

# **Four Challenges in Water Resources**

ISSUES THAT WILL SHAPE THE 22<sup>ND</sup> CENTURY  
(and beyond)



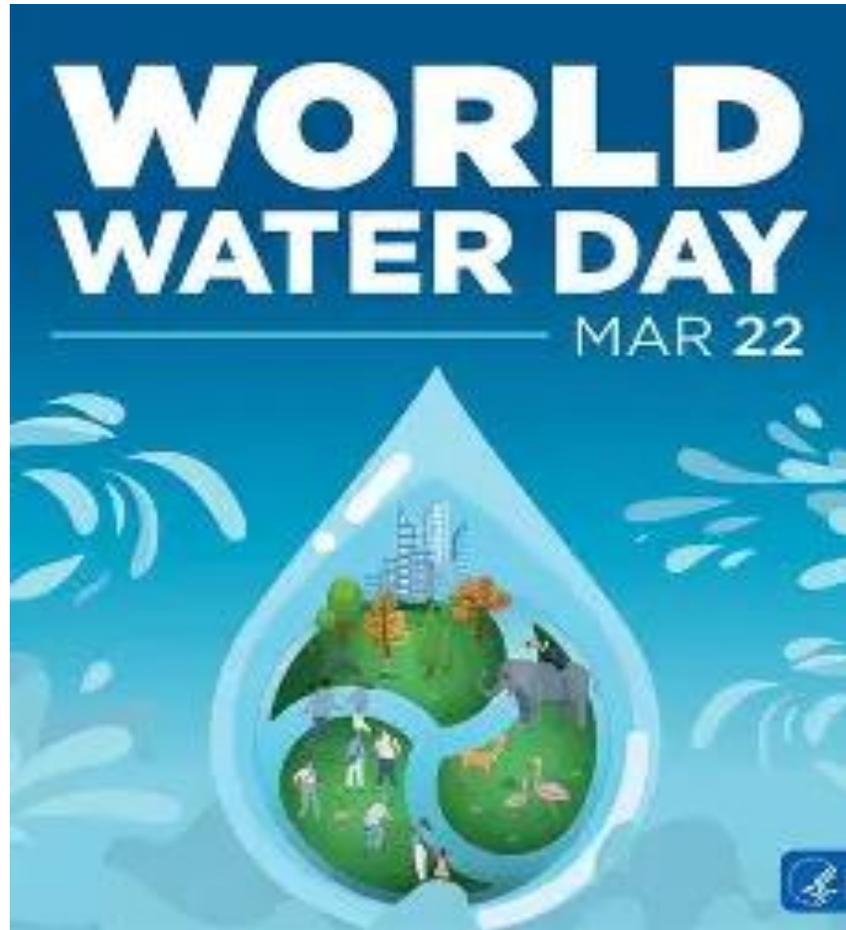
# **Four Challenges**

## **in Water Resources**

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1. Definition of “Water”
- 2. Water Distribution to Growing Urban Areas**
3. Surface Water Systems Degradation/Destruction
4. Growing Politicization of Water

# World Water Day on March 22, 2026



# **The Problem(s)**

There is an abundance of water on the planet, but that water is not always located in the areas where humans choose to live.

And that problem is growing larger as more people relocate (and are born) into areas with limited local water supplies.

And the places where more people are moving to often have poorly designed or deteriorating water systems.

And on top of that, humans are despoiling the water that is proximal to their homes.

# **The Problem(s)**

And on top of that, humans are depleting water reserves in the very locations where humans are growing their food.

And on top of that, humans are growing their food in a manner that is wasteful of water.

And on top of that, humans often grow water-demanding crops in areas of little water.

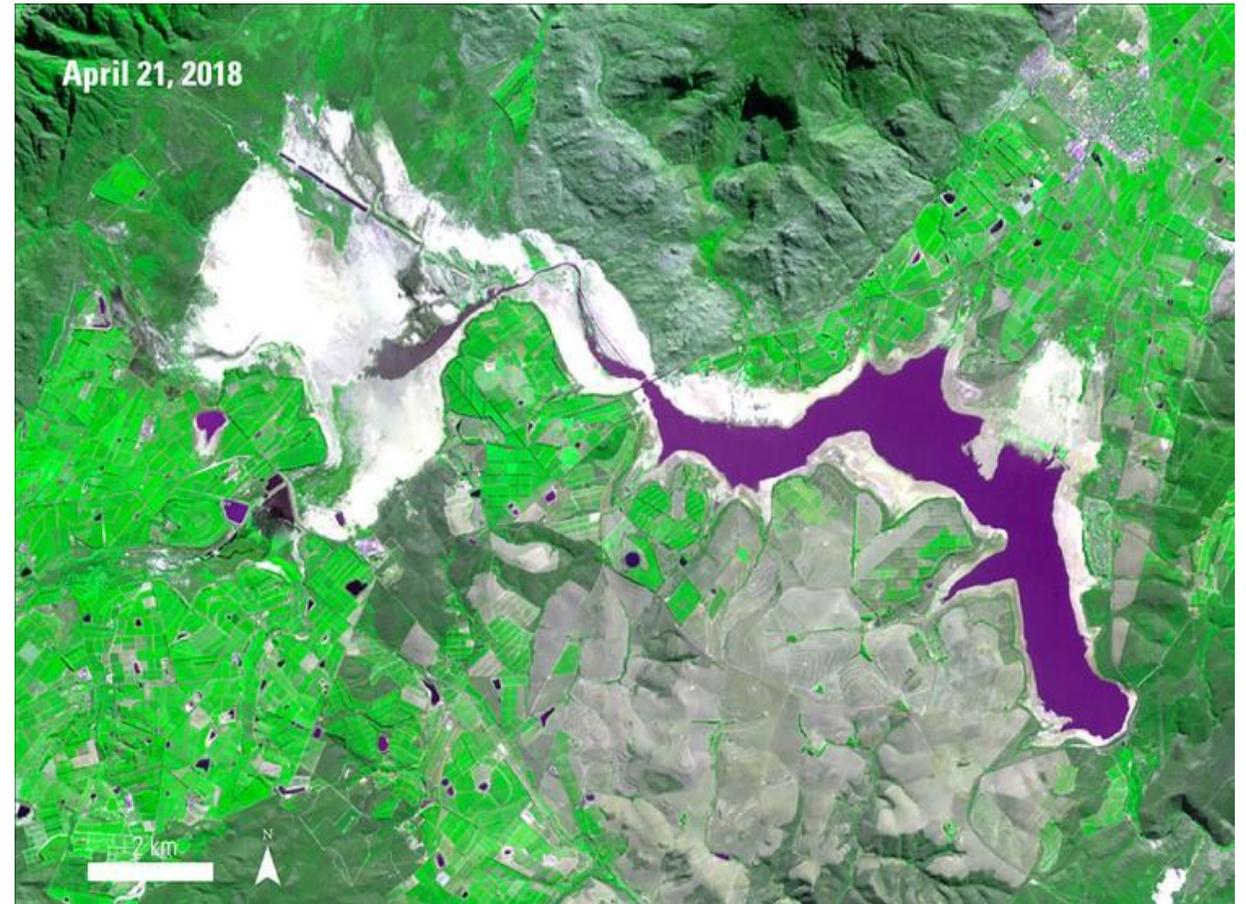
None of these issues are directly discussed in this class although central water systems for human consumption and central water systems for irrigation are often interconnected either directly or hydraulically.

## Challenge #2: Distributing Clean Water in Growing Urban Areas

Cape Town, South Africa had a population of 4.4M in 2018. Three years of subnormal rainfall left three of the six city reservoirs virtually empty and the primary reservoir at 17% capacity (see photo). Severe water restrictions were implemented, with residents provided with 50 liters of water per day (13 gallons). City officials stated that the City was “within weeks” of a complete water shut-off.

A series of storms in mid-2018 averted “Day Zero”.

In 2025, the population of Cape Town was estimated at 5M.



## Challenge #2: Distributing Clean Water in Growing Urban Areas

Chennai India had a population of 6.7M in 2019. A severe drought (3 years of subnormal monsoons) left all four city reservoirs virtually empty in June of that year. On June 19<sup>th</sup>, “Day Zero” was declared.

