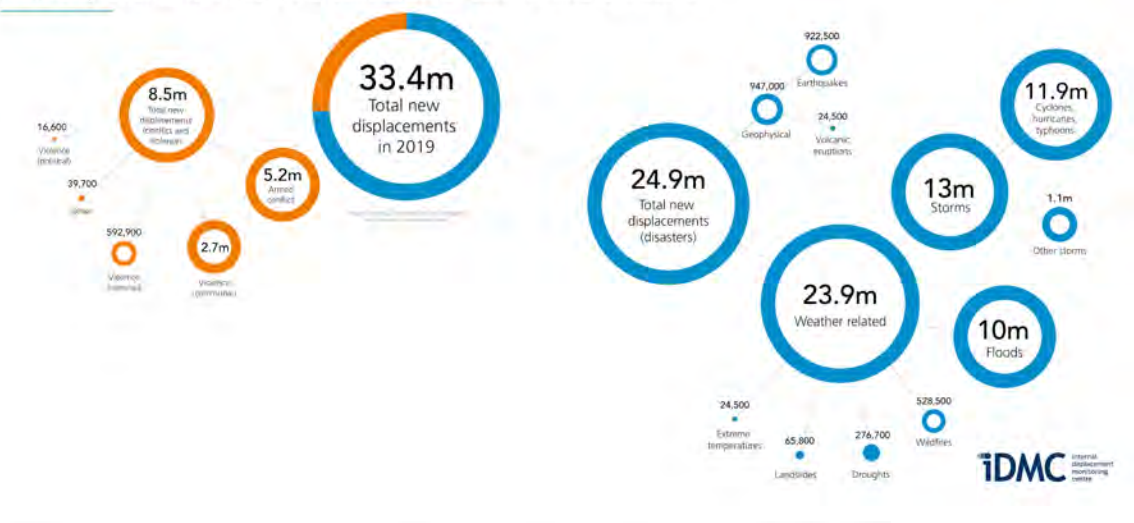
[Water supplies](#) are particularly vulnerable. In coastal areas, rising sea levels and [storm surges](#) contaminate fresh water supply sources. Flooded areas face challenges related to [water quality and safety](#) as sanitation systems are overrun. Heat waves and droughts create [demand on power](#) and water systems, increase the level of pollutants in the air and water, and enhance the likelihood of wildfires which in turn affect water and air quality. For a deep dive into the relationship between climate change, weather, air quality, and water quality, see the 2013 research publication on the [state of knowledge in the field](#). For more information on how water and wastewater utilities prepare for extreme heat, see the [EPA's Incident Action Checklist](#).

On the other hand, water also serves as an adaptation resource in some areas. For example, cities continue to explore how water may be deployed to help residents [cope with extreme heat](#).

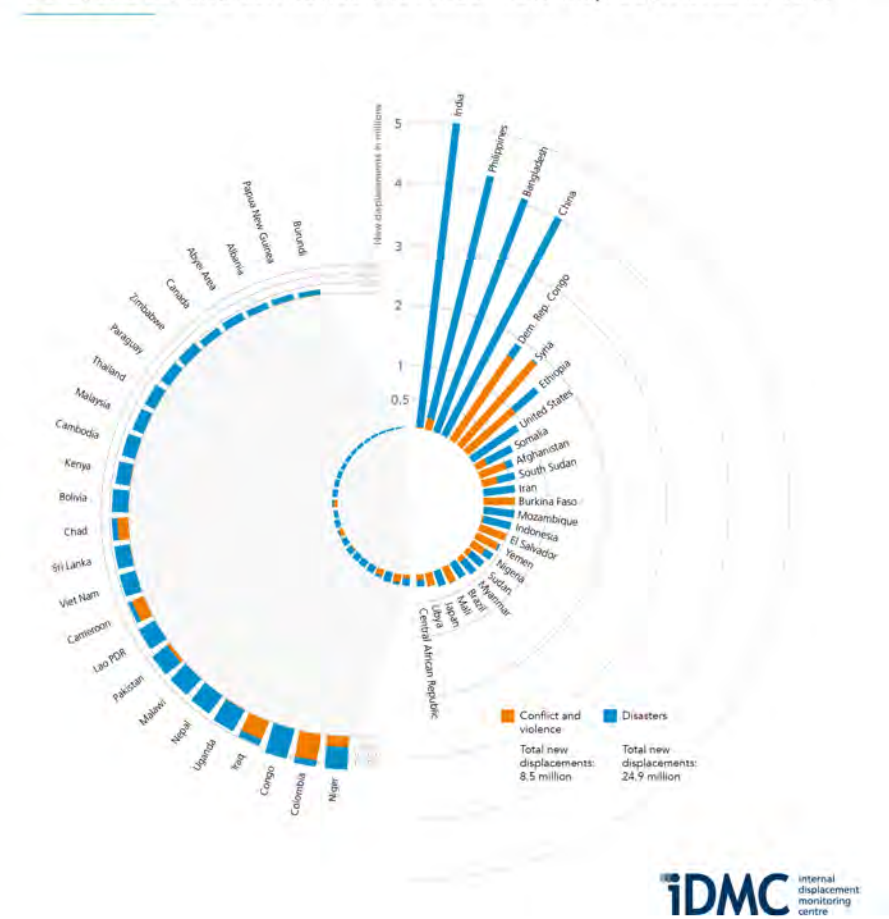
→ **Migration and climate refugees.** Breakdowns in infrastructure caused by extreme climate events will lead to migration of populations seeking refuge from the aftermath of an extreme climate event. Disruption in services and resources are experienced most acutely by vulnerable populations such as older adults, children, women, and those living in poverty. In turn, those populations are susceptible to the most harm from migration. Additional factors such as COVID-19 and the [inevitable continued appearance of global pandemics](#) further complicate migration and vulnerability.

In 2018, the UN General Assembly adopted the [Global Compact on Refugees](#), in part acknowledging the increasingly significant role climate change--experienced through extreme events--would play in driving refugee movements. According to the [Internal Displacement Monitoring Center's 2020 report](#) on population displacement within nations, new displacements in 2019 numbered 33.4 billion: 8.5 million of those displacements were the result of conflict and violence while 23.9 were the result of weather-related disasters (see Figures ____ and ____ for a breakdown of those displacements by disaster event and nation).

New displacements in 2019: breakdown for conflict and disasters



50 countries and territories with most new displacements in 2019



The U.S. recorded over [916,000 disaster-related internal displacements](#) in 2019. A majority of those were the result of floods and wildfires. Wildfires triggered more than 423,000 displacements in 2019; 400,000 of those in the state of California. This year saw the [two largest Colorado wildfires on record](#) and burned roughly 700 square miles at a cost of over \$215 million.

For more information on what has been called [The Great Climate Migration](#), including images of those displaced, see [New York Magazine's 2020 special issue](#).



Climate refugees in California after the Camp Fire tore through Paradise and left tens of thousands homeless. Photo credit: GABRIELLE LURIE / SAN FRANCISCO CHRONICLE / POLARIS / PHOTONEWS VIA GETTY IMAGES

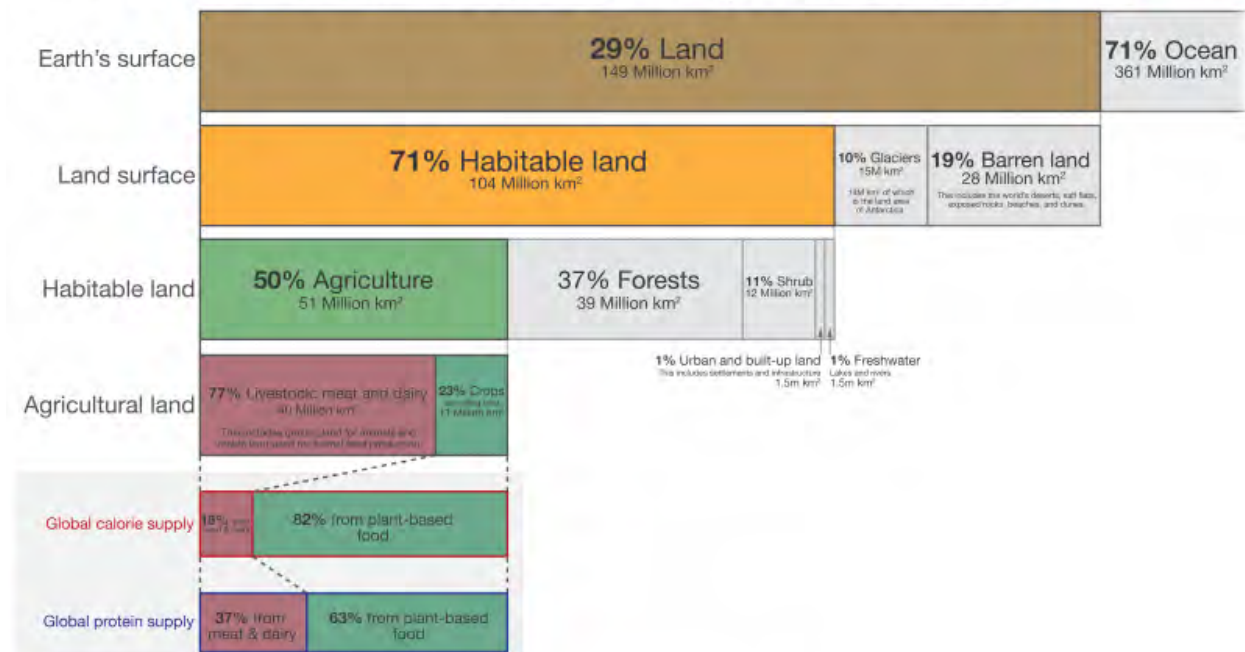
Land use practices and soil health. The health of our soil is integral to the health of our water. Soil is a natural [filtration system](#) for water. It [acts as a sponge](#) to prevent runoff and maintain moisture. And when soil suffers, water does, too.

Half of the habitable land on the planet is used for agriculture (see Figure ____). As mentioned earlier, [shifts in land use](#) to meet food production demands often lead to [land degradation and desertification](#), processes that in turn contribute to the negative effects of extreme events. Rainfall in degraded areas--although often badly needed--is [not absorbed into the ground](#) due to

packed soil and lack of vegetation. These areas then become primed for floods due to precipitation runoff. Lack of water or poor water quality resulting from degradation and desertification contribute to a [myriad of health risks](#) including malnutrition and the spread of water- and airborne diseases. Responsible agricultural practices help ensure the soil and land--as well as the water used to cultivate the land--remains healthy and therefore more resistant to extreme events. Those practices include [regenerative farming](#), [greenhouse or vertical farming](#), [terracing](#), and [strip cropping](#). For an in-depth look at healthy soil and agricultural practices in the U.S., see the 60 minute documentary *Living Soil* below.

Global land use for food production

Our World
in Data



Data source: UN Food and Agriculture Organization (FAO)

OurWorldinData.org - Research and data to make progress against the world's largest problems.

Licensed under CC-BY by the authors Hannah Ritchie and Max Roser in 2019.

[\[Living Soil video\]](#)

History & Trends

History

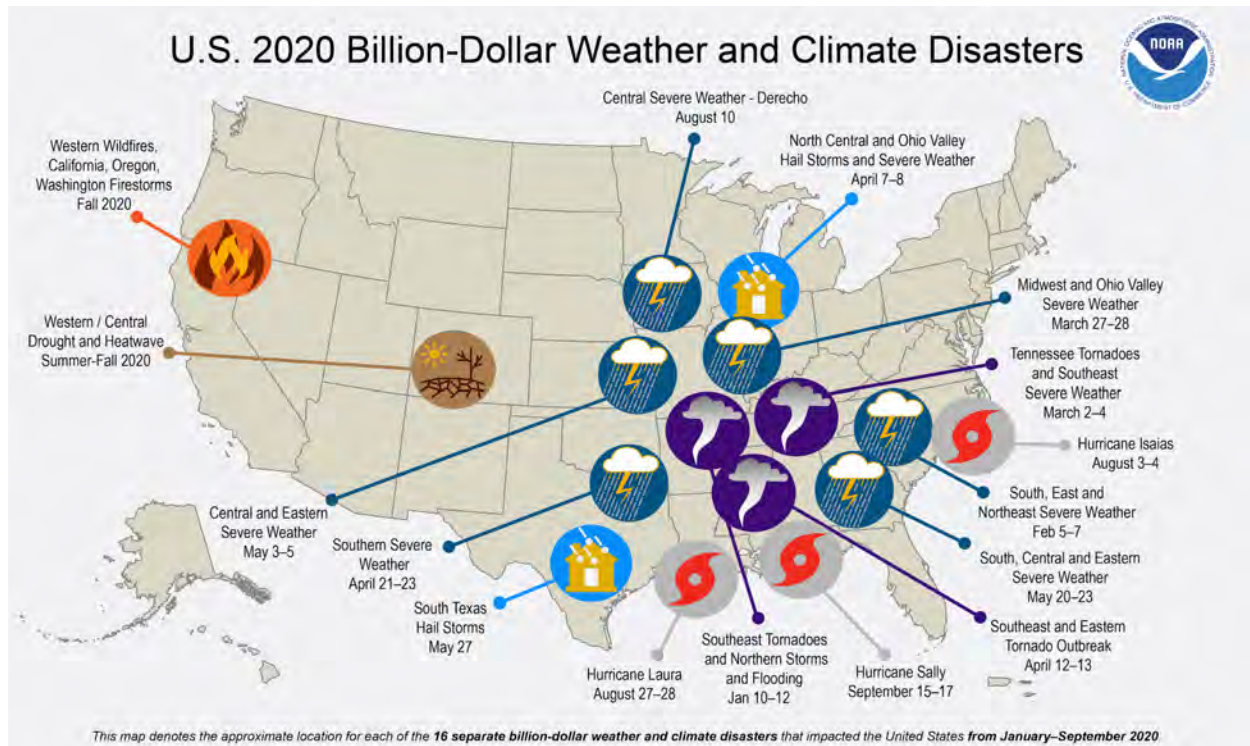
Human influence on weather. Weather is nothing new. Even the extreme variety has a [long and storied history](#) of influence over human activities. What is relatively new is the ability for [human activity to influence weather](#). The 1930s [Dust Bowl](#) drastically changed agriculture and [living conditions](#) across the Great Plains and made a significant impact on the U.S. economy.

However, the Dust Bowl was also caused in part by changes in [land policy](#), [agricultural practices](#), and [cultural philosophies](#). Also new is the intensity, frequency, and magnitude of extreme weather events as a result of climate change. Over the past 4 decades, extreme weather events occur more frequently. The global instances of floods, for examples, have [quadrupled](#) since 1980.



Farm machinery buried by a duststorm in South Dakota, May 1938. Credit: United States Department of Agriculture via Wikimedia Commons

More--and more intense--extreme events. More extreme events with greater intensity and reach facilitate another historical shift: a rise in [cost](#). The annual average of billion dollar events from 1980-2019 is 6.6. As of October 7, 2020, the number of billion dollar extreme events in the U.S. was 16 (see Figure ____). By every indication, these costs will continue to rise in correlation with frequency. For more information on the rising cost of extreme events, see the 2017 report from the Center for American Progress [Extreme Weather, Extreme Costs](#).



Trends

Worsening wildfires. Bigger fires. And more of them. That's the global trend over the past decade. In the U.S., California has become [“ground zero for meteorological turmoil”](#) in part stemming from dry conditions, high winds, and hot temperatures. After California, Texas and Colorado are the states most threatened by wildfire risks (see Table ____).

Top 10 States At High To Extreme Wildfire Risk, 2019 (1)

Rank	State	Estimated number of properties at risk	Rank	State	Percent of properties at risk
1	California	2,019,800	1	Montana	29%
2	Texas	717,800	2	Idaho	26
3	Colorado	371,100	3	Colorado	17
4	Arizona	237,900	4	California	15
5	Idaho	175,000	5	New Mexico	15
6	Washington	160,500	6	Utah	14
7	Oklahoma	153,400	7	Wyoming	14
8	Oregon	151,400	8	Oklahoma	9
9	Montana	137,800	9	Oregon	9
10	Utah	136,000	10	Arizona	8

(1) As of September 2019

Source: Verisk Wildfire Risk Analytics used data from FireLine®, Verisk's wildfire risk management tool.

More wildfires mean significant deterioration to water supplies and quality. Most of the drinking water in the U.S.--[roughly 80%](#)--originates from forested watersheds and [wildfires threaten the safety this of source](#). In communities devastated by fire, water supplies often contain [high levels of contaminants](#) such as benzene, naphthalene, and styrene, all associated with cancer. Treating water after wildfires--removing debris [like ash](#), as well contaminants, and [sediment](#)--is costly. Adding to the cost is the likelihood of flood following wildfires. Denver Water estimates it spent over [\\$26 million](#) to repair infrastructure and remove sediment from the flash floods following wildfires in 1996 and 2002. For more information on the interaction between wildfires and water quality, see Denver Water's site "[From Forests to Faucets.](#)"

Strategic approaches to wildfires. In 2014, the [Wildland Fire Leadership Council](#) (an entity jointly established in 2002 by the U.S. Secretaries of the Interior and Agriculture) adopted a strategic approach to mitigating future wildfires. The approach, titled a [National Cohesive Wildland Fire Management Strategy](#) and often referred to as the "Cohesive Strategy" highlights three key areas (see also Figure ___):

1. Restore and Maintain Landscapes
2. Fire Adapted Communities
3. Response to Fire

The Cohesive Strategy continues to set the tone for current approaches to wildfire management and mitigation.



Wildfire budgeting. In 2018, in response to the year's massive and deadly wildfires, including the fire in Paradise, CA, Congress passed a funding package that [included changes to how funds are allocated for and applied to wildfires](#). The ["fire funding fix"](#) began in fiscal year 2020 and continues through 2027; it approaches wildfires like other natural disasters and appropriates funds for suppression and establishes a reserve fund for deployment during extreme wildfire seasons.



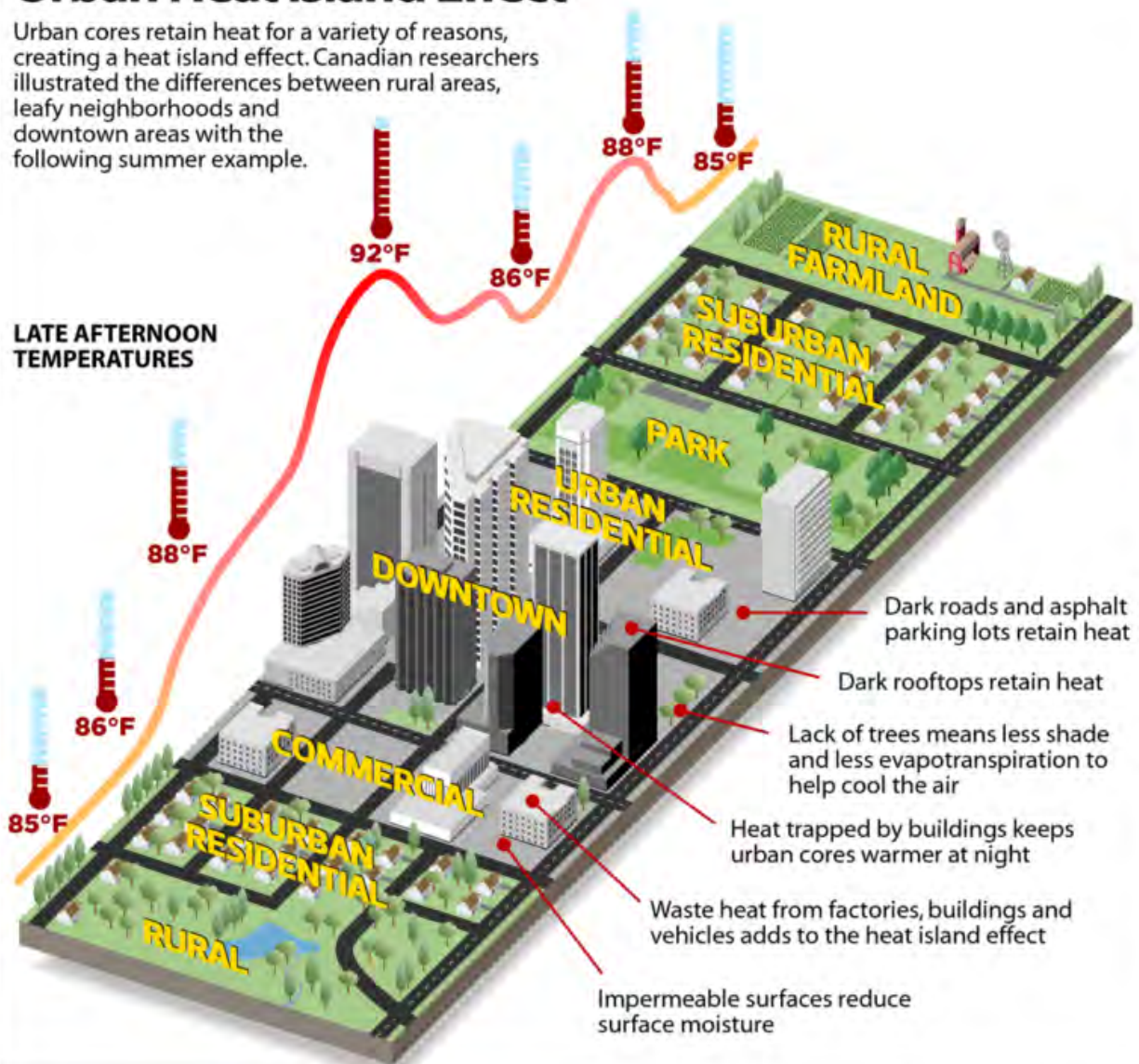
A melted high density polyethylene water pipe burned in a 2020 fire in the San Lorenzo Valley, CA. Credit: James Furtado/San Lorenzo Valley Water District

Extreme heat. It's getting hot in here. And [then hotter](#) on top of that. Extreme heat is measured by intensity, frequency, and duration and all three factors have been on the rise in past decades due to climate change. [Researchers predict](#) higher temperatures and more extreme heat in every region in the U.S. by the year 2100. By that time, current high temperatures could increase by 10 degrees. [Health effects of heat waves](#) include heat stroke, respiratory illness, and cardiovascular illness.

Extreme heat is detrimental to agriculture--both [crops](#) and [livestock](#)--hobbles the energy infrastructure, and threatens the daily life of residents in cities. Major U.S. metropolitan areas like [Atlanta and New York](#) are expected to see the largest rates of human exposure to extreme heat in the coming decades. City planning and layout create "[heat islands](#)" wherein temperatures are significantly warmer within the city region than the surrounding rural areas, mostly as a result of human activity and human construction (see Figure ____).

Urban Heat Island Effect

Urban cores retain heat for a variety of reasons, creating a heat island effect. Canadian researchers illustrated the differences between rural areas, leafy neighborhoods and downtown areas with the following summer example.



SOURCE: D.S. Lemmen and F.J. Warren, Climate Change Impacts and Adaptation

PAUL HORN / InsideClimate News

Water is a resource in extreme heat. Drinking plenty of water tops the list of [health recommendations](#) during heat waves and water can be used to [cool bridges](#) and other structures susceptible to heat failure. This in turn, affects supply levels in cities and areas wherein water resources are needed to safeguard against fire danger.

