New tool developed to assess global freshwater stress

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A new method to make better use of vast amounts of data related to global geography, population and climate may help determine the relative importance of population increases vs. climate change.

While several recent studies suggest that much of the world is likely to experience freshwater shortages as the population increases and temperatures rise, determining the relative impact of each has been difficult. An Oak Ridge National Laboratory paper published in *Computers & Geosciences* outlines a process that might help.

"Our work establishes a new method to couple geographic information system data with global climate outputs and statistical analysis," said ORNL's Esther Parish, lead author. Using this technique, researchers can now conduct assessments that will provide information critical to policymakers and stakeholders.

"Our tool provides a simple method to integrate disparate climate and population data sources and develop preliminary per capita water availability projections at a global scale," said Parish, a member of the Department of Energy laboratory's Environmental Sciences Division.

Parish and co-authors Evan Kodra, Karsten Steinhaeuser and Auroop Ganguly began working on this approach at ORNL in the summer of 2009. At that time, it was unusual to integrate population, climate and water data into one model. Although just a first step, the toolkit, which has been made freely available, may be further developed for more

involved analysis.

While results of the study point to areas potentially vulnerable to water shortages, Parish cautioned that this set of calculations is based on just one set of ensembles from one climate model with static population growth rates applied on a per country basis.

By water stress, researchers are referring to per capita freshwater availability of less than 450,000 gallons per person per year, but the ways society chooses to store and allocate water will determine whether an actual shortage exits. For example, water can be allocated for industry, agriculture or residential use, or any combination of the three.

For this study, the team used ORNL's high-resolution Global LandScan population distribution dataset in combination with population growth projections from the Intergovernmental Panel on Climate Change. This allowed them to estimate changes in freshwater demand by 2025, 2050 and 2100. The researchers also used the Community Climate System Model 3 to estimate future freshwater availability during those same time periods. Researchers then combined freshwater supply and demand projections to yield estimates of per capita water availability around the world.

Given the number of variables, the process can quickly become unwieldy.

"Analyzing the interrelationship between human populations and water availability is greatly complicated by the uncertainties associated with climate change projections and population storylines," said Parish, who added that for this exploratory study population growth appears to have a greater impact than temperature.

To test the new tool, Parish and colleagues plugged in four IPCC

greenhouse gas emissions scenarios – from low to high – along with global population projections to arrive at different potential scenarios. None paint a promising picture for freshwater availability.

The study suggests that by 2100, 56 to 75 percent of the world's population could be vulnerable to significant freshwater security threats. In areas like the Great Lakes region, freshwater may be easier to replenish than portions of Florida and the Southwest, but people in most areas of the country will face challenges.

"The worst case combination of per capita freshwater availability indicate that many major U.S. cities may experience some degree of water stress by the year 2100," Parish said.

In addition, the feedback between population shifts and water resources scarcity may exacerbate the situation. Thus, as pointed out in other recent studies, the projected water scarcity in parts of Central and South America may have ramifications for population movement and hence water scarcity in the United States.

"While we have not considered migration as part of this paper, these are precisely the directions we believe require further research," Ganguly said.

The researchers noted that while this paper outlines a proof of concept that lends some preliminary insight to the relative importance of climate change vs. population, output from multiple climate models must be incorporated in future research.

"By investigating multiple models, we may be able to quantify -- or at least qualify -- uncertainty in how different climate change scenarios could affect water availability," Parish said. "Given that population growth is likely to be an even bigger factor in water availability than

climate change, it will also be critical to reassess areas of concern with regional- or state-level population growth scenarios."

Ganguly added: "Our understanding of multiple stressors on natural resources as well as dynamically coupled natural and human systems is critical to address emerging concerns like urban sustainability."

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