Resilience as a Policy Guide for Water Management

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October 27, 2021

As core values, we often discuss economic efficiency and, at times, equity as guides to policy. Too rarely, however, do we value resilience. In the face of increasing systemic risks—a dangerous pandemic, cybersecurity attacks, electricity price shocks, wildfires, and droughts—we would be wise to take resilience seriously. In particular, with climate change threatening our world, the importance of elevating resilience as a core part of our policy toolkit will only increase.

For my talk today, I will focus specifically on resilience as a policy value as relevant to our water management challenges. In particular, I will first discuss the concept of resilience—a value more relevant than ever in a range of contexts beyond water management, including emergency response, pandemic preparedness, and cybersecurity. I will then move to the context of water management, explaining how a range of necessary investments in water infrastructure relate to the importance of resilience. Finally, I will offer some reflections on resilience as a policy goal.

I. Understanding Resilience

As an initial matter, it is key to understand that resilience is sometimes overlooked. This is because we tend to focus on economic efficiency as a central policy goal, focusing on the ability to provide goods and services at the lowest cost basis possible. Speaking broadly, efficiency seeks to maximize the value of the desired outputs given the available inputs. But there are a range of variants on this basic definition, including the well-known concept of "pareto efficiency," which means that any effort to deliver a product more cheaply to one party does not raise costs to another party.

The importance of resilience is it guards against systemic risk. One concept that is useful to keep in mind here is "margin for error." If an airplane carries extra fuel, for example, that provides more margin for error in case something goes wrong. But doing so comes at an economic cost, meaning there is a tradeoff between economic efficiency and resilience.

The airplane fuel example captures a core element of resilience—any operation must decide how much margin it wants to include against a possible error. In the case of the risk of wildfires, for example, one can imagine managing regular burning of forestland as a "fire brake" to prepare for the potential for larger, unplanned fires. Doing so, as Pierre DeVries explained, promotes resilience, meaning that "the collapse phase at one scale need not trigger the collapse of the entire ensemble."[1] For that reason, and to avoid the impact of fires contaminating our water, Denver Water is now proactive in thinning our forests, monitoring forest health, and engaging in fire management.[2] By doing just that, it is working to develop an *adaptive* system that is more

[1] Jean Pierre DeVries, *The Resilience Principles: A Framework for New ICT Governance,* J. ON TELECOMM. AND HIGHT TECH. LAW, 2011, at 152, http://jthtl.org/content/articles/V9I1/JTHTLv9i1_DeVries.PDF (last accessed July 12, 2021).

[2] https://www.denverwater.org/your-water/water-supply-and-planning/watershed-protection-and-management.

resilient because it includes mechanisms that enable it to adapt to and manage changes and external shocks like wildfires.

For an example of how the failure to take account of resilience can be devastating, consider Texas's recent experience with electricity prices during last year's cold wave. The reason that the Texas electricity market was not resilient—and vulnerable to both price shocks and a loss of electricity during a severe winter storm—is because it was not designed to withstand what were foreseeable shocks. As former FERC Commissioner Tony Clark explained:

> The Texas market was built around the theory that high prices and market volatility would encourage generation investment, thereby achieving resource adequacy. *But when a system is designed to run at the razor's edge of scarcity and average citizens are at risk of losing power when they need it most, that is a market failure*. No market should threaten the safety and well-being of citizens. Resource adequacy must be built into the system, and compensation must be provided for those resources that can provide it. In this regard, the regulated utility model has certain advantages which may better consider how resource adequacy is supported.[3]

Put differently, the design of the Texas electricity market did not include any investment in extra capacity and there was very little "slack" built into the system, putting it at risk of just the type of shock that led prices to soar and customers to go without power.

The Texas electricity market failure underscores how overvaluing economic efficiency arguments premised merely upon short-term prices for a product or service can lead to disastrous results. In theory, if one could implement the principle, a longer term insurance policy against systemic shocks purchased in the short term could capture the true costs of elevating economic efficiency concerns and de-valuing resilience concerns. In practice, however, it is very difficult to purchase insurance for a range of systemic shocks and, moreover, some of the systemic harms—losing access to electric power or water, for example—are not easily insured against. That is why former FERC Commissioner Clark stated: "The analyses are just emerging when it comes to the tragedy of recent weeks, but one thing is certain: resilience is crucial."[4]

One lesson from the 2021 Texas electricity debacle is a call for humility in system design and a recognition of the ongoing risk of shocks to an entire system. As Pierre de Vries put it, the "deep uncertainty about [complex] systems also implies the need for flexibility since, more often than not, one cannot be sure of either the problem or the best solution."[5] Such flexibility means that systems require ongoing monitoring and management, recognizing the potential for systemic risks and evaluating what margin for error is built into the particular system. Put in the language of economics, "resilience is a public good and tends to be underprovided because no individual

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[3] Tony Clark, *Five Myths of the Texas Power Crisis,* REAL CLEAR ENERGY, March 5, 2021, https://www.realclearenergy.org/articles/2021/03/05/five_myths_of_the_texas_power_crisis_766812.html (last accessed July 12, 2021).

