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How Water Scarcity Will Shape the New Century
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It is exciting for me to be part of this 10th Water Symposium. I am especially impressed with what a few dedicated people in a rather small country like Sweden can do to draw global attention to an issue that desperately needs it. First, I would like to pay particular tribute to Malin Falkenmark, who has been leading this effort for so many years. I think it was Margaret Mead who said all great social movements begin with one committed individual, and I think Malin has demonstrated very well what a committed individual can do, and all the colleagues that have gathered around her to make Sweden a leader in this field. Malin has been a mentor for me and many others, helping us to understand the water issue and its importance.

Over the next 35 minutes, I will be talking about how water will shape the new century, affecting every facet of our lives, from the use of recreational time to the structure of our diets.

World water use has tripled over the last half-century. Seventy percent of all the water that is withdrawn from rivers or from underground sources is used for irrigation. Twenty percent is used by industry, ten percent for residential purposes. Forty percent of our food supply now comes from irrigated land, which now plays a disproportionately large role in the world food economy. The demand for water has tripled since 1950 and is continuing to rise as we add 80 million more people each year.

While the demand continues to rise, the basic amount of fresh water supply provided by the hydrological cycle does not. I would like to talk about two of the principal signs of stress as the demand for water outruns the supply. One is rivers running dry, the other is falling water tables.

Many of the world's major rivers now fail to make it to the sea, or there is very little water left in them when they do reach the sea. The Colorado River, the major river in the southwestern United States, rarely reaches the Gulf of California. It is drained dry to satisfy the agricultural needs in Colorado, Arizona and, importantly, California. The Nile River, the lifeline of Egypt, has little water left in it when it reaches the Mediterranean. The Ganges, shared by India and Bangladesh, is almost dry when it reaches the Bay of Bengal. This has become a negotiation between India and Bangladesh — how to divide the limited supply of water in a river basin where a few hundred million people live.

Consider too, China's Yellow River, the cradle of Chinese civilization. It first ran dry in 1972 for some 15 days, and then it ran dry intermittently for several years. But beginning in 1985, it has run dry for part of each year. And, as someone mentioned earlier, in 1997, it ran dry for more than half the year. For some months, it did not even reach Shandong, the last province that it flows though en route to the sea.

The Yellow River provides a fascinating study of the competition that develops in a river valley when there is not enough water to go around. The Chinese government has decided that the interior provinces, the poor provinces of the country, will get priority in the use of the water in the Yellow River basin. There are literally hundreds of projects now underway and planned that will reduce further the amount of water in the lower reaches of the basin. The Yellow River flows though eight provinces en route to the sea, originating in Qinghai-Tibet plateau and ending in Shandong Province. Shandong used to get half of its irrigation water from the Yellow River, with the other half coming from the province's underground aquifer. But now, farmers are not getting enough water. The World Bank estimates that in China as a whole, farmers with irrigated land only have 80 percent of the water they need to maximize their yields.

There was a major riot in Shandong a few weeks back when the government tried to repair a large reservoir that had been leaking for years. The local people, who depended on the leakage from the reservoir, rioted to protect their water supply. One hundred and twenty villagers were injured, 50

policemen were injured, and one policeman was killed. This riot is just a small indication of what people will do when they are deprived of the water they need. And this scenario is going to be repeated many times around the world in various forms wherever there is competition for water. Shandong province is important agriculturally in China because it accounts for a fifth of China's corn harvest and a seventh of its wheat harvest. The government's actions in giving upstream provinces priority suggests that Beijing is prepared to sacrifice irrigated agriculture in the lower regions of the basin in order to develop the interior because there is such a huge income gap between the coastal provinces and the interior.

In the competition for water, agriculture almost always loses. The reason is basic economics. In China, for example, if you have a thousand tons of water, you can use it to produce one ton of wheat which is worth about 200 USD at most, or you can use that thousand tons of water to expand industrial output by 14,000 USD.

A country that needs growth and is desperately trying to create jobs does not use scarce water for food production if it can afford to import food. So we are seeing some major policy shifts in China now. One, which they have publicly announced, is that in the increasingly intense competition for water, cities and industry will come first, with agriculture becoming the residual claimant. China has also announced that it is giving up the goal of self-sufficiency in the production of grain. It now recognizes that because of water shortages, it is going to have to begin importing more grain in the future.

