How to assess a community's resilience

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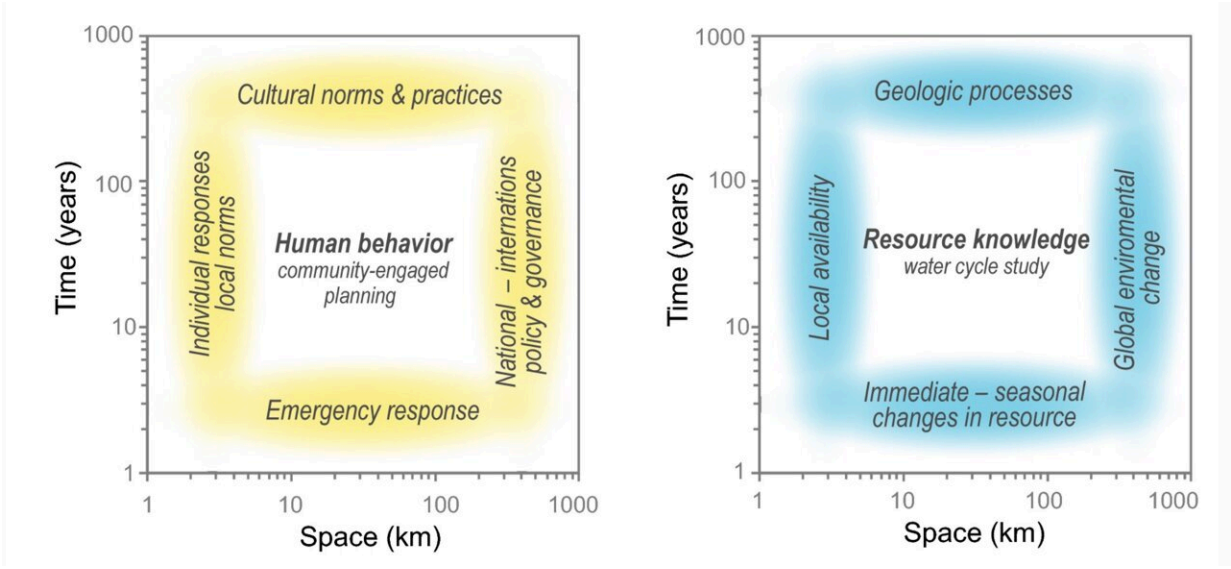

Resilience framework. Response to social and/or hydrological perturbations can occur across spatial and temporal scales plotted here. Credit: University of Utah

For ranching communities on the east side of the Baja California Peninsula, groundwater springs are their primary source of freshwater. The economic livelihoods of roughly 4,000 people, who call themselves Choyeros, are closely tied to the springs and to wells, which provide water for their families and their livestock. Communities like this, large and small, exist throughout the West, where water is life. Social systems are entwined with water systems, so water supply challenges are social challenges.

To understand how the connection between those systems impacts communities' water supply resilience, University of Utah ("the U") researchers and their colleagues have developed a new framework to think about social water resilience. Water supply issues can be local or regional, they write, and can happen quickly or slowly. A highly resilient society can respond on the same scales of time or space, while a society that can't maybe in trouble. The study is published in Sustainability Science. What does this resiliency framework mean for the Choyeros?

Resiliency at scales of time and space

The story begins at a faculty "think tank" organized by the U's Global Change and Sustainability Center (GCSC). Brenda Bowen, GCSC director and a professor of geology and geophysics, listened to anthropologist Shane Macfarlan present on the work he and his colleagues had conducted with the Choyeros, documenting how and when members of their society learn about the plants, animals and other elements of the natural world around them. The research team had, over several years, built a relationship of trust with the Choyeros, as well as an understanding of the community and the issues it faces. Bowen made the connection between the spring-fed society of the Choyeros and the work U graduate Jory Lerback, now at UCLA, had conducted on the geology and hydrology of springs. "The community lives close to the water, land and ecosystem," Bowen says, "and therefore presented a unique opportunity to explore the connections between people, water and place." Inspired, Bowen, Lerback and Macfarlan assembled an interdisciplinary research team, with the help of seed funding from the GCSC, the U's Society, Water & Climate faculty group, and the NEXUS Institute, an interdisciplinary research group in the College of Social and Behavioral Science. The team also included Eric Schniter from California State University Fullerton, Juan Jose Garcia from Salt Lake Community College and Liliana Caughman from Arizona State University.

But the team of social and physical scientists needed to find a common language to talk about hydrological and social systems. "We needed a way to step back from the ivory tower's siloed disciplines and think more about shared objectives," Lerback says. Looking at the data available and the research questions they wanted to ask, the team focused on the themes of space and time. You'll see that in the outline of the frameworks. Both systems—social and hydrological—have dimensions of space (on the horizontal axis) and time (on the vertical axis).

