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OPINION

Turning global water security research into policy and action

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Water is a major contributor to climate change—producing 10 percent of global emissions, largely from energy use for water treatment and transport, and organic and wastewater decomposition [1]. And still, today two billion people live without access to safe drinking water, most notably in countries with among the lowest per capita emissions [2], and four billion experience water stress at least one month a year [3]. The linkages between climate change and water insecurity are clear, as are the implications for the global economy. Yet in my experience, my water research colleagues in higher education often remain reluctant to directly engage with policymakers to take action toward global water security. Often researchers do discuss the potential policy implications of our research, but are either hesitant or uncertain about how to engage with policymakers. There is perhaps also an optimistic view of "if we build it they will come" with regards to the impact of research and technology products. While perhaps unfortunate, journal articles and online data dashboards do not, intrinsically, create change on their own without linking those tools to improved policies, incentives and management practices.

There are emerging opportunities to both improve water security while reducing emissions—a 2024 report commissioned by WaterAid and the Voluntary Carbon Markets Integrity Initiative identified that 1.6 billion tonnes of CO_2e, monetizable as carbon credits, could be avoided or removed within the water sector globally [4]. Given the opportunities and increasing pressures wrought by climate inaction, in the past year my team and I have more often directly engaged with elected representatives both in the State of Colorado and in the US Congress, as well as leadership in major agencies such as the US Environmental Protection Agency (EPA), the US Agency for International Development (USAID) and the Colorado Department of Public Health and Environment (CDPHE) to translate our research into direct community-level water security actions. We have worked to link technological and community practice research with the economics of climate finance toward new approaches in water security.

On a global level, our team has worked since 2007 [5] to demonstrate the potential of carbon markets and improved technologies to improve accountable, financially sustainable water service delivery in low income settings. USAID Administrator Samantha Power [6] highlighted our water security efforts at an early 2024 event celebrating the 10th anniversary of the Water for the World Act on Capitol Hill earlier this year, "When Kenya's recent drought sparked a spike in water-related conflicts among rural farmers, as it tends to do, Kenya faced the challenge of more efficiently delivering scarce water resources to hard-to-reach communities. USAID, working again with private companies and nonprofit organizations, helped upgrade more than one hundred water systems across the country and establish real-time monitoring and remote sensors to detect failing pipes and boreholes from hundreds of miles

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away. In total, this partnership helped provide fresh water for more than 460,000 people in drought-prone areas, as well as the crops and livestock that helped feed and support entire communities," (USAID, 2024). USAID recently [7] further invested in this drought resilience program in northern Kenya, enabling our partners at the Millennium Water Alliance to repair boreholes and generate revenue generating carbon credits to pay for ongoing water services.

In the United States our engagement with Colorado elected legislators started with a commissioned report—we were tasked through 2021 legislation [8] with identifying emerging technologies and methods to improve Colorado water management. Our review identified key new opportunities in translating water quality science into community watershed restoration policy and action. State Senator Cleave Simpson, who is also the executive director of the Rio Grande Water Conservation District and a multigenerational alfalfa farmer, then partnered with us to advance watershed restoration technologies and finance opportunities through direct engagement with the legislative and regulatory process.

With Senator Simpson, we focused on the fact that over half of rivers in the United States are dirty—they currently don't meet the Clean Water Act 'fishable, swimmable, drinkable' standards [9]. Socially and economically marginalized communities everywhere are often the most negatively impacted by poor watershed health. This means communities across the United States are going to have to build more expensive, energy intensive and carbon emitting drinking and wastewater treatment infrastructure. Water and wastewater treatment plants currently account for about 2% of energy use [10] and 45 million tonnes of carbon dioxide equivalent (CO2e) emissions per year in the United States. Further, gray infrastructure technology upgrades will likely continue to increase overall energy demand and emissions. However, there is an alternative that is allowed under the Clean Water Act, whereby restoring wetlands, controlling soil erosion, and using regenerative agricultural practices communities can clean water holistically without building more infrastructure. We estimate that this approach of replacing the demand for electricity-driven water treatment with nature based solutions could avoid 30 million and sequester 4 million tonnes of CO2 per year in the United States [11].

These types of formal, market-based 'water quality trading' programs were established and recently strengthened by the EPA and several state-level regulators, but have not achieved large national scale despite often being much more cost effective. In order to identify barriers to scale, we have interviewed stakeholders including municipality, utility, non-profit, and state and EPA regulator staff. We found that regulators can find monitoring watershed projects challenging when compared to putting sensors in wastewater plants. And utilities won't spend public money on projects without a regulator's permit, which are more complex to draft and finalize for nature-based solutions. So regulators and utilities both would often rather build the gray infrastructure and benefit from its guaranteed performance and ease of monitoring rather than manage the complexity of nature-based solutions.

Given these challenges, working with Colorado State Senators Simpson and Jeff Bridges and consulting with CDPHE staff, in late 2023 we drafted and proposed new legislation in Colorado that was passed into law in 2024 entitled, "Green Infrastructure for Water Quality Management" [12]. This new legislation puts our team at the University of Colorado Boulder and Colorado State University in direct partnership with CDPHE to help overcome these barriers, marrying research and development of new water quality monitoring and modeling solutions with policy innovations to encourage regulated utilities to take pre-permit watershed actions that ultimately could be credited towards a Clean Water Act Permit.

These same community and state-policy level conversations also led Congressman Joe Neguse [13] of Colorado to provide a nearly million-dollar earmark in the 2024 NASA appropriations bill to enable advancing technologies to monitor Colorado's rivers and support accelerating watershed restoration programs. And the new National Science Foundation

Directorate for Technology, Innovation and Partnerships (NSF TIP) has been intentionally designed to encourage more direct community and policy engagement by local university researchers. Our team led the use-inspired research contribution to our successful up to $160M Colorado-Wyoming Engine Award [14], and our Convergence Award is already deploying water quality solutions in rivers in Colorado. Both of these awards are being leveraged toward advancing technologies, community engagement and policy innovations in watershed science and restoration in Colorado and beyond.

Separately, each of these initiatives could be viewed in isolation as conventional faculty research and service engagements. Together, they instead create a refreshed model for civic engagement by researchers—combining public and private research funding with community engagement and policy innovations toward direct water security actions both domestically and abroad.

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