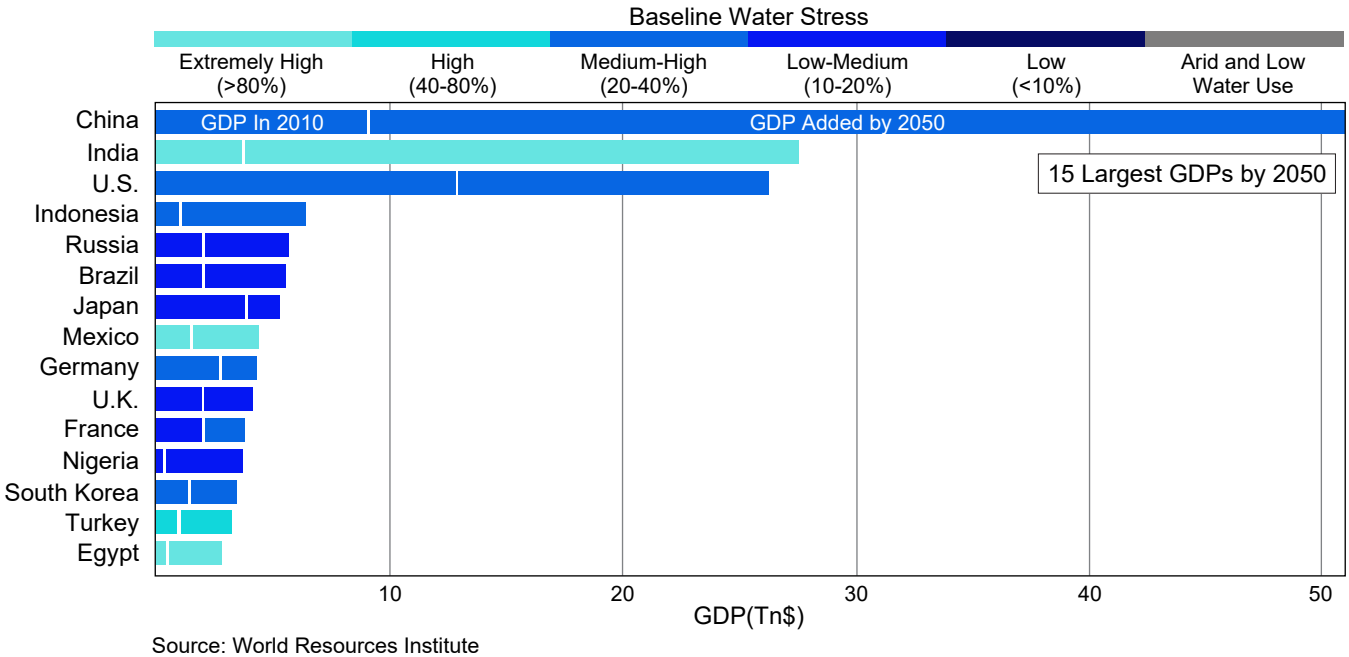
Future Water Security Hinges On Innovation

Aging water infrastructure, unsustainable water management practices, and changing hydrological patterns have placed global water security under "unprecedented stress". Water is not only essential to sustain life but is also the cornerstone of economies as nothing can be grown or manufactured without it. An alarming new report highlights that by 2050, the worsening water crisis could lead to an average global GDP loss of 8%, with lower-income countries potentially experiencing losses of up to 15% (Chart 1).[1] Today, outdated water infrastructure already causes economic losses estimated at approximately $470 billion annually.[2]

The world has transitioned into an era where water will fuel geopolitical conflicts, economic instability, food insecurity, and resource-based nationalism. Earth's most abundant resource is dangerously evolving into its most precious commodity (Chart 2).

