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Edited Transcript

Impact of Global Warming on Agriculture Around the World

William R. Cline explains how he has analyzed the effect of climate change on agriculture on a country-by-country basis, where the impact will be greatest, and what we need to do to reduce the risks.

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Sherman Katz: Welcome to Peterson Perspectives. Today, Bill Cline discusses his book *Global Warming and Agriculture: Impact Estimates by Country,* which examines the likely impact at the country level of climate change on farming, especially in China, India, Brazil, and poor countries in the tropical belt in Africa and Latin America. Bill Cline has been a senior fellow with the Peterson Institute since 1981 and a senior fellow at the Center for Global Development as well since 2002.

Sherman Katz: Bill, what impact does global warming have on the way crops develop, and how does that altered path of crop development in turn contribute to drier conditions?

William R. Cline: If you ask why warming would affect agriculture, I find the simplest way to think about that is to remember the book by John Steinbeck, *Grapes of Wrath,* in which the United States experienced hot, dry conditions in the 1930s. The consequence was the Dust Bowl that basically wiped out farmers in Arkansas and Oklahoma and was the subject of that book.

The process of warming increases the evaporation from the soil and increases what's called transpiration, evaporation of water from plant leaves. And that goes up more than linearly with the temperature, and it outraces any increase in precipitation. So except in certain locations where there would be a concentration of increased rainfall, you're going to get drier conditions. The dryness is disadvantageous to agriculture; water is an input in producing hydrocarbons.

In addition, the warmer conditions speed the plant through its development, so it doesn't have as much time to develop grain filling. So there are good reasons to expect adverse effects. The United States itself with the Dust Bowl has historical experience with such consequences.

Sherman Katz: How did you go about trying to evaluate the longer-term impact on agriculture?

William R. Cline: The first step was to get what the climate will look like toward the end of this century, and there are several climate models that have projections posted on the website of the International Panel on Climate Change. I converted those models all to standard geographical areas of about 100 square miles. Then I had today's temperature, the future temperature, today's rainfall, and the future rainfall from the climate models.

The second thing was to combine that with agricultural impact models of two types: crop models where the experimental research stations will actually try different combinations of different crops and different amounts of fertilizer that generate patterns of the response of productivity to temperature into rainfall; and a second category of statistical models that take the county-level data across the United States, for example, and look at what's the value of the product that's being produced there and how does that relate to all of these factors, whether it's land quality, closeness to cities, etc., but in addition to the temperature and rainfall. So you've got the climate models and two types of agriculture models, and I use them to predict the impact on agriculture by the 2080s.

Sherman Katz: How did you take into account that plants might benefit from having more carbon in the air?

William R. Cline: The process of producing hydrocarbons involves sunlight, water, and carbon dioxide as an input. So it stands to reason that if you get more carbon dioxide, you should get more output. There have been experiments in laboratories that show that if you enrich the atmosphere with carbon dioxide, you will in fact get higher yields. What I did was to look very carefully at the latest information on that, which uses open-field experiments where they actually enrich the atmosphere in a small area in an open field and you tend to get smaller yield increases than had been the results in laboratory experiments.

So I took carbon fertilization into account, and the bottom line is that, with the amount of carbon dioxide in the atmosphere by the 2080s, you had increased the yields potentially by something like about 15 percent. Some of the earlier estimates had said maybe double that, but I think 15 percent is a fair estimate. What I have is two sets of estimates: one without that effect, and one with it. And of course the estimate with carbon fertilization is more favorable.

It's also important to recognize that I do not take into account the adverse effects of severe drought and the increased pests. So my estimates without carbon fertilization can be seen as taking account of the fact that there are some negative effects that I'm not including.

It's also important to recognize that the warming will not stop in the 2080s if we don't do something about it. It will get worse and worse in the decades after that. So by taking a snapshot of the 2080s, I'm also in some sense understating the potential future damage.

Sherman Katz: Tell us where on the globe the impact will most likely fall.

William R. Cline: Through all these calculations, this pattern starts to emerge, which is that the greater damage is closer to the equator. That makes sense because the temperatures, except for high plateaus where you have elevation helping you out at the equator, the temperatures at the equator are already closer to crop tolerance levels.

The impact tends to hit the developing countries disproportionately because they tend to be the ones located at the equator. So you have impacts that are most severe in Africa and in Latin America.

Probably the most sobering estimate is that for India , agricultural yields would fall by 30 to 40 percent. It's interesting to contrast India to China because China in my estimates could have either a plus 6 or 7 percent or a minus 6 or 7 percent, depending on whether you include this carbon fertilization influence. And if you think about it, China is farther from the equator than India, and it fits that pattern.

