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The Role of Irrigation in Meeting the Global Water Challenge

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Peter Rogers has a wide range of research experience in the consequences of population on natural resources development and in improving methods for managing the world's natural resources and the environment for sustainable development. Rogers presented his views on the global water challenge we now face and the role irrigation technology might play to meet that challenge.

In addressing the role that irrigation might play in the global water challenge, Peter Rogers explained that precipitation falling on the earth's surface is the ultimate source of water. He described its eventual separation into "green" and "blue" water, a concept first introduced by the Stockholm International Water Institute and further illustrated in *Water for Food, Water, For Life: Comprehensive Assessment of Water Management in Agriculture* published by the International Water Management Institute in 2007. According to IWMI, blue water is water in rivers, groundwater aquifers, reservoirs and lakes and is the main water source for irrigated agriculture. Green water refers to the soil moisture generated from rainfall that infiltrates the soil and is available for uptake by plants. It constitutes the main water resource in rainfed agriculture.

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On average, about 56 percent of the water falling on the surface evaporates or transpires from forests, grazing lands and other natural habitats. About 4.5 percent evaporates or transpires from rainfed agriculture and another 2 percent from irrigated agriculture. The percentage of rainfall consumed by cities and industry is only 0.1 percent of the total rainfall.

How scarce is water?

Given that irrigated agriculture uses such a low percentage of precipitation, how can the Earth run out of water? The total available blue water, which is available for use from streams and groundwater, is about 12,500 cubic kilometers. The rest of the blue water is unavailable because it is either in the wrong place, such as remote arctic streams, or comes at the wrong time, such as during a flood. Based on these estimates, humans use 50 percent of the available blue water supply, which is close to the edge of sustainability.

If blue and green water are considered, humans use only 23 percent of the available water supply. Most of that is used by rainfed food, fiber and forestry crops. "You can heave a sigh of relief and say, well, gee, 23 percent is a lot better than 50-something percent," Rogers said. "So part of my argument again is, we have a global water problem coming up and … how close to the edge are we?"

How scarce is water? Water scarcity is based upon physical resource availability and economic resource availability. In economics, the price of a commodity usually is a good indication of scarcity. If something has a price, it's scarce. Yet people rarely pay for water, so the price of water is not a good economic indicator of scarcity.

The IWMI Comprehensive Assessment examined four types of water scarcity, noting the difference between not having any water and having water but not being able to use it. If less than 25 percent of the blue water is used, there is little or no physical scarcity; if more than 75 percent of blue water is used, there is a physical scarcity. Economic scarcity is caused by a lack of investment in water or the human capacity to access it, classified as less than 25 percent of the blue that water is being withdrawn.

According to the Comprehensive Assessment, key areas suffering from physical scarcity or near scarcity of water include northern and southern Africa, eastern Europe, southern India, southwestern U.S., and parts of China and Australia. Eastern India, large parts of Sub-Saharan Africa and western parts of South America are suffering from an economic scarcity of water. A tremendous amount of water is available in these areas, but proper infrastructure access has not been developed. These areas provide an excellent opportunity to increase food production.

The impact of climate change and socioeconomic changes on water demand

According to Rogers, the potential impacts of climate change are unclear. The Earth's temperature is rising and scientists suspect various areas will experience precipitation changes, but the impact is difficult to quantify. The Intergovernmental Panel on Climate Change says predictions about precipitation beyond 2050 are uncertain. Combining the output of 18 global climate change models shows a number of areas will have increased precipitation and runoff. Yet in other areas, including the southern U.S., Central America, regions around the Mediterranean, southern Australia and the southern tips of South America and Africa, mean surface water runoff will decrease 20 to 50 percent. "Certainly these areas are of concern," Rogers said.

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Rogers cited a study by Charles Vorosmarty (2000) that examined the forecasted changes in demand for blue water discharge for industry and agriculture compared to current uses under three scenarios: climate change only, population increase only and climate change with a population increase. The smallest increase in demand for blue water would occur under climate change only. With only population change, increases up to 20 percent could occur in many areas of the populated world, except the western U.S. and Australia. Given climate change *and* population increases, demand could rise more than 20 percent in most of the populated world. Rogers suggested that experts need to concentrate on how to handle the third scenario.

The IPCC fourth assessment report states that moderate global warming of only 3 degrees Celsius could benefit crops and pastures in the mid- to high latitudes but decrease yields in seasonably dry and low-latitude regions. Without major climate change, the number of undernourished people could decline from 820 million today to 100 to 380 million. With climate change, the number of undernourished could rise to 740 million to 1.3 billion. Changes in the frequency and severity of extreme events also could have significant consequences for food and forestry production and increase the risks of fires, pests and pathogen outbreaks. "We could do pretty well under climate change … or not," Rogers said.

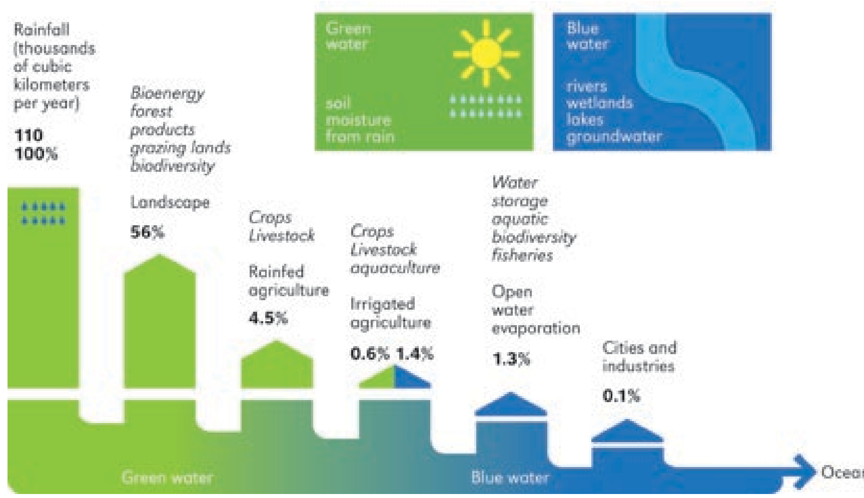
Domestic water use by U.S. households is 333 liters per capita per day, almost the same amount used by the ancient Romans, Rogers said. He suggested that the conventional view that water use varies greatly among populations is true only when agricultural