Chart 1 GDP Growth Threatened By Water Availability

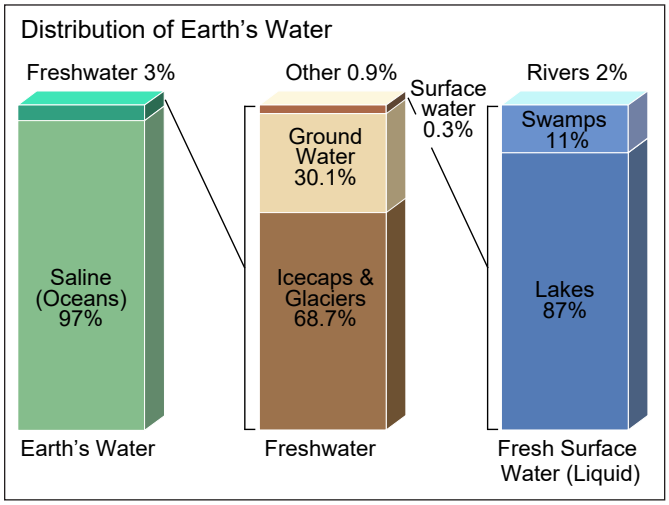


Source: World Resources Institute

1 Global Commission on the Economics of Water

2 Wilson Center "Infrastructure and Management Vital to Meeting Global Water Needs" (April 11, 2023).

Chart 2 Breakdown Of Global Freshwater Reserves



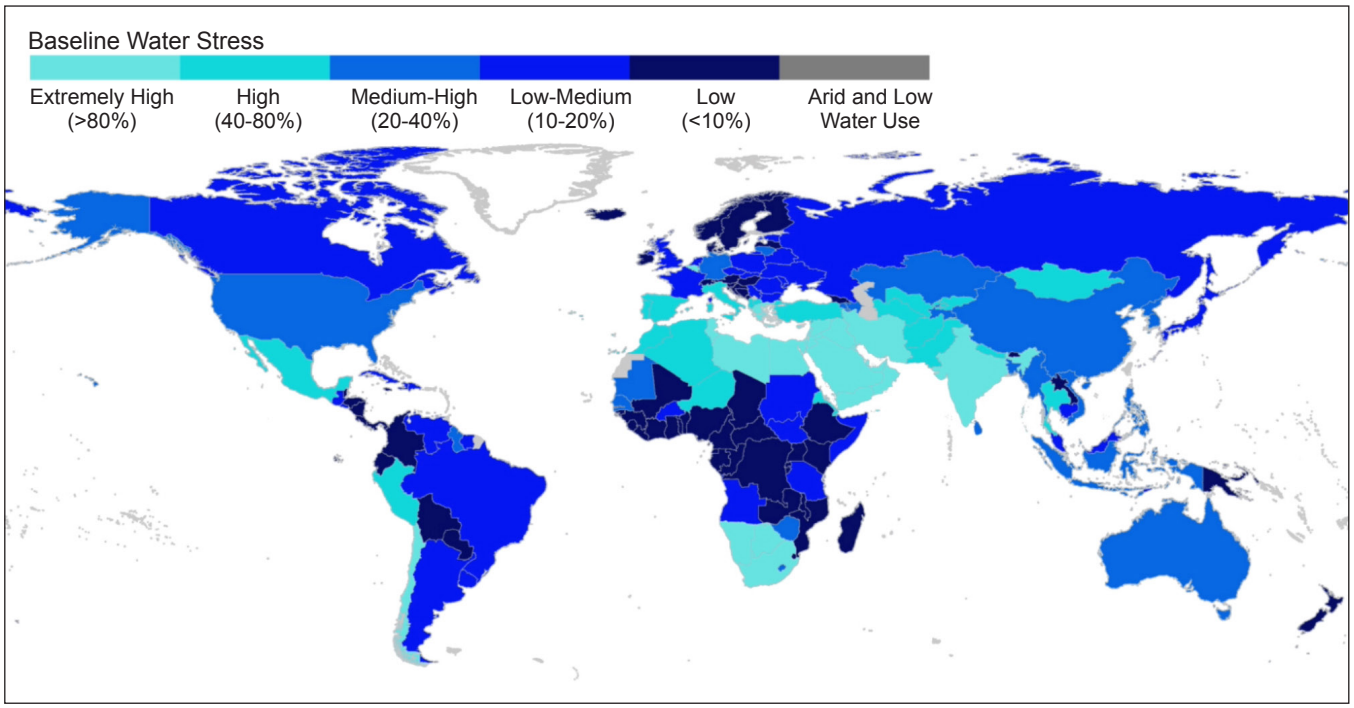
Source: U.S. Geological Survey

This report will argue that a comprehensive overhaul of global water infrastructure and management is essential for ensuring water security. It is crucial for modernization efforts to focus on enhancing both the efficiency and resilience of water infrastructure. Key areas in need of significant transformation include