Water quality is also vulnerable in extreme heat conditions. Rising water temperatures in freshwater systems [harm fish and other aquatic life](#) with negative effects for the \$4.61 billion [recreational fishing industry](#). Warmer water means ripe conditions for [algae blooms](#) which not only harm fish but create toxic water conditions, making freshwater unsafe for recreational use and consumption. For more information on the effect of climate change on fishing and

aquaculture, see the [comprehensive report](#) from the Food and Agricultural Organization of the United States. Ohio experienced an algal bloom-caused [water quality emergency](#) in 2014. High temperatures combined with agricultural runoff allowed a harmful algae bloom (HAB) to flourish in Lake Erie and eventually overwhelm the water supply intake serving over 500,000 people in and around the city of Toledo. The city issued a “do not boil/do not drink” mandate, the governor declared a state of emergency, and the National Guard arrived to help distribute water to residents. Six years later, the city is still [grappling with the aftermath](#) of its water emergency as it works to rebuild small businesses and community trust.



Algal bloom in Lake Erie's western basin. Photo: © John Delmotte

Heat waves aren't just for land anymore, or freshwater. Rising marine water temperatures, dubbed "[marine heat waves](#)" are on the rise. Recent years have seen two substantial marine heat waves off the United States' west coast: one known affectionately as "[The Blob](#)" persisted and grew from 2014-2016. The [more recent](#) was noted in 2019. Marine heat waves have dire [consequences](#) for fisheries and aquaculture as well as the overall marine ecosystem.

As temperatures rise, moisture evaporates from soil and vegetation, contributing to drought conditions.

Intense drought. Feeling parched may be the new norm for many parts of the world as droughts persist and intensify. In some places of the United States, the term drought doesn't cut

it anymore. Only “[megadrought](#)” will do. According to [research](#), the western U.S. is in the midst of a megadrought the likes of which haven’t been seen in the last 1,200 years (see Figure ____).

North American Drought Monitor

September 30, 2020

(Released Friday, Oct. 9, 2020)

<https://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/>

Analysts:

Canada - Trevor Hadwen

Alyssa Klein

Mexico - Reynaldo Pascual

Minerva Lopez

USA - Brian Fuchs*

Brad Rippey

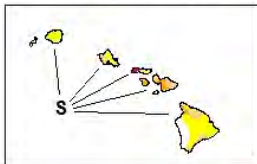
(* Responsible for collecting analysts' input & assembling the NA-DM map)

Intensity

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Drought Impact Types:

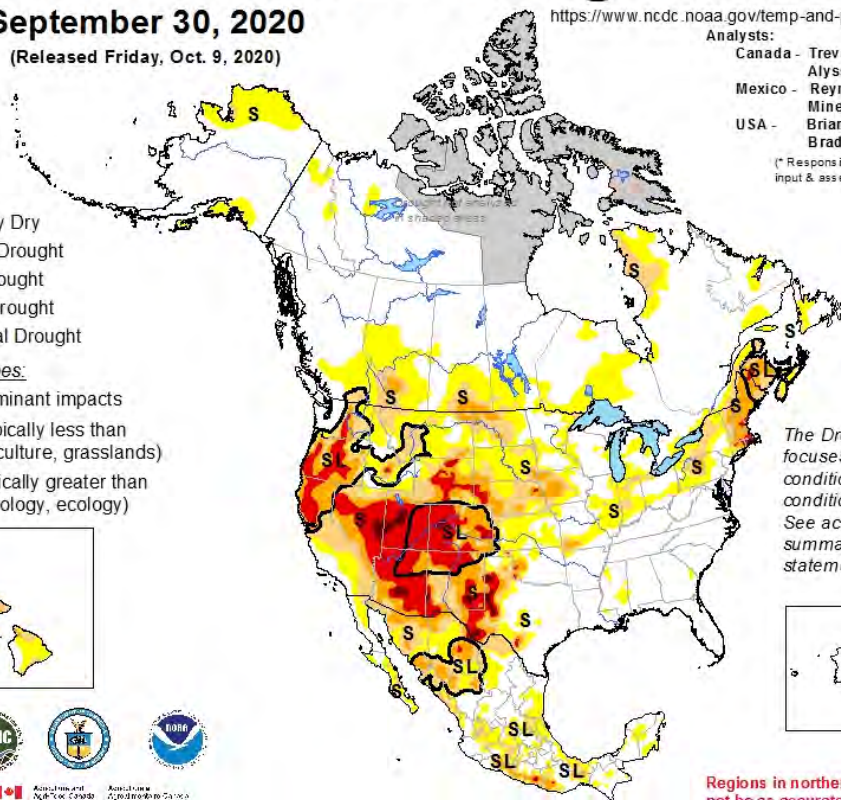
- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)



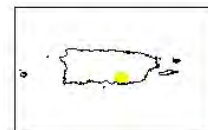
CONAGUA
Comisión Nacional del Agua

Government of Canada
Ministry of the Environment and
Climate Change Canada

Government of Canada
Ministry of Natural Resources
Canadian Centre for
Drought Management



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



Regions in northern Canada may not be as accurate as other regions due to limited information.

The rising temperatures of climate change have contributed to the duration of the drought as well as its acceleration. Drought is, of course, tied directly to water, or a lack thereof. [Drought](#) occurs when a period of low rainfall leads to a shortage of water. The [environmental results](#) include lower flows in rivers, dry out along river edges resulting in the death of plant and animal life, reduced fish migration, algae blooms, and a reduction in the health of wetlands, agricultural areas, and natural vegetation. And don't forget [wildfires](#).

While a lack of water causes drought, drought has numerous effects on water quality and quantity. Less water means less opportunity for pollutants to become diluted in water. Contaminants become more concentrated and harmful. [Ground water sources](#) decrease and grow [more salinated](#). Supply deteriorates, threatening roughly [40% of the world's population](#) with water scarcity. As many as [700 million people](#) are at risk of displacement as a result of drought and water scarcity across the globe by the year 2030. The escalating realities of drought are not lost on water utilities. For more information on how water utilities address drought, see the [Environmental Protection Agency's guide](#) to drought response and recovery.

More hurricanes. Forays into the Greek Alphabet--necessary for naming hurricanes after the Latin alphabet has been exhausted in a hurricane season--may be the new norm. The 2020 hurricane season was the [busiest on record](#) and by many indications, [climate changes contributes](#) to this uptick. Climate change not only ups the frequency of hurricanes, but makes hurricanes [more dangerous](#) as well.

Populations & Agents

Vulnerable Populations

While all populations are vulnerable to extreme events and climate change there are varying degrees of vulnerability due to demographics and socioeconomic factors. The factors contributing to vulnerability include:

- Poverty
- People under the age of 5
- People over the age of 65
- Renters (those who are not homeowners)
- Language proficiency
- Vulnerable households (older adults living alone, single mothers, households without a car)
- Educational attainment
- Vulnerable people (those living with disabilities, those without health insurance)

[Neighborhoods at Risk](#) provides census-tract based maps of vulnerable populations in line with the above measures. For information on each of the measures or to explore vulnerability in a particular area, see their interactive website.

Agents

Category	What they do	Examples
Water Utilities	Safe and timely distribution of water and other related services, such as wastewater treatment. Water utilities are generally local but may operate across states. Create and follow (or in some cases, neglect) disaster avoidances plans related to extreme events.	Denver Water American Water Works Association XYLEM Eversource Energy

Elected Officials	Determine energy and water policy at a local level; this policy connects to water issues in the wake of extreme events, as was the case in Texas' energy deregulation	State Water Policy handbook for state of Colorado See the Western State Water Policy database for specific policies
Communities/Users	End users grappling with disruption in water services and water quality and safety issues as a result of extreme events. May face displacement.	Households Businesses Neighborhoods
Government Agencies	Regulate resources, monitor environmental protections, and respond to disasters	FEMA , EPA , Federal natural resource agencies
Industry Sectors	Use water on a larger scale and with specific needs. May experience service interruptions due to water supply and safety with ramifications for business and production.	Agriculture, Energy
Insurance Companies	Addresses a portion of the cost of some extreme events (flooding is considered an insurance gap in the U.S: only 15% of U.S. homeowners have a flood insurance policy)	Jeuter Insurance Group AON (see AON's 2020 Annual Report on mitigating risk of climate change) Allstate Amica
Disaster Mitigation and Response Sector	Offer services for reducing risk in extreme events or in cleanup post event	Colorado State Forest Service Mitico Wind Mitigation Retrofit Solutions Front Range Arborists

Existing Approaches & Workarounds

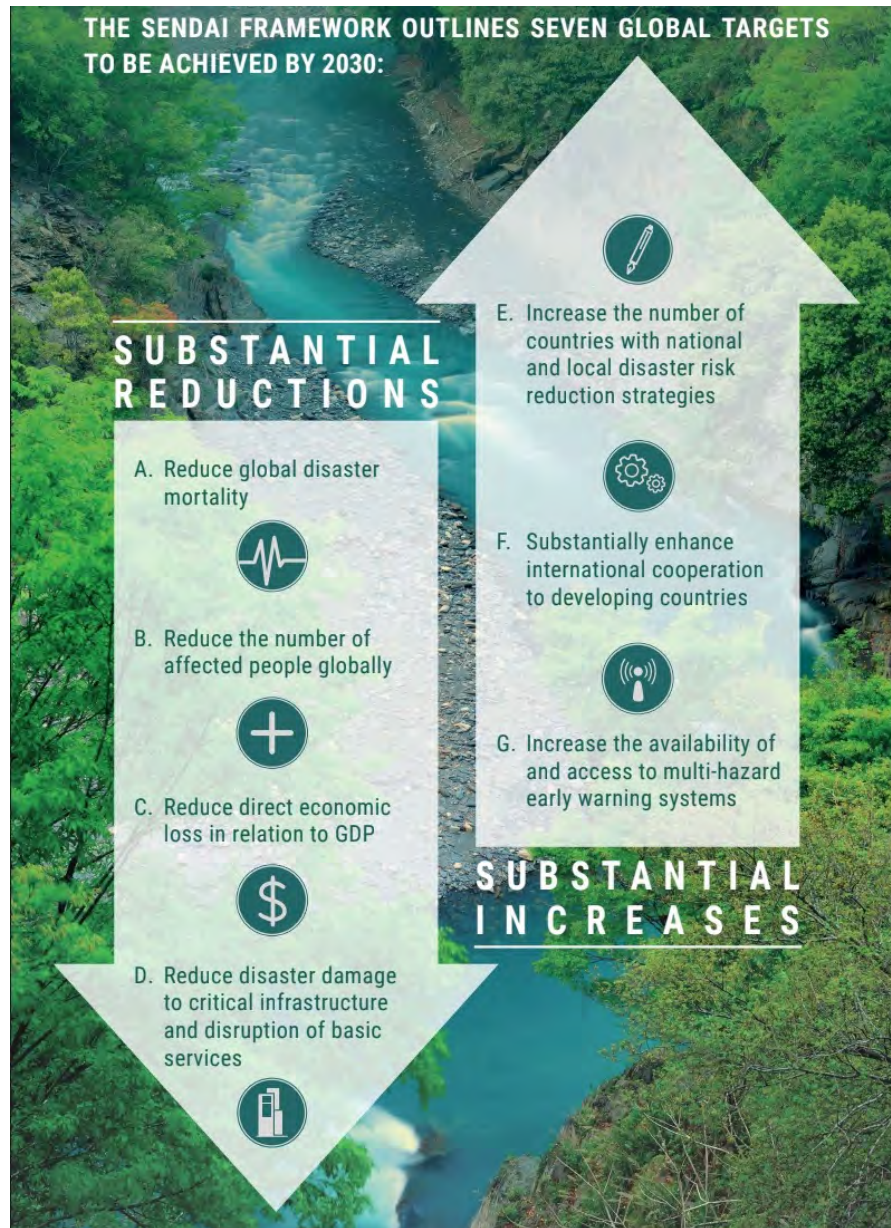
Approaches

Disaster risk reduction (DRR). Disaster risk reduction is a broad term referring to any efforts to reduce the risk of natural disasters. The [United Nations](#) has an office dedicated to it--the UN

Office of Disaster Risk Reduction (UNDRR). And a plan. The [Sendai Framework for Disaster Risk Reduction 2015-2030](#) outlines targets and priorities (see Figure __) for reducing the harm of disasters, enhancing preparedness, and fostering resilient recovery. In 2015, the UN also created the [Private Sector Alliance for Disaster Resilient Societies \(ARISE\)](#), a membership network of private enterprises from around the world working to incentivize risk reduction. Roughly 520 billion USD is lost globally each year as a result of disasters and as the UNDRR states, disaster risk reduction is “everybody’s business.” What exactly that business looks like is quite varied.

The multi-national nonprofit organization [CADENA](#), based in Mexico, is one example of an entity working to reduce risks posed by disasters and help communities recover and rebuild. Funded in part by support from large corporations such as Wal-Mart, Home Depot, and Volvo, and P&G, CADENA serves a logistics hub for DDR.

In the for-profit sector, DRR often takes the form of [prediction and monitoring](#). One example is [Diviroad](#), an analytics company using data to help manage potential water risks. Satellite technology and drones are the foundation for new technologies and services in monitoring and predicting weather, climate change, and extreme events. Companies like [Baron](#) and [FT Technologies](#) develop new technologies and approaches to enable more accurate forecasting of extreme events.



Mitigation strategies. Prevention is not often possible with extreme events, therefore, mitigation--actions to reduce risk to life, property, and disruption of social and economic activities--is an important route in DDR. Despite the benefits of mitigation activities, many communities are reluctant to adopt them, citing barriers such as cost, time and effort, or political will. For each extreme event, there are multiple mitigation strategies offering insight into how to manage resources, work with weather and climate in particular areas, and simultaneously pursue economic and community development. A few examples of mitigation strategies are listed below for droughts, wildfires, and floods.

- Drought mitigation. [Drought mitigation](#) strategies include interventions for crop and animal agriculture such as crop rotation, [erosion control](#) structures, and rainwater harvesting, reduction in herd numbers, and [percolation ponds](#). Additional strategies are [policy](#) or [consumer](#) based.
- Wildfire mitigation. Strategies for [mitigating wildfire](#) intensity and frequency include how to protect [individual buildings](#) as well as [cities](#) (see examples of city plans from [Palo Alto](#), [Boise](#), and [Colorado Springs](#)). [Forest management](#) is a significant tool in wildfire mitigation.

For the private sector, disaster mitigation slides into [recovery and restoration](#), and usually follows the route of [construction clean up](#) or [data recovery](#). Exploring the realm of prevention through risk and damage mitigation (rather than the realm of reaction post extreme event) seems a relatively open market opportunity with numerous potential target markets from large corporate campuses to agricultural. Of course, risk denial--see below can be a barrier to prevention and mitigation approaches.

Multi-hazard early warning systems. These systems provide warnings for extreme events. They are much more than a simple warning, however. To be effective, early warning systems require monitoring, forecasting, and communication. For more information about the components of warning systems--including their promise and shortcomings--see the World Meteorological Organization's [Multi-hazard Early Warning Systems: A Checklist](#). In the wake of the [COVID-19 pandemic](#), health and disaster researchers have invested more effort in exploring the [use of multi-hazard early warning systems for global health risks](#).

Information and communication technologies. Warning systems can be considered an off-shoot of the [Information and Communication Technology](#) sector as warnings require a means by which to [relay information and reach a variety of audiences](#). Figuring out how best to reach various groups requires review of informational channels and platforms and consideration of who has access to different modes of communication. Existing [ICTs](#) are increasingly deployed to collect and relay information about extreme weather events. The technologies involved range from [satellite imaging](#) to [text messaging](#).

A 2014 [report from the International Telecommunication Union](#) explores the connection between the ICT sector and climate change, specifically exploring the role ICT can play in addressing climate change related disasters. Opportunities lie not only in thinking about how to deploy ICT in service to warning systems, information gathering, and outreach but in how to continue to ensure ICT resilience in the face of extreme events.

Extreme event attribution. Making evidence-based connections between extreme weather events and climate change is a [growing scientific research field](#). This work helps enhance an understanding of the role of climate change, grounds mitigation, and DRR efforts in predicting and preparing for extreme events. Determining how to plug this new field into existing and emerging technologies and services in the ICT sector or within DRR efforts will be an increasing

need in coming years. Extreme event attribution fills a gap in knowledge by taking into account a growing body of data in the age of climate change and has implications for designing infrastructure, legal liability, insurance, and a number of additional fields.

Workarounds

Urban development and structural measures. Traditional approaches to spatial planning in urban development include structural measures to lessen the risk from extreme events. These are often [engineering approaches](#) such as seawalls, embankments, and floodgates or [building retrofitting](#) like HVAC systems for heating and cooling or strengthening buildings to withstand extreme weather conditions. Decision-making to adopt these approaches is often based on a cost analysis benefiting higher income areas. Buildings and [neighborhoods](#) in lower income areas may not be included or may suffer from “down stream” measures--the effects of implementing structural changes in one area thereby making another area even more vulnerable to damage. For more information on these discussions and structural measures, see pp. 291-306 in the Intergovernmental Panel on Climate Change special report, “[Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation](#).”

Reducing emissions. While it is important to decrease the amount of CO₂ in the atmosphere, [research shows](#) reductions in emissions have little overall effect on global temperatures and reduction strategies must go hand in hand with additional measures.

Substitutes for oil. Fuel alternatives receive a lot of attention. However, often the [production of those alternatives](#) requires oil and gas, and in some cases, energy alternatives are used to [extract more oil](#). Any discussion of fuel alternatives must occur with a critical look at how that alternative is produced and brought to market.

The human response to risk. You know that thing many of us do when we [think about risk](#)? We tend to see risk as more relevant to people other than ourselves. Sure, Bob down the street may see his home go in a wildfire, but ours will be ok. Sometimes we ignore risk because we don’t know much about the risk or its relevance to us. Other times, we very pointedly elect not to think about or take efforts to avoid risk, despite the information available. This is called [neglected risk](#). One of the most well-known examples of neglected risk is the city of New Orleans. Various stakeholders had been aware of the risk posed by extreme weather and a weakened levee system for years but elected to neglect the risk. For a fascinating look at large scale neglected risk see Kathryn Schulz’s *New Yorker* article “[The Really Big One](#).”

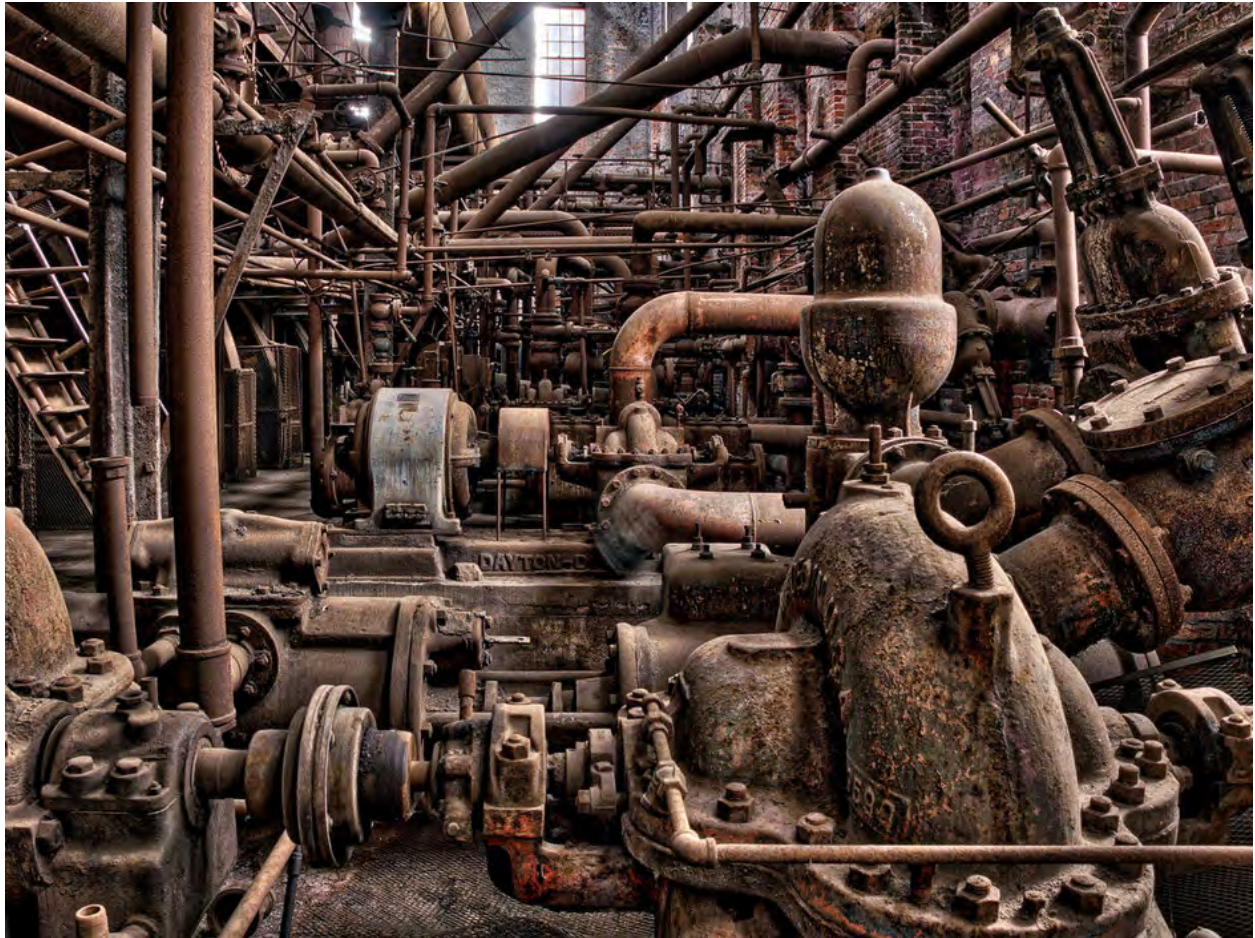
Additional Resources

- For more information on the connection between extreme events and the energy industry, see <https://nca2014.globalchange.gov/report/sectors/energy> and <https://www.energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf>
- For more on drought across the globe and in specific regions, see <https://noaa.maps.arcgis.com/apps/Cascade/index.html?appid=aec0b8fc5b504a449f99ba162af904fd>
- For more on climate change and extreme events, with expansive attention to managing the risk of extreme events, see https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf
- For more information on neighborhoods at risk for extreme events and climate change, see <https://toolkit.climate.gov/tool/neighborhoods-risk>
- For more on the Incident and Emergency Management market (Figure ____), see <https://www.marketsandmarkets.com/Market-Reports/incident-emergency-management-market-1280.html>
- For more information on climate change and climate refugees, see <https://www.brookings.edu/research/the-climate-crisis-migration-and-refugees/>
- For more on vulnerable populations and extreme events, see https://www.samhsa.gov/sites/default/files/dtac/srb-low-ses_2.pdf
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https://in2ecosystem.com/wp-content/uploads/2021/01/IN2-State-of-the-Cleantech-Landscape-White-Paper-2021_final.pdf

Infrastructure



Infrastructure: The average age of water and sewage pipes in the U.S. is 45 years; in over 600 towns and cities in the U.S. the age of pipes is north of 100. These pipes--in some cases exceeding their intended life span by more than four decades--are not aging gracefully. A water main breaks in the U.S. every two minutes, resulting in a loss of 6 billion gallons per day and an estimated cost of \$7.6 billion in treated water per year. Climate change worsens the conditions of aging infrastructure via an onslaught of extreme events such as storms or floods that stretch the limits of infrastructure resiliency. To combat the deluge in costs and face ongoing threats, local governments will spend an estimated \$300 billion on repairing and updating water and sewage pipes in the next ten years. These figures represent the deteriorating nature of much water infrastructure locally and globally. And it's not just pipes. Water infrastructure refers to the systems, including the workforce, the technology, and the processes related to the treatment, delivery, storage, supply, and resource management of drinking water, wastewater, and stormwater, increasing the complexity of infrastructure challenges. The American Society of Civil Engineers gave grades of D and D+, respectively, to the entire U.S. water and wastewater infrastructure systems. As these systems continue to age, the cost of operating and maintaining

them will rise, exponentially increasing the cost of deteriorating infrastructure and further opening infrastructure to the threats of climate change, including rising water demands in response to heat waves, drought, and other extreme events. Not only is water infrastructure essential to individuals and households, entire industries from healthcare to manufacturing to mining rely on water and wastewater systems to function. Without significant investments to and changes in water infrastructure within the shifting reality of climate change, service disruptions could cost water-reliant businesses roughly \$250 billion by the year 2039 and costs to U.S. households could reach seven times that of current water costs. Finally, a deteriorating water infrastructure produces a multitude of health risks, be it metal seeping into the water from aging pipes as was the case in Flint, Michigan, to waterborne diseases resulting from sewage contamination. These risks threaten familial and community health and often occur in municipalities and neighborhoods with high levels of poverty, further complicating mitigation or innovation efforts.

