Societal reliance on the global freshwater resources

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Life on Earth depends on freshwater water, a resource that is becoming scarce. Demographic growth and the increase in per capita use of food, fibers, and other ecosystem services, are directly or indirectly enhancing the societal pressure on the global freshwater resources. Meeting the competing water needs of ecosystems and societies is a major challenge that mankind has to face today. Research in hydrology is trying to clarify the complex patterns of societal dependence on water. Critical interactions between hydrosphere and anthroposphere are associated with food production, which accounts for most of the human appropriation of the global freshwater resources. Some aspects of the societal and hydrologic controls on water (and food) security remain poorly understood, including the way societies virtually enhance their access to freshwater resources through trade and globalization; the drivers of virtual water trade; and the dependence of population growth on water availability.

Overall, by buying and selling commodities in the global market, countries virtually import or export the water required for the production of those goods. Known as "virtual water trade", this phenomenon allows populations in water-scarce regions to meet their demand for food, fibers, and goods. Virtual water trade has often been acclaimed as a mechanism that allows modern societies to avoid malnourishment, famine, and water wars. There are, however, some negative impacts of virtual water trade. The emergence of a disconnection between production and consumption regions limits the effectiveness of any attempt to foster environmental stewardship. Many countries use more (virtual) water resources than they control and are becoming increasingly dependent on a handful of major food and (virtual) water exporters. In fact, more than 50% of the net virtual water exports worldwide are controlled by Brazil, Argentina, Canada, Australia, and the USA. It has been suggested that virtual water trade might cause a possible loss of societal resilience to drought. Moreover virtual water trade appears to be driven by economic factors rather than by water solidarity. Globally, trade is not reducing the inequalities in the access to freshwater resources. These points are here discussed along with their impacts on water security and population growth.

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Paolo D'Odorico received his Ph. D. degree from the University of Padova (Italy) in 1998. He continued his studies as a postdoctoral research associate at Texas A&M (1998) and Princeton University (1999). He was hired by Texas A&M (1999-2001) as an assistant professor and moved to the University of Virginia, Department of Environmental Sciences in 2001. His research focuses on the role of hydrological processes in the functioning of terrestrial ecosystems. Starting from analyses of mechanisms underlying the coupling between hydrological processes and the biota, his research has contributed to the emergence of the relatively new field of ecohydrology. He has investigated the role of soil moisture dynamics in biogeochemical cycles, vegetation water stress, ecosystem productivity, land-atmosphere interactions, and soil susceptibility to wind erosion. Through field observations and modeling studies he is studying new mechanisms of desertification that involve positive feedbacks between vegetation dynamics and resource availability or disturbance regime. Similarly, he is investigating the role of positive feedbacks between vegetation and resource (e.g., nutrients, light, or energy) availability in dry tropical forests, freshwater wetlands, mangrove swamps, and seagrass meadows. His research has also shown how environmental variability may increase the complexity of ecosystem dynamics by inducing new bifurcations and pattern formation, and enhancing stability and resilience.

He is currently investigating the global patterns of virtual water trade and their impacts on water equity, societal resilience, and food security.

Mr. D'Odorico has been awarded the *Prof. E. Guggino Prize* for "best dissertation in hydrology" (Mediterranean Polytechnic Foundation), The *University of Virginia Teaching Fellowship* (2003), the *Lagrange Fellowship* in complex systems research (Fondazione CRT & Fondazione ISI, Torino, Italy, 2004), the *Sustainability Science Award* (Ecological Society of America, 2009), and the *Fulbright Distinguished Lectureship (2011).* He has been elected a *Fellow of the John Simon Guggenheim Memorial Foundation* (2011). He is currently the *Ernest H. Ern Professor of Environmental Sciences* at the University of Virginia.