

Avoiding Disaster by Developing Resilient Infrastructure through Decentralization

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Abstract

Water scarcity is perhaps the greatest existential threat facing humanity. It is widely acknowledged that natural disasters are becoming more common as a result of climate change, leading to increased risk for water insecurity. The recent COVID-19 Pandemic has highlighted another area of risk that is under explored; the connection between public health, pandemics, & water scarcity. We have seen how one crisis can create a ripple effect straining supply chains, economies, and ecosystems creating exponentially increasing risk that is difficult to forecast or mitigate.

This risk is compounded in part due to the delicate balance between water and the other Sustainable Development Goals.

The first part of this article underscores the importance of water security. The second reviews the barriers to providing improved drinking water using current methods. The third explores why current methods may not be enough, and the final part proposes a new solution based on creating a localized and decentralized water management system that embraces both the circular nature of the water cycle and the circular economy of the future.

The Importance of Water Security

Water scarcity is perhaps the greatest existential threat facing humanity.

According to the United Nations, water use has grown at more than twice the rate of increase in population over the last century, and it forecasted that by 2025, two-thirds of the world's population will be living in water-stressed regions.¹

While this burden is disproportionately shared; with both the poor & women being adversely affected, water scarcity already affects every continent.² Even those who have access to improved water sources are subject to risks from emerging contaminants³ and infrastructure failure.⁴

Adding to the urgency of the water crisis is the recognition that without water security there can be no sustainable development as “water touches every aspect of development and it links with nearly every Sustainable Development Goal (SDG). It drives economic growth, supports healthy ecosystems, and is essential and fundamental for life itself.”⁵

Despite the known shortfalls in water infrastructure investment as well as the known future need for improved water, the most pressing risk does not come from the future global water shortages that are the primary focus of public policy; rather, it seems the greatest risk is most likely to come from a Black Swan Event that has not been considered in existing sustainable development strategies.⁶

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Thinking beyond known deficiencies in the global healthcare system due water scarcity, what if the next pandemic is water-borne; possibly caused by antibiotic resistant *E. coli*⁷ that spreads

¹ UN-Water, “Scarcity: UN-Water,” UN, accessed June 1, 2022, <https://www.unwater.org/water-facts/scarcity/>.

² Ibid.

³ Lofrano, Giusy, Giovanni Libralato, Sureyya Meric, Vincenzo Vaiano, Olga Sacco, Vincenzo Venditto, Marco Guida, and Maurizio Carotenuto. “Occurrence and Potential Risks of Emerging Contaminants in Water.” *Visible Light Active Structured Photocatalysts for the Removal of Emerging Contaminants*, 2020, 1–25. <https://doi.org/10.1016/b978-0-12-818334-2.00001-8>.

⁴ Bain, Robert, Ryan Cronk, Rifat Hossain, Sophie Bonjour, Kyle Onda, Jim Wright, Hong Yang, et al. “Global Assessment of Exposure to Faecal Contamination through Drinking Water Based on a Systematic Review.” *Tropical Medicine & International Health* 19, no. 8 (2014): 917–27. <https://doi.org/10.1111/tmi.12334>.

⁵ “Overview.” World Bank. Accessed June 15, 2022. <https://www.worldbank.org/en/topic/water/overview>.

⁶ Cort, Todd. “Black Swans and Sustainability.” Yale Center for Business and the Environment. Accessed May 2, 2022. <https://cbey.yale.edu/our-stories/black-swans-and-sustainability>.

⁷ Whitmer, Grant R, Ganga Moorthy, and Mehreen Arshad. “The Pandemic Escherichia Coli Sequence Type 131 Strain Is Acquired Even in the Absence of Antibiotic Exposure.” *PLoS pathogens*. Public Library of Science, December 19, 2019. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6922328/>.

through drinking fecal contaminated water, irrigating with it⁸, or from contaminated biosolids from wastewater treatment being used as fertilizer?⁹

However, rather than being concerned about the direct impacts of water insecurity, perhaps we should most concerned about the increasing near-term risk that stems from indirect impacts impacts as many other necessary resources are also heavily reliant on water; such as agriculture or energy.

As counter-intuitive as it seems, we should be most concerned about the risk that stems from war over water as nations struggle to adapt to the fragility of global and national infrastructure and the challenges of climate change. Resource wars are a leading cause of conflict globally.

Imagine for a moment that a single country or region chose to expand its agriculture to support its growing population. As this requires more water for irrigation, they build a dam. At first, everything seems great as they now have more food & water, but their neighbors are facing a water shortage which means soon they will be facing a food crisis.

Now imagine it has occurred in a major agricultural region and there are other nations that rely on the food exports this nation that could be facing a crisis as well. This situation has occurred and is occurring.¹⁰

Only one nation or region need experience a significant enough crisis and we could see the world plunged into war.¹¹

Faced with a known mid to long-term risk from the direct impacts of water scarcity and an unknown amount of near-term risk from indirect impacts, water scarcity is perhaps the most pressing concern for humanity. Seeing now how urgent & important the issue of water scarcity is for the future of humanity, let us now turn to the barriers preventing us from achieving the elimination of water scarcity.