How might we create resilient water infrastructure in the face of growing demand and climate change threats?

Contributing Factors	
Aging infrastructure (lead service lines) Climate change (extreme events, pollution) Underinvestment Population growth	
History & Trends	
History	Trends Workforce challenges Rising O&M costs Full-cost pricing COVID-19 Public opinion Water quality regulations

Populations & Agents	
Existing Approaches & Workarounds	
Workarounds	Approaches
Business as usual/failure to act Energy efficient appliances	

Contributing Factors

100 years and counting. Much of the infrastructure in the U.S. is old. Decades, and in some cases, centuries old. This is a problem in a number of areas, from transportation to water, as [each of these systems](#) experience further degradation and potentially failure. The [American Society of Civil Engineers](#) (ASCE) regularly reviews the state of U.S. infrastructure and in its [last review](#), awarded U.S. infrastructure in general a grade of D+, with the a D and D+ for the nation's water and wastewater systems respectively.

Water infrastructure represents the structures, facilities, operations, and personpower required to provide drinking water as well as wastewater and stormwater services to a majority of U.S. homes and businesses through [public](#) or [investor-owned](#) utilities. It's the treatment facilities, the workforce operating the facility, the pumps, the storage, and the pipes. All of it is aging and all of it requires investment, innovation, and attention.

According to the American Water Works Association (AWWA), a majority of water pipes in the U.S. will need to be [replaced by the year 2040](#). These pipes have outlived their intended lifespan (see Table ____). The AWWA also releases a [yearly report on the state of the water industry](#). The report includes data from surveys of water professionals across the U.S. and Canada. For the past five years, addressing aging infrastructure has topped the list of concerns facing the industry (see Table ____). Old pipes are dangerous and costly. They may leach

materials and minerals into the water supply, as was the case in [Flint, MI](#), and are prone to leaks and breaks. The gallons of water lost per year due to leaks and breaks is roughly [1.7 trillion at a national yearly cost of \\$2.8 billion](#). In one year, from 2017-2018, the rate of water main breaks [increased by 27%](#), resulting in 250,000-300,000 water main breaks per year, or an average of a break [every 2 minutes](#).

Component	Useful Life (years)
Reservoirs and dams	50-80
Drinking water treatment plants (concrete structures)	60-70
Wastewater treatment plants (concrete structures)	50
Drinking water and wastewater treatment plant structures (mechanical and electrical)	15-25
Drinking water trunk mains	65-95
Drinking water pumping stations (concrete structures)	60-70
Drinking water pumping stations (mechanical and electrical)	25
Drinking water distribution	60-95
Wastewater collection	80-100
Force mains	25
Wastewater pumping stations (concrete structures)	50
Wastewater pumping stations (mechanical and electrical)	15
Interceptors	90-100

Property lines delineate the pipes and systems under the purview of utilities and those for which a homeowner or business are responsible (see Figure ____). Repairing breaks or leaks within a home or individual property is also costly. The [average cost of water main break repair](#) for homeowners is between \$800-\$1,200. Finding and fixing leaks, on the other hand, can lead to roughly [10% in monthly water bill savings](#).

Utility-owned vs Customer-owned portion of the service line



Useful lifespan of water infrastructure components.

Top 10 Issues Facing the Water Industry, 2016–2020						
	2020		2019	2018	2017	2016
1	Renewal and replacement of aging water and wastewater infrastructure	↔	Renewal and replacement of aging water and wastewater infrastructure	Renewal and replacement of aging water and wastewater infrastructure	Renewal and replacement of aging water and wastewater infrastructure	Renewal and replacement of aging water and wastewater infrastructure
2	Financing for capital improvements	↔	Financing for capital improvements	Financing for capital improvements	Financing for capital improvements	Financing for capital improvements
3	Long-term water supply availability	↔	Long-term water supply availability	Public understanding of the value of water systems and services	Long-term water supply availability	Public understanding of the value of water systems and services
4	Public understanding of the value of water systems and services	↔	Public understanding of the value of water systems and services	Long-term water supply availability	Public understanding of the value of water systems and services	Long-term water supply availability
5	Watershed/source water protection	↔	Watershed/source water protection	Public understanding of the value of water resources	Public understanding of the value of water resources	Public understanding of the value of water resources
6	Public understanding of the value of water resources	↔	Public understanding of the value of water resources	Watershed/source water protection	Watershed/source water protection	Watershed/source water protection
7	Aging workforce/ anticipated retirements	↑	Groundwater management and overuse	Aging workforce/ anticipated retirements	Emergency preparedness	Public acceptance of future W/WW rate increases
8	Emergency preparedness	↑	Aging workforce/ anticipated retirements	Public acceptance of future W/WW rate increases	Cost recovery (pricing water to accurately reflect cost of service)	Water conservation / water use efficiency
9	Compliance with current regulations		Emergency preparedness	Emergency preparedness	Public acceptance of future W/WW rate increases	Cost recovery (pricing water to accurately reflect cost of service)
10	Groundwater management and overuse	↓	Cost recovery (pricing water to accurately reflect cost of service)	Governing board acceptance of future W/WW rate increases	Water conservation / water use efficiency	Groundwater management and overuse



American Water Works Association

©AWWA 2020 State of the Water Industry

Climate change. Anticipating gradual changes in climate is part of the long term planning process for infrastructure needs and capital improvements. It's called [climate stationarity](#)--the use of past data to provide a picture of the relative stability of climate in the future. Except, climate stationarity [doesn't apply today](#) in the same way it did 50 or 100 years ago, when much existing infrastructure was designed and built. Today, the intensity and rate of climate change throws one giant monkey wrench into anticipating the demand on infrastructure and that reality is most evident when considering extreme events.

→ Extreme events. When something is old and degrading, it's generally not able to stand up to extreme circumstances. This is certainly the case when it comes to [water infrastructure](#). Aging pipes and facilities are increasingly under pressure from the [manifestations of a changing climate](#), especially the pressure of extreme events. Hurricanes, droughts, floods, and heat waves strain existing systems. The 2020 AWWA State of the Water Industry report notes water professionals [ranked extreme events](#) as the most significant large-scale phenomena of negative impact for water utilities. The

year 2020 was the [sixth consecutive year](#) in which the U.S. experienced ten or more billion dollar weather and climate events, meaning the cost in damage to cities, utilities, homeowners, and business totaled at least \$1 billion. These events are not costly in the immediate term but wreak havoc on water systems and facilities, often exacerbating current states of disrepair. See Table ____ for more detail on how climate change affects various components of water infrastructure. For the complete table, see pages 4-8 of the [USAID Climate Resilient Infrastructure Report](#).

Table 1: Climate Change Impacts on Various Components of Water Supply Infrastructure

CLIMATE DRIVERS AND EFFECTS	INFRASTRUCTURE IMPACTS AND CONSEQUENT RISKS
Increased Mean Annual and/or Intensity of Precipitation	
<p>Higher intensity rainfall and flooding during storms</p> <p>Extreme precipitation events are location-specific and can cause flooding and landslides when downpours exceed the capacity of river or urban drainage systems. Uncertain climate projections, expected to intensify in some areas.</p>	<p>River Water Resources</p> <ul style="list-style-type: none"> • Increased water turbidity after heavy storm events • Shifts in river morphology from increased erosive capacity of river during storm events may affect water withdrawal • Need for dredging to remove sediment, rocks and debris deposited after storm events <p>Water Impoundments</p> <ul style="list-style-type: none"> • Additional storage facilities needed to capture water during shorter, higher intensity storms • Higher turbidity of stored water due to erosion requires more treatment chemicals and time for clarification during treatment; temporary suspension of treatment of stored water may also occur in cases of extreme turbidity • Decrease in storage capacity of impounding reservoirs due to high sediment deposition <p>Wells and Spring Sources</p> <ul style="list-style-type: none"> • Well contamination from flooding • Physical damage to structures from flooding • Intake pipes on soft soils or steep slopes prone to landslides • Destruction of spring boxes on steep areas from landslides • Need for relocation of water intake structures due to shifting riverbed and sediments during storm events • Higher maintenance costs to keep water intake structures clear of debris deposited after storm events • Cracks in or total destruction of spring boxes from landslides <p>Storage Tanks</p> <ul style="list-style-type: none"> • Contamination due to flooding for cisterns • Physical damage due to landslides <p>Pipelines</p> <ul style="list-style-type: none"> • Corrosion of metal pipes weaken structures over time • Physical damage to pipes from flooding and landslides



- Network contamination from pipes damaged by flooding or landslides

Treatment Facilities

- Physical damage to structures from flooding
- Water damage to chemical supplies due to flooding
- Lower treatment effectiveness due to higher than normal turbidity or disrupted/shorter treatment operation
- Need for higher treatment plant capacity due to higher precipitation depending on capacity of transmission lines

Auxiliary Services

- Loss of power supply
- Loss of telecommunication facilities
- Loss of data

The terms “resilient infrastructure” or “[infrastructure resilience](#)” appear often in considering how to address the threat of extreme events on water systems and refer to the ability to recover from or withstand disruptions, thereby saving costs and potentially saving lives. The National Infrastructure Advisory Council includes people/processes and infrastructure/assets into its thinking about the [four fundamental concepts of resilience in infrastructure](#): robustness, resourcefulness, rapid recovery, and adaptability (see Figure ___). Each of these areas represents potential for innovation and intervention in helping water utilities prepare for extreme events.




→Water quality and pollution. Extreme events [alter water quality and contribute to pollution](#), further taxing infrastructure. Water runoff and rising sea levels [increases the salinity in water](#), requiring [extensive treatment](#). The chemicals historically used to fight wildfires make their way into the water yielding dangerous levels of what are referred to as “[forever chemicals](#)” or [PFSA](#)s in groundwater, surface water, and drinking water supplies. Treating water to eliminate pollutants is not only costly, it is an every-shifting battle as nascent contaminants require monitoring and testing to ensure safe water.

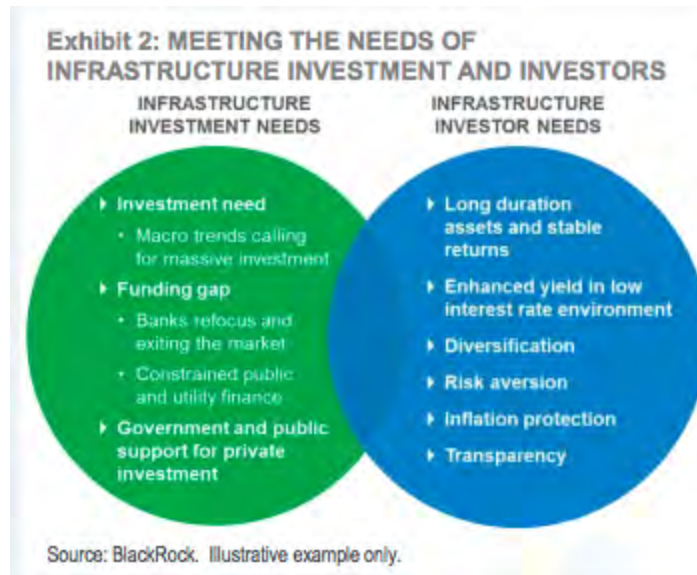
Underinvestment. Addressing the nation’s aging infrastructure will require significant financial investment. The EPA estimates the investment needed to bring water infrastructure up to date by making repairs and replacing deteriorating systems is [\\$472.6 billion](#) over the next 20 years. Current infrastructure investments cover a small portion of this amount. The [ASCE notes](#) the US. needs to invest \$129 billion per year in water infrastructure to keep water systems working. In 2019, that investment total was \$48 billion for a gap of \$81 billion. As investments fail to keep

pace with need, the infrastructure [investment gap](#) will continue to grow. Currently cities cover a majority of water externally funded infrastructure costs, with [local governments](#) covering [95% to 98%](#) of drinking water and wastewater infrastructure costs. Utilities and local and state governments seeking to invest in infrastructure do so by funding it directly through spending reserves or rate increases or through financing such as loans or bonds repaid over time. See Table ____ for a list of utility funding sources as noted in the [AWWA 2020 State of the Water Industry Report](#).

Utility 2020 Funding Sources	
RANKING	UTILITY FUNDING SOURCES RANKED BY % MENTIONS
1	Rate increases (25%)
2	Bonds (18%)
3	Grants (14%)
4	Operational savings (13%)
4	Reserves (13%)
4	State Revolving Funds (SRFs) (13%)
5	Water Infrastructure Finance and Innovation Act (WIFIA) (4%)

 American Water Works Association ©AWWA 2020 State of the Water Industry

The potential return for investing in water infrastructure is substantial, in part due to the reliance of a variety of industries on water. The [US Department of Commerce's Bureau of Economic Analysis](#) estimates for each additional dollar of revenue invested in the water or wastewater industry in a year, the increase in economic output across all industries is \$2.62 in that year. In the long term, each dollar invested increases the GDP by \$6.53. The return on investment is also experienced in job growth. The same analysis by the Bureau of Economic Analysis notes adding one job in water and wastewater management and infrastructure creates 3.68 jobs in the national economy, or a total of [1.3 million American jobs](#).



→ Rising costs. As [utilities stretch to address the gap](#) in infrastructure investment, one lever they can pull is raising rates. In fact, most utilities plan to raise costs in the coming year, causing challenges for some customers. For more information on how water utilities need to adjust their financial benchmarking and consider new models to address rising costs, see the video below.

Link to video: https://youtu.be/pfs0brT_jkU

Population shifts. The U.S. population, currently at ____, is expected to hit ____ by 2050. Much of this growth will occur in areas of water scarcity such as the American West (see Table ____). Population growth and internal migration in the U.S. will contribute to strain on infrastructure by increasing demand for treated water and taxing the facilities for drinking and wastewater treatment. And it's not growth alone. Shrinking populations in smaller communities also presents challenges to water utilities due to shrinking customer bases and decreasing revenue. To learn more about internal population shifts, see the [interactive internal migration map](#) from *Forbes*.

Rank	Top Sending Counties	Top Receiving Counties
1	Los Angeles County, CA	Los Angeles County, CA
2	Cook County, IL	Harris County, TX
3	Harris County, TX	Maricopa County, AZ
4	Travis County, TX	Cook County, IL
5	Dallas County, TX	Dallas County, TX
6	Kings County, NY	San Diego County, CA
7	New York County, NY	Riverside County, CA
8	San Diego County, CA	Orange County, CA
9	Maricopa County, AZ	Tarrant County, TX
10	Orange County, CA	King County, WA
11	Queens County, NY	San Bernardino County, CA
12	King County, WA	New York County, NY
13	Santa Clara County, CA	Broward County, FL
14	Tarrant County, TX	Clark County, NV
15	San Bernardino County, CA	Kings County, NY
16	Riverside County, CA	Travis County, TX
17	Miami-Dade County, FL	Fulton County, GA
18	Fulton County, GA	Orange County, FL
19	Alameda County, CA	Alameda County, CA
20	Fairfax County, VA	Queens County, NY

History & Trends

History

The history of water and wastewater infrastructure is the history of development. As settlements grew into towns and cities, infrastructure was required to literally “build America.” Today, we hear [“rebuild America”](#) as an oft repeated refrain, one pointedly employed during [President Barack Obama’s](#) second term. Rebuilding America refers to the need to [upgrade infrastructure](#)--from aviation to roads and bridges to school to hazardous waste to water--across the U.S. and in so doing, [create jobs](#). It’s also a history of economic growth and public-private partnerships. Canals were built to facilitate transport goods. Businesses and cities together bore the cost of canal construction. Railroads, then highways replaced canals as the predominant

form of traversing distance, yet the combination of [public-private partnerships](#) remained constant.

The history of water infrastructure is similar, with the addition of [health](#) as an influential factor. As cities became more crowded during the Industrial Revolution, concerns about safety and hygiene grew more prominent and water was seen as a connection to either sickness or health. Safe and accessible water was needed to quell disease, help grow businesses, and protect the community from fire. In 1850, there were [83 public water supplies in the U.S.](#), 50 of which were privately owned. That number grew to 136 by 1886 and reached 3,000 by the turn of the century, split relatively equally between public and private entities. Not long after these entities were established, they began to serve important roles in health. As early as 1908, the city of Jersey City, NJ was [treating its drinking water](#) to ensure its safety.



Photo: Nebraska State Historical Society, image RG2608.PH2494

Sewer pipe installation in Kearney Nebraska, 1889.

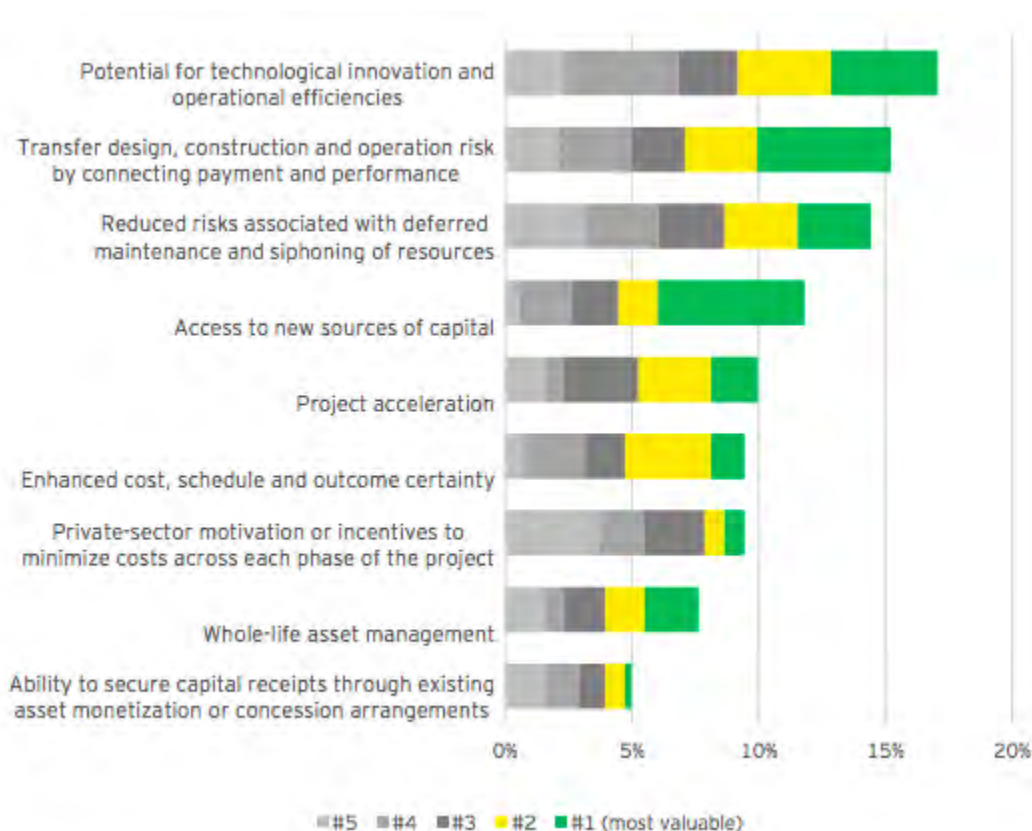
The provision of wastewater services by way of comprehensive sewage systems emerged in the U.S. in the mid 19th century. Around this time treatment of wastewater became part of the wastewater process. Previously, [sewage was pumped back into the nearest body of water](#) which usually doubled as a community's water source. In 1892, the U.S. included only 27 cities with wastewater treatment works. Most cities thought treating wastewater was an unnecessary cost. Thinking changed in the mid-20th century. In 1948, the Federal Water Pollution Control Act outlined the need for sanitation infrastructure and directed local and state governments to pursue this need. Decades later, the 1972 Clean Water Act made wastewater treatment mandatory and in 1974, the Safe Drinking Water Act was adopted to regulate public drinking water supplies. For an expansive review of the history of the Safe Drinking Water Act see the EPA's report [Twenty-five Years of the Safe Drinking Water Act: History and Trends](#).

Drinking and wastewater regulation continues today. Dictated and enforced by the EPA, these regulations pose opportunities for providing safe and reliable water services but also present challenges in ongoing compliance requirements. For a full list of drinking water regulations see

the EPA's table of [National Primary Drinking Water Regulations](#). For more information on wastewater, see the EPA's National Pollutant Discharge Elimination System [program areas](#). Stormwater collection is also a primary function of most water utilities; for more information on stormwater management see the EPA's [NPDES' Stormwater Program](#).

Trends

Public private partnerships. While public private partnerships (P3s) have a solid place in the history of building infrastructure in the U.S. a developing trend is the return to these partnerships to help [address rising costs, supply funds for improvements, and provide technology and innovation](#). P3s allow utilities to partner with outside entities to bring in the investment and expertise needed to address the [expanding challenges](#) of water supply and treatment (see Figure ____). According to the AWWA, more than 2,000 municipalities have entered into a P3 arrangement for all or part of their water supply needs. For more information on P3s in water infrastructure, see the AWWA's report [To P3 or not to P3](#).



Typically cited benefits deemed most appealing to P3 involvement.

COVID-19. Water utilities have felt the repercussions of the pandemic in [budget shortfalls](#). As water use in areas like restaurants and hospitality dip drastically and many businesses are closed, revenue--based on usage--falls. [Rural community](#) utilities are some of the hardest hit, bringing in roughly half of typical monthly revenue. The pandemic has also [heightened inequities](#) around water access and vulnerable populations reinforcing the need to examine [cost](#), access, and supply to those who need it most.

An infrastructure bank. In recent years a number of trends have emerged to address the need to finance infrastructure projects across the U.S. One of these trends is the [National Infrastructure Reinvestment Bank](#), proposed by legislators in 2007 and backed by President Obama in 2008. The bank's proposal has since been through [many iterations](#) the most recent of which was [introduced in Congress in June 2020](#) as the Infrastructure Bank for America. Unlike previous proposals, the Infrastructure Bank of American would be privately owned, managed, and funded.

Climate bonds. Fixed-income financial instruments, [climate bonds](#) (also known as green bonds) have positive environmental or climate benefits. Proceeds from their issuance are applied to pre-specified projects such as the creation of a hydropower plant. Projects must [comply with standards](#) established by the Climate Bonds Initiative. For more information on climate bonds see the [Climate Bonds Initiative website](#).

Green cities. As more people populate cities and many cities in turn work to curb carbon emissions, development of green cities and green city planning is on the rise. This year, Resonance Consultancy identified the [world's ten greenest cities](#) based in part on a city's walkability, public transportation, number of green spaces, and levels of air pollution. Water systems and water planning will [increasingly play a role](#) in the creation and maintenance of green cities as cities consider how to plan for future events and build and develop in line with water conservation practices.