Sherman Katz: What about the impacts in the United States and Mexico?

William R. Cline: For the United States as a whole, the impact turns out to be almost the same as for China, which is it could be plus or minus 7 percent, depending on whether you have the carbon fertilization. But the differences are stark between the northern and southern parts of the United States. You get very substantial losses in the southern part of the country versus gains in the north. In Mexico, the loses would be on the order of 25 to 35 percent. For example, in the United States, the impact in the northeast, the Great Lakes region, would be a gain of about 5 to 20 percent. But in the southwest plains, there would be a decline of 35 to 25 percent.

Sherman Katz: Are there some countries in Africa or Latin America that would be particularly vulnerable?

William R. Cline: Well, Senegal is an example of a country with extremely large negative effects, as is Mexico, but most of Africa has adverse effects.

Sherman Katz: Would Ecuador be badly hurt, and are there others on that same line in Latin America?

William R. Cline: Ecuador would have substantial adverse effects 20 percent to 30 percent, even though it does have the advantage of elevation in parts of it. Northeast Brazil does poorly as well, also with losses of 20 to 30 percent, whereas southern Brazil does considerably better.

Sherman Katz: What should we and other nations do to reduce these risks?

William R. Cline: The principal message is that this is a disaster that doesn't have to happen. This disaster happens if we continue to have ever-rising global carbon emissions from something like seven billion tons of carbon today annually, rising to something like 20 or more billion tons of carbon by the end of this century. That's the driver of this problem.

If we can get an international effort that's effective at curbing our reliance on carbon-based energy—and coal is particularly an important offender but so is oil—then we can avert this problem. So I think it's very encouraging that the political environment in the United States seems to be shifting toward taking meaningful action on this issue after the eight years of the present administration where essentially we were resisting that.

Sherman Katz: Do you think the proposals of either candidate John McCain or candidate Barack Obama will make a significant difference?

William R. Cline: The last time I checked their websites, McCain was advocating a reduction of emissions by 44 percent by 2050. Obama was calling for an 80 percent reduction. Those are the right kind of numbers. The Intergovernmental Panel on Climate Change is saying you need to cut emissions by 50 percent from their 1990 levels by the year 2050.

Now, you need to do this globally. The cuts would be more severe for the developing countries because they have not yet gotten to higher income levels, so they'd have to avoid a rising path of emissions. That means more than a 50 percent cut for countries like the United States.

So in principle, the answer is, yes, the proposals could go a long way toward solving the problem. My concern is that in terms of actually implementing these, there are lots of challenges. And I worry a little bit that, because the targets are set so far in the future, they might not be taken for serious implementation over the next 10 or 15 years. And by the time we get to 10 years from now, we might say, "Oh well, we can't really meet that timetable. Let's do it a little bit differently." But in principle, yes, I think it's encouraging that the US political environment seems to be shifting direction.

Sherman Katz: Do you prefer a carbon cap-and-trade solution or a carbon-tax solution, or is there something else you think might help?

William R. Cline: Like most economists, I have tended to prefer a carbon tax because it sends a uniform price signal to everybody around the world in principle, but certainly to every user in a country if it's a country-specific tax. I know a lot of environmentalists are worried about that because they're afraid that might not actually get the absolute limit you need on the emissions. I think that can be addressed by the fact that if the emissions are still going along too rapidly, then you can increase the tax. This is a very long-term process.

The politics behind this seem to have moved relatively far toward a cap-and-trade where you have emission rights, and then those could be traded. It's understandable why that's the case; the existing emitters are going to feel a lot more comfortable if they are given a right that is grandfathered in. And then not only that, they can then sell those off and maybe make money on them. So the political economy of getting the job done is understandably facilitated by talking about cap-and-trade as opposed to a tax.

If you shift from a cap-and-trade that's grandfathered to a cap-and-trade where the emission rights are auctioned off over time, then that part of the political economy starts to disappear. And arguably, there are ways you can make them basically comparable.

Maybe one way to think about this is to start with a cap-and-trade and then move toward a tax system. But perhaps the important thing is to have a reliable penalty on carbon, not just in the United States but also internationally that is about the same everywhere, because then that would get all of the firms responding in terms of new inventions and technologies they choose to avoiding carbon-intensive energy.

Sherman Katz: You've made an important statement on the agricultural impacts of the path we're headed on in your book *Global Warming and Agriculture.* Thank you very much for this conversation.

William R. Cline: Thank you.