Today we find water tables falling on every continent. Aquifer depletion is a new problem. We have had problems in irrigation from the very beginning, some 5000 years ago. But the depletion of aquifers is a new problem, one that has emerged only in the last half century or so, because it is only during this period that we have had the pumping capacity to quite literally deplete aquifers. We see this in the Punjab, the breadbasket of India. Beginning in the mid-1960s with new high yield varieties, that are also earlier maturing varieties, India was able to institute a very productive double cropping system of high yield winter wheat and high yielding rice as the summer crop. But it takes water — a lot of water — to produce two high yielding crops. What has happened is that the water table under the Punjab is falling by half a meter per year. At some point India is going to have to make some adjustments.

A similar situation exists in China. The government has reported that the aquifer under the North China plain, which produces 40 percent of China's grain harvest, is falling by 1.5 meters (roughly five feet) per year. At some point, there will have to be some major cutbacks in the use of irrigation water on the North China Plain.

My colleague Sandra Postel has attempted to calculate the size of the world water deficit — the amount of overpumping in the world. She has concluded, using data for India, China, the Middle East, North Africa, and the United States, that worldwide we are now each year overpumping by a 160 billion tons of water, which equals 160 billion cubic meters.

Since it takes a thousand tons of water to produce one ton of grain, a 160 billion-ton water deficit is equal to a 160-million-ton grain deficit. Stated otherwise, roughly 160 million tons of the world's grain supply is now being produced by overpumping. Assuming a person consumes one third of a ton of grain each year, the current global average, 160 million tons of grain will feed 480 million people. This means that of the world's current population of six billion, we are feeding 480 million with grain produced with the unsustainable use of water. Stated otherwise, we are now beginning to feed ourselves with water that belongs to our children. We are borrowing water from the next generation.

Ironically, world grain prices right now are at the lowest level during the last two or three decades. To an economist, this looks like a situation where we have excessive productive capacity. To an environmentalist, it looks like a situation where we are overproducing by using resources — importantly water — unsustainably.

Let me illustrate the difference between these two views. If we were to decide next year that worldwide we would no longer overpump aquifers, recognizing that there is some point where we have to stop overpumping and stabilize water tables, grain harvests would drop an estimated 160 million tons, and

world grain prices would go off the top of the chart. In our long-term projections of agriculture supply and demand, we have come not close to doing an adequate job of incorporating the water situation.

One of the new things we are beginning to see in the world water economy is that water scarcity is crossing national boundaries via the international grain trade. In an increasingly integrated global economy, water scarcity — traditionally a local issue — is quickly becoming an international issue. The fastest growing grain market in the world today is North Africa and the Middle East — Morocco, Algeria, Tunisia, Libya, and Egypt and the Middle East eastward through Iran. Every country in that region is facing water shortages. As water becomes scarce, the growth and the demand for water in cities and by industry is satisfied by taking water from agriculture. This is then offset by importing grain.

A number of countries in that region now import half or more of their grain. The water required to produce the grain and other foodstuffs imported into that region last year was equal to the annual flow of the Nile River. Stated otherwise, if you want to visualize the size of the current water deficit in North Africa and the Middle East, it's equal to another Nile River flowing into the region in the form of imported grain. And the deficit is growing rapidly year by year.

It is now commonly said that future wars in the Middle East are more likely to be fought over water than over oil. This could be. But it is difficult to win water wars. My guess is that the competition for water in the Middle East, and indeed throughout the world, is going to take place in the world's grain markets. And it's the countries that are financially strongest, not those which are militarily the strongest, that are going to win in this competition.

We have seen, for instance, growing import needs in many Middle Eastern countries. Iran last year displaced Japan as the world's leading wheat importer. That was driven in part by drought. It is an indication of how rapidly the growth and import demand is growing in water short countries. Egypt this year will also pull ahead of Japan, becoming the number two wheat importer. Water is beginning to shape international grain trade patterns in much the same way that land scarcity has historically.