Public support. Support for investment in infrastructure is one of the few bipartisan areas of agreement. A whopping [80% of Americans](#) support investing in infrastructure and 84% support investment in water infrastructure specifically. For more on public opinion about water infrastructure see the presentation from the [Value of Water Campaign](#).

Regulation. Emerging contaminants mean the need for more regulation addressing harmful elements in water. While regulation is necessary, meeting shifting regulatory requirements is costly for utilities. Water utilities are regulated at the national level by the EPA and the Safe Drinking Water Act but are also subject to [state and a variety of local regulations](#) as well.

Deregulated electricity markets. Since mid-February of 2021, Texas is the best-known state with a [deregulated electricity market](#). While a number of states have deregulated electricity markets, the recent extreme cold weather in Texas and near-catastrophic barely-avoided complete grid failure has drawn attention to the difference between regulated and unregulated markets and what those differences mean for water quality and availability.

[Regulated electricity markets](#) mean energy utilities own and control the entire energy vertical, from energy production to individual home energy metering. Market competition is minimal or nonexistent. In a [deregulated market](#), a number of providers may be responsible for electricity supply, allowing for more market competition and in turn, the potential for better prices and services.

Texas deregulated its electricity market in 1999. Texas is also completely [energy independent](#). By refusing to share energy across state lines, Texas isolated itself from the national energy grid and avoided regulations for utilities involved in interstate commerce. Deregulation and energy independence-turned-isolation were significant precursors to the disaster wrought by days of cold weather in mid-February. Temperatures plummeted, households across the state turned up their heat, and [the energy draw coupled with lack of energy reserves and safeguarding procedures](#), saw the state seconds away from a catastrophic blackout event.

Families huddled in their cars or gathered closely together around makeshift campfires to stay warm. As communities across the state faced ongoing outages, more challenges unfolded, turning the crisis in energy into a water crisis. Pipes in homes and businesses and [domestic violence shelters](#) froze, cutting off the water supply, and then burst causing extensive damage. Water treatment plants struggled to keep up with broken water mains, pipes, and inactive pumps and treatment mechanisms useless without power. [Water reservoirs were depleted](#) due to leaks and increased use. More than 800 public water systems serving 13.1 million people experienced disruptions. The state of Texas implemented a [boil water notice](#) for roughly 7 million individuals in response to concerns over the water's safety due to utilities' inability to maintain water pressure. The crisis in Texas demonstrates the interconnectedness of energy and water and the susceptibility of water utilities to disruption as a result of crises in other infrastructure sectors.

Skilled workforce. The average age of the water infrastructure workforce is higher than the average age of the overall workforce, revealing the need for the water infrastructure sector to consider how to replace retiring workers. As the industry increasingly incorporates technological approaches and solutions, the need for a skilled and tech-savvy workforce will be all the more pressing, requiring water infrastructure players [adopt new approaches](#) to securing a future workforce.

Populations & Agents

Vulnerable Populations

A neighborhood's [racial composition](#) is a strong indicator of the degree to which its infrastructure is capable of withstanding threats, or its degree of deterioration. In contrast to communities of predominantly white residents, communities of people of color and low-income communities have a disproportionate amount of outdated infrastructure systems, putting them at greater risk for water scarcity, safety issues, and hazardous conditions resulting from extreme events.

Yet issues related to water infrastructure also span the nation. A few of the cities listed as having the [worst tap water problems in the nation](#) include Pittsburgh, Milwaukee, Detroit, and Baltimore. And Mississippi, Massachusetts, and New Jersey are at the top of the [list of states with the worst infrastructure](#). Despite the prevalence of infrastructure issues, vulnerable populations such as those of lower socio-economic status, or those experiencing unstable housing conditions, are most susceptible to the intersection of challenges accompanying poor infrastructure including less access to healthcare and other basic resources.

Agents

Category	What they do	Examples
Regulatory bodies	Oversee issues related to water quality and safety.	EPA FDA
Water utilities	Provide water supply systems, maintain infrastructure	Denver Water American Water Works Association
Associations	Provide resources and expertise as well as an external check for infrastructure.	ASCE AWWA
Communities	Neighborhoods, cities, or municipalities with varying degrees of water service and infrastructure needs.	Rural communities Urban areas
Consumers	Receive varying levels of infrastructure support and water supply. Shape water conservation and reuse practices via public opinion. Advocate for access to safe water and engage in a range of water use behaviors.	Indian Tribes Urban centers Rural communities
Industry	Rely on water to produce goods/services and sustain industry. Participate in both positive and harmful water use practices thereby affecting other industries and their water uses.	Recreation Agriculture Energy
Investors	Provide financial backing for water infrastructure and in some cases, own water utilities.	Water Asset Management Climate Change Bond funds

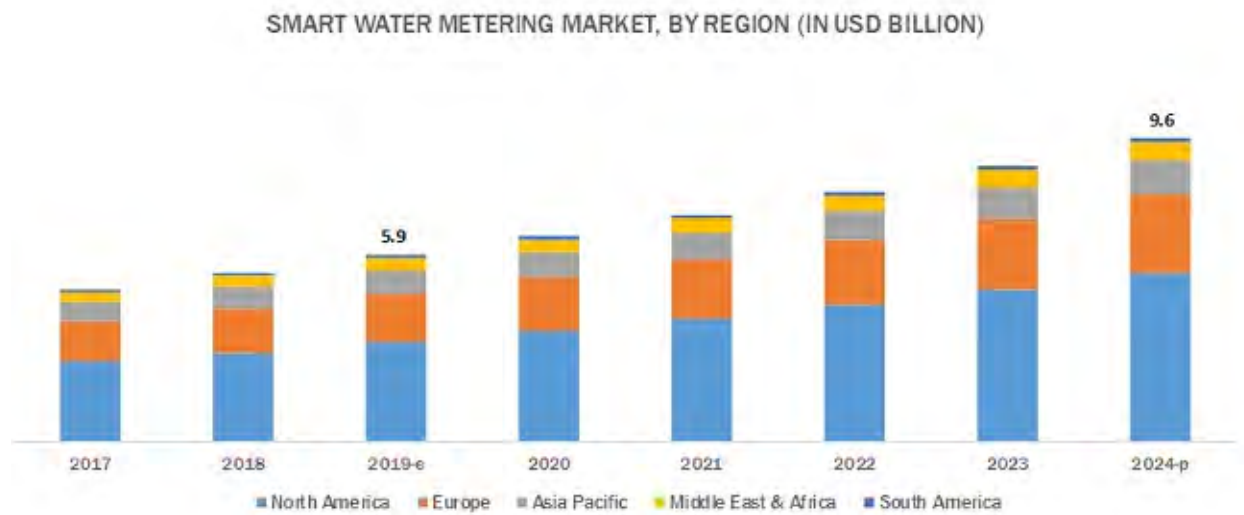
Existing Approaches & Workarounds

Approaches

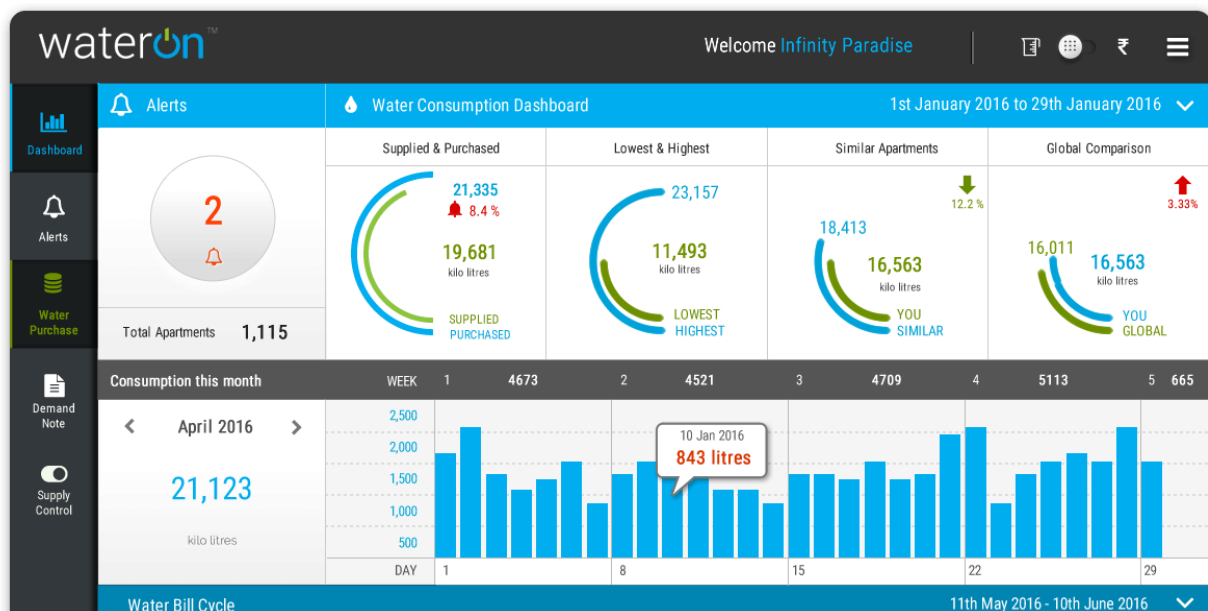
Smart water management and advanced metering infrastructure. [Smart water management](#) includes the hardware, software, processes, analytics, and advanced pressure management systems for monitoring water via the IoT. As a whole, the [smart water management market](#) was \$9.6 billion in 2017 and is expected to reach \$31.6 billion by 2024.

Advanced metering infrastructure is one technological innovation within smart water management. Integrated sets of smart meters work together to create [advanced metering infrastructure \(AMI\)](#). AMI allows for advanced data collection, as well as the potential for two-way communication between the customer and utility. Unlike traditional water meters requiring regular visits from utility personnel to a household or businesses, [automatic meter readers \(AMRs\)](#) provide ongoing data to a utility on an hourly basis. AMI is one step up, enabling [data sharing with the customer](#) as well as the utility. While AMI presents many [possibilities for utilities](#) in the realm of more accurate and immediate data and [benefits to the customer](#), transitioning to AMI also presents cost challenges as utilities segue to new hardware and structures as well as new employee skill sets. Smart metering companies include [Itron, Inc.](#), [WaterSmart](#), [Badger Meter](#), and [Elster Group](#).

The [AMI market](#) consists of smart meters and the communication modules required for their use, with the smart meters representing the larger share of the market. Market expectations are strong in the near future due in part to pressures on utilities to improve customer service and increase efficiencies. The [worldwide smart water metering market](#) is \$5.9 billion and expected to reach \$9.6 billion by 2024 (see Figure ____ for global growth predictions).



A range of technological innovations are increasingly helping to protect against leaks and breaks, both in the home and on behalf of utilities. Smart water metering as addressed through devices like [WaterOn](#) offer automated water monitoring (see Figure ____) for apartment buildings or multi-family homes to reduce consumption and help identify leaks and potential water waste. Geographic Information System (GIS) data as supplied by companies like [Esri](#) through their service [ArcGIS aids utilities](#) by providing location specific data. To learn more about the integration of ArcGIS with utilities, see the [Esri case study of Arkansas water](#).



Example of WaterOn's information dashboard.

Green infrastructure. Effective, economical, and environmentally sound, [green infrastructure](#)--sometimes referred to as [natural infrastructure](#)--uses natural processes and materials to manage water and protect the water cycle. Often, green infrastructure may [supplement or replace costly traditional infrastructure](#); restoring wetlands and green spaces instead of investing in a water treatment plant, for example. In addition to saving costs, green infrastructure also creates jobs. [New York City's sustainability plan](#) is projected to create 4,449 water infrastructure jobs per year.



In Nevada City, California, a rain garden is used to catch rainwater runoff from parking lots and allow the water to sink into the ground. Photo: Jacob Dyste.

Further examples of green infrastructure include [rain gardens](#), [permeable pavement](#), and [green](#) or [blue roofs](#).

Retrofitting medium-sized office, apartment, or retail buildings with green infrastructure is expected to [yield positive returns](#) in energy savings, [incentives](#), and reduced risks for extreme events as well as non-monetary benefits to livability, community, and quality of life (see Figure ____).

POTENTIAL BENEFITS		NON-QUANTIFIED BENEFITS	
Energy savings due to reduced demand for heating and cooling	\$3,560 Annually	Water conservation	+
Avoided costs for conventional roof replacement	\$607,750 net present value over 40-year analysis period	Increased property value	++
Tax credit	\$100,000 one-time credit in year of installation	Reduced infrastructure costs due to use of permeable pavement system	+/-U
Increased retail sales	\$1.2 MILLION per year	Reduced crime	+/-U
Stormwater fee reduction	\$14,020 Annually (projected to increase 6% per year)	Improved health and employee satisfaction	+ (for tenants and employees)
		Reduced costs associated with flooding	U
Total present value benefits (over 40-year analysis period)	\$24,202,000 + (including \$22,963,800 in increased retail sales, which accrue to the tenants)	+ would likely increase net benefits; ++ would increase net benefits significantly; U direction of net change is uncertain.	

Potential benefits of green infrastructure in a mid-size retail center.

[Philadelphia, PA](#), has adopted widespread green infrastructure projects to conserve and protect water. I highly recommend checking out the abbreviated [Green City, Clean Waters](#) plan as well as the video below for inspiration. In the semi-arid west, green infrastructure may also be referred to as [low-impact development](#) (LID). See the city of [Fort Collins](#) for example of LID.

Video link: <https://vimeo.com/17306371>

According to the Organization for Economic Development and Cooperation (OECD), roughly 60% of urban infrastructure that will exist in 2030 has yet to be built. For more information on how to invest in and scale up green infrastructure see chapter three of the OECD's online report [Green Infrastructure in the Decade for Delivery](#).

Green infrastructure companies include [Pattern Energy Group](#), [Clearway Energy Group](#), [Hannon Armstrong](#), and [Brookfield Renewable Partners](#).

New materials. Water [pipes of old](#) were often iron or even wood. Today, [a variety of materials](#) are considered to replace aging pipes. These [materials range](#) from a variety of [plastics](#) to [pre-stressed concrete](#) (see Table ___ for comparison info on pipe material). Rehabilitation of existing pipes is expected to be the greatest category of spending for utilities in the near future with annual growth from \$253 million in 2019 to \$576 million by 2028. Pipe rehabilitation and replacement is generally conducted by utilities or private developers. According to [Water Finance and Management Magazine](#), the market and capital spend for "legacy materials" such as iron and steel still comprises a large segment of material use--65% representing \$32 billion over ten years--however, plastic and emerging materials are growing and represent the remaining 35% of market share for \$17.3 billion over a ten year period. Additionally, emerging materials growth is outpacing the sector as a whole. Average annual growth of plastic pipe investment is 4.5% versus 2.1% for legacy materials.

PIPE MATERIAL	LENGTH MILES	NUMBER OF FAILURES	FAILURE RATE #/(100mi)/(year)
CI	33611.0	8204	24.4
DI	33238.7	1620	4.9
PVC	26840.3	689	2.6
CPP	2355.3	128	5.4
Steel	4300.1	581	13.5
AC	13502.8	954	7.1
Other	3755.3	787	21.0
TOTAL	117603.4	12963	11.0

Water Main Failure Data Over A 12-Month Period. Source: Water Main Break Rates in the USA and Canada, April 2012, by Steven Folkman, Utah State University (CI=cast iron, DI=ductile iron, PVC=polyvinyl chloride/non-metallic coated plastic, CPP=concrete pressure pipe, AC=asbestos cement)

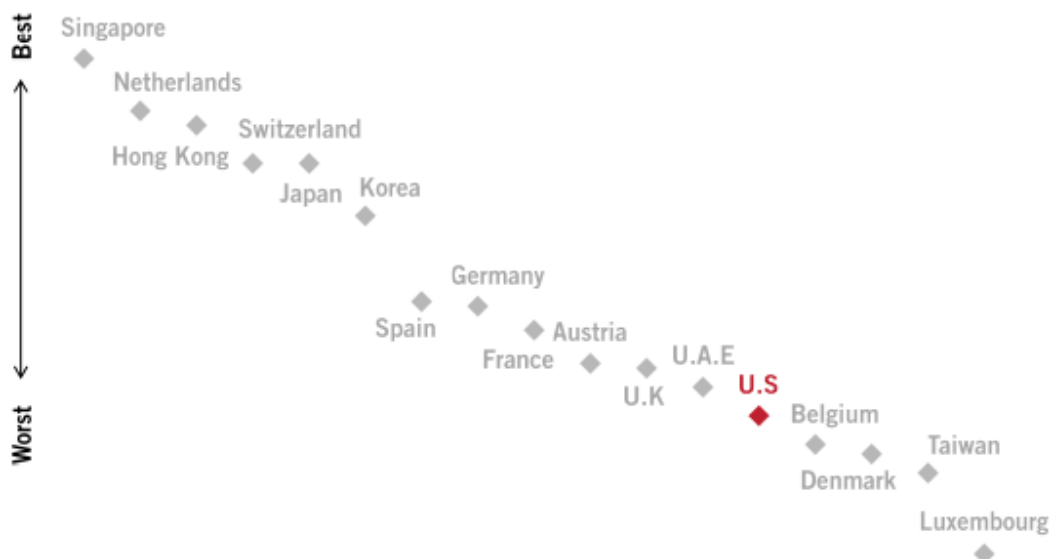
Investing in water. [Infrastructure investment](#) is increasingly an approach to addressing infrastructure needs and [offers the potential for payoff](#), albeit with a turn around often involving decades and [specific risk considerations](#), for investors who are looking for alternatives to traditional investments (see Figure ____ for an example from [BlackRock](#) regarding infrastructure and investor needs met from infrastructure investment). Infrastructure private equity is similar to [real estate private equity](#) in that both invest in properties but with one key distinction: infrastructure private equity invests in properties that in some way involve the provision of an essential service. For more on infrastructure investment and private equity see Mergers and Acquisitions' [Infrastructure Private Equity: The Definitive Guide](#) and for more information regarding who finances infrastructure see the American Rivers' [Advocates Guide on Drinking Water Infrastructure](#).

Workarounds

Failure to act. Also known as looking the other way or kicking the can down the road. It represents much of the U.S. approach to infrastructure needs over the past few decades, which is why the U.S. ranks [13th globally](#) for the state of its infrastructure (see Figure ____). The American Society of Civil Engineers estimates a continued failure to respond to the increasingly pressing demands in water infrastructure needs will have significant economic costs. To quote the [ASCE report](#):

- Service disruptions would cost water-reliant businesses \$250 billion by 2039.
- Underinvestment would lead to a cumulative \$2.9 trillion decline in the gross domestic product by 2039.
- Costs incurred by US households due to water and wastewater failures would be seven times higher in 20 years than they are today.
- Failing water infrastructure would result in \$7.7 billion in cumulative healthcare costs to households over the next 20 years.

QUALITY OF OVERALL INFRASTRUCTURE



SOURCE: World Economic Forum, The Global Competitiveness Report 2019, October, 2019.

NOTE: The World Economic Forum score on overall infrastructure includes transport, utility, and water. Only the top 20 ranked countries are shown.

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Home water-leak management. As soon as I read an article telling me to manage leaks and cut down on water waste by putting [food coloring in my toilet bowl](#), I stop reading. I'm all for mitigating water loss and doing my part in the home but when home solutions start to sound like 15 step craft projects I am out. However, and as mentioned earlier, these kinds of artsfair activities call attention to the blurry lines between home systems and community infrastructure. Is it possible to find simple, shared approaches to infrastructure issues in the home and beyond?

Trained incapacity. Literary theorist [Kenneth Burke](#), using a concept from an earlier economic theorist, [Thorstein Veblen](#) calls attention to the idea of trained incapacity in Burke's 1954 book, *Permanence and Change*. Trained incapacity, Burke says, is the state wherein one's training or education may function as blindness. In other words, Burke believed our way of seeing things limited our ability to see potential solutions and closed us off to possibilities. For example, when faced with congested highways the solution often seems to be to add more lanes and increase the number of cars on the road, which only causes more congestion. This solution is in part a function of the training and previous experience of those tasked with addressing the problem. If infrastructure like roads or water pipes has served a particular purpose for a century, and people have been trained to address any deterioration in those roads or pipes, then an ongoing cycle of repairing and [rebuilding](#) infrastructure as it currently exists seems like the only viable solution.

Indeed, that is the predominant approach to water infrastructure issues. Rather than rely on repair and rebuild is it possible to transcend our blindnesses and also include [reinvention](#) in our approaches?

In the meantime, the water infrastructure repair market is substantial. Top players in the industry include companies such as [Xylem](#) (its tagline is “Let’s Solve Water”), [Danaher Corporation](#), [Mueller Water Products](#), [Aegion](#), [Black and Veatch](#), and [Sulzer](#) working in every region across the globe. Each company presents varying levels of innovations in addition to repair. Black and Veatch devote services to [sustainable infrastructure](#) and Mueller Water Products features the [smart water hydrant](#). As of 2019, the global water infrastructure repair market size was [\\$88.190 million](#) with a compound annual growth rate of 6.9% over the next few years to reach \$141,410 million by the end of 2026.

Additional Resources

The ASCE runs an ongoing list of #Gamechangers in water and infrastructure on its website: <https://www.infrastructurereportcard.org/solutions/gamechangers/>

More information on infrastructure bank proposals throughout history: <https://www.enotrans.org/article/look-infrastructure-banks-part-1/>

Check out this case study of a the state of Connecticut’s Green Bank: <https://cdn.gihub.org/umbraco/media/2631/usa-case-study.pdf>

For more on climate bonds, see <https://climatetrust.org/climate-bonds-overview/>

A list of the top companies in water and wastewater treatments: <https://meticulousblog.org/top-10-companies-in-water-wastewater-treatment-market/>

Water Supply & Scarcity



According to the United Nations, water is “at the heart” of adaptation to climate change. Human-caused climate change, including the contributing factor of population growth, has resulted in less reliability in water supply resources as well as greater variability between water excesses and shortages. The result is growth in the frequency and intensity of water scarcity across the globe and escalating uncertainties concerning water supply. Over 748 million people around the world are without basic water access. That’s more than twice the population of the United States. As population growth continues--particularly in urban areas--so will instances of water supply scarcity. Almost *half the world's population* will be living in areas of high water stress by 2030 and water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people. Climate change can significantly alter the water cycle, making predictions and planning for scarcity or water crisis events all the more challenging. As scarcity increases, attention to various sources and supplies of water, as well as more efficient water allocation and use, become essential for human survival and for economic growth. The estimated cost benefit to the U.S. of reducing agricultural water scarcity globally is \$94 billion a year. Each water source--from groundwater, to sea water, to rivers, to rainfall, to reused water--includes climate change related challenges ranging from pollution and supply levels to consumer comfort and cost. Further, supply issues overlap with infrastructure and capacity limitations, technology considerations, and neglect of rural areas.

How might we provide water to those who need it and protect or enhance water supply sources?