Current Barriers to Providing Improved Drinking Water

When it comes to achieving SDG Goal 6 and successfully supplying improved water sources globally there are two primary considerations; water supply and water quality. These issues can be further considered according to their diverse categories of cause; such as Environmental,

⁸ Canizalez-Roman A;Velazquez-Roman J;Valdez-Flores MA;Flores-Villaseñor H;Vidal JE;Muro-Amador S;Guadrón-Llanos AM;Gonzalez-Nuñez E;Medina-Serrano J;Tapia-Pastrana G;León-Sicairos N; “Detection of Antimicrobial-Resistance Diarrheagenic Escherichia Coli Strains in Surface Water Used to Irrigate Food Products in the Northwest of Mexico.” International journal of food microbiology. U.S. National Library of Medicine. <https://pubmed.ncbi.nlm.nih.gov/31146052/>.

⁹ Horswell J;Ambrose V;Clucas L;Leckie A;Clinton P;Speir TW; “Survival of Escherichia Coli and Salmonella Spp. after Application of Sewage Sludge to a Pinus Radiata Forest.” Journal of applied microbiology. U.S. National Library of Medicine. <https://pubmed.ncbi.nlm.nih.gov/17897236/>.

¹⁰ Al-Anani, Khalil. “Water Conflict between Egypt and Ethiopia: A Defining Moment for Both Countries.” Arab Center Washington DC, April 7, 2022. <https://arabcenterdc.org/resource/water-conflict-between-egypt-and-ethiopia-a-defining-moment-for-both-countries/>.

¹¹ Feitelson, Eran, and Amit Tubi. “A Main Driver or an Intermediate Variable? Climate Change, Water and Security in the Middle East.” Global Environmental Change. Pergamon, March 23, 2017. <https://www.sciencedirect.com/science/article/abs/pii/S0959378017302790>.

Economic, Technological, Social, & Geopolitical causes, all of which can lead to impacts on water supply as well as water quality.

A closely related issue, sanitation must be included alongside water, as research indicates that fecal contamination is a leading cause of water insecurity impacting up to 10% of existing improved water sources exposing up to 1.8 billion people to water-borne illness.¹² This suggests that the “global burden of disease estimates may have substantially understated the disease burden associated with inadequate water services.”¹³ Owing to their deep connection, this likewise suggests cost and difficulty estimates for existing sustainable development projects may have been underestimated.

The most obvious cause of water insecurity is due to physical scarcity leading to lack of access to a sustainable water supply, while issues of water quality prevent water from being utilized even though it may be abundant.

Industrial and Agricultural water withdrawals can lead to loss of potable freshwater due to either overuse or contamination making these economic barriers of primary importance to address.

Economic and Technological barriers are the next most pressing. The World Water Council estimate that costs to implement the necessary new water infrastructure may be as high as \$22.6 trillion by 2050,¹⁴ while the American Water Works Association estimates the necessary investment at \$1.7 trillion just in the United States. 54% of this investment would be required to go to replace existing infrastructure that has degraded.¹⁵

As an example of an environmental cause of water supply issues, we know that globally, coastal freshwater is being lost due to freshwater salinization caused by rising sea-levels.¹⁶

Additionally, water levels rising leads to flooding which leads to contamination of ground and surface water. Finally, temperature increase & weather pattern changes due to climate change leads to more evaporative losses of surface water, higher demand for consumption from industry and municipalities, and less rainfall. Example of environmental causes of water quality issues may include contamination with arsenic, radon, microorganisms such as Cholera, etc.

Social and Geopolitical issues such as ethnic conflict and issues of transboundary water access provide ample evidence that there is no one sized fits all solution to water security. We will need multiple solutions that embrace the principles of Appropriate Technology.

¹² Bain, Robert, Ryan Cronk, Rifat Hossain, Sophie Bonjour, Kyle Onda, Jim Wright, Hong Yang, et al. “Global Assessment of Exposure to Faecal Contamination through Drinking Water Based on a Systematic Review.” *Tropical Medicine & International Health* 19, no. 8 (2014): 917–27. <https://doi.org/10.1111/tmi.12334>.

¹³ Ibid.

¹⁴ “Fit to Finance?” Water. Accessed June 5, 2022. <https://www.worldwatercouncil.org/en/publications/water-fit-finance>.

¹⁵ “Home | American Water Works Association.” Accessed June 7, 2022. <https://www.awwa.org/Portals/0/AWWA/ETS/Resources/BuriedNoLonger2012.pdf?ver=2020-09-21-095318-407>.

¹⁶ Lassiter, Allison. “Rising Seas, Changing Salt Lines, and Drinking Water Salinization.” *Current Opinion in Environmental Sustainability* 50 (2021): 208–14. <https://doi.org/10.1016/j.cosust.2021.04.009>.

Why Current Methods or Improving Drinking Water May Not Be Enough

The current focus on creating sustainable systems for providing improved drinking water sources for the developing world relies largely on implementing the same centralized water infrastructure in the developing world as is currently used throughout the developed world.

However, it is short-sighted to believe the same solutions that are failing in the developed world are suitable for the developing world. Even if we ignore the various environmental, social, & economic issues related to implementing infrastructure similar to the developed world to provide improved drinking water to the developing world, there remains a stark, yet simple truth; centralized water infrastructure has failed to provide a lasting, sustainable solution for even the small percentage of the population that currently has access to it. We stand in need of new ideas.

Potential New Solutions

To overcome the multiple barriers identified, a renewed focus on decentralized point of use solutions is required. Another underutilized approach in need of further adoption is an emphasis on water reuse and reclamation. Open-Source Technology would be an ideal solution.