[4] *Id.*

[5] DeVries *supra* note 1, at 154.

competitor is willing to carry the buffer needed for robustness in the face of catastrophe."[6] That public good can be addressed either as a matter of public regulation or public investment. In the case of the Texas electricity disaster, neither took place—and the shock to the system extended beyond Texas, as natural gas prices rose in states throughout the Midwest.

II. Resilience Lessons for Water Law and Policy

In today's world of extreme weather, including droughts and wildfires, resilience means that we need to prepare for changing weather patterns and its impact. In the case of water management, three policy priorities bear emphasis—(1) support for more adaptability and resilience in our agriculture sector; (2) investment and support for smart storage solutions; and (3) effective measurement and monitoring of water sources. Let me discuss each in turn.

A. Water for a range of agricultural crops and users

The challenges for water management include the need to reflect more deeply on what agricultural crops can be sustained in an era of increasing droughts. As Pierre deVries recognized in a different context, reliance on a single crop, without an ability to change, is a recipe for systemic risk. In particular, he explained, "a lack of bio-diversity has contributed to several agricultural disasters, including the Irish potato famine of 1846, the European wine industry collapse in the late 1800s, and the U.S. Southern Corn Leaf Blight epidemic of 1970."[7]

For today's farmers, a critical question is whether, when, and how they might diversify crops, adapting to the realities of climate change. Consider, for example, reporting in the *New Yorker* that "researchers at the University of California system concluded that the state's climate had changed so significantly that urgent adaptation was needed in the agricultural sector to address a number of accelerating negative trends, including 'crop yield declines, increased pest and disease pressure, increased crop demands . . . and uncertain future sustainability of some highly vulnerable crops.'"[8] In short, we are facing a range of challenges related to climate change that call for collaboration and innovation.

We need collaboration and innovation on several different fronts. For starters, let me highlight two of them. First, we must support farmers as they re-evaluate and adjust which crops they grow on account of not only market prices, but also based on a changing climate and more variable access to water. Second, we must develop institutional arrangements that allow for the transfer of water usage when circumstances call for it. The Arkansas Valley Super Ditch, for example, is achieving just that. In that case, several irrigators pooled their water rights to temporarily lease them to cities. Under that system, farmers earn income from the lease, farmers continue to plant appropriate crops, and communities can manage their water effectively (including

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[6] DeVries *supra* note 1, at 161 (citing THOMAS F. HOMER-DIXON, THE UPSIDE OF DOWN: CATASTROPHE, CREATIVITY, AND THE RENEWAL OF CIVILIZATION 286 (2006)).

[7] DeVries, supra note __, at 168.

[8] https://www.newyorker.com/news/california-chronicles/growing-uncertainty-in-the-central-valley

recharging wells).[9] Using a similar model, the System Conservation Pilot Program has demonstrated that producers in the Colorado River basin can also achieve success while temporarily, and voluntarily, reducing their water use.[10]

Colorado's Water Plan commits to maintaining Colorado's agricultural economy while adjusting to a changing climate with increased droughts and water variability.[11] One mechanism for achieving this goal is to develop voluntary agricultural transfer pilot projects, allowing the sharing of at least 50,000 acre-feet of agricultural water using voluntary alternative transfer methods—also known as water-sharing agreements—by 2030.[12] To that end, the Colorado Water Conservation Board has developed programs and grant funding to support water-sharing arrangements that seek to maintain agricultural productivity and water rights ownership while maintaining the right to buy or sell water rights.[13] Those agreements contain a wide range of options such as fallowing agreements, deficit irrigation, water banking, interruptible supply agreements, rotational fallowing, water conservation programs, and water cooperatives. Each of these options increase adaptability. And together with diversifying crops types and shifting to less water-intensive crops when and if economically viable for farmers, developing alternative transfer methods promises to bolter resilience.

I recognize that creating these sorts of changes will not happen overnight. Thankfully, Colorado State University is leading the way in interdisciplinary research and teaching related to preparing for a sustainable water future. I look forward to your continued work in this area.

