WATER ENOUGH FOR THE FOOD SUPPLY? OUTLINING THE CHALLENGE

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It takes an astonishing volume of water to grow a typical human diet: over 1000 gallons for what most of us will eat today. Here in Wisconsin and in the near future this does not appear to be a problem, but globally and looking forward to 2050, the water required to grow human diets may prove to be an enormous challenge. Earth's population is sure to grow substantially, diets are changing toward requiring more water to produce, there is a persistent number of people who do not receive enough to eat each day, and we are coming to learn that we must reserve some water in rivers, lakes, wetlands, and in groundwater to keep ecosystems healthy. Can the global food system meet this challenge?

Scientists who study this sort of thing estimate that between now and 2050 there may have to be nearly a doubling of the amount of water that is involved in producing the global food supply (Table 1). At present some 6800 Gm^3/yr of water passes through the world's food production system (numbers like this are impossible to envision, but they can be compared: about 139 Gm^3 of precipitation falls on Wisconsin each year, or about 2000 m^3 per person). To adequately feed Earth's existing population (particularly the nearly 900 million people who are currently undernourished) requires about 2200 Gm^3 more, and finally feeding the additional 3.3 billion humans expected to be on Earth in 2050 might be accomplished with 3600 Gm^3 more.

Table 1. Estimates of current and needed water use to produce the global food supply (Rockström 2003).

Component	**Water Volume** (Gm^3/yr)
present production	6800
eliminate current undernourishment	2200
food for additional population (8.9 billion)	3600
Total	12600

The major assumptions that go into this estimate involve: human population growth, dietary choices, the water requirements of plants (almost all of this is evaporation through plants), and the technologies we can use to produce food. Human population is currently 6.6 billion, but the rate of increase has been slowing in the past few decades. Current estimates for the population in the year 2050 generally fall between 8 and 11 billion; at the lower side of this range the total population should be leveling off to a steady value by that time. The midrange estimate is about 9 billion (United Nations 2007).

Human diets vary a great deal in how much water is required to produce them. At the low end is about 1 m^3/day for a vegan (folks who eat no animal products at all), while a meat-rich diet can require 5 m^3/day. The United Nation's Food and Agricultural Organization has the goal of making available to every person a diet that supplies 3000 kcal daily, with 20% from animal protein; this diet takes about 3.6 m^3/day, or 1300 m^3/year. Rising purchasing power in China is enabling a growth rate in meat consumption there of about 5% yearly, causing the dietary water requirement there to increase.

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The total amount of water that, say, a crop of corn or rice uses during its lifetime is counted as "embedded" or "virtual" water in the grain. All of the embedded water in the feed given to an animal is subsequently summed to give the estimated water embedded in meat from that animal. Thus a potato has about 6.5 gallons of virtual water, while a hamburger has some 635. Just how much water is embedded in a plant product depends on the plant type, the level of technology (genetics and fertilizer), and considerably on the climate of the place where the crop is grown. Thus a corn crop can require as much as 30,000 gal water/bu to grow in arid, lower-technology regions of India, compared with 3500 gal/bu in optimal climates and with high levels of inputs (Oyebankde 2004, cited in World Bank 2006). Thus the total amount of water required to feed the world can be considerably reduced by growing crops in appropriate places and with the fertilizer and management inputs needed for high yields.

Irrigation is, of course, the obvious technology for making sure that plants do not run short of water and yield to their potential. Worldwide about 20% of crop land is irrigated and this land yields 40% of the world's crop production, attesting to the power and significance of this technology. Unfortunately, irrigation has proven to have many limitations, from soil salinity buildup (first noted 4,000 years ago) to soil water-logging that in turn makes necessary artificial drainage. Disposal of this drainage water is emerging as a worldwide problem, increasing the cost and negative environmental impacts of irrigation. The area of irrigated land per person worldwide peaked in 1978 at about 115 acres, and has decreased since. Continued population growth is largely to blame, but international funding for further development of irrigation has also decreased, as the best spots are already developed and the full environmental and social costs of irrigation are better understood.

The total additional requirement for water involved in the food system may be reduced from the above estimates by improved management of both irrigated and rainfed crops. However, there are additional challenges looming, including demand for bioenergy and the growing appreciation of the importance of "ecological flows," that is, water that must be allocated to conserving nature. The protection of valued and valuable ecosystems, such as estuaries, wetlands and streams, is a competing demand for water that governments and environmental interest groups will need to add into the search for sustainable ways of meeting the human food requirement. Allocating water among the food and energy demands of ever more people on Earth, combined with possible climate change and our wish to conserve nature, is among the great challenges facing humanity in the coming 50 years.

References

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