water use is not included. Household, service and industrial water use is 366 cubic meters per capita annually in the U.S., 232 in Europe and only 25 in Africa. But if water for agriculture is included, total usage is similar: 3,104 cubic meters per capita annually in the U.S., 2,970 in Europe and 1,393 in Africa. Additionally, people tend to eat more meat when a country's socioeconomic situation changes and their incomes rise. "This is part of the reason we're seeing in places like China and India a huge demand for animal products, and animal products use an awful lot more water than grain," Rogers said.

Can we meet the water demand for higher food production?

The 2007 IWMI Comprehensive Assessment stated that agricultural production must increase 80 percent by 2050 to feed greater numbers of people demanding more animal protein. To meet this target, rainfed cropland must increase by an additional 85 million hectares and irrigated land by an additional 60 million hectares. Governments will need to spend $304 billion to rehabilitate 222 million hectares of irrigated land and construct additional storage for 766 cubic kilometers of water. Based on these estimates, water scarcity will occur. Adding water for the production of biofuels means the system becomes considerably stressed.

Despite these predictions, Rogers was optimistic. The Comprehensive Assessment estimated crop evapotranspiration and irrigation withdrawals in 2050 under various scenarios: optimistic and pessimistic, rainfed, irrigation, trade and comprehensive management scenarios. Global water use today is about 7,500 cubic kilometers. Estimated water use in 2050 is 10,000 cubic kilometers, based on rainfed scenarios with productivity improvement. Without productivity improvement, global water use in 2050 will be 12,500 cubic kilometers. Rogers concluded these scenarios indicate that with production improvements and increased agricultural trade from water-rich to water-scarce nations, global food needs can be met.



Graphic adapted from the 2007 IWMI Comprehensive Assessment

Some technical fixes

Rogers proposed technical fixes to improve water availability. The first was virtual water – the water that a country saves by importing crops instead of growing them. The U.S. exports 100 cubic kilometers of water each year, the equivalent of a hundred billion tons, in the form of grain and other agricultural products. Australia and southern South America are the other major virtual water exporters, while large parts of the world are net importers. The total virtual water trade was 700 to 900 cubic kilometers per year in 2003 – a huge amount of water that receiving countries avoided using.

How would free trade affect virtual water flows? Rogers studied the effects of the North American Free Trade Agreement and found that relatively free trade sped up the process, with the U.S. importing more Canadian water and exporting more grain (virtual water) to Mexico and to Canada. "I think we need to look at these types of things," Rogers said, as they offer one solution to reduce the need for excessive amounts of local water for agriculture.

Desalination is another technical fix. In a World Bank study of the Middle East/North Africa region – one of the world's most arid – the return to water use in dollars per cubic meter was calculated at 50 cents for vegetables, 8 cents for wheat and 5 cents for beef. Water can be desalinated for about 50 cents per cubic meter, and some believe the cost could dip as low as 30 cents. This makes it economically realistic to use desalinated water for high-value crops, such as vegetables. "I wouldn't have believed this myself until I read this report that you could actually afford to use desalinated water for irrigation." Rogers said.

A third technical fix is economic and regulatory controls, which is the issue of freeing up trade. "What's wrong with more crop per drop?" Rogers asked. He cautioned although increasing crop per drop of water consumed is important, the real objectives must be clear. Is the goal to increase the kilograms of crop per cubic meter of water, the monetary return or the amount of protein or calories? All are important. Rogers stressed that the efficiency of all production inputs, including water, and the overall economic consequences must be assessed, otherwise "you can get silly conclusions."

"Water pricing is a very tough issue around the world."

Rogers closed with a list of six actions that could be used to manage water to meet future food challenges.

1. Water pricing. "Water pricing is a very tough issue around the world. It's tough in the United States. It's tough in every country I've visited," he said. However, some pricing is reasonable and makes people consider the cost of consuming water, using electricity to pump it and employing other inputs.

2. Conserve irrigation water, technical changes. "A 10 percent improvement of efficiency in irrigation applications would give you more water than you would need for all of the domestic and industrial water combined for a country," Rogers said. Improving the efficiency of irrigation and improving crop productivity and water use will reduce the amount of irrigation needed, "and irrigation water is the name of the game, obviously."

3. Invest in water infrastructure, maintenance issues. Improved maintenance of facilities would reduce water losses and non-beneficial evaporation.

4. Adopt ecosanitation. Recycling and reusing wastewater is already occurring in Orange County, Calif., and Singapore, where a reverse-osmosis water factory will start recycling 500 million gallons a day this year.

5. Ship virtual water, rationalize world food trade and exploit desalination.

6. Consider the conclusions of the IWMI Comprehensive Assessment:

- Sufficient land and water resources exist globally to produce food for a growing population over the next 50 years.
- It is probable that today's food production and environmental trends, if continued, will lead to crises in many parts of the world.
- The acute freshwater challenge facing humankind over the coming 50 years will be met only by improving water use in agriculture.

"I think it's a very sensible and a cautionary tale," Rogers said. "This is not going to be easy."