pipelines, pumping stations, water storage systems, treatment plants, drainage networks, and high-water-use sectors such as agriculture. Below, we will examine the main threats to water security and highlight innovations poised to mitigate these challenges.

An Emerging Crisis Of Massive Proportions

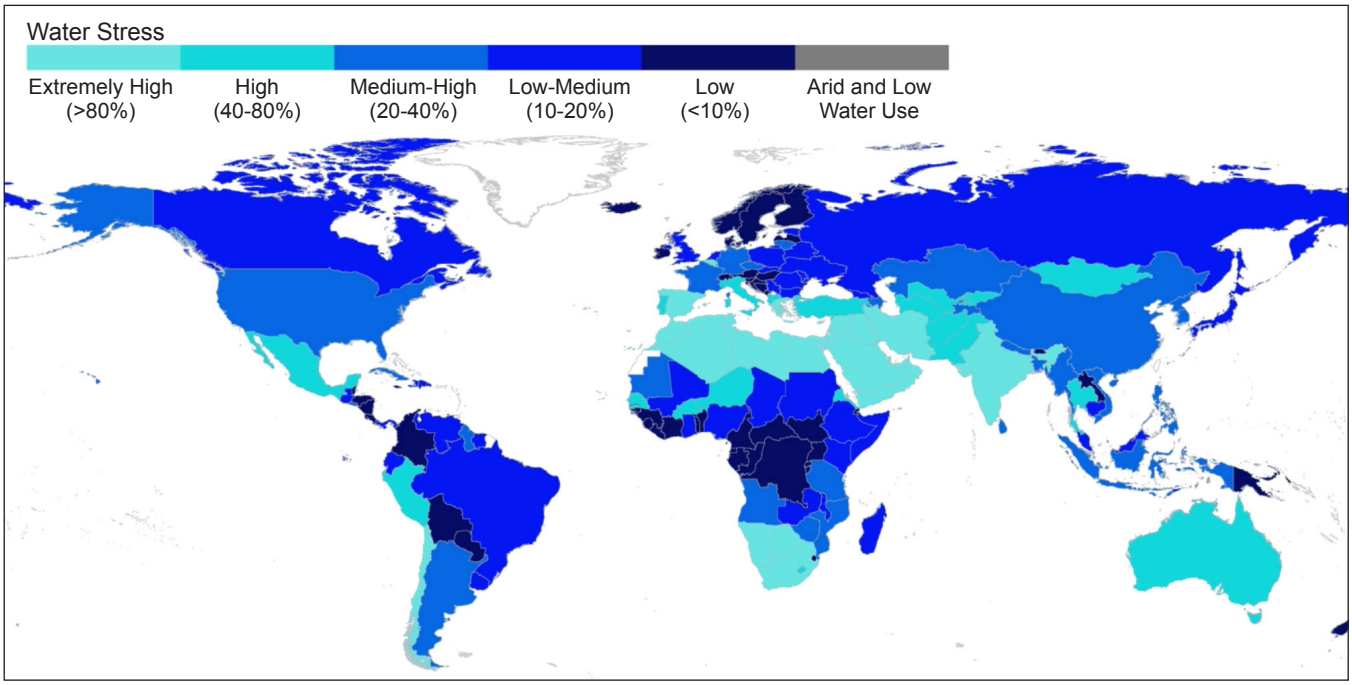
Over the past 50 years, global water consumption has grown by approximately 1% annually. By mid-century, global water demand could increase by more than 50%. However, this projection may be conservative due to the rise of new water-intensive technologies, such as AI, that have nebulous impacts on consumption. For instance, Virginia, home to the world's largest concentration of data