Severe water use restrictions were implemented and the State government trucked into the City 10,000,000 liters of water per day until the monsoon rains returned.

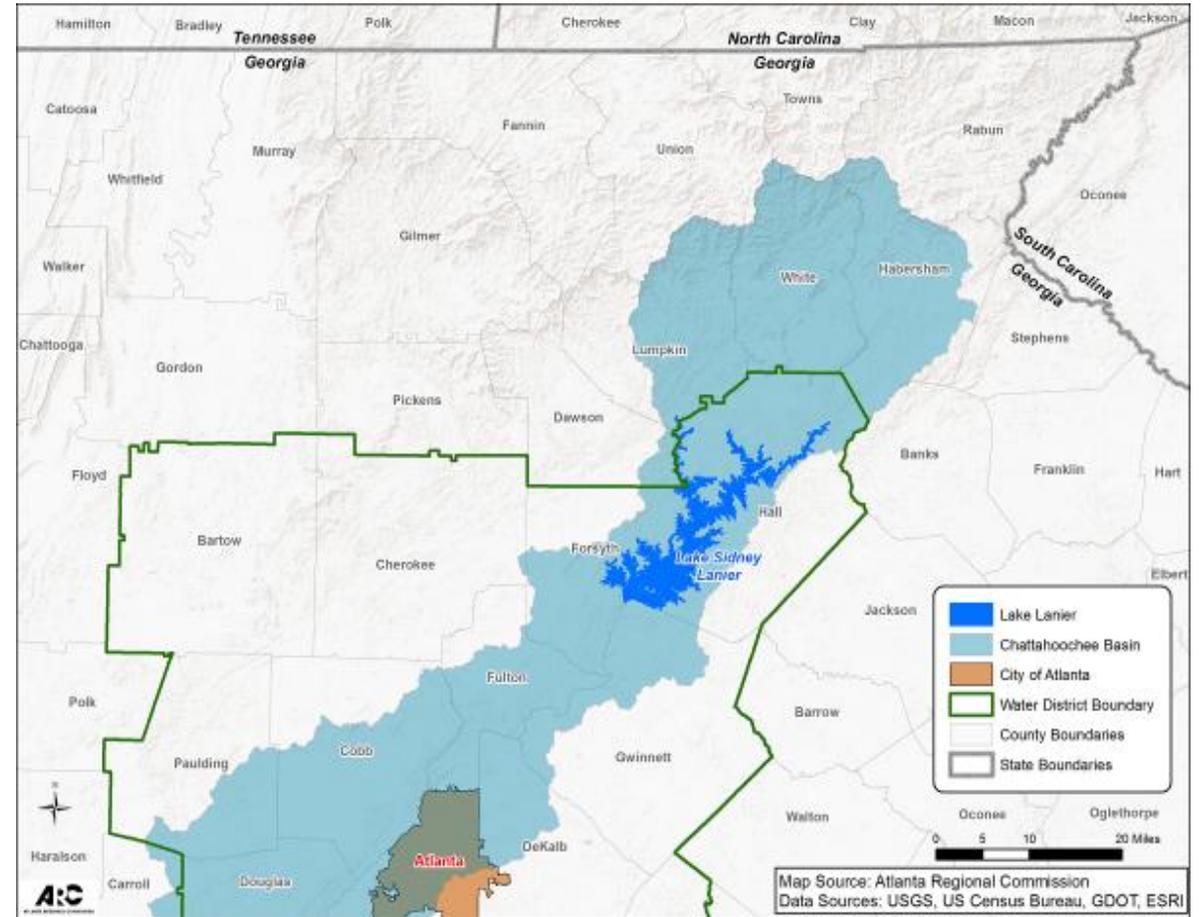
In 2025, the population of Chennai was estimated at 12.3M.



# Challenge #2: Distributing Clean Water in Growing Urban Areas

Atlanta, Georgia's water comes primarily from Lake Lanier, a reservoir that has become the center of a three-state water war between Georgia, Florida, and Alabama. The U.S. Army Corps of Engineers' 2024 water management plan showed Lake Lanier at 65% capacity, well below normal levels.

Metro Atlanta's population has surged to over 6 million people, making it one of the fastest-growing regions in the country. The Georgia Environmental Protection Division projects that without new water sources, the region could face severe shortages during drought conditions by 2028. The situation is complicated by legal battles over water rights that have lasted over two decades, leaving long-term planning in limbo.



## Challenge #2: Distributing Clean Water in Growing Urban Areas

“Day Zero” is the most dramatic result of this water crisis.

But chronic shortages represent an equally constricting dynamic.

Currently (2024), Mumbai, India operates on a 15% daily water shortfall. As a result of economic inequities in the City’s infrastructure, one municipal ward is provided with water 24/7, while the remaining 23 wards receive an average of 5.37 hours of water per day.



## **Challenge #2: Distributing Clean Water in Growing Urban Areas**

Rapid urbanization is straining existing infrastructure, often in locations where natural water supplies (either precipitation or groundwater resources) are insufficient to accommodate the projected demand. This process is occurring in areas of existing infrastructure as well regions with poor or no infrastructure.

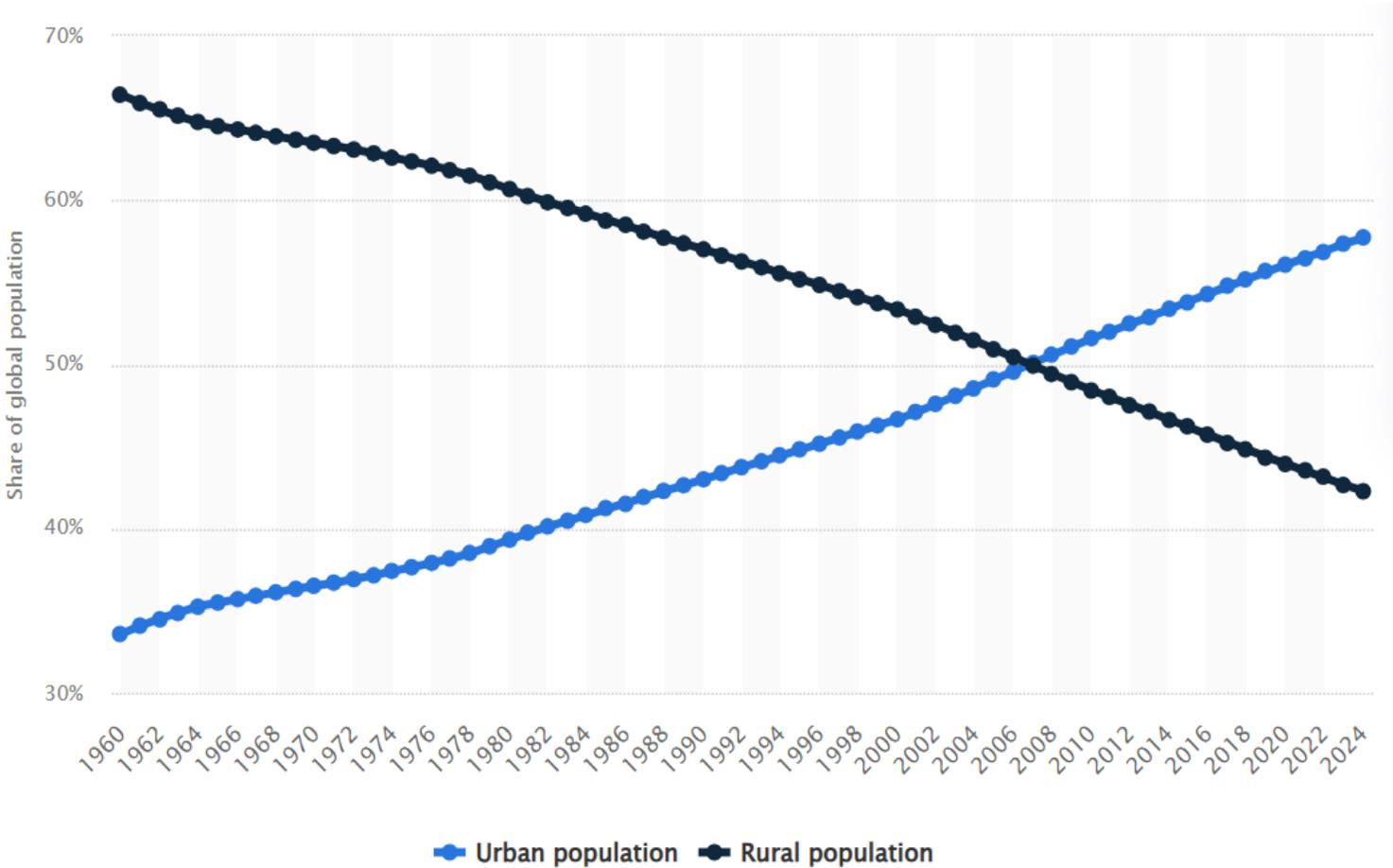
And then there is the added complication of:

- Deteriorating pipes
- Climate change

# Challenge #2: Distributing Clean Water in Growing Urban Areas

In 1960, only a third of the world's population lived in urban areas.

