WATER

What scale for water governance?

Water management is a central responsibility of civil society. Major questions persist regarding practice, policy, and the underlying evidence and methods to inform both. Over the next 3 weeks, *Science* presents essays invited to debate key issues in freshwater research and management. This week: local versus global. When, and to what extent, should a global viewpoint replace, or work in tandem with, enduring localized perspectives?

Fresh water goes global

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Although water problems have been traditionally perceived, understood, and acted on locally, recent progress in Earth-system simulation, remote sensing, and analysis of water governance is producing new perspectives on fresh water. The advances reveal previously unrecognized global forces at work driving local-scale problems. The stage is reset for water research and policy-making.

LOCAL ACTION, GLOBAL CONCERN. Although water problems come best into focus locally, countless local stressors and impacts have accumulated to global significance (*1*). Local misuse provokes regional water crises that could easily spill into the global domain should transboundary cooperation collapse for rivers (*2*) or should source waters fail in the Himalayan "Third Pole," which would affect one billion people (*3*). Local water management even transcends fresh water itself, as when a large reservoir traps river-borne sediment destined for the ocean and reduces the capacity of the shoreline to withstand coastal erosion (*4*).

POLICY

Fresh water is essential to human development. It is no surprise then that Amazonia, the Congo, and Borneo are targeted for massive water engineering projects (*5*), yet protecting biodiversity in these ecosystems generates little conservation investment, even if its loss would have global effects (*6*). Despite the importance of water to community prosperity, social fabric, and environment, the World Economic Forum declared proliferation of water crises to be the greatest collective risk to the global economy (*7*).

GLOBAL ACTION, LOCAL CONCERN. The sources of local water problems may not be as local as they seem. They are influenced by global mechanisms, primarily climate (water availability) and the world economy (patterns of water use). These define the spatial and temporal character of water scarcity. These patterns show current usage already reaching maximum renewable global supplies (*8*, *9*).

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Much of the world's water use and pollution arises from production for global trade, which embodies impressive flows of virtual water. Such trade exacerbates local overexploitation and creates potential conflicts over water. It outsources environmental problems to countries with lax regulation that host highly polluting manufacturing or agriculture (*8*). Decisions on water infrastructure are made far from its ultimate point of installation or impact, and externalities largely remain unregulated.

GLOBAL GOVERNANCE FOR LOCAL STEWARDSHIP? Persistent water syndromes show local water governance unable to prevent global damage (*1*). At the same time, many global actors (United Nations, banks, multinationals) and rules are already in play, like the UN Watercourses and Ramsar conventions.

WATER DEBATE SERIES

Yet, global water governance has not found its place among other scales of authority. Existing regimes are legally fragmented and dominated by local and mesoscale solutions (10). Large-scale governance focuses mainly on transboundary surface waters (versus groundwater), pays scant attention to pollution, fails to reconcile mismatches between river basins (and aquifers) and administrative jurisdictions, and has few incentives for sustainable water use in a globalized economy. It is difficult to harmonize ownership, rights and access to water, and cultural norms across the international playing field. Absent a global perspective, nexus issues on food, energy, and climate will be hard to address because linkages will remain essentially invisible, as with virtual water trade, which is regulated by trade agreements for commodities and not water.

With clear guidelines and legal responsibilities, consumers, governments, and investors could reverse the proliferation of free riding, commodification of public goods, secret international contracts and arbitration, and environmental neglect. Without such, widespread damage and nonsustainable water use will remain the norm.

A GLOBAL TEST CASE. An example of comprehensive water planning is unfolding in the intergovernmental arena with the post-2015 Sustainable Development Goals (SDGs) (*11*), which build on the earlier Millennium Development Goals (MDGs). Although MDG outcomes have been mixed [the drinking water target for the poor attained ahead of schedule, but delayed for sanitation (*12*)], they served as an important motivator for member states to prioritize water development efforts. SDGs expand the MDG agenda to include developing and developed world alike. Current SDG water proposals seek ecosystem protection, limits to pollution, and early responses to water-related hazards.

SDGs should lead to converging national policies, but much of the planning still focuses on local-scale solutions that fail to recognize broader-scale realities, like the connectivity of water systems. Thus, whereas sewering a developing world city improves the lot of urban dwellers, failure to install wastewater treatment destroys aquatic biodiversity and elevates health risks and water treatment costs downstream. Because 80% of today's sewage is discharged untreated (*11*), the issue is far from theoretical. Water systems will require substantial rehabilitation, nearly always much more costly than problem prevention, and will miss opportunities to apply new ecosystem-based approaches (*1*).

Despite their importance, the water-related SDGs alone will not effect a transition to global governance. International trade agreements need to be supplemented with context-specific but universally agreed-upon rules and standards on sustainable water use, water quality, and environmental flows. Principles like polluter/user pays and equitable water sharing are key to avoiding perverse incentives that have historically externalized impacts.

The global perspective is essential—but not a panacea. It may be counterproductive should it obscure, devalue, or fail to reflect the unique character of local or national settings. Experience shows that implementation of global measures is contingent upon political will, robust design, and institutional capacity at subsidiary scales (*7*).

