Green water supplies and global limits

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Aerial view of the Amazon rainforest. Credit: Jorge.kike.medina, CC-BY-3.0/Wikimedia Commons

Access to dwindling freshwater supplies is one of the defining issues of our time as global populations expand amidst a changing climate. Water access and limitations and related issues are rightly considered a possible flashpoint for global conflict; they also represent a major cause of concern from environmental and ecological perspectives as well as a global security standpoint.

Water availability in terms of "blue water"—that is, precipitation in the form of free flowing surface water run-off and groundwater—has been well documented in in the existing scientific literature. "Green water" limits however—green water being precipitation that is captured by plants or biomass and recirculated back into the atmosphere via evapotranspiration (ET) or bound up in soil—have thus far received scant attention by researchers. The distinction between blue and green water in understanding water scarcity is far from trivial, since green water represents the greater part of water use by human populations.

Reporting in *PNAS*, a Dutch-American team has contributed a significant study with far-reaching policy implications. The study successfully differentiates green water use from blue while offering a regional and country-by-country analysis of green water use in terms of natural and human services, and the interplay of existing and potential limitations between the two. Typical human appropriations of green water supplies include uses such as growing food and fiber crops, timber, and bioenergy resources, and raising livestock. Increasingly, however, these human land uses come at the expense of natural systems and the ecosystem services they provide to human and non-human communities alike.

Joep Schyns and colleagues sought to answer three principal questions with their study: "What is the appropriation of green water by the human economy, specified geographically? What are the geographically explicit limits to the human appropriation of green water? Where are these limits approached or exceeded?"

To answer these questions, the researchers first defined a green water footprint (WF_g) in terms of timber production, agriculture, urban areas, etc, at a 5 x 5 arc-minute resolution of spatial cells. Next, they quantified the maximum sustainable WF_g ($WF_{g,m}$) as the total available green water flow less the green water flow to be preserved for natural systems. In establishing a measure of $WF_{g,m}$, the study authors took into consideration factors such as agroecological accessibility and biodiversity conservation needs. Biodiversity conservation needs here were based on criteria from the Aichi Biodiversity Target 11, which stipulates a protected area of at least 17% of lands globally. Finally, Schyns and company assessed green water allocation by way of human activities versus natural services in order to determine whether human activities were approaching or had already overshot the $WF_{g,m}$ at the level of each 5 x 5 cell. For this, they calculated green water scarcity (WS_g) at the country-wide level as the ratio of the national aggregate WF_g to the national aggregate $WF_{g,m}$.

They found that 56% of the sustainably available global green water flow has already been allocated for human purposes, though at the regional level the WF_g-to-$WF_{g,m}$ ratio varied dramatically. Areas such as Scandinavia, Canada, Africa and elsewhere, for example, had not yet approached $WF_{g,m}$, whereas other regions such as Central Europe, South Asia, the Middle East, and Central America were fast approaching or had already overshot $WF_{g,m}$. And just 10 nations, the investigators found, accounted for more than half of the overshoot: "United States (8.6%), Brazil (6.9%), Indonesia (6.4%), India (5.2%), China (5.0%), Colombia (4.9%), Philippines (4.4%), Mexico (4.0%), Germany (3.1%), and Malaysia (2.5%)."

Perhaps somewhat surprisingly, countries with seemingly ample rainfall such as Germany, the UK and New Zealand showed high WS_g, where green water resources were already fully or almost fully allocated to human activities. In the case of Germany, the researchers point out, vast sections of land have been converted to monoculture production of rapeseed to meet that country's sustainable energy goals. This, in turn, is believed to be responsible for the decline of flying insects even within protected areas of Germany. Biofuels production has led to similar consequences in the US.

The destruction of rainforests, mainly in the Global South, is largely driven by commodity production pressures to expand into lands with adequate rainfall thus far unused by humans, at the expense of major biodiversity loss. Activities such as cattle ranching and crop production for feed and biofuels are driving expansion into the forests and grasslands of South America, while logging and conversion to palm oil plantations are major threats to lands in Southeast Asia. These areas are hotspots on the water scarcity map too. As the study authors ominously note, "The tensions between green water for humans versus nature are intensifying as the green water demand for biomass in the economy grows. This growth is not only driven by population growth, but also by increasing green water demands per capita due to changes in the food and energy mix."

Aside from policy measures to slow down the human WF_g–- particularly those directed against the consumption of resource-intensive livestock and the use of biofuels –- there are steps that can be taken to improve green water productivity: for example, improving the water-holding capacity of soils through no-till agriculture or the application of mulches to slow evaporation. Beneficial blue water flows however may be impacted by improved soil management techniques, and blue and green water flows are ultimately interrelated and communicating systems, both of which are ultimately dependent on precipitation. Stress resistant crop cultivars that are well adapted to water-scarce conditions are another possible adaptation to limited green water flows.

The historical decisions regarding green water use for human purposes versus natural purposes have mostly favored human endeavors at the expense of natural habitats and biodiversity. But even in characterizing these decisions as "trade-offs" of the human versus the natural, the study investigators cite "trillions of dollars in losses of ecosystem service values" owing to the human allocation of green water resources. Thusly, they conclude: "The world's limited green water flow is shared by human society and nature. By ignoring limits to human's [sic] growing WF_g—driven by an increased demand for food, feed, fiber, timber, and bioenergy—we risk further loss of ecosystem service values. Green water is a critical and limited resource that should explicitly be part of any assessment of water scarcity, food security, or bioenergy potential."

More information: Joep F. Schyns et al. Limits to the world's green water resources for food, feed, fiber, timber, and bioenergy. PNAS published ahead of print February 25, 2019. doi.org/10.1073/pnas.1817380116