Can we achieve global food security without compromising the use of water to meet other human and environmental needs?**

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Summary
One of the most urgent challenges for the 21st century is to achieve and sustain global food security without compromising the use of water to meet other pressing human and environmental needs. Doing so in the face of a changing climate will be extraordinarily difficult and will require scale- and context-specific science and science-based policies and institutions. Research and development will be needed to generate innovative technologies and practices to improve the efficiency and sustainability of agricultural water management and to enhance our understanding of the bottlenecks that constrain the adoption of such innovations. Science-based policies and institutions are needed to (i) create incentives for the adoption of innovative technologies and practices for efficient use of water in agriculture; (ii) control water use to ensure sustainability, especially of groundwater resources; and (iii) manage water storage to help cope with climate extremes.

Current realities
At present, almost a billion people have insufficient food to lead a healthy and active life. While the numbers of people living in poverty have decreased significantly in the last couple of decades and are expected to continue to decrease in the decades ahead, meeting future food needs in light of water constraints will be exceptionally challenging. From the food perspective, overall food requirements will increase at a greater pace than population growth as a result of improving diets resulting from rising incomes. From the water perspective, economic growth and rapid urbanization will result in increased use of scarce water resources, greater levels of water stress, and less availability for use in food production, a situation that will be exacerbated by the impacts of climate change on both water requirements and availability. For these reasons, one of the most urgent challenges for the 21st century is to achieve and sustain global food security without compromising the use of water for other pressing human and environmental needs. Importantly, some of these other needs, especially safe drinking water and sanitation, are vital to ensure appropriate food use and nutrition to the world's most vulnerable populations.

Scientific opportunities and challenges
With regards to water, perhaps the most promising approach to meet this challenge is to improve the management and use of water by and for agricultural and food systems, enabling more food to be produced with less water and less energy. There have been important advances in this area in recent decades, involving innovations in agricultural, irrigation, information, and food processing technologies. Further progress, however, requires better scientific understanding at multiple levels and scale- and context-specific solutions. Research and development will need to focus on generating innovative technologies and practices, such as abiotic stress-tolerant crops, irrigation technology to reduce water losses, and water-smart food processing technologies to reduce water used by the food and beverage industry. Solid social science research is needed to enhance our understanding of the bottlenecks that constrain the adoption of innovations that boost water productivity.

Beyond the use of water, approaches include reducing food waste and increasing agricultural trade to water-short regions. Reducing the significant levels of food waste that currently affect the food supply chain along the full “farm to fork” spectrum, in both more- and less-affluent countries, would help improve water availability and water quality for other purposes and reduce overall pressure on the world’s natural resources. The practical and scientific challenges and risks involved, however, are considerable: at the “fork” end of the spectrum, reducing waste involves formidable issues of behavioral change by consumers that will not be easily overcome; while the investments required to reduce waste at the “farm” end of the spectrum are huge. Increasing trade in agricultural products from water-rich to water-short regions and countries (a concept known among water specialists as trade in virtual water) enables water-short countries to save scarce water resources by importing rather than growing food. However, increased trade in virtual water is not a panacea. Although food imports help in ensuring physical access to food, they can negatively affect economic access in countries in which agriculture is the main source of income and livelihoods. In addition, most countries are hesitant to rely too heavily on food imports to address their domestic food needs.

Policy issues

Science-based policies and institutions are required to create incentives for the adoption of innovative technologies and practices for efficient use of water in agriculture, to control water use to ensure sustainability, especially of groundwater resources, and to manage water storage to help cope with climate extremes.

- *Local authorities and state governments need to create incentives for the adoption of innovative technologies and practices for efficient use of water in agriculture.* Without appropriate incentives, new technologies and practices for efficient use of water in agriculture may never be adopted in practice. In many areas, farmers currently have few strong incentives to conserve water, largely because they do not have to pay for the true value of the water they use. This is a classic problem of externalities, which can be addressed through market-based policies to "internalize" the external costs and benefits to third parties by ensuring that water charges reflect the true costs of water consumed or otherwise impacted by agriculture. In areas where groundwater is the principal source of irrigation water, energy policy can also affect water use; where energy prices are high and the costs of pumping groundwater are considerable, farmers have a strong incentive to reduce water usage and thus pumping costs. The adoption of new technologies and practices for efficient use of water in agriculture also requires appropriate policies to foster the development of supply chains and technical assistance, especially in countries in which such systems are weak.

- *Governments should establish local institutions and policies to control water use to ensure sustainability, especially of groundwater resources.* Good water governance to control and conserve water is needed to ensure sustainability of the resource, in terms of both quantity and quality. Groundwater, as a resource shared by large numbers of current and potential users, is often in danger of being overdrawn, and effective institutions are needed to control its use. Nebraska’s Natural Resources Districts (NRDs) provide an excellent example of such institutions. Created in 1972, the NRDs are local watershed-based authorities governed by a locally elected board of directors and with revenue from property taxes and other sources. Over the last 40 years, the NRDs have played a significant role in ensuring that Nebraska’s abundant groundwater resources (equivalent to 19 Aswan dams) have remained stable despite the major expansion of groundwater irrigation during that period. Local watershed-based authorities like these, tailored of course to local contexts, might prove helpful in avoiding groundwater depletion in other areas where the groundwater resource is in danger of being overdrawn.

- *Water storage should be appropriately managed to help cope with climate extremes.* Water storage can play a huge role in smoothening out variability in water supply and thus coping with climate extremes (e.g., floods and droughts). Physical storage options range from surface reservoirs and aquifers to wetlands, lakes, ponds, and soil moisture. Decision making around storage can and should involve farmers — the ultimate water managers — as well as local, state, or federal agencies. Farmers can increase soil moisture storage through no-till farming or by adopting drought-tolerant crops that allow roots to dig deeper for water. Public agencies can also use science to increase effective storage, for example by better understanding groundwater recharge and flow processes or predicting reservoir inflows to reduce unnecessary spilling of stored water. Effective water storage management was a major factor in Nebraska's success in coping with the 2012 drought: good groundwater governance by the state's Natural Resource Districts coupled with augmented water storage through farmer adoption of drought-tolerant crops and conservation tillage enabled farmers to mitigate the impacts of drought. This kind of integrated approach, tailored as always to local contexts, could help in coping with drought in other situations.

References

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