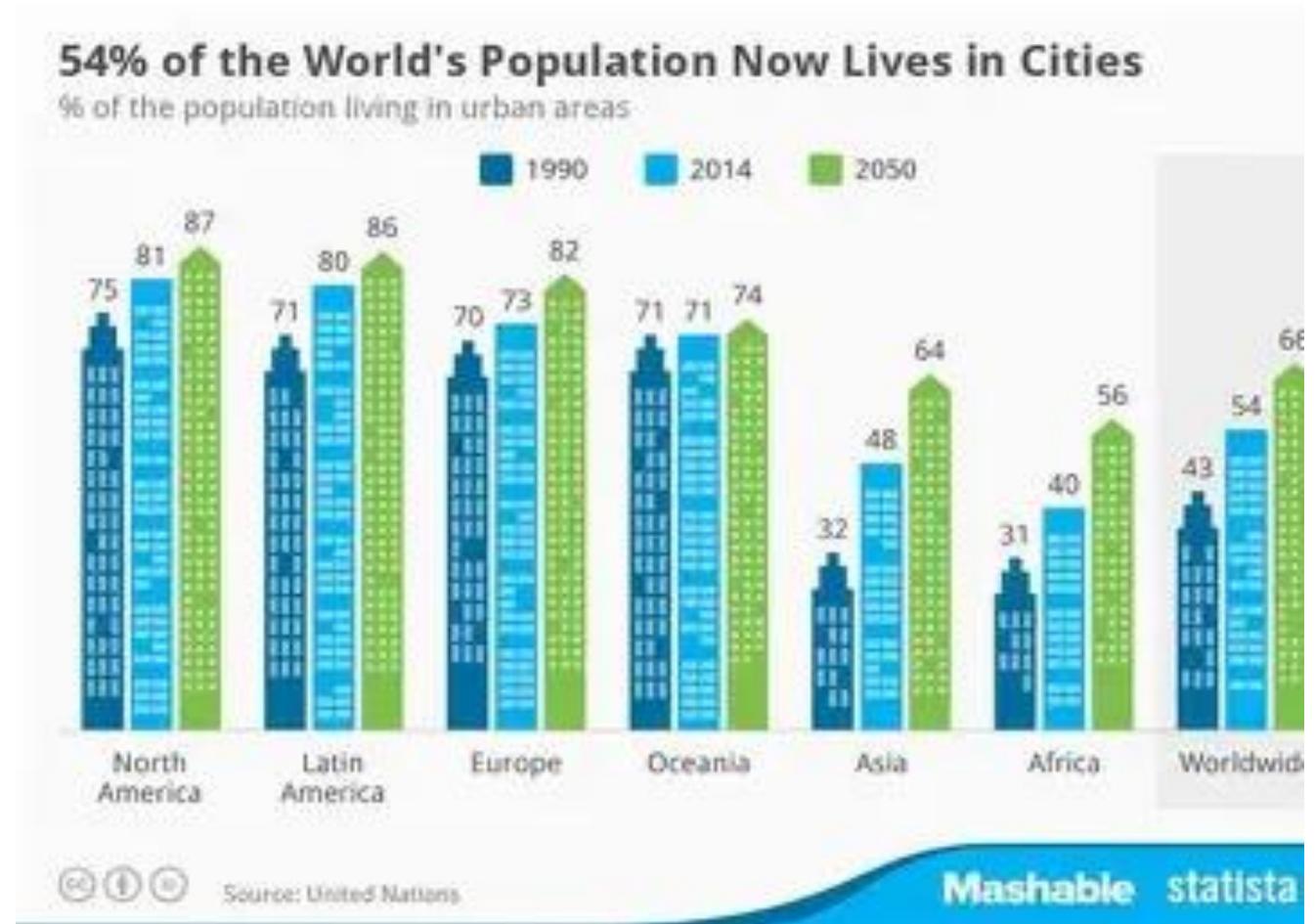
2007 was the first year when more people (around the world) lived in urban areas than rural areas.



## Challenge #2: Distributing Clean Water in Growing Urban Areas

It is projected that by 2050 more than two-thirds of the world's population will live in urban areas.

This amounts to a projected increase of 2.3 billion people into urban areas in the next 25 years.



## Challenge #2: Distributing Clean Water in Growing Urban Areas

Two additional dynamics will contribute to this future crisis:

1. The majority of this population increase will occur in developing nations (see photo of Dhaka, Bangladesh), where money and innovative technology is limited; and
2. Much of this population growth will occur along coastal areas.

The World Bank is predicting (2023 report) that 65% of the world's population could face water shortages by 2035.



## Challenge #2: Distributing Clean Water in Growing Urban Areas

But population increases do not fully describe the complexity of the challenge, particularly in the developing world.

In addition:

- Aging infrastructure in developing nations contributes to leakage (waste) and inequitable distribution
- Poorly designed infrastructure leads to incomplete/inefficient distribution and possible distribution of water-borne diseases
- Corruption within public agencies delay improvements
- Public ignorance of the challenge contributes to inefficient consumption habits

In 2005, none among 35 Indian cities with populations above one million distributed water more than a few hours per day, despite generally sufficient infrastructure. Due inadequate water pressure, people struggled collecting water even when available. Service benchmarking carried out 2006 across 28 cities found average supply duration around 3.3 hours daily, ranging from one hour every three days up 18 hours daily.

# Why Does This Matter?

The need for expanded and technologically advanced water systems is generally located in parts of the world where there is no (or limited) money to construct such needed systems.

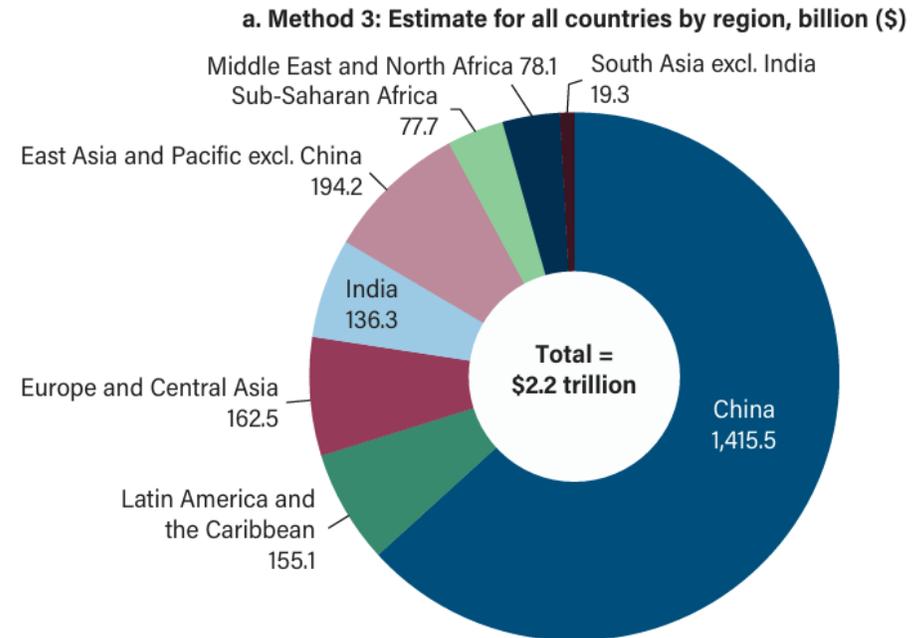
At its core, the issue of constructing water systems is a conversation of inequity.