B. Importance of Slack in the system, storage, able to divert

As I noted above, a system that operates with very little slack is vulnerable to systemic shocks, such as a drought. As an historical matter, Colorado enjoyed natural water storage in the form of snowpack. On account of climate change, however, Colorado has less natural snowpack today than we did 20-30 years ago. To build in more slack into our system, allowing us to adapt to droughts, we need to develop new forms of smart storage (such as Greeley did recently in finding a way to replenish aquifers[14]), build incentives and ability to conserve water when necessary, and re-use water to the fullest extent possible.

Conservation is where each of us, as individual citizens, can do our part to consume water more carefully. Every time individuals and businesses develop the ability to conserve water, it

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[9] https://www.hcn.org/issues/47.10/can-leasing-irrigation-water-to-keep-colorado-farms-alive

[10] https://www.coloradobasinroundtable.org/wp-content/uploads/2019/02/WaterBank_report_design_FINAL.pdf

[11] Colorado Water Conservation Bd., Colorado Dep't of Nat. Res., *The Colorado Water Plan*, 1-8—1-9 (2015) https://dnrweblink.state.co.us/cwcb/0/doc/199498/Electronic.aspx?searchid=80d50cb3-95bf-405c-bfa5-587c633c7136.

[12] Colorado Water Conservation Bd., Colorado Dep't of Nat. Res., *The Colorado Water Plan*, 6-116—6-117 (2015) https://dnrweblink.state.co.us/cwcb/0/doc/199517/Electronic.aspx?searchid=69705cbe-d4c1-446a-a4b9-00a411d2dad7.

[13] https://cwcb.colorado.gov/grants

[14] https://www.kunc.org/2021-02-15/greeley-sees-its-water-future-in-a-big-underground-bucket

creates more slack in our system and builds our resilience. Many Colorado cities, for example, offer rebates to change standard spray irrigation with alternatives like drip irrigation, replace certain types of water-intensive landscaping with low-water alternatives, and update inefficient plumping fixtures.[15] As we demonstrated already, our ability to make these changes is a conservation tool we have in our toolkit. But conservation alone is not and will not be enough. Indeed, a singular focus on conservation actually risks eliminating slack in the system because once conservation measures are fully implemented, we lose the ability to turn to those reforms to adapt to changing availability of water. In short, resilience demands a wide range of solutions.

Reuse is another tool that we must put to use as we create a resilient system. Reuse, particularly in Front Range cities, can reduce the need to import additional water from the Western Slope or buy water that is currently being used to irrigate agriculture. Aurora Water has committed much of its water future to reuse. Its Prairie Waters Project, for example, is an innovative potable reuse system that uses a sustainable water source by recapturing river water as a cornerstone of a water supply plan that will help meet much of Aurora's needs for decades.[16] Prairie Waters uses both natural cleansing processes and state-of-the-art purification technology to deliver up to 10 million gallons of water per day.

Resilience requires us to work together to employ many different tactics to achieve our collective goal. Stated simply, we need more creativity and innovative solutions, an area where CSU's leadership is also most welcome and valuable.

C. Opportunities for Simulation and modeling; advance planning and constant reassessment

Each of the examples I've mentioned so far is designed to create slack in the system. But maximizing the utility of that slack requires knowing how much there is at any given time or location. After all, "you cannot manage what you don't measure[17]." With respect to water management, there is a clear lesson here—we have an imperative of improving our measurement and monitoring of water. Thankfully, technological change is on our side, with emerging technologies that enable sensors and other forms of measuring water flows to operate effectively and inexpensively. We do have the challenge, however, of deploying that infrastructure. Over time, the concept of smart water management can and will become a reality.

The benefit of more effective measuring and monitoring of water flows in Colorado is that we can know in real-time what level of water is available to what users and what constraints may exist. In theory, such measurement systems can enable automatic decisions on when water can be used by whom, for example, by using Blockchain technology. To explore how such a model would

[15] shttps://coloradosun.com/2021/08/06/colorado-water-conservation-cuts/

[16] https://www.auroragov.org/residents/water/water_system/water_sources/prairie_waters

[17] This quote is attributed to Peter Drucker (https://hbr.org/2010/10/what-cant-be-measured), however Drucker may not have said this (https://www.drucker.institute/thedx/measurement-myopia/).

work, the Colorado General Assembly called for a study to evaluate how different remote sensing technologies can be used to monitor water flows and the usage of water.[18]

I recognize that there are ongoing experiments and innovations related to water measurement. At CSU, for example, such technologies are being tested and used to evaluate, for example, the amount of water evaporation.[19] And for water sharing arrangements, building such systems is absolutely essential. Moreover, such systems can also be used to monitor and manage soil health as well as ensure appropriate protection of groundwater reserves.