Contributing Factors	
Water in the West The Colorado River Climate change (varying snowmelt, drought) Pollution Competing stakeholder interests Consumer comfort Data/information Water policy and water rights Sourcing	
History & Trends	
History Western waters Developing the West Selling the West The Law of the River Environmental Movement	Trends Population growth Conflict and collaboration Water use Extreme events Municipal utility consolidation Tribal water rights
Populations & Agents	
Populations Women and children Residents of water scarce areas	Agents Industry sectors Consumers Water-managing bodies

Existing Approaches & Workarounds	
Approaches	Workarounds
Ancestral and Indigenous water practices Water markets and water trading Desalination Water-sensitive cities Water and technology Satellite data	Deeper wells drawing more groundwater Ignoring infrastructure Privatization of water sources Water rights sector Private companies

Contributing Factors

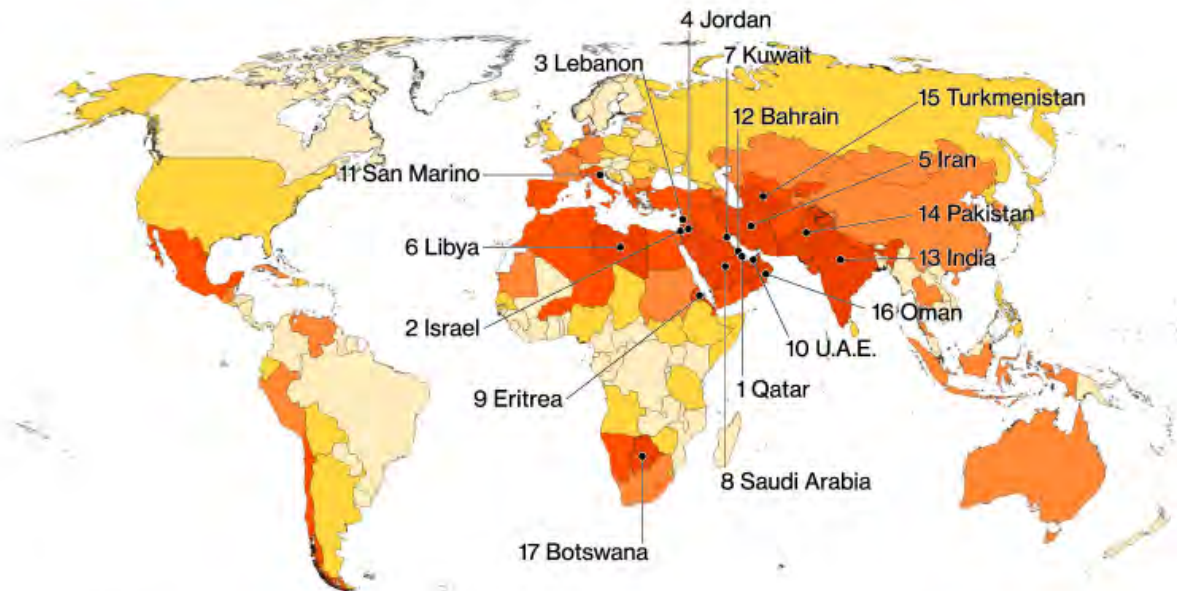
Water in the West. Water scarcity and supply issues are relevant in many places all over the globe. In fact, the [countries most at risk of a water crisis](#) are located primarily in the Middle East (Figure ____). While issues of water in the West may not be the most pressing globally when it comes to water supply and scarcity, in many ways, the West is a microcosm wherein two pressing realities related to water intersect. The first is interconnectedness. Water in the West represents a level of interconnection demonstrating the need for collaboration and transparency when it comes to water challenges in any region. What happens in the [Rocky Mountains](#) has direct results for how water is used in [California](#). And vice versa: how water is allocated in California affects supply levels and demand in the headwater state of Colorado. The second reality is in some ways paradoxical to the first: water issues--despite the interconnectedness of regions--are driven and molded by [local concerns](#). When communities are suffering from drought or dwindling water supplies, local concerns take precedence over conditions in the next state over. Is it possible to reconcile local concern with regional interdependence? In many ways, this question is at the crux of water issues in the West and serves as inspiration for further exploration.

“It seems odd to characterize an entire region by what it lacks, but water has always been the most consistent and frequently cited tie that binds the West.” -- Fahlund, Choy, and Szeptycki, [“Water in the West”](#)

High and Dry

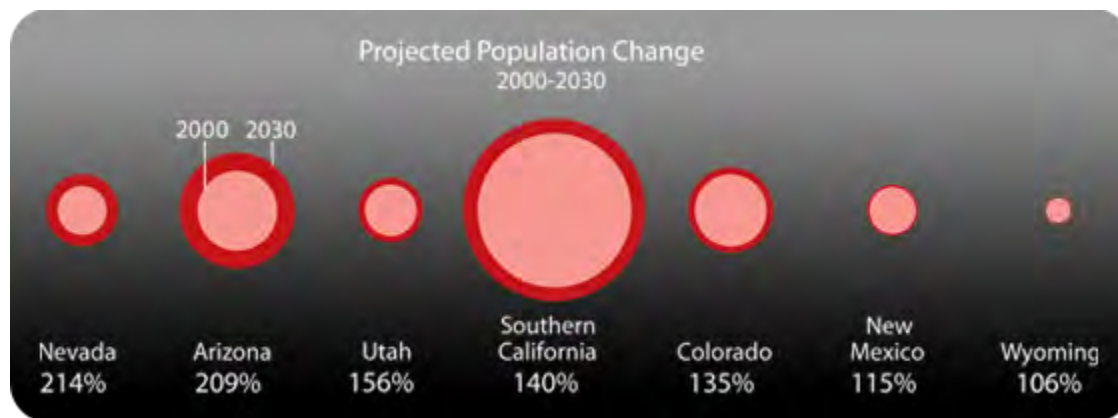
17 countries, mostly in the Middle East, face the risk of extremely high water stress

Low  Extremely high



Note: Data on water withdrawal, available water and groundwater are used to calculate baseline water stress.
Source: World Resources Institute's Aqueduct Water Risk Atlas

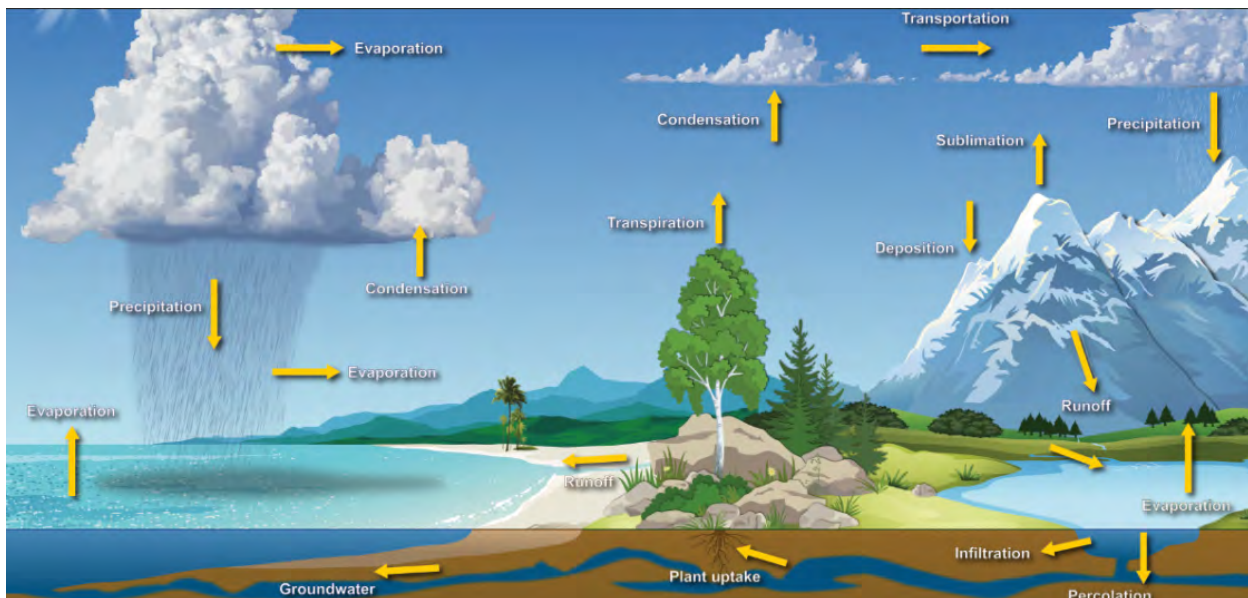
The Colorado River. It's been called "[The American Nile.](#)" Indeed, the Colorado River is the lifeblood of much of the western U.S. and plays a central role in the [economic vibrancy](#) of nearly half of the United States. But as [climate change](#) and [population growth](#) (see Figure __) have increased pressure on the river, much of the west [has grappled, and will continue to grapple](#), with best managing this resource. For in depth exploration of the challenges relating to the Colorado River, see the Yale School of the Environment five-part series titled, [Crisis on the Colorado](#).



The population of Colorado River basin states is expected to grow 53% by the year 2030.

Climate change. The effects of climate change on water include a change in the *timing* of water availability as snowpack melts faster due to increased temperature, change in *demand* due to higher temperatures or drought conditions, change in surface water *availability* and groundwater storage levels, change in the number and intensity of extreme events, change in sea levels, and a change in water quality due to varying levels of chemicals, toxins, and saline. In sum, climate change interferes with segments of the hydrologic cycle (Figure ____). This interference makes it difficult to predict and count on water resources. Cities, industries, and consumers face increasing uncertainty when it comes to water.

→ Varying snowmelt. One of the most significant factors related to water in the western United States is snowpack levels. Roughly 75% of the water supplying the western U.S. comes from snowmelt. Less snow, or snow melting earlier in the year due to increasingly warm winter and spring temperatures means less water for many of the states relying on

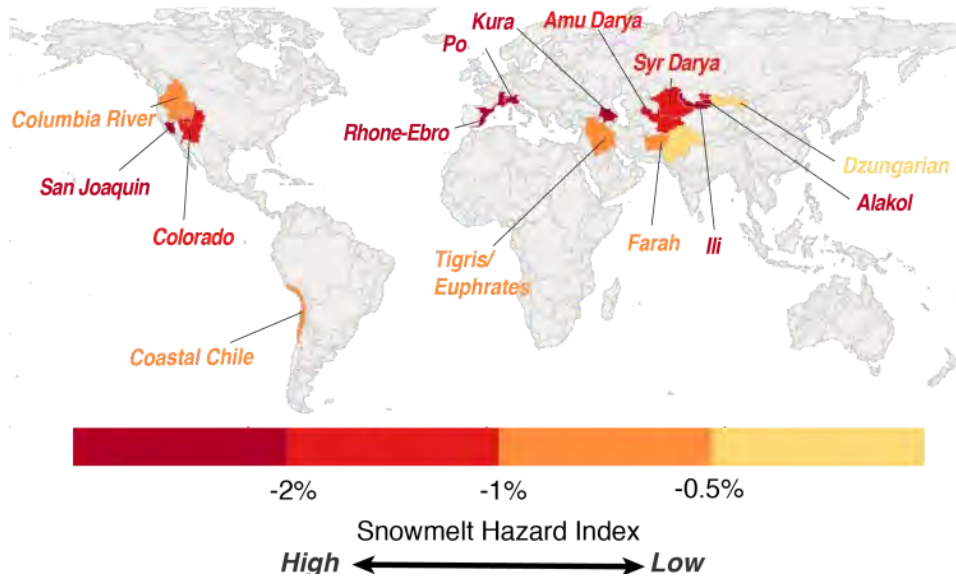


these supplies. The amount of food grown in some of the most productive agricultural counties in the U.S. depends on surface water originating from snow in the Rocky Mountains (see Figure ____). California is the leading producer of fruits and vegetables (Figures ____ and ____) yet the state's climate is primarily desert. Farmers rely on snowmelt to fill rivers; those rivers become irrigation sources for farmers.

→ Drought. As temperatures warm less snow falls and in general, warming temperatures due to climate change contribute to drought conditions. Prolonged drought in turn leads to water scarcity. In times of drought, the water in rivers, streams, and lakes dries up causing communities to rely more heavily on other sources, such as groundwater--a resource itself depleted in times of drought. Drought is tied to the economic health of a region. Cities, communities, and industries require resilient water sources in times of drought, yet, particularly in arid climates, resiliency is difficult to achieve.

Highest risk agricultural areas as climate warming shrinks snowpack

Mountain snowpack serves as a natural slow-release reservoir for agriculture, but climate warming will lead to less snow. A projected 7-degree increase in temperatures could reduce the contribution of melting snow from 38% to 23% of the water available to grow crops in the Colorado River Basin. *Map courtesy of Nature Climate Change, "Agricultural risks from changing snowmelt."*

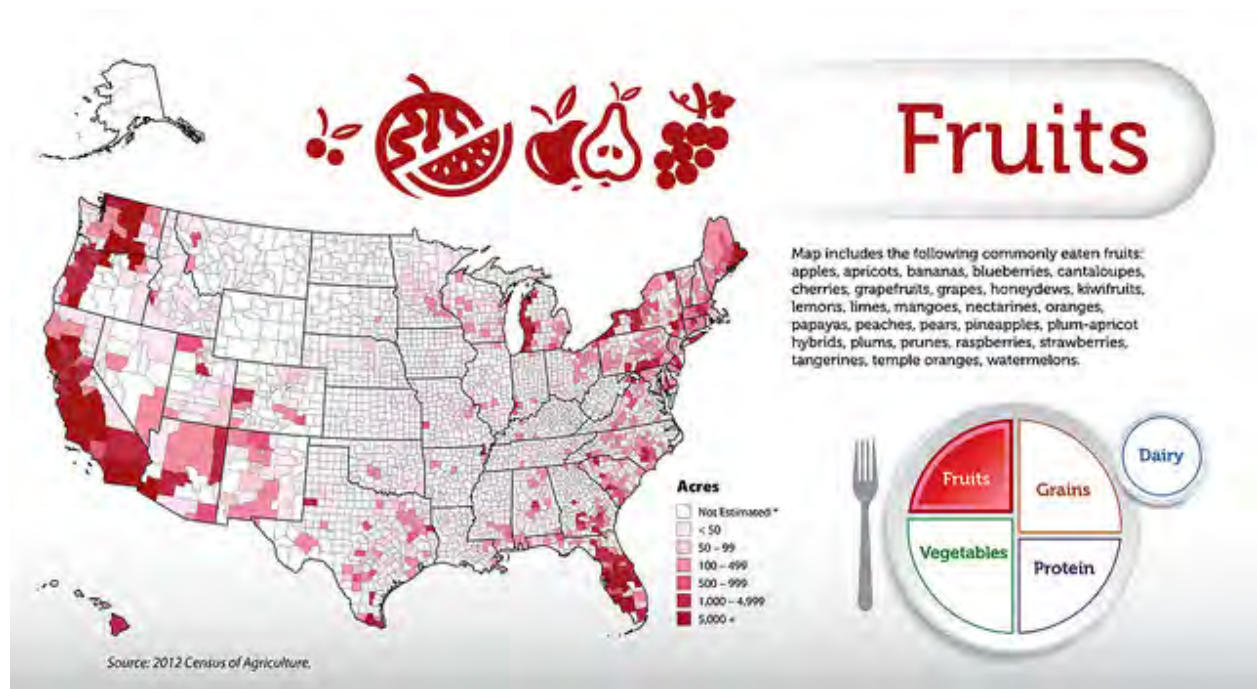


Leading Vegetable States in 2017

Rank	Area harvested		Utilized production		Value of utilized production	
	State	Percent of total	State	Percent of total	State	Percent of total
1	California	39.1	California	57.3	California	56.7
2	Florida	6.6	Washington	5.5	Arizona	12.1
3	Minnesota	6.6	Arizona	5.0	Florida	7.6
4	Wisconsin	(D)	Florida	5.0	Georgia	3.3
5	Washington	6.2	Wisconsin	(D)	Washington	2.4

(D) Withheld to avoid disclosing data for individual operations

Source: USDA NASS Vegetables 2017 summary



Pollution. Water seems plentiful. In fact, 72% of our planet is covered in water. And there's even more under the ground. So we are ok, right? Not exactly. Of that bounty, most--97%--is seawater and only [1% of the freshwater](#) on the planet is available to us. A majority is locked away in icecaps. Pollution threatens the freshwater we do have, decreasing the supply of safe water consumed in homes, agricultural, and business. Water pollution, in the form of [toxins](#), [chemicals](#), or [microorganisms](#), degrades water quality and the surrounding environment. Causes of water pollution include [sewage](#), [industrial water](#), [eutrophication](#), and [nuclear waste](#). For a thorough exploration of the myriad [causes of water pollution](#), including exploration of the [types](#) of water pollution like [microplastics](#) and [chemicals](#), see [The Water Pollution Guide](#).

Competing stakeholder interests. Because everyone needs water, everyone has a stake in how it is used. Table ___ breaks down a number of the stakeholder groups involved in water discussions. Often these groups have different approaches and opinions. The amount of water in any given area at a particular time is unpredictable and certainly finite. Therefore, what are called "[water wars](#)" or water conflicts can be contentious as they crop up among different groups and populations as well as different countries. Water conflict in the [western U.S.](#) is an ongoing concern as exemplified in the story of [Porterville, CA](#), a small town where [wells ran dry](#) during the state's 2011-2019 drought and hundreds of residents were left without water. [Water restrictions](#) in urban areas were met with pushback and criticism, particularly from those who felt the agricultural industry, responsible for [40 to 80%](#) of water use in the state ([depending on the data source](#)), [wasn't sacrificing enough](#). Competition for water among various stakeholders

including [urban, agricultural, and energy](#) sectors will most likely increase as population and demand also rise.

SECTOR	STAKEHOLDER
Public	Utilities, local governments
	Hydropower generation companies
	National environmental authority
	Local environmental authorities
	Water authorities
	Irrigators
Private	Utilities
	Hydropower generation companies
	Bottled water and soft-drink companies
	Agricultural associations
	Industries
Academic	Research Centers
	Universities
Local Communities	River associations, water boards, irrigation boards
	Indigenous communities
International Cooperation	Multilateral co-op organizations (e.g. WB, IDB)
	Governmental co-op agencies (e.g. GTZ, USAID)
	Non-Governmental Organizations



Many Porterville residents had to import water from outside their homes for basic use. Here, Guillermina Andrade, who hadn't had water for two years, pours water into her toilet to flush it. Credit: Genaro Molina, LA Times.

Consumer comfort. As traditional water supplies come under threat from climate change, increased demand, and pollution, alternative water sources are an option. [Sea water](#) and [recycled water](#) (also called reclaimed water or referred to as "[toilet to tap](#)" efforts) are two of the most referenced alternative sources. While these alternatives present viable possibilities for water supply, they aren't well accepted among consumers and the [costs of desalination](#) can be prohibitive. Research demonstrates recycled water is often met with disgust and associations of contamination from consumers. See Table ___ below for common associations researchers found related to recycled and desalinated water from sample groups in Africa and Australia. Transcending existing consumer comfort levels will be key to moving forward with supply alternatives.

Frequencies and column percentages (in brackets) of the affective imagery of respondents for country and type of water.

Category	South Africa		Australia	
	Recycled water	Desalinated water	Recycled water	Desalinated water
1. Cleanliness (clean, clear, pure, purified, hygienic)	57 (26.4%)	59 (27.2%)	22 (10.7%)	31 (15.9%)
2. Disgust (disgusting, rotten, ew, yuck, toilet, urine, poo, stinky, gross)	25 (11.6%)	0 (0.0%)	29 (14.1%)	3 (1.5%)
3. Contamination (dirty, polluted, used, wastewater, waste, grey water, impure)	33 (15.3%)	17 (7.8%)	47 (22.9%)	18 (9.2%)
4. Organoleptics (tasty, salty, tasteless, taste, fresh, refreshing, cold)	8 (3.7%)	29 (13.4%)	8 (3.9%)	11 (5.6%)
5. Environment (environment, conservation, green, planet, sustainable)	12 (5.6%)	3 (1.4%)	24 (11.7%)	6 (3.1%)
6. Cost (expensive, cost)	3 (1.4%)	6 (2.8%)	2 (1.0%)	14 (7.2%)
7. Minerals (Minerals, NaCl, salt)	0 (0.0%)	28 (12.9%)	0 (0.0%)	38 (19.5%)
8. Uses (Garden, irrigation)	6 (2.8%)	2 (0.9%)	10 (4.9%)	0 (0.0%)
9. Bottled water (Bottled water, valpre, aqua, volvic)	10 (4.6%)	7 (3.2%)	3 (1.5%)	1 (0.5%)
10. Saving water (saving water, less wastage)	15 (6.9%)	0 (0.0%)	9 (4.4%)	0 (0.0%)

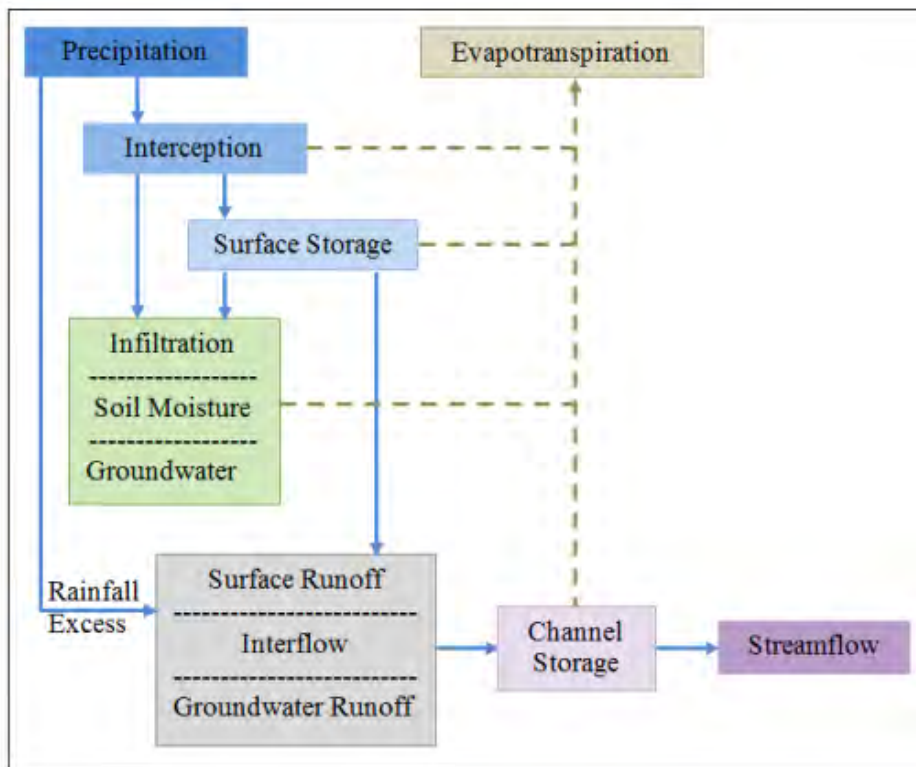
Data and information. Water use is measured via [withdrawal and consumption](#). Although these metrics appear relatively straightforward, there is much we don't know about measuring water and even more we don't utilize when it comes to data-sharing. There are currently no frameworks for measuring water resiliency, for example. To explore attempts to create such a framework see, the [2018 UK "Measuring Resilience in the Water Industry"](#) report. Additionally, [Groundwater science](#) is an increasingly significant area of study focusing on groundwater levels, movement, and use.

Challenges relating to data and information include data sharing, particularly among regions, entities, or nations using varying metrics and platforms as indicators of water supply. For an indepth look at the challenges and possibilities related to water and data, see the Aspen Institute's report [Internet of Water: Sharing and Integrating Water Data for Sustainability](#).