# Why Does This Matter?

From an economic perspective, the need for water in developing nations represents in total expenditures one of the largest capital investments in world history.

The areas of need do not correspond to areas of wealth which makes the construction of water systems an opportunity for tremendous wealth transfer.

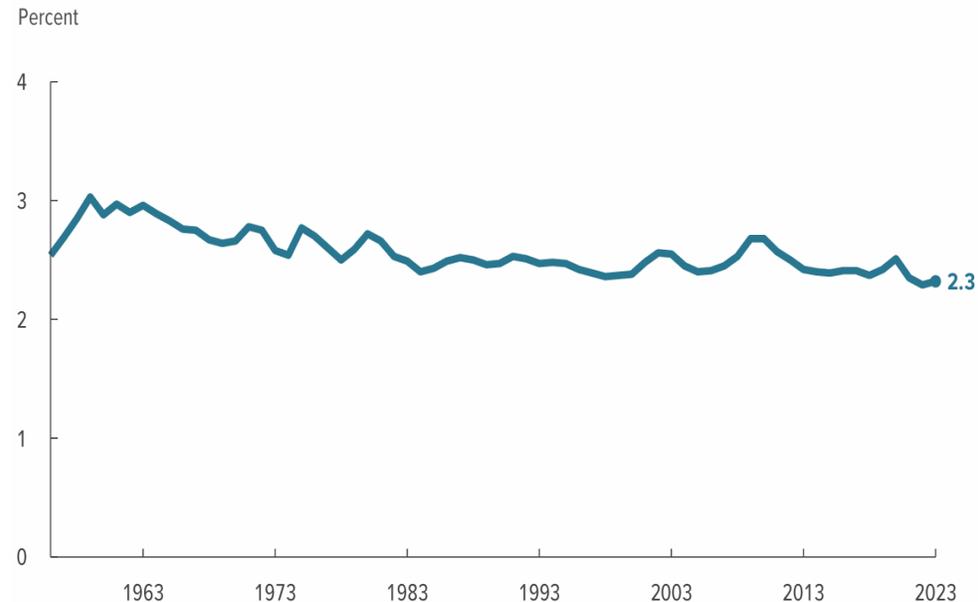


# Why Does This Matter?

From an economic perspective, the need for water in developing nations becomes an enormous financial opportunity for developed nations to sell services and innovative products as well as to transfer technology.

The amount of this needed investment has never been calculated although in 2024 the World Bank put forth an estimate of around 1%\* of world GDP annually, or \$1.1Trillion.

**Public Spending on Transportation and Water Infrastructure as a Share of GDP, 1956 to 2023**



\* The US, from 1956-2023, spent roughly 0.7% of GDP on water and sewer projects according to a 2025 CBO report.

# Why Does This Matter?

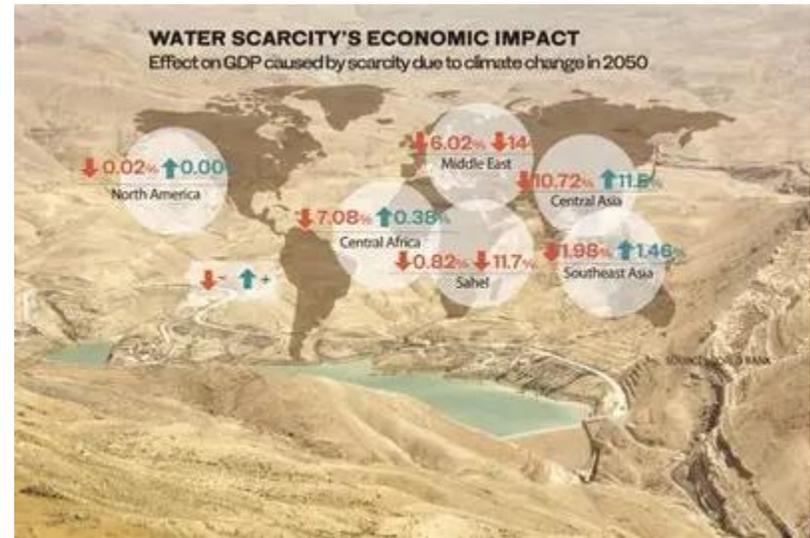
Currently, the world's investment in central water and wastewater projects is one-tenth of that value.



# Why Does This Matter?

From a political perspective, the elimination of water insecurity promotes political stability.

Water insecurity is defined as “the capacity to safeguard access to adequate supplies of potable water and to have reasonable confidence in the presence of those supplies in the future.”



# Why Does This Matter?

Currently, 4 billion people experience severe water scarcity for at least 1 month per year.

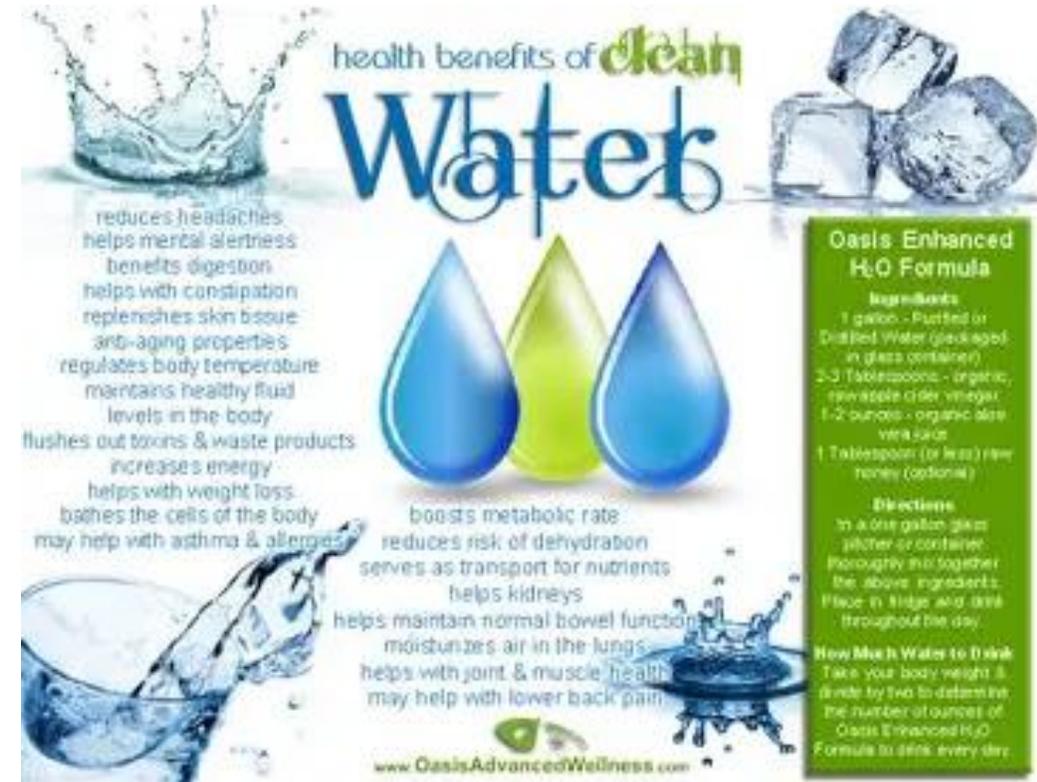
According to the WHO, over 2.1 billion people do not have access to potable water.



# Why Does This Matter?

From a Health perspective, the establishment of central water and wastewater systems contribute to:

- Reduction in the spread of pathogens
- Reduction in water-borne conditions including diarrhea
- Promotion of hygienic conditions



health benefits of **clean**  
**Water**

reduces headaches  
helps mental alertness  
benefits digestion  
helps with constipation  
replenishes skin tissue  
anti-aging properties  
regulates body temperature  
maintains healthy fluid levels in the body  
flushes out toxins & waste products  
increases energy  
helps with weight loss  
bathes the cells of the body  
may help with asthma & allergies

boosts metabolic rate  
reduces risk of dehydration  
serves as transport for nutrients  
helps kidneys  
helps maintain normal bowel function  
moisturizes air in the lungs  
helps with joint & muscle health  
may help with lower back pain

**Oasis Enhanced H<sub>2</sub>O Formula**  
**Ingredients**  
1 gallon - Filtered or Distilled Water (packaged in glass container)  
2-3 Tablespoons - organic, raw apple cider vinegar  
1-2 ounces - organic aloe vera juice  
1 Tablespoon (or less) raw honey (optional)

**Directions**  
In a one gallon glass pitcher or container thoroughly mix together the above ingredients. Place in fridge and take throughout the day.