One of the wild cards in the water situation and one of the things that makes assessing the future water situation difficult is climate change. At the Worldwatch Institute, we have been tracking various climate indicators, initially sort of the first level ones, like carbon emissions, atmospheric CO2 levels, and rising temperatures (the fifteen warmest years of the last century have all come since 1980). There has been a very distinct upturn in global temperature. But now we are beginning to look at some of the secondary effects, like ice melting. And some of the things we see are scary.

In the Arctic Ocean, the ice sheet has shrunk by nearly 40 percent over the last 35 years. A recent Norwegian study indicates that in another half century there might be no ice left in the Arctic Ocean in the summertime — an enormous change. But it is when ice on land begins to melt that we will see rising sea levels, and we are beginning to see that. One of the things that is going to affect water supply, particularly for agriculture, is the temperature rise in mountainous regions.

A rise in average temperature in mountainous regions of 1 or 2 degrees Celsius can substantially alter the precipitation mix between rainfall and snowfall, with substantial increases in the amount of precipitation coming down as rain and a reduction in the amount coming down as snow. This change translates into more runoff and more flooding during the rainy season but less water being stored as snow and ice in the mountains for use in the dry season.

We have been taking these "reservoirs in the sky" for granted. They have been there ever since agriculture began, certainly since irrigation began some 5,000 years ago. But they are beginning to melt. Ice is melting in all the major mountainous regions of the world. In the United States, Glacier National Park located in the State of Montana, had 150 glaciers in it a century or so ago. Now there are only 50. And the US Geological Service is projecting that in another 30 years, there may not be any left at all. Consider, too, the Andes, where melting is accelerating, or the Alps, where there has been an enormous shrinkage in the snow/ice mass.

That’s why we discovered the iceman at the Austrian "Italian border several years ago, emerging from the ice. It was not the only one. Our ancestors are emerging from the ice with a message for us. And that message is, “The Earth is getting warmer.” As it does, the ice and snow are melting.

The snow/ice mass in the Himalayas, which is the third largest in the world after the two polar ice caps, is now beginning to shrink, and at an accelerating rate. This is of importance to us at this conference, because every major river in Asia originates in that snow/ice mass. Whether it is the Indus shared by India and Pakistan, the Ganges shared by India and Bangladesh, the Mekong, and the Yangtze or Yellow River, they all come out of that central Asian snow/ice mass. And it is shrinking. This could alter the hydrology of Asia in ways that we cannot now even in some ways begin to understand, with more runoff during the summer rainy season, and less snow melt to feed rivers during the dry season.

We have seen the projections of water supply and demand for a few countries, but in very few countries have we done what the World Bank has done for South Korea, which is to project the amount of water that will be available for agriculture as the water needs for industry and cities increase. The projection for South Korea is that 13 billion cubic meters used each year for irrigation today will shrink over the next 30 years to 7 billion cubic meters. We need those kinds of projections for major countries everywhere so we can better understand what the future water balance is going to look like.

What do we do about this unfolding situation? I would like to quickly touch on several things that I think are important. First of all we need to take a fresh look at population. We are currently projected to increase from six billion at present to nearly nine billion by mid century. But almost all of the three billion projected growth increase will come in countries that are already suffering water shortages.

I did a recent article on hydrological poverty. With populations growing fast in water-short regions of the world, scores of countries are facing acute hydrological shortage — simply not enough water to satisfy basic human needs. This is a new situation, and we need to look at it closely. First, we need to look at the UN population projections and think about moving from the midlevel projection of nine billion to their low projection of seven billion. Unfortunately, adding even another billion people in countries that are already overpumping aquifers poses a serious issue. I think the time has come where we have to begin thinking about trying to hold the line everywhere, at two surviving children. Otherwise, hydrological poverty is going to be inevitable and, unlike other forms of poverty, inescapable. While we cannot tremendously alter the amount of water available in any particular country, we can use it more efficiently. But even with more efficient use — much more efficient use — there is still not nearly enough to go around given the population projections. So, shifting to smaller families is necessary sooner not later, when it could well be too late.

I could talk about more recent irrigation technologies, but it would not add very much to what you already know and have been discussing in various symposia. For instance, the success of drip irrigation is obvious; however, the economics are currently limited for the most part to high-value crops. This is an area where Israel has done some important pioneering work — low-pressure sprinklers for overhead irrigation, a definite advantage over the high-pressure ones or surface irrigation.