Chart 3 25 Countries Are Currently Exposed To Extremely High Water Stress Annually



Source: World Resources Institute

Chart 4 By 2050, An Additional 1 Billion People Are Expected To Live With Extremely High Water Stress



Source: World Resources Institute

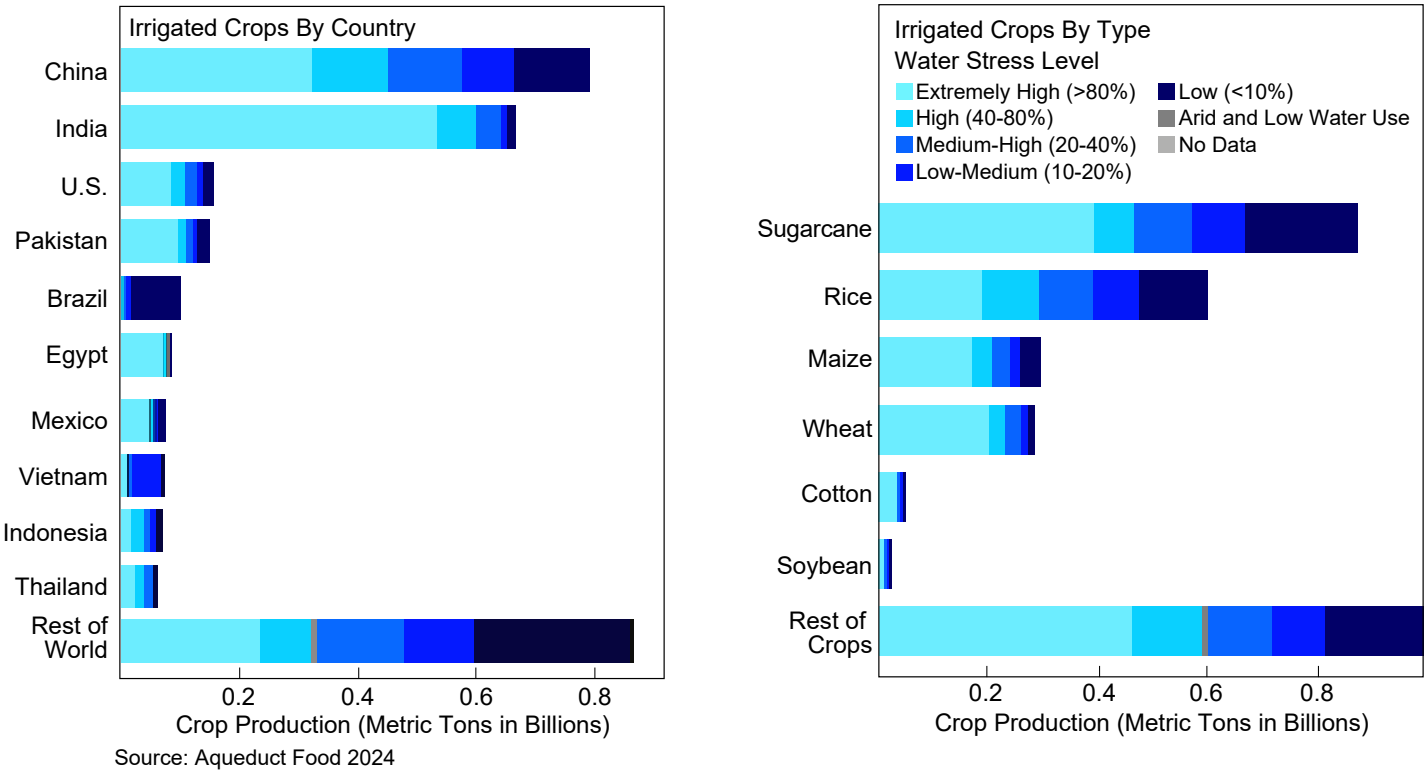
centers, has experienced water usage rise by nearly two-thirds between 2019 and 2023. Large data centers can consume over 5 million gallons daily – roughly equivalent to the water usage of a town of 50,000 people.