**How Much Water to Drink**  
Take your body weight & divide by two to determine the number of ounces of Oasis Enhanced H<sub>2</sub>O Formula to drink every day.

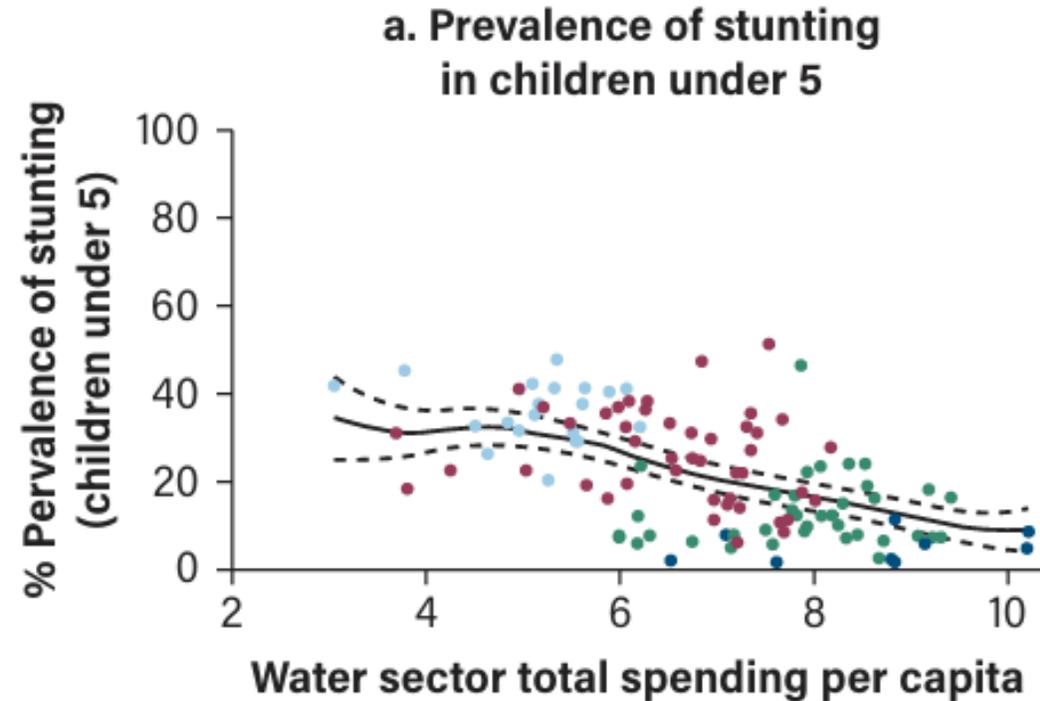
[www.OasisAdvancedWellness.com](http://www.OasisAdvancedWellness.com)

# Why Does This Matter?

From a Health perspective, the UN and most international health organizations have tied the provision of adequate supplies of potable water to food security and, by extension, adequate nutrition.

In the World Bank report, the following statement is made:

“at every level of income, higher spending per capita on the water sector is positively associated (correlation coefficient of 0.59) with lower stunting.”



# Why Does This Matter?

From an economic development perspective, the presence of a stable water supply promotes economic growth and economic self-sufficiency.



# Objectives

1. To expand access worldwide to dependable potable water for all people regardless of income by focusing on:
  - Source control (where the system's water comes from)
  - Source enhancement (expanding the capacity of that source)
  - Improvements in product distribution
  - Inclusion and active participation of all stakeholders
2. To promote institutional, corporate, and residential water management strategies that result in sustainable water consumption practices.

# Solutions

To reach these objectives, solutions will be:

- Multi-faceted, employing several separate strategies at once
- Flexible, to be effective with varying sectors of the world economy/society
- Dynamic, to be responsive to changing conditions and to be capable of modification as conditions change
- Immediate and long-lasting
- Economically impactful, with that impact being disproportional to the current generation

# Solutions

## Solutions Discussed:

- Improvements in Water System Efficiencies
- AI and ML
- Desalination
- “toilet to Tap”
- Interbasin Transfers

## Other solutions:

- Rainwater harvesting
- Reservoir management (capping, reductions in infiltration, improved piping)
- Watershed enhancements

# Solutions

It cannot be overstated the impact of climate change on this issue. Rising sea levels will threaten existing water systems (all 14 WWTFs in NYC are at risk of flooding by 2070) and should raise legitimate concerns about even investing in urban areas subject to flooding such as Mumbai (anticipated displacement of 28M people by 2100).

Computer image of the impact of rising sea levels on Miami, Florida



# Efficiency in Water Distribution

Older water distribution systems (as well as the older portions of newer water distribution systems) leak. A recent estimate of US central water systems calculated a loss of over 2 Trillion gallons each day, the equivalent of 20-30 million homes. In NYC (one of the oldest and largest in the US), the water distribution system loses about 12-15% between collection and tap. Most engineers consider a 3-5% leakage rate optimal.



Leak Size	Gallons Lost Per Day	Gallons Lost Per Month
	360	11,160
	3,096	95,976
	8,424	261,144
	14,952	463,512

# Efficiency in Water Distribution

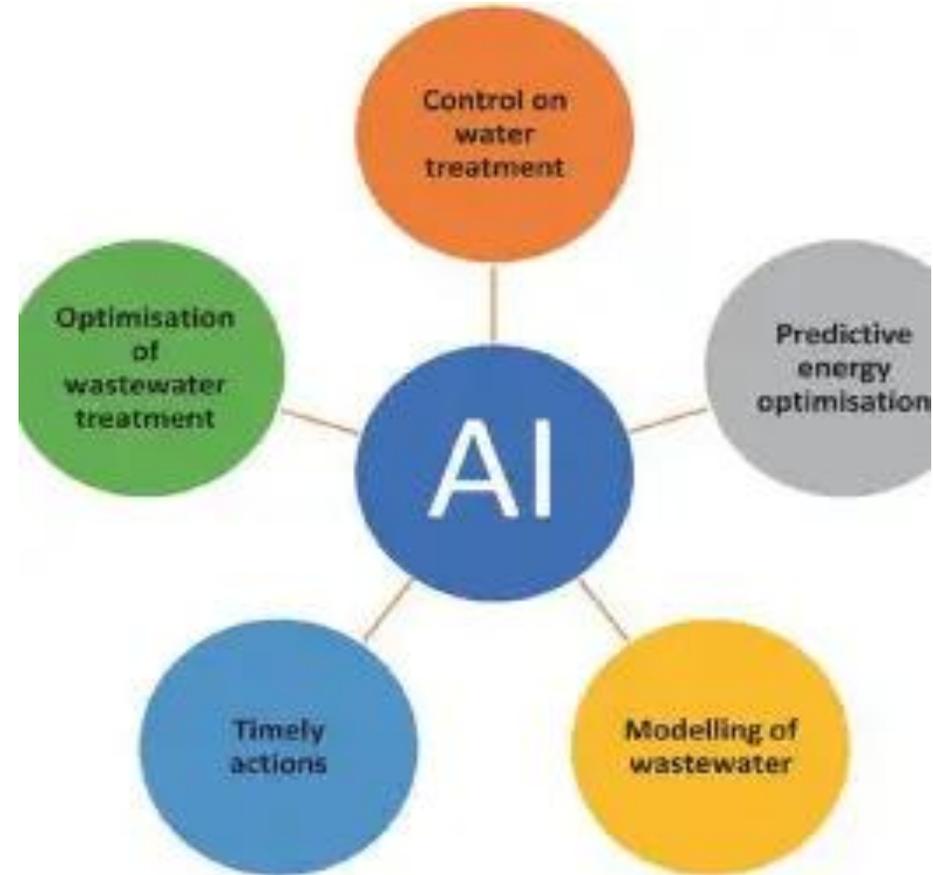
In India, the rate of loss in central water distribution systems is estimated at between 25% (US NIH, 2006) and 40% (India Infrastructure, 2023). In the City of Bangalore, a 2022 study estimated Non-Revenue Water (loss and waste) to be 50%.