Let's use a couple of examples to illustrate this framework. One might be a suburb of a large metropolitan area that experiences a short-term contamination of its water supply. The time scale of the problem is relatively short, maybe a few days, and limited in space, on the order of a few square miles (tens of square kilometers). In the hydrological framework, you might represent this vulnerability as a small square in the bottom-left corner. The human response could also be limited in time and space, and might include using social channels to communicate a boil order to the affected neighborhoods or trucking in clean water to a central location. In the human behavior framework, the response would also be a small square in the bottom-left corner. The squares overlap. The community is resilient.

But what happens when those squares don't overlap? Like, if the hydrological challenge is on the scale of regional or even global climate change? Trucking in water for a few days won't cut it. "When the human and 'non-human' or water systems function on very different spatial and/or temporal scales, it is an opportunity to develop policy precisely to bridge those divides," Bowen says. As another example, if climate change is a global problem and policies to curb climate change are local, then maybe coordination between local communities can broaden the scale of the human response to match the scale of the problem. "We hope this is a way to look at how ideas fit together and represents a first-order approach to defining mutual goals," Macfarlan says. "We see this

framework as a tool to generate conversations between many groups and less a prescriptive policy tool."

Resilience of the Choyeros

Back to the Choyeros, with their small community and single water source. This community, Macfarlan says, removes some of the confounding factors that could arise in a study of, say, the Salt Lake Valley. "Although working in a small community (approximately 115 people) means we have less data overall, it does mean we have greater depth of knowledge about each data point (who are real people who we know well) and greater ability to interpret our findings by communicating directly with people in this study."

"In a small region," Lerback adds, "the water movement is more visible and not 'abstracted' by infrastructure like in many cities, where metrics of water use are generally more available but arguably less meaningful."

So the team began to assess the scales of social and hydrological resilience. They surveyed the Choyeros about their experiences with and knowledge about the spring (Have you ever experienced a spring going dry in your lifetime? What causes the springs to exist?) as well as their social systems (When livestock go missing or you want to sell artisanal crafts, from whom do you ask for assistance?). Only one of the people on the 31 ranches interviewed had heard a second-hand story of the spring going dry. But 26 expressed concern that it someday might. Water was shared between ranches, they found, with sharing occurring more often between ranches that were close to each other or had shared labor with each other.

At the same time, the researchers measured the amounts of carbon-14 and tritium isotopes in the water to assess the water's residence time, or how long it had been underground before returning to the surface. This

would give an idea of how quickly climate conditions might affect the spring—and how long it might take to recover. Water ages, they found ranged from around 75 years to 230 years. This suggests that to at least some degree, changes in rainfall amounts could lead to changes in spring output within human lifetimes. So how could their water future change? If increased demand on well water lowers the water table, the springs could reduce their output. On similar timescales, ranchers can share water and build water infrastructure to distribute throughout the community. Those squares, according to the resilience framework, overlap. But climate change and land use changes could lead to decreased amounts of water entering the ground, a process that happens on the scale of tens to hundreds of years and occurs over larger areas. Current social systems may not be able to respond. The squares overlap slightly.

How is this framework useful for planning for the future? If the Choyeros decide to improve their resilience, then can look at this framework as a place to start. Maybe they would want to expand their water-sharing network geographically or put measures into place to ensure long-term water storage. The study shines a light on a cultural group that has received little attention in Mexico, Macfarlan says, "but links them to hydrological processes that are relevant to many global regions, including the arid Southwest U.S."

The framework is relatively simple, Lerback says, compared to water usage models that might otherwise be used to assess resilience. "These take a lot of data, a long time to build and test," she says, "and are often presented as a rather 'black box' where the methods are a bit opaque, where you can test scenarios and see predicted outcomes, but required a lot of trust with the developers."

Lessons for the Salt Lake Valley

While a resiliency analysis of the Salt Lake Valley wasn't a part of this study, the authors say that the framework that applied to the small Choyero community can also be applied to the bustling Wasatch Front. "As we need more water resources," Bowen says, "we must expand our reach in either space, such as moving water from rivers for municipal use, or time, such as capturing seasonal water resources in reservoirs to extend the period of availability, or mining groundwater that recharged thousands of years ago." The team looks forward to seeing how this interdisciplinary framework can apply to other fields, including food production and waste management. The experience, they say, was beneficial for all involved.

"It's a way for academics to have a little humility," Macfarlan says. "There needs to be a way to communicate and understand things intuitively—this will help build trusting relationships and belief in the numbers."

More information: J. C. Lerback et al, Development of a graphical resilience framework to understand a coupled human-natural system in a remote arid highland of Baja California Sur, *Sustainability Science* (2022). DOI: 10.1007/s11625-022-01101-6

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