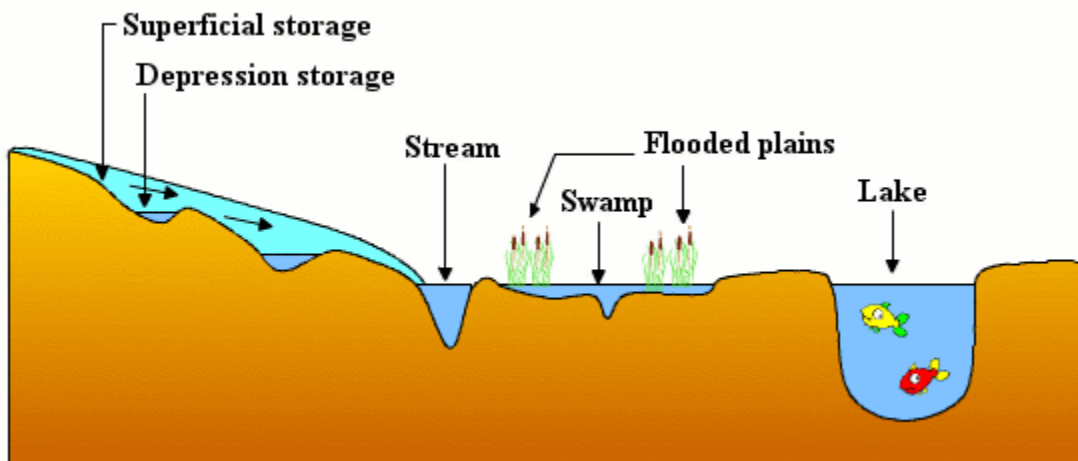
Additional measures, like city sustainability are relevant to understanding water supply data, but are also nascent. One example is the Water Sensitive Cities (WSC) Index, a tool from the [Cooperative Research Center for Water Sensitive Cities](#). See the "Approaches" section below for more information on the WSC Index.

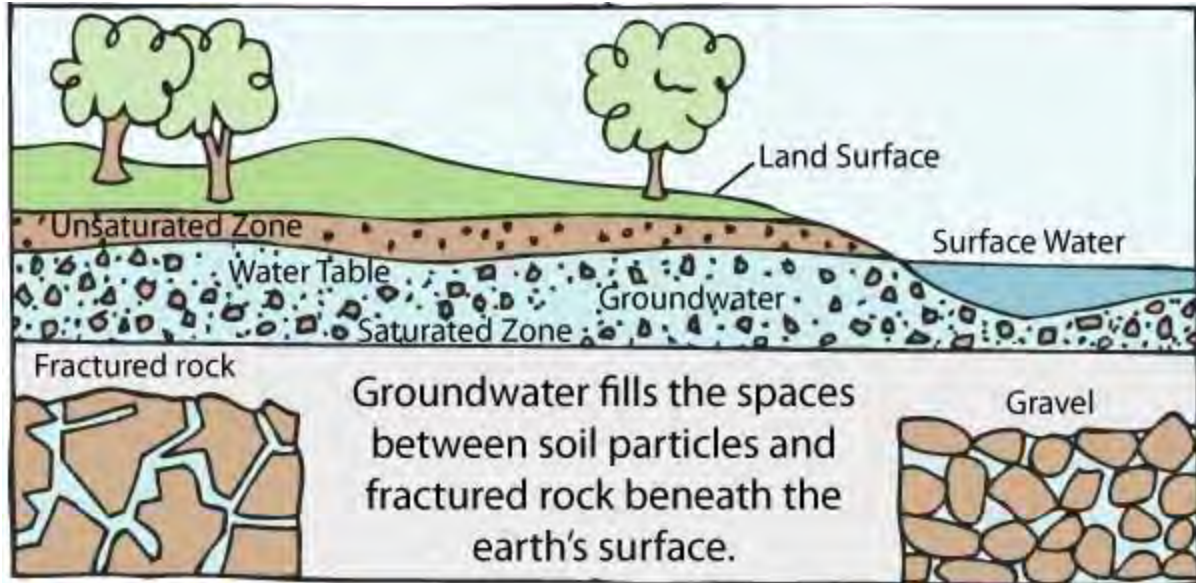
Water policy and water rights. Water is a mobile resource. It moves and is therefore difficult to bind and contain much less own. Yet, particularly in the American West, this hasn't stopped anyone from trying to do just that for centuries. In the west, [appropriative water rights](#) dominate (as compared to the east wherein [riparian water rights](#) are used) which means water is disconnected from land ownership. Via appropriative rights, water can be diverted at one point and appropriated to use at another point. Priority is given to the most senior appropriators--those who were "first in line" may use as much water as is appropriated to them--and states grant water rights to users. For more information on water rights see the [overview provided by the National Agricultural Law Center](#) or see the slideshow breaking down western water rights via the [example of Arizona](#). Water rights, and the contentions they cause in considering [tribal water rights](#), play a role in supply. Increasingly, there is [more water appropriated than there is water available](#) for use.

Sourcing. A variety of sources provide the freshwater needed for consumption, agriculture, and additional water needs. Each of those sources involves distinct challenges (such as [pollution](#)) and opportunities for supplying water. Reviewing the [hydrologic cycle](#) offers further insight into the connectedness of each water source (see Figure ____ for a schematic representation). In essence, a few factors serve as core components of the hydrologic cycle: precipitation, evaporation, storage, and runoff. Precipitation may be in the form of snow or rain; [storage](#) involves intercepting precipitation in some way and includes surface storage (see Figure ____) such as lakes or rivers, or below surface storage via [groundwater](#) and [aquifers](#) (Figure ____). Interception may be naturally occurring or involve human participation, such as [rainwater collection](#). Each component influences the availability of water at a given time and location. California, for example, has turned to groundwater in the face of ongoing drought and must [replenish aquifers](#). Nineteen of Colorado's 64 counties [rely heavily](#) on groundwater. Globally, over half of aquifers are at [a critical threshold of sustainability](#) as groundwater is withdrawn faster than it is replenished. For more information on components of the water cycle, including a review of the variables and equations used to determine water availability, see the [European Commission's technical report on water balances](#).



The hydrologic cycle, represented schematically.





History & Trends

History

Western waters. The tale of [water in the West](#) is, in many ways, the tale of a connection between Colorado, the headwater state for the Colorado River as well as secondary rivers such as the Fraser and Eagle, and California, where the river ends just shy of the Gulf of California. All [along the Colorado River's 1,450-mile course](#) are human interventions--places where the river has been diverted, dammed, siphoned, and piped--in service to making the arid and semi-arid landscape not only habitable, but hauntingly hospitable. One of the [most heavily engineered waterways in the world](#), the Colorado River has been a fundamental mechanism in fulfilling the promise of the American West.

Developing the West. Much of the West was settled in response to [mining booms](#). These settlements, and the mining itself, required water. And because water as a resource was less abundant than it was in the East, [water rights](#) were grounded in whoever got their first (often referred to as "first in, first in right"). This system [allowed miners, and later farmers](#) to divert water from its source and put it to "good use." Historically good use referred to irrigation, mining, domestic, or municipal use. The foundation of this system still exists today via [prior appropriation water rights](#).

Water in the West short video: <https://youtu.be/qq6JCVguHtM>

Selling the West. In his book [The Dreamt Land: Chasing Water and Dust Across California](#), author Mark Arax refers to the early 1900s as a time infiltrated by the “folklore of California climatology.” And this folklore was everywhere. Sponsored by the California State Agricultural Society and companies like the [Southern Pacific railroad](#), editorials and articles appeared in the likes of *Harper’s* alongside ads for travel by train. While advertisements featured a paradise of plenty--oranges and watermelons the size of small boulders--Arax notes the subterfuge behind the sales pitch: “This was fertility supercharged by irrigation and the science of the Agricultural College at the University of California--the most extensive and intensive farming experiment in the world. No other landscape in history had been so bent by the design of man.”

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San Jose	San Francisco	San Francisco
San Jose	San Francisco	San Francisco

SOUTHERN PACIFIC LINES



As settlements in the West continued to grow, it became clear the water resources couldn't keep up with demand. The federal government intervened in the early 20th century with the passage of the [Reclamation Act](#), allowing the Bureau of Reclamation under the Department of the Interior to study and fund water development projects in each state. The Great Depression and [subsequent public works](#) and job creation efforts meant more water development projects in the early to mid 1900s. While many of [these projects](#) were initially intended to provide the infrastructure for irrigation, federal projects--and emerging state water projects--expanded to provide water infrastructure for cities. Las Vegas, Phoenix, and Los Angeles experienced rapid growth in population as well as storage and sanitation infrastructure. For an expansive education on public work projects in the West, see [The History of Large Federal Dams: Planning, Design, and Construction in the Era of Big Dams](#), a report by the U.S. Bureau of the

Interior Bureau of Reclamation, the U.S. Army Corps of Engineers, and U.S. Department of the Interior National Park Service.

The Law of the River. It may sound like an early 90s western starring Kevin Costner, but the [Law of the River](#) is a term used to represent the laws, court decisions, governing documents, and policies directing management of the Colorado River. The foundation is the [Colorado River Compact of 1922](#), entered into by seven western states. The Compact outlines how the water of the Colorado River is divided among the states. It's [governed use for decades](#) but as climate stress continues to cause drought the ongoing utility of the agreement is a [topic of debate](#).

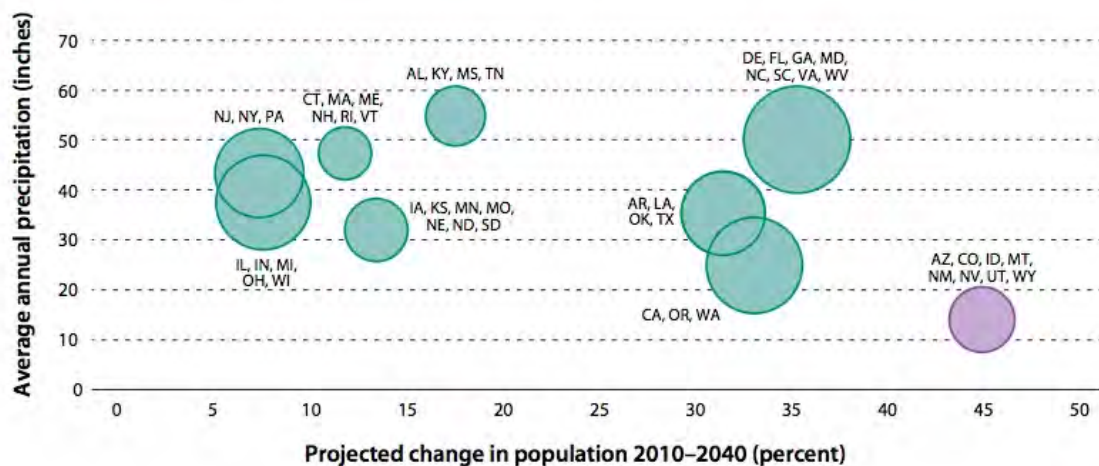
The Environmental Movement. The burgeoning [modern environmental movement](#) of the 1960s and 1970s featured a greater understanding for the health of water ecosystems, including the role of water pollution in environmental degradation. A string of legislation reflected the desire to protect water as a resource: the [Wild and Scenic Rivers Act of 1968](#), the [National Environmental Policy Act of 1970](#), the [Clean Water Act of 1972](#), and the [1973 Endangered Species Act](#). Ongoing development in some cases collided with environmental concerns, setting the stage for conflicting perspectives that [continue today](#).

Trends

Population growth. Population growth is a [global phenomenon](#) and, for the West, a local one as well. Western states--the driest in the U.S.--have seen some of the [largest population increases](#) in the past decade (see Figure ____). Population increases put pressure on resources, including water. Yet we seem to be doing more with less. A 2015 [report from the U.S. Geological Survey](#) found as a result of water efficiency behaviors and technologies, water use levels in American households decreased to usage rates not seen since the 1990s.

Average Precipitation and Projected Percent Change in Population, by Census Division

The fastest growing area of the country receives the least precipitation.



Sources: National Oceanic and Atmospheric Administration n.d.; U.S. Census Bureau 2012, n.d.; Weidon Cooper Center for Public Service 2012; authors' calculations.

Note: Circle sizes are proportional to the population in each division in 2010. Alaska and Hawaii are excluded from the analysis. The population growth for each division as well as the average annual precipitation for each division are weighted averages using the 2010 Census population of each division. For more details, see the technical appendix.

THE
HAMILTON
PROJECT
BROOKINGS

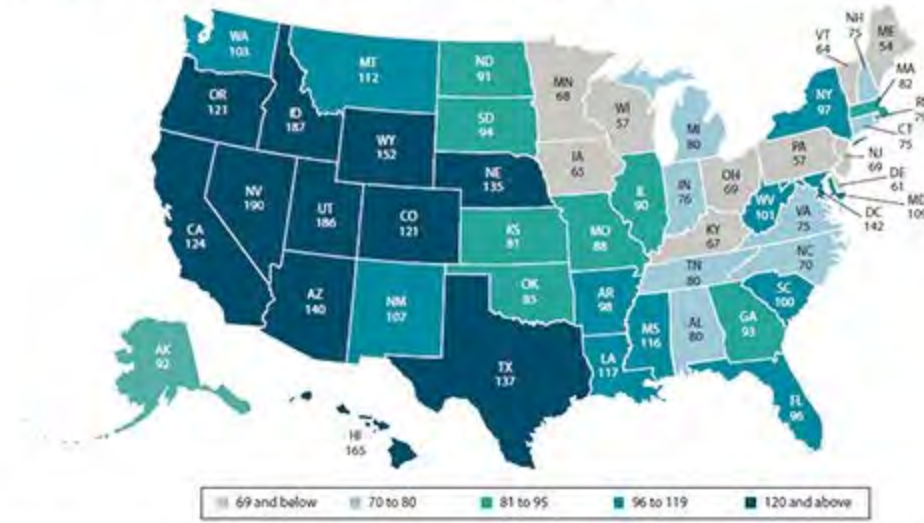
Conflict and collaboration. While [water conflicts have continued](#) into the 21st century, [cooperative approaches](#) are increasingly common. Examples include the [Colorado River Cooperative Agreement](#) of 2013 and [efforts among utilities](#) to collaborate when it comes to supply options.

Addressing water conflict globally via collaboration is a means to not only prevent scarcity, but protect vulnerable populations and build peace. For more on water conflict and global peace building, see the [brief animated short from the Wilson Center](#).

Water use. The driest states also tend to include the greatest [domestic consumers of water](#) per capita (see Figure __), in large part because of landscaping and lawn watering.

Domestic Water Use per Capita (in gallons per day) by State, 2005

Nevada, Idaho, and Utah lead the nation in rates of domestic water use per capita.



Source: Kenny et al. 2009.

Note: 2005 is the latest year for which data are available. The five categories were constructed to contain roughly the same number of states. Domestic water includes self-supplied withdrawals as well as public-supply water deliveries.

THE HAMILTON
PROJECT
BROOKINGS

Extreme events. Extreme weather events, made more intense and frequent due to climate change, affects water supply and scarcity. Intense drought and extreme heat contribute to water scarcity and test resource resiliency. Dry areas are more prone to wildfire threats and, due to dry and hard packed soil, precipitation runoff and floods.

Municipal utility consolidation. The water industry has long been a fragmented market. The predominant model is one in which each community is served by its own water utility. There are roughly 53,000 water suppliers in the U.S. compared to around 3,300 electricity suppliers. Shrinking populations in rural markets and the need for high-volume service to generate profit have prompted water utilities like EJ Water Cooperative to consider consolidation. Other recent consolidations include the DELCORA Aqua merger and a variety of in process deals facilitated by the expansion of Fair Market Legislation. FML allows municipalities access to resources for infrastructure improvements.

Tribal water rights. To refer to tribal water rights as a “trend” feels egregious, however, it is representative of the extent to which the rights of indigenous people have been granted consideration over the past few hundred years. The Supreme Court case Winters v. United States confirmed water rights were implicitly granted to reservations at the time of their creation, granting them senior prior appropriation. In 2018, the Bureau of Reclamation and the Ten Tribes Partnership produced the Colorado River Basin Ten Tribes Partnership Tribal Water Study. The study quantified the amount of water allocated to the 29 tribes in the Colorado River Basin and acknowledged--despite the significant amount of over 2.8 million acre feet allocated to tribes each year--the ongoing conditions of water scarcity for many tribes. The report also concludes: “none of the Partnership Tribes currently has the basic infrastructure or legal and administrative flexibility to fully use or realize the full economic value of its reserved water rights.” For more

information on Indian water rights see the 2019 Congressional Research Service report [Indian Water Rights Settlements](#).

Populations & Agents

Vulnerable Populations

Women and children. Water scarcity places an undue burden on [women](#) and [children](#). Globally, women walk an average of 4 miles a day--often with children in tow--to retrieve water. A [study in Tanzania](#) found reducing the journey a girl takes to retrieve water from 30 minutes to 15 minutes results in a 12% increase in girls' attendance at school. Further, low water supply levels are often accompanied by other risks such as decreased [water quality and sanitation](#), both of which also affect [women and children](#) in greater numbers.

Residents of water scarce areas. Additional populations at risk include those in [regions where water is scarce](#) and drought is more likely such as the western United States, and the Middle East. Within [these regions](#), water scarcity and supply challenges affect a variety of industries beyond agriculture and recreation. Affected industries include the [paper and pulp](#) industry, the [semiconductor industry](#), and [textile production](#).

Agents

Category	What they do	Examples
Industry Sectors	Rely on water to produce goods/services and sustain industry. Participate in both positive and harmful water use practices thereby affecting other industries and their water uses.	Recreation Agriculture Energy
Consumers	Receive varying levels of infrastructure support and water supply. Shape water conservation and reuse practices via public opinion. Advocate for access to safe water and engage in a range of water use behaviors.	Indian Tribes Urban centers Rural communities
Water-managing bodies	Represent larger water interests including various populations, spread out among different areas, with a range of water needs. Plan for water needs and collaborate with other entities to address needs via policy, infrastructure, or conservation.	Bureau of Reclamation (manages much of the Colorado River's supplies) Regional water boards

		Transboundary river basin management authorities
Water rights sector	Industries and professions related to water that offer advice or guidance on water supply issues.	Attorneys Land management
Private companies	Package and sell water, often in plastic bottles.	Nestlé Waters Danone
Water utilities	Provide water supply systems, maintain infrastructure	Denver Water American Water Works Association

Existing Approaches & Workarounds

Approaches

Before analog was analog. When it comes to water, everything old is new again. Communities in [South America](#) are returning to ancestral and Indigenous water practices to conserve water resources and increase resiliency. [Studies or these ancient practices](#) are revealing new ways to think about water technology.

Water markets and water trading. [Water markets](#) introduce a degree of flexibility into existing water rights arrangements. Water is [traded and sold](#) through short and long term leases as well as permanent sales. In December of 2020, water became the most recent commodity to be [traded on Wall Street](#) with \$1.1 billion in contracts tied to water prices in California. The Nasdaq Veles California Water Index ([NQH2O Index](#))--launched in 2018 at a value of \$371.11 per acre foot--monitors the price of water rights across California's largest regions for water trading. As of January 20, 2021 the value was \$506.66, representing water leases and sales of the prior week. For more information on water markets, see the article, "[Water Markets in the United States: Trends and Opportunities](#)."

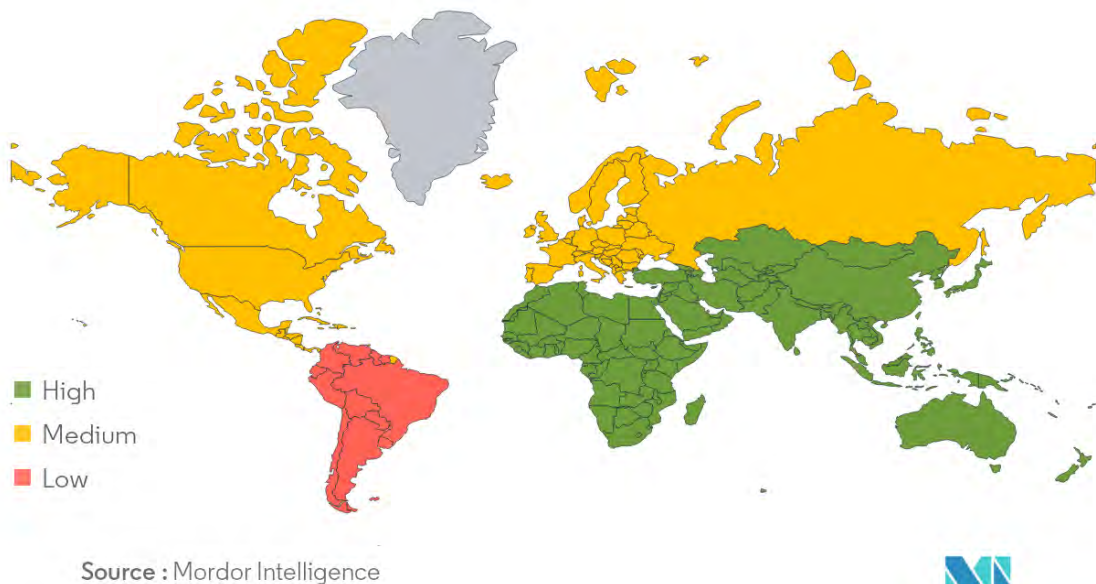
Reactions to [water futures and water trading are mixed](#). Do these mechanisms commodify water in ways antithetical to notions of water as a human right or do they offer safety nets for water consumption in an uncertain future?

Desalination. Seawater is abundant. So can we convert that abundance into a means of addressing the scarcity of freshwater in some regions? [Desalination](#)--the process of removing mineral components from salt water--is an increasingly common practice, with more than [eleven desal plants](#) in California and over [20,000 worldwide](#) serving more than 300 million people. But

it is also [costly](#) and not without its environmental [drawbacks](#). What happens to [all of that salt](#), for example? Recent resource retrieval efforts are exploring ways to [reuse the brine](#) produced as a byproduct of desalination.

The desalination market is delineated by the technological method used to separate salt from the water such as [membrane](#) or [thermal](#) technology. The compound annual growth rate for the market overall is [10% in the next five years](#), with the largest growth opportunities in the Middle East and North Africa (see Figure ____). Major market players include [Veolia](#), [Suez](#), [ITT Corporation](#), and [Fisia Italmimpianti](#).

Desalination System Market - Growth Rate by Region, 2019-2024



Water sensitive cities. Learning how cities may do more with less is a growing consideration and one that applies to water. The [Water Sensitive Cities \(WSC\) Index](#) charts a city's progress to water sustainability and is an example of an holistic approach to a city's water supply.

Water sensitive cities index video: <https://youtu.be/ybG9lOhbDDc>
<https://watersensitivecities.org.au/solutions/wsc-index/>

Water and tech. The [digitization of water](#). The [internet of water](#). There are many ways to talk about the growing synergies between [water and technology](#) and a good deal of those synergies apply to [water supply and scarcity](#). A few examples involve the [use of data to aid consumers](#), the use of [drones to locate water leaks](#), and the use of [“smart membranes”](#) to desalinate water. The EPA [released a report](#) in 2014 outlining a number of promising areas within water ripe for technological innovation and encouraged broader application of technology to the water sector. Thought leaders agree and [discussions over the future of water technologies](#) are interesting

entry points into understanding the myriad of possibilities. Examples of companies devoted to noteworthy water technologies (as identified by BlueTech Forum, a water innovation conference and showcase) include [Nijhuis Industries](#)' mechanism to desludge water and [WaterMax](#)'s aeration technology for wastewater treatment.