The current system would need to provide double the amount of water needed.



# Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) are being increasingly used in water supply management to optimize operations, predict water demand, and detect leaks. For instance, AI-powered predictive analytics can help water utilities forecast water demand based on historical data, weather patterns, and other factors.



# Artificial Intelligence and Machine Learning

Some examples of AI and ML applications in water supply include:

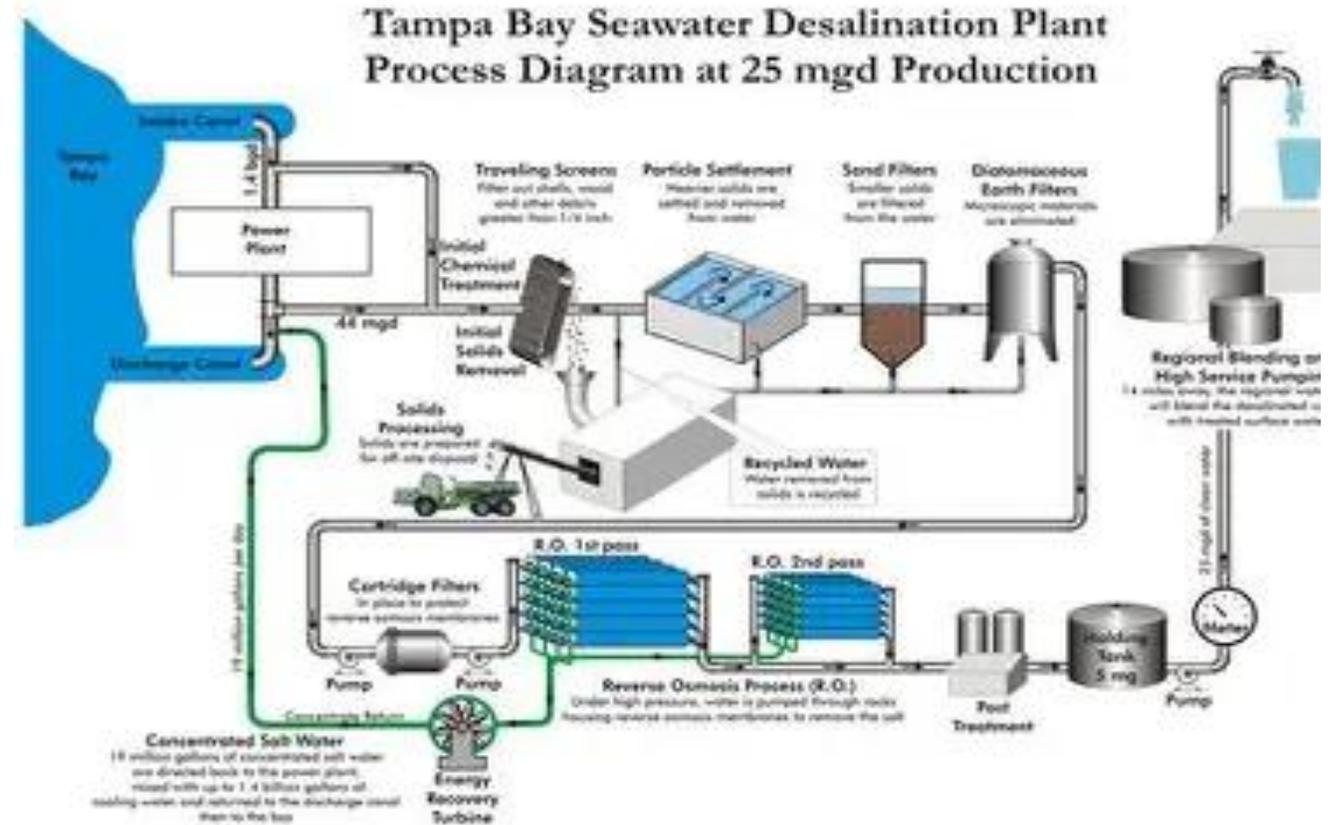
- Predictive maintenance: AI-powered sensors can detect anomalies in water infrastructure, enabling utilities to perform proactive maintenance and reduce downtime.
- Water demand forecasting: ML algorithms can analyze historical data and weather patterns to predict water demand, allowing utilities to adjust their supply accordingly.
- Leak detection: AI-powered acoustic sensors can detect leaks in real-time, enabling utilities to respond quickly and minimize water loss.



# Desalination

Desalination (the process of producing potable water from salt water such as oceans) is often referred to as the “drought-proof” solution to water problems.

97% of the world’s water is saline and roughly 15% of the world’s population (1.2 Billion) lives within 15 kilometers of a coast. In India alone, over 250M people reside by the ocean (and that number is growing).



# Desalination

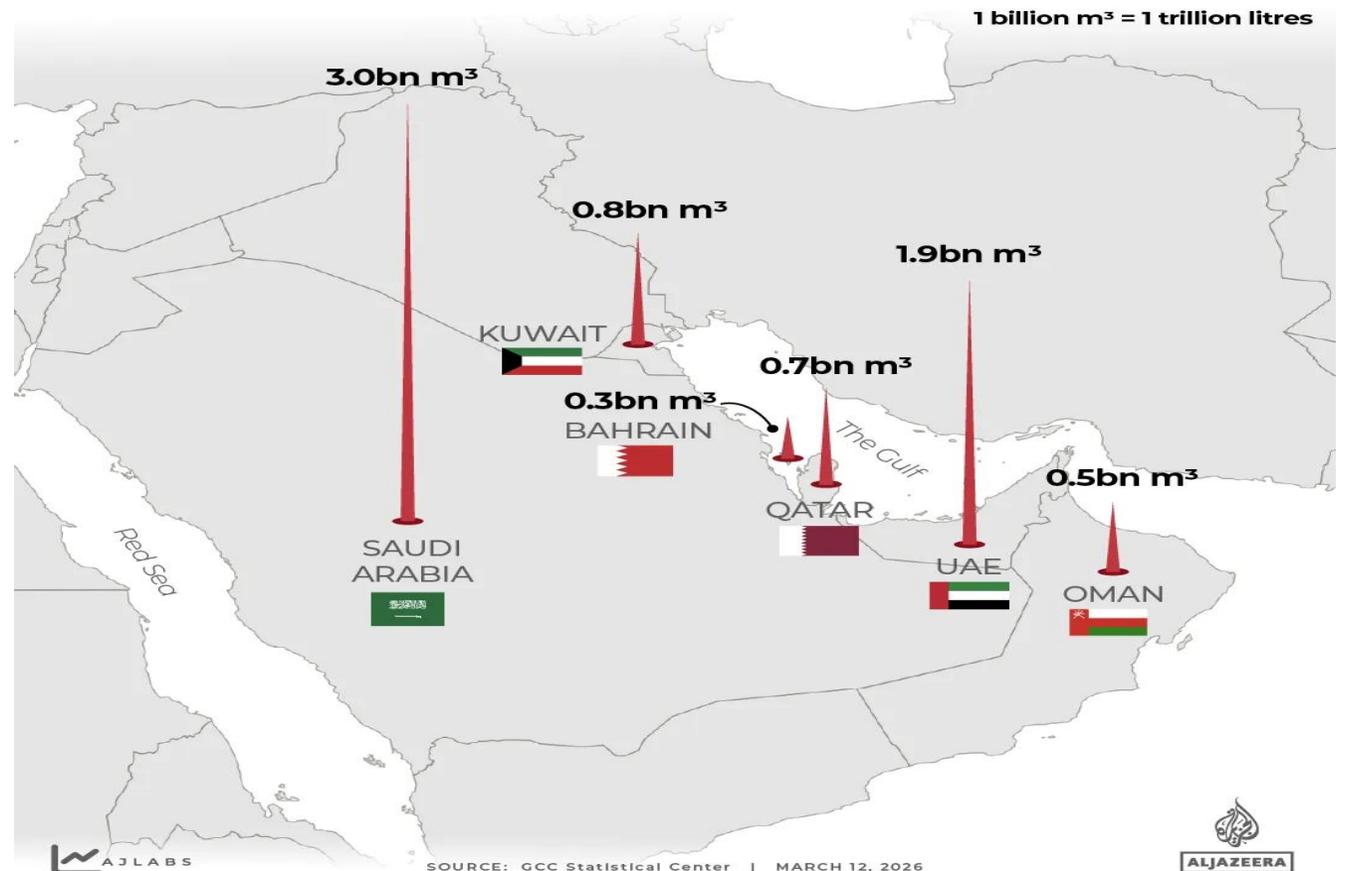
CC BY-NC-SA

Worldwide, desalination currently provides water to about 1% of the world's population. According to *Fortune* (7/26/2024): "16,876 desalination plants in 177 countries produce enough desalinated water to support up to 972 million people per day, which equates to only 1% of the world's clean water supply."

