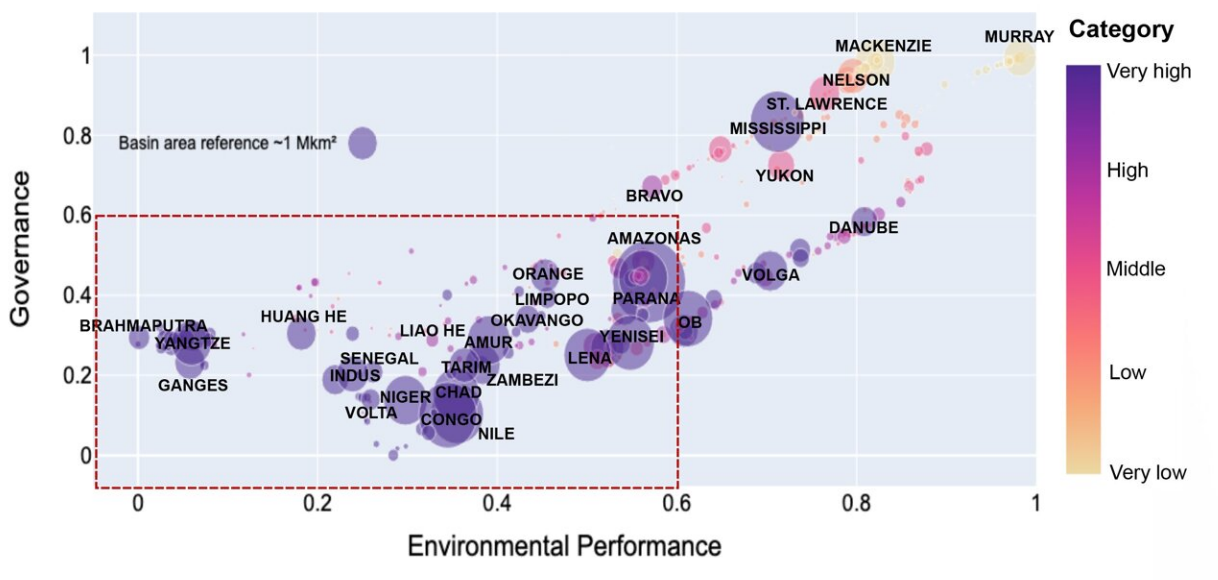
The risk of global water scarcity is greater when accounting for the origin of rain, study shows

September 2 2024



The relationship between the risk to water security in each hydrological basin and the governance and environmental conditions in the regions upwind. The relationship between governance (y axis), environmental performance (x axis), the level of risk to water security of each hydrological basin relative to the 379 basins used in the study (color gradient) and the area of the basin (size of the circle). Governance is calculated as the mean of the five governance indicators; voice accountability, political stability, government effectiveness, regulatory quality and the rule of law (reported by the World Bank). Environmental performance is given by the 40 indicators of the Environmental Performance Index from the Yale Center for Environmental Law and Policy. The dashed red polygon highlights basins with low levels of upwind governance and environmental performance. Credit: Stockholm University

Securing the world's water supply is one of the greatest challenges of our time. Research at Stockholm University is now presenting an alternative method for quantifying the global risk of water scarcity. Results indicate higher risks to water supply than previously expected if accounting for the environmental conditions and governability where rain is produced.

The common idea of global water supply is rain falling on the earth's surface and then stored in aquifers, lakes, and rivers. This idea is usually used to assess water security and the risk of water scarcity. However, a study, titled "Upwind moisture supply increases risk to water security" in *Nature Water*, shows how the water risks are dependent on governance and environmental conditions present upwind, which means the areas where the moisture for rain comes from.

"Water supply really originates beforehand, with moisture evaporated from land or in the ocean traveling in the atmosphere before falling as rain. This upwind moisture is commonly overlooked when assessing water availability," says Fernando Jaramillo, associate professor of physical geography at Stockholm University and responsible for the study.

When a lake or river is shared between different countries or authorities, assessments and regulations mainly apply an upstream perspective, considering conditions in the direction upriver from the water body. Instead, an upwind perspective considers the area where evaporated water is transported before ending up as rain. The area is known as a "precipitationshed" and can cover large areas of the earth's surface.

"For instance, in tropical South America, most of the Amazon basin is downstream of the Andes mountain range, whereas large areas of the Andes are in themselves downwind of the Amazon rainforest and depending on it, which makes these two regions dependent on each other for water supply," says Jaramillo.

The study examined 379 hydrological basins worldwide, revealing that risks to water security are significantly higher when considering the upwind origin of water.

"With this approach, we see that 32,900 km^3/year of water requirements worldwide face very high risk, a near 50% increase, compared to the 20,500 km^3/year resulting from the more traditional upstream focus," says José Posada, former doctoral student at Stockholm University and main author of the study.

Political control can have major consequences

Since a large amount of water is evaporated from plants, changes in land use can affect downwind water availability. If deforestation and agricultural development are predominant in upwind areas, the amount of moisture vegetation provides may decrease, reducing rainfall downwind and increasing the risk to water security.

"For coastal countries such as the Philippines, most of the rain comes from the sea, which means that land-use changes pose very little risk to water security. Rainfall in inland countries such as Niger, on the other hand, comes mainly from moisture that evaporates in neighboring countries such as Nigeria and Ghana. This puts many land-locked countries at high risk regarding how water security is affected by changes in land use," says Jaramillo.

In other words, political factors such as environmental management and regulations in areas where moisture first evaporates can affect water safety in completely different areas.

"For instance, the Congo River basin, heavily reliant on moisture from neighboring countries with low environmental performance and governance according to global indicators, faces considerable risks due to potential deforestation and unregulated land use changes in neighboring areas," says Lan Wang-Erlandsson, researcher at the Stockholm Resilience Center at Stockholm University and co-author of the study.

Environmental regulation requires an upwind perspective.

The study reveals why the lack of governability and environmental performance in a country upwind may be relevant to the water supply of a country downwind. It stresses the codependence between upstream/downwind and downstream/upwind countries.

"It is not possible to ignore the interdependence between countries. In the end, all water is connected, so we should not only mind how we manage our water resources within a region or country but also how our neighboring countries do," says Wang-Erlandsson.

"We hope that the findings of this study can help identify where and to whom cooperation strategies and efforts can be directed to mitigate the causes of water-related tensions, including atmospheric water flows in transboundary decision-making and water governance frameworks. We stress the need for international cooperation to effectively manage upwind moisture sources," concludes Jaramillo.

More information: Upwind moisture supply increases risk to water

security, *Nature Water* (2024). DOI: 10.1038/s44221-024-00291-w , www.nature.com/articles/s44221-024-00291-w

Provided by Stockholm University