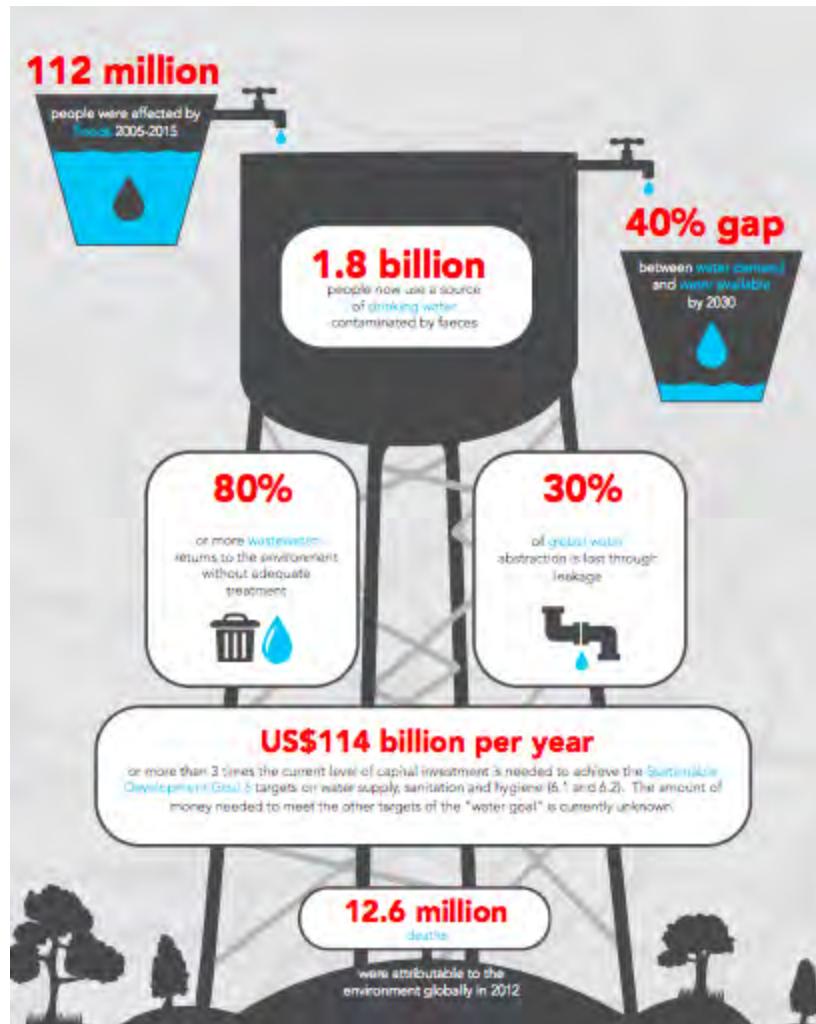
Water reuse and repurposing. One of the most promising areas for the application of technology is reusing and repurposing waste water. Wastewater facilities in the U.S. discharge roughly [32 billion gallons](#) of wastewater per day. Reusing that water would alleviate much of the stress on existing sources of supply, like groundwater. This burgeoning area of innovation is not without its hurdles, however, chief among them is [public reaction](#) to wastewater reuse. A handful of [cities around the world](#) have seized upon repurposing as a solution; their work and efforts serve as examples for greater attention to water reuse and repurposing more broadly. The [global water and wastewater treatment market](#) is expected to reach \$211.3 billion by 2025.

Satellite data. On-the-ground data has traditionally been the only way to learn about water supply. Today, [satellites](#) help provide more accurate data about surface water and more importantly, can reveal info about water quantity under the ground. [NASA's Gravity Recovery and Climate Experiment \(GRACE\)](#) mission has been providing satellite data and imagery regarding global water levels for the past 15 years and will continue to provide information via a launch of [Grace Follow On](#) (GRACE-FO) in 2018. Future considerations, however, include how to best make sense of, compare, and share the vast amounts of incoming satellite data across platforms. A [Sentinel-1 satellite](#) for example, maps the world every 12 days and delivers 1 raw terabyte of data per day. Where to store that data, how to organize it, and how to train users on its application are just a few of many pertinent questions.

Workarounds

Deeper wells drawing more groundwater. [Groundwater depletion](#) is the state of groundwater extraction exceeding replenishment. When surface water resources are depleted, groundwater is even more taxed. But [more and deeper wells](#) drawing greater quantities of groundwater is a short term solution to an ongoing problem.

Ignoring infrastructure. Roughly [2.1 trillion gallons](#) of treated water is lost each year in the U.S. due to [infrastructure failings](#) such as leaky pipes or broken water mains. In fact, [30%](#) of global water is lost each year due to infrastructure failings (see Figure ____).



Privatization of water sources. Blame [bottled water](#). As [sales](#) of bottled water have boomed in recent decades companies have eagerly gobbled up sources. Nestle, for example, [owns 50 freshwater springs](#) in the U.S. Access to natural springs and pristine supplies are central marketing claims for companies selling water in a bottle. Criticisms of these efforts are numerous and widespread, ranging from the use of plastics (and the ramifications [for the body](#) as well as [the planet](#)) to how the [privatization of water](#) denies water [to those in close proximity](#) to a source.

Additional Resources

For a story map depicting the issues related to water in the west, see <https://storymaps.arcgis.com/stories/7dcc2493f3a04e9e972b36914a9c66b7>

For more on the "Groundwater Crisis" see <https://blogs.ei.columbia.edu/2015/08/03/the-growing-groundwater-crisis/>

For one of the most celebrated tomes on water in the West, read [*Cadillac Desert: The American West and its Disappearing Water*](#), by Marc Reisner.

For more on water affordability in Colorado see the [article from Water Education Colorado](#) on COVID-19 and water cost.

For more information on water affordability nationwide, see the National Association of Clean Water Industries [2019 Clean Water Index](#).

Water Quality and Safety



More people die from unsafe water than from all forms of violence, including war. While surface water quality has improved in many parts of the developed world in recent decades, those improvements face threats from economic growth, population increases and shifts, and climate change. Climate change and its effects increase the possibility of compromised water quality in the U.S. and around the globe. A warming climate produces warmer water temperatures wherein harmful bacteria or algal toxins thrive, creating dangerous conditions for water use and water recreation. The growing frequency and intensity of extreme climate events such as storms and floods means more water runoff, eutrophication, and pollution of water sources and in coastal areas, salt-water contamination of freshwater sources poses a threat to water quality. Those living in poverty, in rural areas, and those who are members of vulnerable communities are disproportionately susceptible to unsafe water. Populations most at risk for lead exposure in drinking water, for example, are low-income, minority status, in urban areas, or residing in buildings constructed prior to 1978. Water quality is also tied to food production. Salinated water, resulting from runoff, poor irrigation systems in dry areas, and intrusion of sea water reduces global agricultural output each year by numbers equal to feeding 170 million people. Finally, water quality runs downstream. Literally. When the quality of a river is compromised,

economic growth for areas downstream drops by roughly one-third due to water quality's central role in recreation and tourism, community health, agriculture, energy production, and manufacturing. Water quality is a wicked problem for many reasons. It is highly connected to other wicked problems such as extreme climate events, infrastructure, and sanitation. It is highly susceptible to the various effects of climate change. Finally, there is a great deal of unknowns when it comes to measuring, understanding, and regulating water quality, including the potential harm of emerging pollutants like microplastics and pharmaceuticals. Despite these challenges, a concern over water quality tops public opinion on water issues throughout the U.S. and safe, accessible water is fundamental to human growth and development around the world.

How might we safeguard water quality to provide clean, safe water to all users?

Contributing Factors	
Climate change (rising temperatures, vulnerability to extreme events, scarcity, pollution) Public opinion Individual households (lack of plumbing, waste disposal, individual wells) Community challenges (contamination, depletion, cost, infrastructure) Data gaps	
History & Trends	
Development and urbanization Water treatment Pollution and Policy	Tribal water access Online plumbing Stress on urban water systems Rising income inequality
Populations & Agents	
Infants and older adults Rural and urban populations	Regulatory agencies Water utilities Individual households Industry Environmental and advocacy groups

	Private companies Food and beverage sector Tourism and recreation sector
Existing Approaches & Workarounds	
Information sharing Water monitoring technologies The IoT Water safety planning Septic technologies	Bottled water Nonprofit assistance In-home systems Dated regulations

Contributing Factors

Climate change. The change in our climate has [consequences for the quality](#) and safety of water. This is not difficult to imagine. After all, climate is a term used to represent the interconnected conditions of temperature, precipitation, humidity, atmospheric pressure, and other meteorological events over time. A change in one has consequences for the other components of this connected system. Interventions in any of the following contributing factors related to climate change will have an effect on water quality and safety.

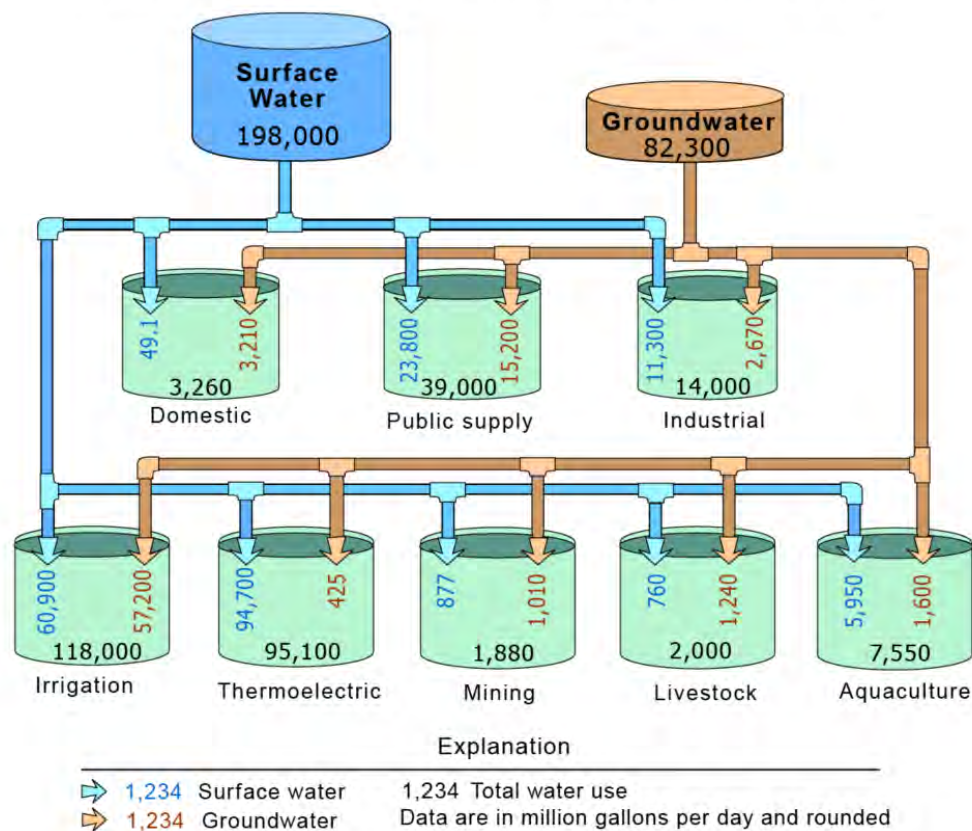
→ **Rising water temperatures.** [Greenhouse gases](#) in the air--a result of fossil fuel emissions--directly [contribute to the air's warming](#) temperature. In turn, rising temperatures have a number of consequences for water quality. Rising air temperatures means corresponding rises in water temperatures with [effects on the levels of pollutants, pathogens, microbes, and toxins](#).

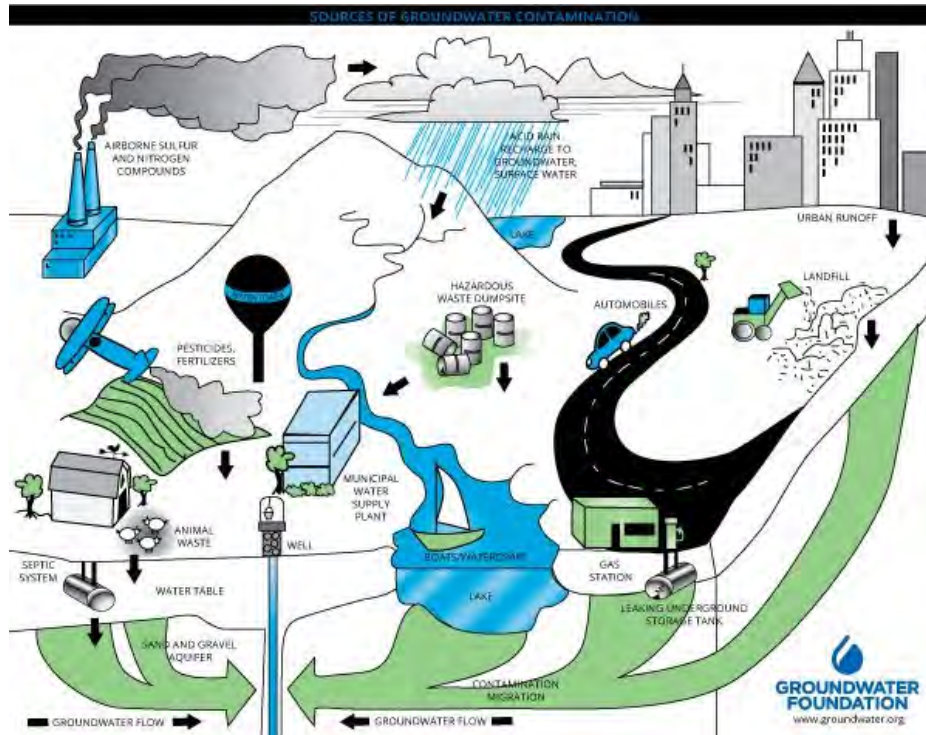
→ **Pollution.** Burning fossil fuels releases a variety of gases and chemicals [into the air](#). Many of those make their way [back to the earth's surface](#) via precipitation and pollute water supplies. Pollution isn't simply toxic chemicals, however. Metals, organic materials, microplastics, and pharmaceuticals are [all found in drinking water supplies](#) in various amounts and all pose risks to individual, community, and economic health. The existence of each of these pollutants in drinking water is the result of human activity, often stemming from unsustainable growth, climatic conditions, or failure to take note of or invest in ["downstream" consequences](#) of waste disposal, manufacturing, and energy production.

There are multiple methods for decontaminating water as well as resources for avoiding water risks in the first place. For the latter, see the World Health Organization's [Water Safety Plan Manual](#). For an in-depth discussion of water safety in the face of climate risk, see the World Health Organization's report on [Climate Resilient Water Safety Plans](#).

Groundwater pollution is an additional concern. Roughly 26% of our drinking water comes from groundwater, which is also used for other sources such as agriculture (see Figure ____). Groundwater pollution may be caused by infiltration of chemicals into the soil and underground water supply. Oil and chemical spills, urban runoff, and illegal waste dumping are a few potential sources of groundwater pollution (see Figure ____).

Source and use of freshwater in the United States, 2015

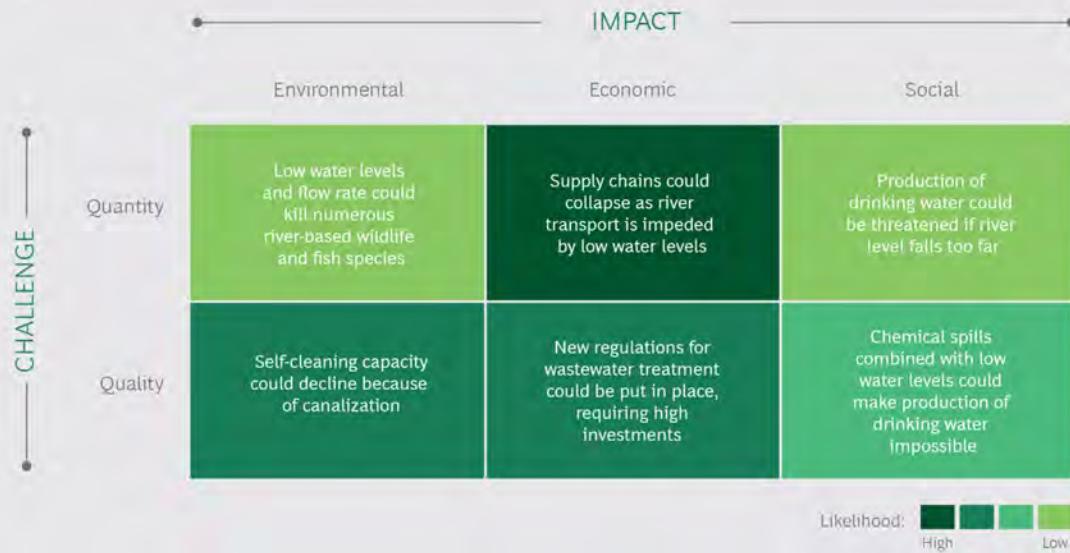




→ Vulnerability to extreme events. Climate change increases the frequency and intensity of extreme events such as hurricanes, droughts, floods, and wildfires. Each of these events threaten water safety both by affecting access and the quality of water sources. Hurricanes and floods can overwhelm water and sanitation systems, creating overflow and potential contamination. Droughts create water scarcity scenarios wherein health and safety of communities is at risk due to less access to water supplies. Wildfires leave landscapes barren, thereby increasing the likelihood of water runoff and the presence of contaminants in supplies. Wildfires also threaten infrastructure, creating dangerous scenarios regarding the ability to get clean, safe water to those who need it.

→ Scarcity. Extreme heat, droughts, and growing populations place demand on existing water supplies. When supplies are already limited and then overtaxed, water safety becomes an issue (see Figure ____). Existing wells may need to be dug deeper into groundwater supplies, an untenable solution. Communities may need to consider costly mechanisms for importing water. Water scarcity may also create poor sanitation conditions.

EXHIBIT 1 | The BCG Water Risk Matrix Applied to the Challenges and Impacts of the 2018 Rhine River Crisis



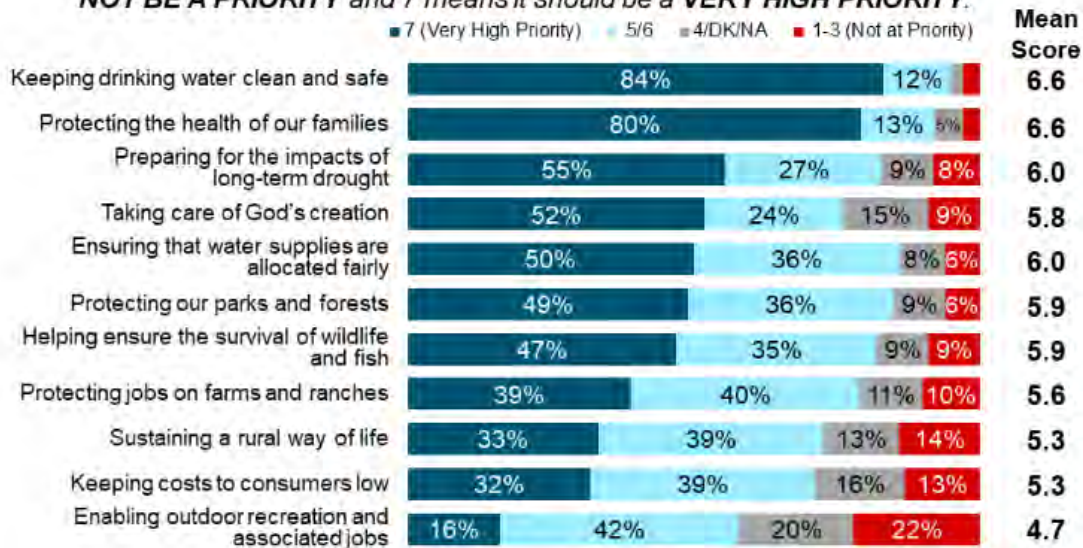
Source: BCG analysis.

The Water Risk Matrix reflects the connection between water quality and quantity.

Public opinion. In the midst of a social and political climate wherein it seems difficult to find a group of people who agree about anything, there appears to be one unifying factor: clean, safe water. According to a [Water Foundation](#) poll of U.S. voters in the west, clean, safe water tops the list of water concerns (see Figure __) and [transcends party lines](#). A national poll reveals Americans rank safe water as a top health concern, less serious than cancer but in line with heroin use (see Figure __).

Health and safety are seen as the most important priorities for future water policies.

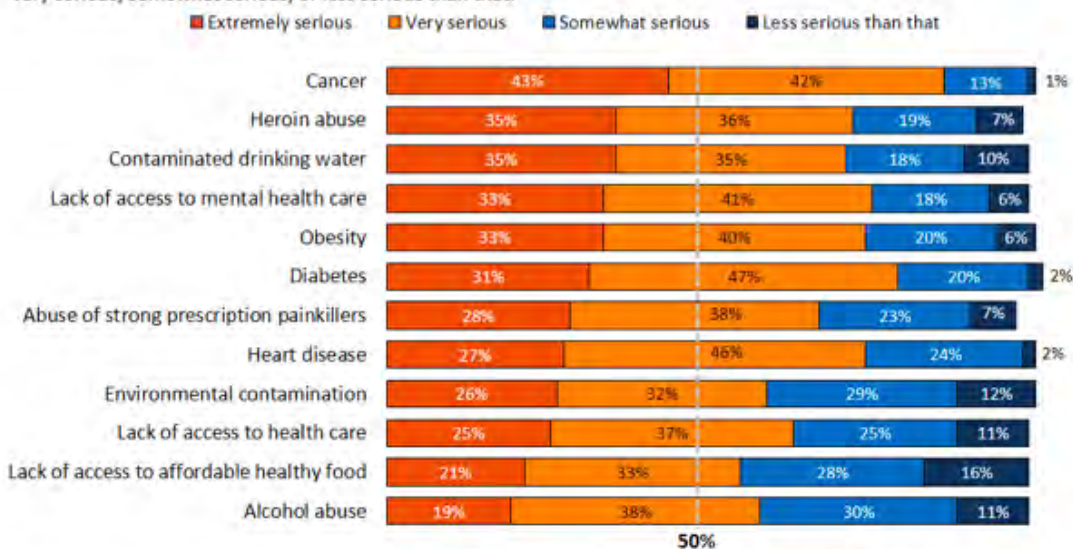
I'm going to read you a list of goals that might be kept in mind when designing policies to address [STATE]'s future water needs. Please tell me how high a priority you think that goal should be, using a scale of 1 to 7 where 1 means it should **NOT BE A PRIORITY** and 7 means it should be a **VERY HIGH PRIORITY**.



Water pollution rated as serious as heroin abuse

Contaminated Drinking Water and Heroin Abuse Rank Among Most Serious Health Problems Facing the U.S.

For each health issue I name, please tell me how serious a problem you think it is in this country – extremely serious, very serious, somewhat serious, or less serious than that.



NOTE: Some items asked of half samples. Don't know/Refused responses not shown. Question wording abbreviated. See topline for full question wording.

SOURCE: Kaiser Family Foundation Health Tracking Poll (conducted April 12-19, 2016)



Infrastructure. Infrastructure plays a large role in water quality and safety. It includes what is available to individual households as well as the mechanisms used to get water to cities and towns via community systems.

→ Individual households. It is tempting to think of water access and safety issues as irrelevant to the United States. When we think about those without access to clean, safe water, we tend to consider places across the globe. In fact, access to clean, safe water is an issue closer to home than many of us realize.

Indoor plumbing. More than [2 million Americans](#) lack access to safe running water and basic indoor plumbing. This includes roughly 1.6 million households without at least one of the following: indoor plumbing providing hot and cold running water, a sink, a bathtub or shower, or a flush toilet. Native American households are 19 times more likely than white households to lack indoor plumbing. For a comprehensive view of access to safe and clean water, see the report titled [Closing the Water Access Gap in the United States: A National Action Plan](#).

Substandard waste disposal. Over [21 million households in the U.S.](#) use a private [septic system](#), and not the public sewer system, for waste disposal. Underground septic tanks are most common in rural areas, particularly in [New England and the South](#). The number of septic systems for individual homes is on the rise, [an area of concern](#) during stay-at-home orders during the pandemic. However, there is a good deal of missing information when it comes to septic system use. The last time each household was asked about their waste disposal system was the 1990 U.S. Census. While regions and communities may keep track of this data individually, it is not widely shared or standardized, contributing to [data gaps](#) in our understanding of the issue. Private septic systems may be more prone to failure and pose a health risk, especially for those with older systems, and are vulnerable to disruption in times of [disaster or extreme events](#).