But 40% of these plants are in the Middle East with some nations (e.g., Qatar at 61%) relying heavily on desalination for drinking water.

## 7.2 trillion litres from desalination

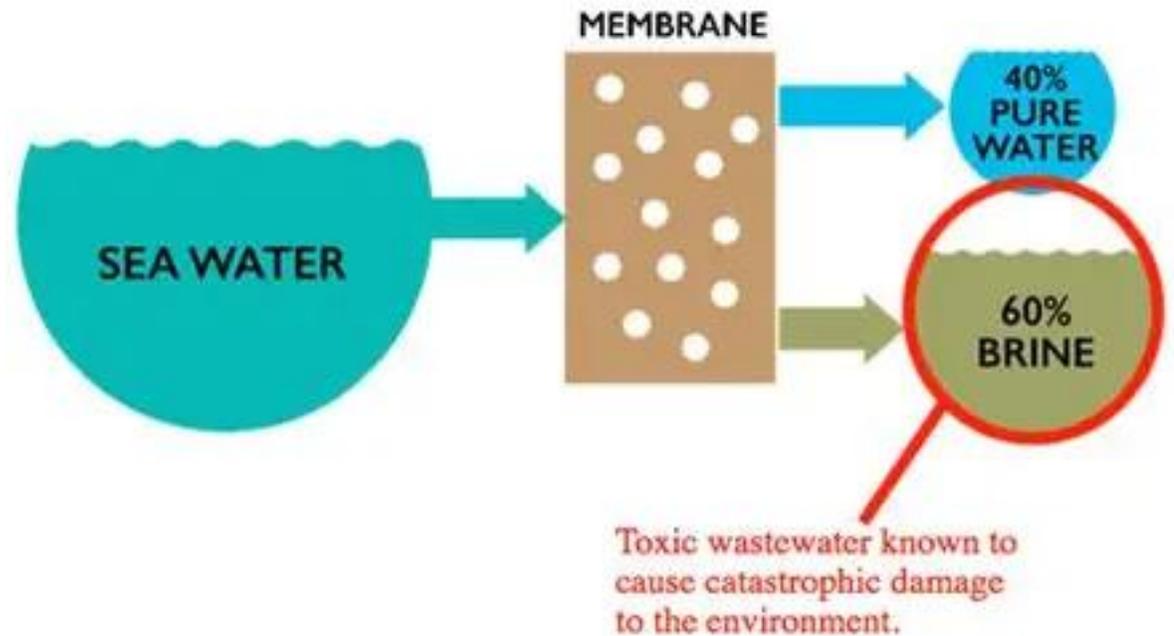
The Gulf countries produce roughly 40 percent of the world's desalinated water and operate more than 400 desalination plants. In 2023, they collectively produced 7.2 billion cubic metres, or 1.9 trillion gallons, of fresh water through this process.



# Desalination

## Impediments to Desalination:

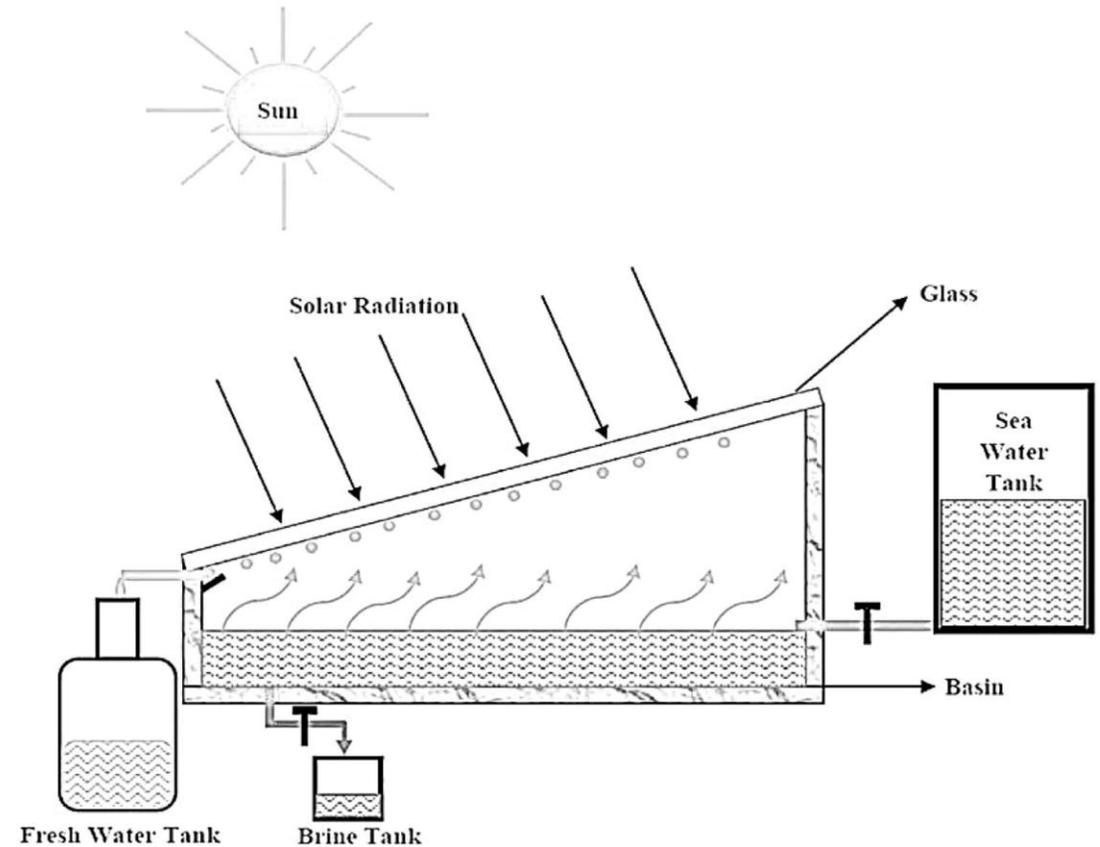
- Expensive. Construction, operations and maintenance costs are significantly greater than freshwater plants resulting in production costs 2.5-6 times higher.
- Changes in seawater quality, particularly increases in coastal algal blooms which clog intakes and foul filtration systems.
- Waste disposal, including brines generated by filters.
- Impacts to aquatic life at intakes and outfalls.



# Desalination

Technological advancements will have a significant positive impact on the cost-effectiveness of desalination plants.