Water stress is a ticking time bomb with no "silver bullet" solution. Data points highlighting the severity of the situation include:

- Currently, at least 50% of the world's population lives under highly water-stressed conditions for at least one month of the year (**Chart 3**).
- By 2030, global freshwater demand is expected to outstrip supply by 40%.
- By 2050, an additional 1 billion people are expected to live with extremely high water stress (**Chart 4**), even if the world limits global temperature rise to 1.3°C to 2.4°C. Over 50% of cities with over 1 million inhabitants will be in water-scarce areas in the same timeframe.

Water insecurity from erratic weather patterns and unsustainable agricultural practices has elevated the risk of a global food shortage. Industrial-scale irrigated agriculture is heavily geographically concentrated, making localized water scarcity events capable of triggering widespread consequences. Just 10 countries account for 72% of the world's irrigated crops, with two-thirds of these supplies already facing high to extremely high water stress (**Chart 5**). Half of all agricultural production areas are currently grappling with worsening water shortages. This is especially alarming given that population growth will demand 56% more calories by 2050, compared to 2010 levels.

Chart 5 Food Production Is Highly Vulnerable



Source: Aqueduct Food 2024

Climate Change Is Exacerbating Water Stress

Extreme weather events are highlighting the need to improve the resiliency of water infrastructure. In 2023, the U.S. experienced a record number of weather disasters, putting additional strain on already compromised and outdated water systems. Excluding extreme weather events, rising temperatures have made the global water cycle unpredictable, leading to more frequent and severe droughts as well as intense rainfall events. This disrupts the natural recharge of groundwater aquifers, which supply over a quarter of the U.S.' water needs. Droughts have become more frequent in 74% of global regions identified by the IPCC as vulnerable to extreme weather.[3]

Storing rainfall to act as a buffer supply during drought and improving stormwater drainage are now critical, especially as human development increases land impermeability. Outdated stormwater systems have left cities particularly vulnerable. For example, New York City's Wastewater Resiliency Plan reported that all 14 of its wastewater treatment plants and 60% of its pumping stations nearly flooded during Hurricane Sandy. In San Francisco, outdated infrastructure is ill-equipped to handle the anticipated 40% increase in rainfall.[4]

While climate change is exacerbating water stress, the unfolding water crisis is primarily due to inadequate investment in infrastructure, unsustainable policies, pollution, and neglect of water resources.[5]

3 A global transition to flash droughts under climate change
4 The Pew Charitable Trusts

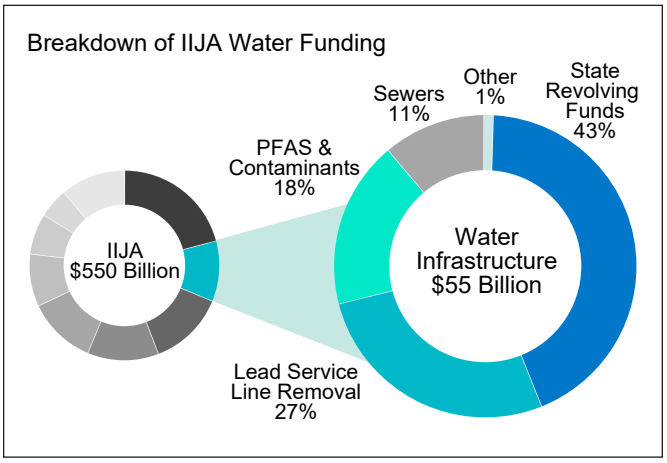
Water Infrastructure Has Been Neglected Globally

The U.S.