III. Resilience as A Core Value

Resilience is a concept whose time has come. As such, resilience principles should be incorporated into policy realms—as well as by business leaders. As our economy and society face greater risks of systemic shocks, we need to invest in resilience by design.

To appreciate the importance of resilience, consider, for example, the recent cyberattack on JBS in March of 2021.[20] This episode underscores the importance of a focus on resilience at two levels: (1) how concentrated is an industry; and (2) how prepared are critical sectors for cybersecurity risks? Even outside the risk of a cyberattack, the risk that "four giant companies that control more than 80% of U.S. beef processing" and could "unfairly leverage their power over farmers and consumers"[21] merited attention. In the wake of the cyberattack, the company shut down "all its U.S. beef plants, wiping out output from facilities that supply almost a quarter of American supplies."[22] From a cybersecurity perspective, this wake-up call—about systemic risks—came only a few weeks after a prior attack on Colonial Pipeline Co., which operates the largest U.S. gasoline pipeline and was shut down for days following a cyberattack.[23]

The COVID-19 pandemic underscores the importance of resilience and highlights how supply chains vulnerable to disruption are another risk that policymakers should attend to. As the *New York Times* reported, many supply chains focused on the goal of keeping inventories low and operating with maximum efficiency—in the face of the pandemic, however, this practice contributed to a range of product shortages, including a lack of PPE and protective gear for medical

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[18] House Agriculture, Livestock, & Water Hearing, Apr. 26, 2021 at 1:40:00 (blockchain is one mechanism for accounting of where water is going) and at 2:00:00 (blockchain as a way to balance and manage augmentation plans for wells) (testimony of Mr. Brown, Pike's Peak Regional Management Authority), https://sg001-harmony.sliq.net/00327/Harmony/en/PowerBrowser/PowerBrowserV2/20210919/32/11498. [CHANGE FN TO MAKE CLEAR THAT THIS WAS CALLED FOR BY GENERAL ASSEMBLY]

[19] https://watercenter.colostate.edu/wp-content/uploads/sites/33/2020/03/CR231.pdf

[20] Fabiana Batista et al., *All of JBS.' U.S. Beef Plants Were Forced Shut by Cyberattack,* BLOOMBERG, May 31, 2021, https://www.bloomberg.com/news/articles/2021-05-31/meat-is-latest-cyber-victim-as-hackers-hit-top-supplier-jbs (last accessed July 12, 2021).

[21] *Id.*

[22] *Id.*

[23] *Id.*

professionals.[24] This development underscored the patent lack of resilience planning across critical industries.[25]

A recent report authored by a British research team explores the opportunity that both public and private sector actors have to develop and implement core resilience principles in the wake of COVID-19.[26] The report discusses the concept and existence of extreme systemic risks, arguing that resilience principles are the key to preparation and mitigation. As a general matter, it highlighted that such risks are readily anticipated yet we often don't invest in the strategies that could mitigate the damage.[27] The costs associated with preparing and mitigating systemic risk through resilience are significantly lower than those expended if a crisis hits with no flex in a system.[28]

For our society to increase the importance of resilience planning involves both an adjustment to our core values as well as a shift in how we invest for the future. The report discussed previously calls for the addition of "chief risk officers" in both government and private companies who would be empowered to evaluate the risks we face as society, develop mitigation plans, and determine how best to implement resiliency practices.[29] We clearly have considerable work to do to adapt to the changing world we live in.

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Today, we are facing a set of intersecting challenges. Many of these challenges revolve around a lack of resilience and our exposure to systemic shocks. Over the last two years, we witnessed how a pandemic, cybersecurity attacks, electric power shortages, droughts, and wildfires leave us exposed on account of a lack of resilience. These failings highlight an opportunity for more learning, more research, and more policy innovation. As we confront these opportunities, I know that CSU will play a critical role in helping us chart our path forward.

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[24] Peter S. Goodman, Niraj Chokshi, *How the World Ran Out of Everything*, THE NEW YORK TIMES, June 1, 2021, https://www.nytimes.com/2021/06/01/business/coronavirus-global-shortages.html?referringSource=articleShare (last accessed July 14, 2021).

[25] *Id.*

[26] Toby Ord et al., *Future Proof: The opportunity to transform the UK's resilience to extreme risks*, at 1,9,10, The Centre for Long Term Resilience, June 2021, https://www.longtermresilience.org/futureproof (last accessed July 15, 2021).

[27] *Id.*

[28] *Id.*

[29] *Id.*