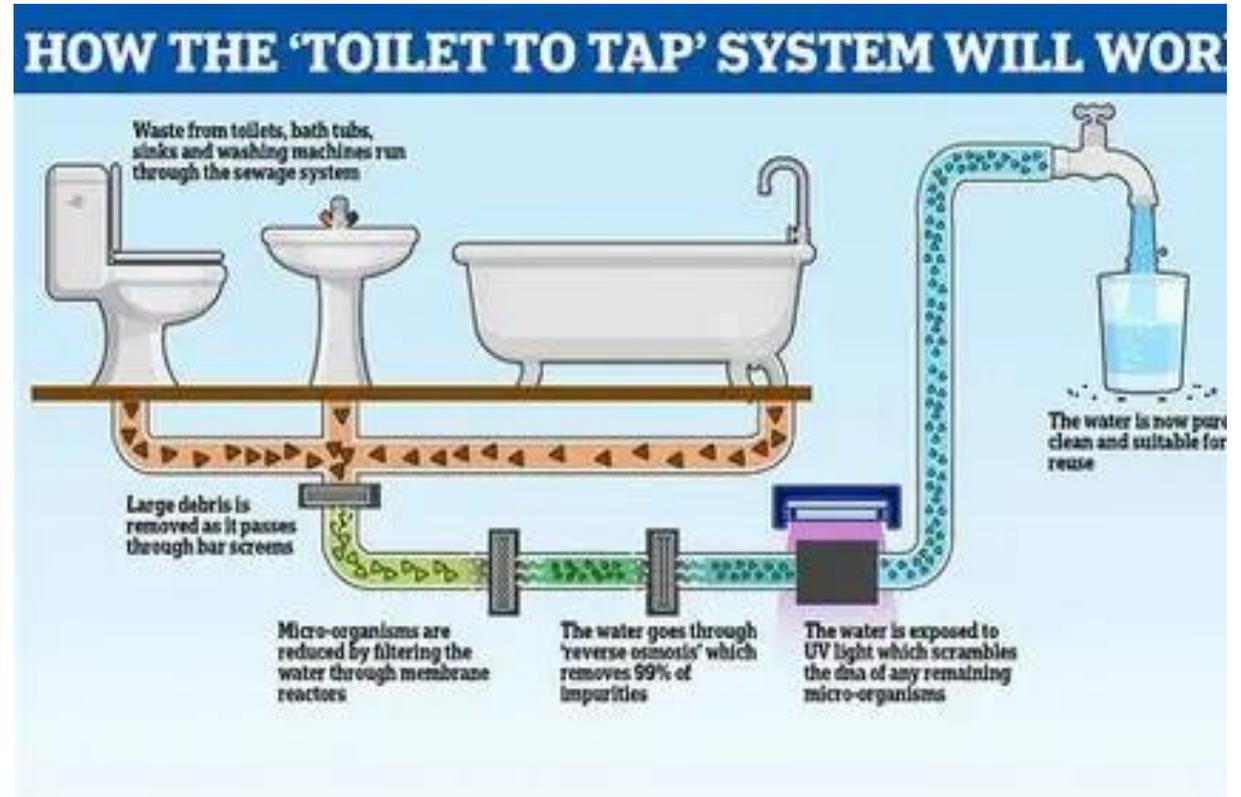
- Membrane efficiencies
- Energy source transition
- Brine repurposing



# Toilet to Tap Systems

The concept is rather simple: create a closed-loop system that allows consumed water that is returned to the system to be processed to levels sufficient for subsequent consumption.

“Greywater” systems already achieve this objective but more aggressive treatment can permit larger water systems to serve a larger population.



# Toilet to Tap Systems

This option is attractive in areas where traditional sources of water (surface water impoundments or groundwater aquifers) are depleted or unreliable).

El Paso, TX offers an example. This City of 679,000 people will bring on line in 2028 a tertiary wastewater treatment plant that will add roughly 10% of their total water usage.



# Toilet to Tap Systems

Logically, it should not matter what the source of one's drinking water is, so long as the treatment process ensures a purity level demanded for human consumption.

In 2023, California became the first state in the union to mandate the construction of such systems.



# Toilet to Tap Systems

Closed-loop systems are fraught with concerns.

- What happens when there is a system failure or contaminant breakthrough?
- What happens when emerging contaminants are identified?
- What are the energy demands for these systems?
- How will the consumption of water in an upstream community impact a downstream community?



# Interbasin Transfers

Water is, in large part, a distribution issue (both spatial and temporal). Water is often plentiful in areas where it is not currently needed and scarce in areas of high demand.

A solution is to move the water from one location to another.

In the early 1960s, the ACOE developed a concept of tapping water in Alaska and Canada and transferring it to drier areas in southwest US.



# Interbasin Transfers

This concept could help developing nations with uneven water distribution, such as India.

Almost 75% of all rainfall in India falls in the Ganges and Brahmaputra watershed but the potential redistribution of this water is complicated.



# Interbasin Transfers

## Advantages to IB Transfers

- Efficient use of water
- Reduction in impacts associated with droughts
- Reduction in use of depleting groundwater resources
- Potential positive step towards sustainability

## Disadvantages to IBWTs

- Significant potential for ecological damages in both originating and receiving locations
- Legal challenges where watersheds extend across state/national borders
- Easy conveyance of pollutants

# Expanding Funding for Water Projects

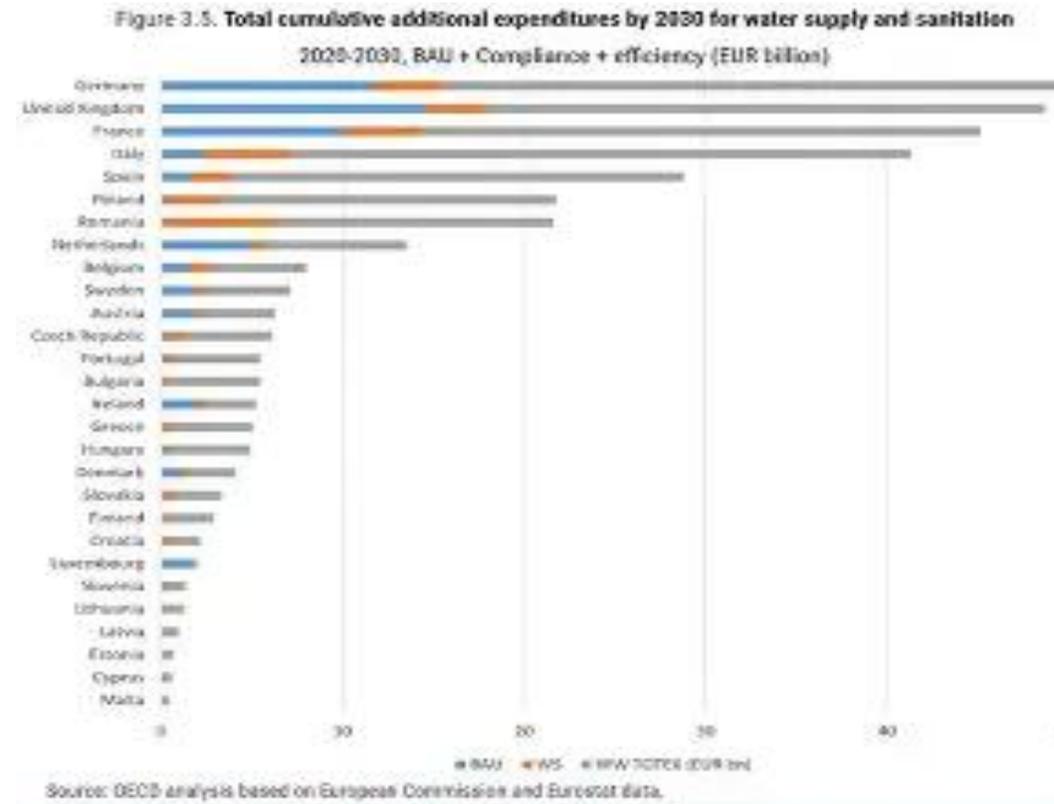
The World Bank estimates that funding for water and wastewater projects needs to increase by \$144B annually to meet current and projected demands for water systems. Current spending is 10% of this value and most of that spending is in areas of minimal need (developed nations).



# Expanding Funding for Water Projects

Future money will come from a combination of funding sources (user fees and direct governmental allocations) and financing (redistribution of costs over time).

Any fiscal proposal that envisions a sizeable contribution from fees will meet resistance from water rights activists.



# Conclusions

The need for central water systems is growing as both individual consumption and total population increases. Demographic shifts to urban areas near the coast exacerbates this crisis.

Potable water in the future will be increasingly met through technological means including desalination, greater water re-use, and mechanical transfers of water.

Existing systems need to be repaired to reduce leakage and improve product distribution.

Funding remains a significant hurdle, reflecting a lack of priority within nations having the financial means to assist.