Deferred U.S. water infrastructure investment has pushed the system to a breaking point. This is creating a multi-year, or even multi-decade, infrastructure investment opportunity. Over $1.2 trillion of water infrastructure investment is needed over the next two decades in the U.S. alone.[6] The below data sheds light on the dismal state of U.S. water infrastructure:

- In its latest infrastructure report card, the American Society of Civil Engineers graded the U.S. with the following marks: Drinking Water: C-, Wastewater: D+, and Storm Water: D.
- The U.S. water distribution web is spread across 148,000 interdependent systems connected by over 2 million miles of pipes. However, over-reliance on roughly 50,000 "community water systems" has created massive single points of failure risk. Just 9% of these community water systems are tasked with supplying nearly 80% of the country's water.
- There is a water pipe rupture roughly every two minutes in the U.S., totaling an estimated 240,000 water main breaks per year. This results in an estimated 2.1 trillion gallons of water loss due to leaks.
- Lead service lines are estimated to account for over 9% of the entire national service line infrastructure. This puts millions of American households at risk of lead contamination.

Chart 6 IIJA Water Allocation Has A Murky Future



Source: Blue Field Research

Legislation passed under the Biden administration is supporting America's water infrastructure revival, although it remains just a drop in the bucket. For example, The Infrastructure Investment and Jobs Act (IIJA) allocates $55 billion to water, wastewater, and stormwater improvements (**Chart 6**). While a Trump presidency could influence the allocation of these funds and potentially roll back clean water regulations, we believe Trump would still prioritize enhancing U.S. water infrastructure, given his strong stance on rebuilding America's infrastructure. During his previous term, he signed an executive order[7] to modernize the nation's water infrastructure.

India And China

India and China are making significant investments in water infrastructure. Both nations are grappling

5 Global Commission on the Economics of Water

6 Clean Water Act, Drinking Water Infrastructure Needs Survey and Assessment

7 Modernizing America's Water Resource Management and Water Infrastructure

with relatively newfound water stress from increasingly unpredictable climate and factors including mismanagement of existing resources, rapid urbanization, and a growing population. For the past two years, China has allocated over $155 billion annually to water projects. This spending follows severe droughts not seen since the 1960s, which also caused energy shortages in southern China due to insufficient river flows for hydropower. Currently, the country is undertaking over 19,000 water conservation projects.

India, the most water-stressed nation globally, has 18% of the world's population but only 4% of its freshwater resources. Prime Minister Modi is focusing on bolstering India's "water economy" with a resilience-centered approach. Over the past decade, India has invested $250 billion in areas such as irrigation, river cleaning, drinking water, and groundwater recharge. However, more investment is critical as India leads the world in groundwater use, with some areas extracting 130% of sustainable levels. Alarmingly, studies suggest that groundwater depletion could triple within 20 years as farmers combat rising temperatures. Agricultural water use in India has surged by 500% over the past 50 years.

Importantly, India is a water-deficient country due to water losses from producing food and non-food commodities for export. "Virtual water" is emerging as a novel strain on the water security of developing nations heavily reliant on exports. In India's case, being the world's largest rice exporter by volume, a vast amount of the nation's water is "traded away".

Europe

European water infrastructure is arguably the worst in the developed world, with nearly two-thirds in "bad condition".[8] Some key European water pipelines have not been upgraded in over a century. Coupled with that, water stress already affects 20% of Europe's territory and 30% of its population every year, as per the European Environment Agency. Europe is also the world's fastest-warming continent due to its proximity to the Arctic, where ice melt is accelerating due to the albedo effect.

This year, 21 countries are urging "concrete action" to boost water security and resilience due to water stress during the summer. A socio-economic study by Water Europe, an organization focused on water-related innovation, found that over €255 billion in water investments will be needed in the next six years to protect Europe's economy.

Investment Considerations

The globe has reached an inflection point for modernizing neglected and antiquated water infrastructure. Improvements are critical to ensuring water security to avoid threats to sustainable growth, social stability, and climate resilience. Nations at the forefront of adopting technology that strengthens water infrastructure through improved management and efficiency will realize a competitive advantage.