One example of this health threat is the [resurgence of hookworm](#) in the rural South. Associated with regions of extreme poverty, hookworm's [widespread appearance](#) in Lowndes County, Alabama, is a [wakeup call](#) for facing the disparity in access to safe water.



Untreated sewage in a Blackbelt neighborhood. CREDIT ALABAMA CENTER FOR RURAL ENTERPRISE

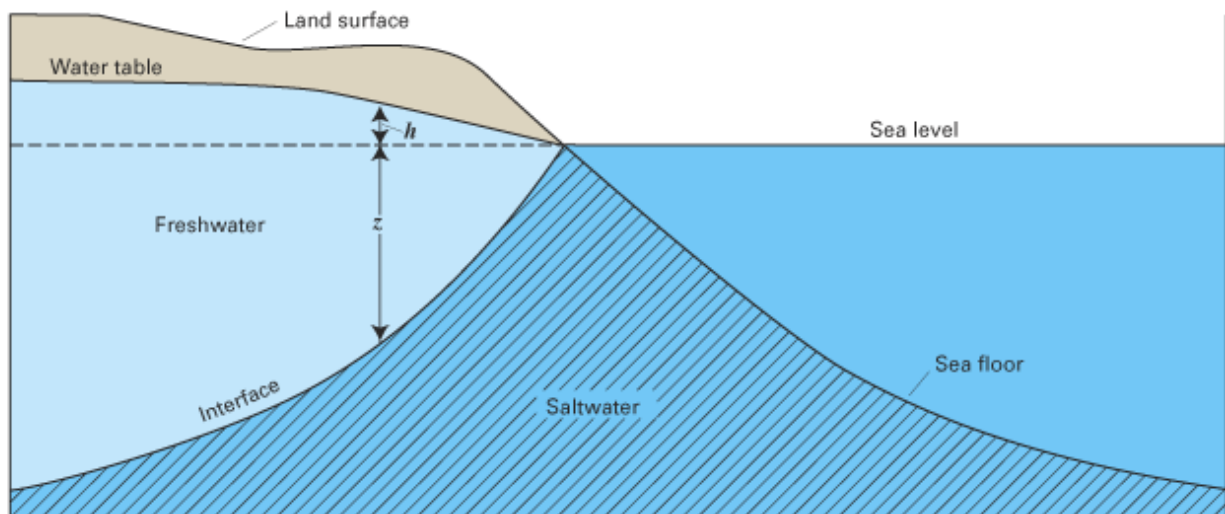
At-risk wells. About [43 million people](#)--15% of the population in the U.S.--get their water from private wells. These wells are not regulated by the Federal Drinking Water Act or by state laws and regulations. A [2009 study](#) of private wells found roughly 1 in 5 wells contained at least one contaminant at higher than human-health benchmark levels. The rates of contamination emphasize the need for widespread testing and monitoring. See the [US Geological Survey](#) study for a complete review of these contaminants and the implications of each.

→ Community system issues. In addition to the challenges within individual households, infrastructure challenges exist within the water systems serving cities and towns. Those challenges include:

Contaminated systems. Contaminated groundwater can threaten an entire city's drinking water supply. Denver, Colorado, is one example of a metro area with [traces of "forever chemicals" in the groundwater](#). Forever chemicals, called so for their resistance to any decomposition or dilution, include [per- and polyfluoroalkyl substances \(PFAS\)](#) used in firefighting foam and some consumer products. While the PFAS levels were found to be under EPA health advisory guidelines in most tested areas, four locations exceeded these levels and a number of surface water sources also exceeded health advisory levels. For complete sampling data, see the [sampling dashboard](#). The state of Colorado has passed new restrictions on use of the firefighting foam but concerns remain, especially given the moniker of

the contaminants. Adding to concerns are questions regarding the accuracy and safety of the [EPA health advisory guidelines](#) and the need for more current and appropriate metrics. Personal note: as a result of learning more about PFAS, this researcher is installing a [reverse osmosis system](#) under her kitchen sink.

Depleted systems. What happens when the water runs out? This is a question more and [more communities](#) in the west are finding themselves answering. A [study of groundwater wells in western states](#) found one out of every 30 wells was dry between 2013-2015 and in the Central California Valley and the western High Plains, that number was one out of five. When already depleted systems are [pumped for more water](#), the [quality of the water may decline](#) as surface water or proximate saltwater reserves are inadvertently pumped into the aquifer (see Figure ____). Accurate and ongoing well and aquifers measurements are necessary to monitor and track supply and quality.



Cost and affordability. The cost of water services [vary widely](#), even within a county (see Table ____). In areas where many people live below the poverty line, water customers may have difficulty keeping up with rates and can face interruptions in their water service. This is even [more pointed](#) during the pandemic. Certain areas in the U.S. are seeing [increase in water rates](#) due to drought or the cost of needed infrastructure improvements. Water utilities may make financial assistance available to customers but these efforts fall short of meeting the needs of the increasing number of low-income households nationwide. Rates in [Baltimore, Maryland](#), for example, are projected to more than double in an eight-year period. Water shut offs have health repercussions for individuals and unpaid water bills can increase the cost for utilities. For more information on the issue of affordable water and the legal challenges involved in providing water assistance, see the University of North Carolina's Environmental Finance Center overview of ["Navigating Legal Pathways to Rate Funded](#)

[Customer Assistance Programs](#)” and the [EPA compendium](#) on Customer Assistance Programs.

Table 1. Most and Least Expensive Water Systems in Los Angeles County

System Name (Population Served)	Annualized Cost for 18 CCF
Five Most Expensive Systems	
1. CA Water Service Co.—Lake Hughes (711)	\$2,244
2. CA Water Service Co.—Leona Valley (1296)	\$1,834
3. LA County Water Works Dist. #21—Kagel Canyon (991)	\$1,658
4. Park Water Company—Bellflower/Norwalk (67,200)	\$1,539
5. Park Water Company—Lynnwood/Compton (45,400)	\$1,502
Five Least Expensive Systems	
1. Maywood Mutual Water Co. #1 (5,500)	\$145
2. Pico Rivera Municipal Water Co. (39,000)	\$192
3. Lomita Municipal Water (20,256)	\$235
4. City of Industry Waterworks System (7,000)	\$278
5. LA County Waterworks Dist. #40—Antelope Valley (9,822)	\$282

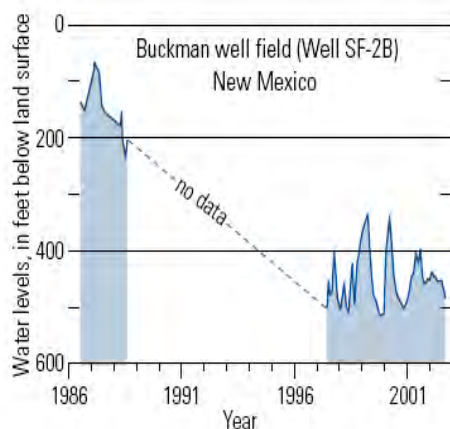
Source: Greg Pierce, UCLA. "Ensuring Drinking Water Affordability: Challenges and Opportunities in Current Policy Making at Local, State and National Levels." Water and Health Conference 2017. 17 Oct. 2017.

Aging infrastructure. Perhaps the most challenging component of the issues related to infrastructure is their intersection. Who is responsible for maintaining pipes throughout a city once those pipes reach into a home? This question became a pressing one in the case of [Flint, Michigan](#), where one contributing factor in the water crisis was lead leakage from [aging pipes](#) stretching throughout the city and into homes. For more on the complex story of water quality in Flint see [“Flint Water Crisis: Everything You Need to Know.”](#)



A corroded pipe a Flint, Michigan, resident removed from her home. PHOTO: KIMBERLY P. MITCHELL/ZUMA PRESS

Data gaps. When it comes to water, there is a lot we don't know. There is even more we don't share. Gaps in data may occur within a particular area, as is the case of the [Buckman well field in New Mexico](#) where water level data was collected for years then inexplicably ignored for nearly a decade (see Figure ____). Over this period the water level declined almost 300 feet. Gaps in data also occur across wide swaths of the country as demonstrated by failure to collect data on in-home plumbing over the past thirty years. And while individual communities may collect their own data on water quality and quantity, there is no existing mechanism for sharing that data with other regions or communities, despite the interconnectedness of water sources. For more information on the opportunities related to data and water, see [Deloitte's report on the top trends in the water sector](#).



A hydrograph showing ground-water-level declines in the Buckman well field, which supplies water for Santa Fe, New Mexico. No measurements were made between August 1988 and June 1997, during which time water levels declined nearly 300 feet, emphasizing the importance of continual monitoring. Long-term data that document the evolving response of aquifers to ground-water development are particularly important for calibrating ground-water-flow models used to forecast future conditions.

History & Trends

History

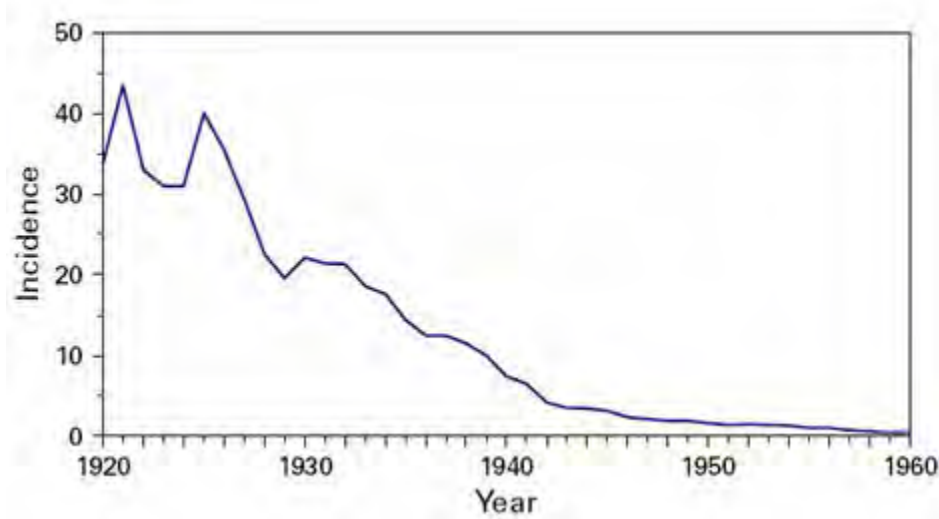
In the 5th century BCE, the Greek physician Hippocrates wrote *Airs, Waters, and Places*, believed to be the first book connecting health and human disease to the physical environment. In it Hippocrates [notes the effect of water quality on health](#). In the millennia since his observation, we still struggle with how best to manage the relationship between healthy communities and water quality.

Development and urbanization. Historically, problems with water quality in the U.S. were often tied to development. More people in an area meant the need for more water and reliable access to it. This, in turn led to the [creation of informal systems](#) for delivering water. These systems became quickly overtaxed and degraded, resulting in water quality and sanitation problems and the eventual rise of illness.

Increasing urbanization in the 19th century and the rising population of the working poor in condensed urban neighborhoods in part ushered in the era of sanitation. Called "[The Great Sanitation Awakening](#)" the first half of the nineteenth century featured changes in engineering and health recognizing the connection between "cleanliness"--be it on the streets or in the drinking glass--and [lower instances of disease](#). More money and attention was paid to the mechanisms of supplying and accessing water, resulting in extensive public works efforts for the next century.

Water treatment. The turn of the century saw the introduction of water treatment processes to ensure safe water and prevent disease. [Chlorination](#)--the purification of water through the application of compressed, liquefied, chlorine gas--became [widespread practice](#) in the U.S. in

the early 20th century and drastically reduced the instances of typhoid, cholera, and dysentery (see Figure ____).



Incidence of Typhoid Fever, 1920-1960.

<https://www.entrepreneurshipinabox.com/18013/plumbing-innovations-new-breakthrough-technology/>

Pollution and policy. The Industrial Revolution supercharged the American economy. It also supercharged levels of industrial waste in lakes and rivers as factories dumped waste [directly into bodies of water](#). Pollution was met with policy meant to regulate levels and protect water quality. The Water Pollution Control Act of 1948 was the first federal law to address water quality and gave the Surgeon General the ability to sue states polluting transboundary waterways. A pivotal moment in addressing water pollution came when the [Cuyahoga River caught fire](#) in Cleveland, OH, in 1969. The fire itself wasn't that unusual--the river, rife with chemicals and manufacturing pollutants, had caught fire nine times already in the past few decades. But this time, and in line with the growing environmental movement, public sentiment across the nation demanded more attention to the health of rivers. A few years later in 1972, in response to widespread concern over environmental and public health as a result of pollutants, the [Environmental Protection Agency](#) was formed. To this day, the EPA [provides guidelines](#) on the quality and safety of water. That year Congress also passed the [Clean Water Act](#) to reduce pollution, regulate waste, and set quality standards for water. In 1974, Congress passed the [Safe Drinking Water Act](#). The SDWA regulates the public drinking water supply for the U.S. and was updated in 1986 and 1996 to expand protections. To learn more about the SDWA, its enforcements, economic impact, and specific regulations, see the [EPA's SDWA overview](#).

Trends

The ongoing failure to provide water to tribes. Although tribes often hold the most senior water rights in most western water basins, [roughly 48% of all tribal homes](#) do not have access to clean, reliable sources of water. Tribes are often left with what is referred to as “[paper water](#)”—meaning despite their water rights, they lack the financial resources to create the infrastructure for receiving water. Lack of infrastructure can also threaten the [safety of the water sources and supply systems](#) that are available on tribal lands. Rising [public consciousness](#) of the history and current realities of indigenous peoples will hopefully lead to closing the gap between the right to water and access to it.

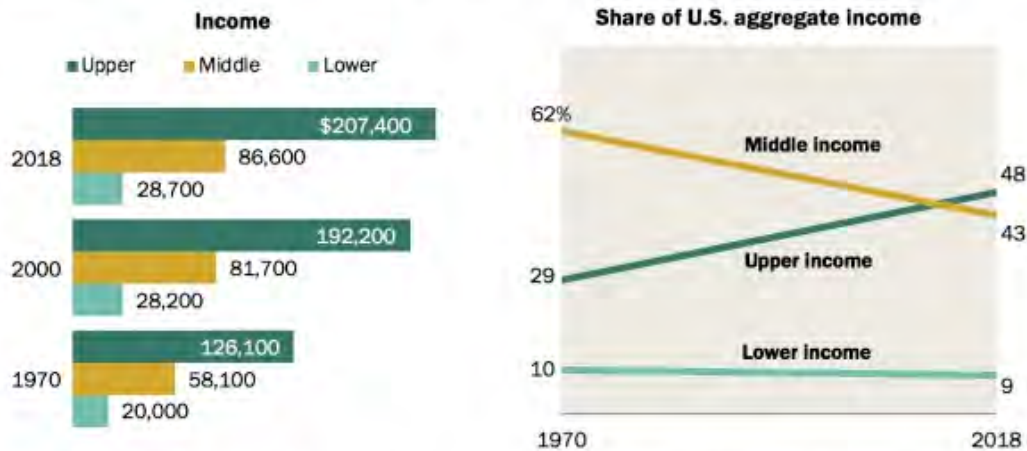
Home plumbing online. [Smart sinks, toilets, and showers](#). These may be terms we hear [more and more](#) about in the coming years. As our [homes](#) in general go online and get “smarter,” we can expect the same for our water fixtures. [Smart plumbing](#) can identify leaks, help eliminate overuse, and provide information on water [quality](#) and [quantity](#). ‘As these monitoring systems take off, it raises the possibility of similar interventions for wider application. [Smart pipes? Smart wells?](#)

Stress on urban water systems. [Population growth, climate change](#), and the stressors both place on urban infrastructure will continue. As these trends march forward, [so must innovation and new thinking](#) when it comes to [how cities manage water quality](#).

Rising income inequality. The [ongoing rise of income inequality](#) in the U.S. will mean lower standards of living for more of the population, affecting household ability to access the resources they need, including clean and safe water. The distance between the haves and have nots (see Figure ____) will not only be [financial](#) but [geographic](#). Those who can afford it will live in areas with higher quality infrastructure and those who cannot will live in neighborhoods with substandard pipes, plumbing, and services.

The gaps in income between upper-income and middle- and lower-income households are rising, and the share held by middle-income households is falling

Median household income, in 2018 dollars, and share of U.S. aggregate household income, by income tier



Note: Households are assigned to income tiers based on their size-adjusted income. Incomes are scaled to reflect a three-person household. Revisions to the Current Population Survey affect the comparison of income data from 2014 onwards. See Methodology for details. Source: Pew Research Center analysis of the Current Population Survey, Annual Social and Economic Supplements (IPUMS). "Most Americans Say There Is Too Much Economic Inequality in the U.S., but Fewer Than Half Call It a Top Priority"

PEW RESEARCH CENTER

Populations & Agents

Vulnerable Populations

Infants and older adults. There are many groups vulnerable to unsafe drinking water. Infants and older adults may be especially vulnerable to [microbial contaminants](#), even when drinking tap water deemed safe by EPA standards. The same goes for those who are immunocompromised from HIV, cancer, or other disease.

Rural and urban populations. Additional vulnerable populations include those in rural areas who may not have access to public water systems and therefore rely on private water and septic systems. The [CDC](#) and EPA [do not regulate private systems](#). On the flip side, people in urban areas may be vulnerable to infrastructure or system failure in the wake of extreme events. When a city's resources shut down, the danger of disease increases, as does the potential for populations to migrate in search of the needed resources. [Climate refugees](#)--those who are displaced due to climate related extreme events--are more likely to be those of [lower socioeconomic status](#). For more information on migration and water, see the report from the Stockholm International Water Institute report [Water, Migration, and How They Are Interlinked](#).

Agents

Category	What they do	Examples
Regulatory agencies	Monitor water quality, provide alerts, sometimes inform new policy and regulation for water safety	EPA CDC US Fish and Wildlife Services
Water utilities	Measure water quality for communities and neighborhoods, provide water treatment services and maintain infrastructure	Denver Water American Water Works Association
Individual households	Possess varying degrees of access to safe, reliable water and via a range of mechanisms	Households with private wells and septic Households without plumbing
Industry	May contribute to pollution levels or work to alleviate water contaminants	Suncor Thor Industries
Environmental and advocacy groups	Work to provide quality water for those without access	Environmental Defense Fund Colorado Water Trust Water Education Colorado
Private companies	Sell bottled water	Nestlé Waters Danone
Food and beverage sector	Require clean and safe water sources for production	Nestlé PepsiCo Tyson
Tourism and recreation sector	Conduct business on or in conjunction with water such as lakes, rivers, and the ocean	Colorado Tourism Board Recreational Fishing Industry and Lobby

Existing Approaches & Workarounds

Approaches

Information sharing. [Decentralized Water Resource Collaborative](#), an effort of the EPA, is an entity to foster collaborative research and data sharing among the many decentralized water and wastewater systems across the U.S. Additional means of [sharing information](#) include

gamification and [simulations](#). One example is the [UVA Bay Game](#), a simulation allowing participants to take part in managing the Chesapeake Bay Watershed.

Water monitoring technologies. Referred to in some cases as [water quality surveillance and response systems](#), water quality monitoring is an [industry unto itself](#) (projected to be worth [\\$4.69 billion](#) by 2025) and one that continues to see [innovation](#) and [fresh approaches](#). A [variety of technologies](#) are deployed to measure water safety. These approaches rely on a range of methods from [bio-sensors](#) to [radiology](#) to detect an array of potential contaminants such as carbon content, chlorine residuals, and biological organisms in a variety of water sources from [groundwater](#) to [surface water](#) to safeguard against a milieu of dangers like chemical warfare or the introduction of biological agents into the water supply. These technologies are designed to serve [water treatment plants](#) or [food and beverage companies](#) more so than individual households. For more information on the need, market, and call for innovation in water technologies, see the EPA's blueprint for [Promoting Technology Innovation for Clean and Safe Water](#).

The IoT and water monitoring. It used to be water monitoring--be it for quality or quantity--had to be done manually. That has changed in recent years with the [emergence of remote, smart water monitoring](#) via the [Internet of Things](#). IoT water monitoring has opened the door for innovation and a variety of new approaches to monitoring. Examples include [system-wide monitoring](#) of water supply and [site-specific buoys](#) to monitor surface water quality. The water sensor, monitoring, and IoT industry is [a growing market](#) with a range of applications to various industries including [agriculture](#) and [recreation](#) as well as [household use](#).

Water safety planning. Water safety plans (WSPs) employ [risk assessment](#) and management to ensure the safety of drinking water through all stages of the water supply chain. The call for plans originated from the World Health Organization's [Guidelines for Drinking Quality](#) (GDWQ). The Guidelines [recommend WSPs](#) as the most effective means to guarantee drinking water and circumvent a public health disaster. The WHO offers a [library of resources](#) for WSP creation purposes, including information on how to ensure [WSPs are equitable](#) and serve vulnerable populations. WSPs are increasingly being used to [mitigate risks in individual buildings](#) as well as wider water systems. Despite the need for WSPs, they may be difficult to implement due to [cost and financial restraints](#). Further, it is increasingly challenging to accurately [assess and plan for risk](#) in the face of growing climate uncertainty.

Septic technologies. No one could blame you if you don't immediately associate layered cake with addressing challenges in wastewater treatment. Yet there is a connection. The [layered cake approach](#) is one example of an innovation from the [Massachusetts Alternative Septic System Test Center](#). The MASSTC is a third-party research and testing facility for innovative and alternative septic system approaches. Additional projects include [wastewater hydroponics](#) and a study of [virus removal](#) in wastewater systems. For a full list of projects, see the Test Center's ["Project Hub"](#) webpage.

Top innovations:

<https://www.wqpmag.com/trends-forecasts/top-5-innovations-water-quality-technology-2020>

Workarounds

Nonprofit assistance. Organizations like [DigDeep](#) and [The Water Well Trust](#) help alleviate the pressures related to water quality and safety. These are not long term solutions but stop gaps meant to aid individuals with water problems.

Bottled water. It may still be [big business](#) but it is not a solution and in many ways, produces more problems than it solves. The [chemicals and plastics](#) in bottled water often makes this water source less safe than water from a tap.

In-home apparati. In home water treatment systems such as a [reverse osmosis system](#) may be a good option, but with [price tags in the hundred of dollars](#), it is not an option for everyone. Water filtration and treatment systems further increase the distance between those who can afford “good water” and those who can not. In-home systems also circumnavigate the need for larger infrastructure or supply-wide fixes. Who needs to clean up the toxic chemicals in the surface or groundwater when “everyone”--or those most likely to advocate for better water due to the resources at their disposal--can address the problem themselves?

Over two decades-old regulations. The last amendment to the Safe Drinking Water Act was in 1996, [raising concerns about the need for updates](#) in response to a changing climate and [increasing presence and levels of chemicals](#) in the water. Most public water systems only test for the chemicals mandated for testing by the EPA and although the EPA may identify new chemicals to test, it hasn’t done so since 1996. Not a single new chemical has been added to its list of 89 chemicals, bacteria, or viruses in over two decades. This boggles the mind, especially as the EPA is also required to keep track of new chemical substances used in the U.S.--a list numbering over [86,000 chemicals](#).

Additional Resources

For more information on innovation in water monitoring see Innovative [Biological Approaches for Monitoring and Improving Water Quality](#).

For interactive maps of water quality on state and local levels see the [American Geosciences website](#).

For more on tribal water rights, see a [list of tribal water issues](#) from the Water Education Foundation.