We need to begin thinking about changing irrigation practices. There is some evidence that rice, for example, can be grown with intermittent irrigation, rather than continuous flooding of the fields without sacrificing yields. That could provide water savings.

More efficient irrigation technologies and practices are important, because 70 percent of all the water extracted from underground and diverted from rivers is used for irrigation. More water-efficient crops would help stretch water supplies further. Wheat, for example, requires less water per ton than does rice. Growing more water efficient crops is an important component of an effort to reestablish a balance between the supply and the demand for water.

Another important step is to restructure the world animal protein economy. Much of the growth in the demand for grain over the next few decades will come in the form of feed grain in developing countries as people throughout the world try to move up the food chain and consume more animal products. Once we

get to the point where we will have to feed to get a decent amount of animal protein, because we have hit the limits both with oceanic fisheries and with grainlands, then feed conversion rates become important.

Cattle require some seven kilograms of grain to add one kilogram of live weight. For pork it is about four kilograms of grain for one kilogram of live weight. For poultry, it is closer to two to one. And for fish in aquaculture (not the predatory species like salmon and trout, but like carp in China, which produces more than half the world's fed fish, or catfish in the United States), the conversion rate is one kilogram of live weight for less than two kilograms of grain, an extraordinarily efficient conversion.

So as we look ahead, we need to be looking at satisfying future demand for animal protein much more from poultry or from fish farming than from beef production or pork production. We can still get the animal protein, but we can do it with a much more efficient use of grain, and if it is more grain efficient, then it is more water efficient. So we have to think about the water efficiency of future animal protein sources.

Another area to consider is water pricing. One of the great problems that we as environmentalists see in the world is that we are underpricing some resources, and that is creating serious problems. We are underpricing gasoline, for example, and various fossil fuels. The result is that we are getting climate disruption. We are underpricing water almost everywhere, whether in the southwest of the United States or in India or in China. India is even subsidizing water use by providing low cost electricity to farmers to run irrigation pumps.

We should not be subsidizing the use of scarce resources. Rather, we need prices of water to reflect the value of water. This is difficult. It is particularly difficult with countries like India or China. Trying to raise the price of water in China is like trying to raise the price of gasoline in the United States. There is a lot of resistance, and it is politically difficult, but it is the only way we can go. When water prices more clearly reflect the value of water, then we will begin to see efficiency permeate the entire economy in the use of water.

We have to think about raising water productivity across the board. About 50 years ago, we were facing a similar situation with land productivity. Up until the middle of the last century, most of the increase in food production came from expanding the land area, but suddenly we reached the point where it became very difficult to expand the area of agricultural land. At this point, we systematically began to shift to raising land productivity.

Governmental policies were designed to raise land productivity, including investment in agriculture research, price support policies in agriculture, credit for farmers, and a whole range of investment in irrigation and in fertilizer. All of these changes raised land productivity. But with water productivity we do not even have a common vocabulary, a common set of indicators with which to measure water productivity. With grain, everyone in the world uses either tons per hectare or, in the English system, bushels per acre. We have a common framework, but we do not have this for water and it is very much needed.

What we need as we begin this new century is a revolution in water productivity, a “blue revolution” as it has been called that is comparable to the concerted effort undertaken a half century ago to raise land productivity.

These are some of the thoughts that I have on this Monday morning as we open this tenth symposium on water. I would like to again commend the organizers for all the work over the last decade for helping escalate the water issue in the public mind. Because water has traditionally been an abundant resource and, essentially, a free resource, we have been taking it for granted. We can do so no longer. We now have to think about water in a very systematic, comprehensive way. We have to recognize water for what it is- a scarce resource.

This morning Minister Kjell Larsson said that when we are exploring space, we get very excited when we see some indication that there might be water on some other planet or some place, because we know that water is the basis for life. But here on earth, we take it for granted.

I think one of the ways of judging the success of these symposia is the extent to which water has been escalated in public importance. I believe it is going to escalate a lot more in the years ahead as we begin to understand what it is like to live in a water-scarce world.

Thank you.