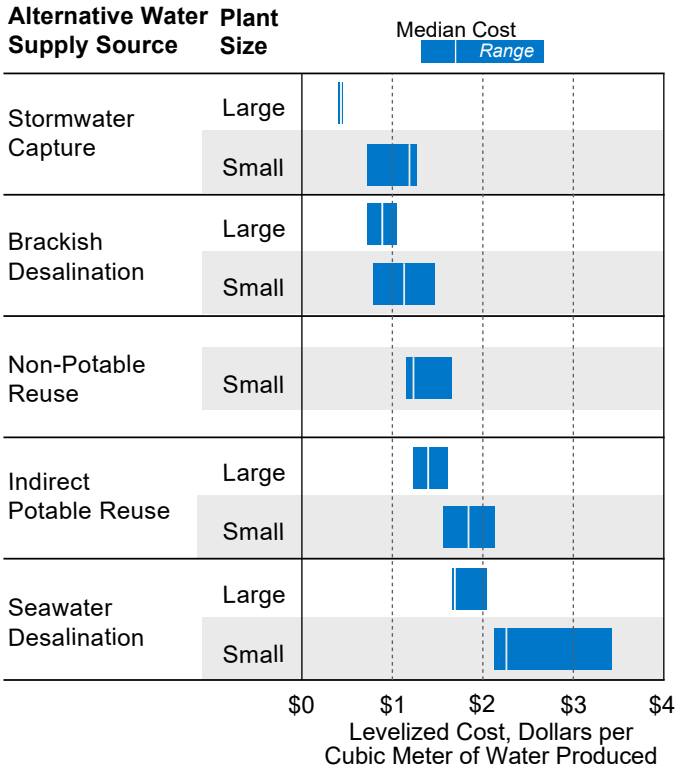
Aside from modernizing critical water infrastructure, we are in the camp that diversifying water supplies by adopting new capabilities across storage and reclamation will become a global megatrend.

8 European Environment Agency

Specifically, water recycling through reclaiming wastewater is positioned to become a key strategic supply (Chart 7). For nations unsustainably depleting groundwater, reclaimed water is proving to be a critical supplement to replenish groundwater aquifers by pumping recycled water back down. Singapore and [redacted], nations with limited water resources, have become the most water efficient nations in the world by reconfiguring their water infrastructure to accommodate advanced recycling and storage. Their water self-sufficiency is a product of rainwater harvesting, large-scale wastewater recycling, and desalination plants. Treated wastewater now provides 40% of Singapore's water, while [redacted] treats and reuses 90% of its wastewater.

The **appendix** on the following page includes key technologies poised to improve water security. Investment vehicles with leading product offerings across the technologies referenced in the table include: Xylem (XYL), Pentair (PNR), Mueller Water Products (MWA), Veolia Environnement (VIE).

Chart 7 **Water Recycling Is Cost Effective**



Source: The Pacific Institute

Noah Ramos
Global Strategist

Key Next-Generation Water Infrastructure Solutions

Improvements	Key Technologies
Smart Water Management Systems and Water Saving Fixtures	Smart meters, IoT Sensors with capabilities across real-time water flow, pressure, leak detection, low-flow faucets
Advanced Water Treatment Technologies	Advanced membrane filtration, ultraviolet and oxidation processes, nanotechnology, automated water quality sensors
Predictive Maintenance and Demand Forecasting	Data-driven insights to forecast failures, optimize maintenance schedules, and predict peak demand times
Cloud-Based Water Management Platforms	Remote system management that facilitates collaboration between water utilities and stakeholders by making data more accessible, digital connection of various water assets within a system
Advanced Water Recycling	Membrane bioreactors, modular water recycling systems
Precision Irrigation Systems	Ultra-precise delivery to root zone, sensors and automated water regulation, soil moisture sensors
Drones and Robotics for Inspection	Drones equipped with cameras and sensors, submersible robots, autonomous inspection of critical water infrastructure