In conclusion, acknowledging that local actions on water continue to trigger global-scale syndromes is a necessary first step toward effective governance. A global perspective is essential for providing context to local conditions, recognizing commonalities in both problems and solutions, identifying where prevention or remediation is needed most, and tracking progress or backsliding. Global thinking will help craft international agreements on water stewardship that ensure social equity and sustainability. Persistent focus on the local scale will miss such opportunities, which could otherwise make meaningful progress in solving 21st-century water problems that are, in fact, global. ■

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Local perspectives on water

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A global perspective on water management predominates in high-level policy discussions. This has the advantage that over-arching issues can be highlighted and international resources mobilized. But water issues arise from local conditions and can only be resolved by people and institutions with local authority and responsibility. High-level policies can only have meaningful impact if they are informed by and responsive to local and regional contexts. In keeping with the principle of subsidiarity, high-level policy-making should support local and regional interests, efforts, and policies.

LOCATION IS IMPORTANT. Renewable freshwater resources derive from precipitation over land, which exhibits substantial spatial and temporal variability. Natural conveyance and storage are also spatially differentiated. The geography of major rivers, deltas, and coastlines has strongly influenced patterns of human settlements, trade, fishing, and agriculture. This is reflected in localized patterns of water demand and alteration of water systems, including draining of wetlands, river channelization, and construction of dams and canals. Urban areas have been local sources of pollution to waterways and coastal areas (*1*).

How infrastructure investment decisions are made can have profound impacts on local livelihoods and development. A global perspective is likely to distract attention and resources away from opportunities to adopt proven effective measures and build on past reforms whose success was based on principle and pragmatism (*2*). Installation of drinking water treatment plants in North America in the early 20th century is estimated to have extended life spans by up to 7 years (*3*). Investments in urban drainage reduced losses from flooding, draining of wetlands removed habitat for disease vectors, and construction of sewers and municipal wastewater treatment improved public health and supported recovery of aquatic habitat and fisheries. Dam construction provided water for irrigation, municipal

"Local actors are well positioned to deal with management issues subject to specific needs and constraints…"

and industrial supply, and electricity generation, as well as flood protection. These gains and associated economic development were accompanied by costs and environmental impacts (*1*), some of which are no longer considered acceptable. This has led to investment in restoration and alternative approaches to water management.

Developing countries face substantial infrastructure deficits. An estimated 2.5 billion people, mainly in low- and middle-income countries, still lack access to improved sanitation; uncontrolled release of human waste and inadequate sewage treatment pose severe health risks (*4*). Water quality in rapidly industrializing countries is degraded by discharge of inadequately treated domestic and industrial effluents (*1*). Waste management that is appropriate for local conditions is needed to recover water, energy, and nutrients.

DOES A GLOBAL PERSPECTIVE HELP? Global policy-making, specifically adoption of the Millennium Development Goals (MDGs), has directed attention to lack of access to safe drinking water and sanitation. Yet the sanitation goal remains unmet (*4*), and pressing issues that go beyond access (e.g., fecal sludge management) have not been adequately addressed (*5*). The drinking water goal is compromised because access to improved water sources does not guarantee adequate water quality (*4*). The post-MDG Sustainable Development Goals will require integrated approaches for water management tailored to local conditions, as well as water-quality standards that can be monitored and related to health outcomes.

Institutions with a global reach (*6*) have an important role to play in sharing information on effective agricultural practices. Irrigated agriculture contributes to increased food security but also can negatively affect biodiversity and groundwater reserves. Increasing water productivity of crop yield in rain-fed areas will require improved water- and land-management practices that are adapted to local conditions and practices. Crop rotation, mulching, and minimizing tillage could increase water-use efficiency. Floodwater harvesting and rainwater runoff trapping are underexploited opportunities for increasing water storage in soil (*7*). Management of soil water, evaporation, and noncrop evapotranspiration is needed.

Agricultural demand for water is linked globally through trade in agricultural commodities, which results in a modest increase in the efficiency of water use (*8*). Virtual water transfer is an observable phenomenon, but it does not constitute a viable policy instrument. It fails to account for local damage resulting from poor water management practices in agriculture. For example, export–oriented agricultural production may increase the competition for water at the expense of local land-use systems, especially in arid and semiarid areas. Agricultural production in areas with high water productivity can be constrained by other factors, including energy demand, labor costs, or higher-value uses of land.

Calls for a global perspective on water governance have accompanied shifts in power from local authorities to a broader coalition of officials, bureaucrats, and interest groups. It is at the local level that interactions, tradeoffs, and choices matter most. Local actors are well positioned to deal with management issues subject to specific needs and constraints and reflecting relevant perceptions, aspirations, interests, and agendas (*2*, *9*). Local-level capacity development for water management may improve governance more generally.

International water management is needed where rivers or lakes cross or define national boundaries. There are often no agreements on how to structure development to the benefit of the countries involved. Past agreements focusing mainly on water allocation were negotiated on a "zero-sum" basis. Many institutions for transboundary water management have limited enforcement authority and effectiveness. Static agreements and institutions are not responsive to changing conditions. A more positive direction in transboundary water management incorporates potential benefits to multiple development sectors (*10*). This can only be effective if assessment of potential benefits reflects local conditions, constraints, and opportunities.

Water resources should be assessed and managed at the scale that is most effective. Concepts promoted from a global perspective may be insufficiently transferable to local contexts and/or may fail to reflect changing circumstances. A focus on the river-basin scale may be counterproductive if the size and complexity of the system overwhelm capacity for joint decision-making and management by the riparian states. A nested, tiered framework for analysis (*11*) may help identify the most effective scale for water management; a single scale may not be most effective in all cases or for all aspects of a single case. ■

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