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## **World Agriculture Faces Serious Decline from Global Warming**

*Developing Countries Face Much Greater Damage than Rich Countries  
India could see drop of 30 to 40 percent by the 2080s*

**Washington D.C.:** World agriculture faces a serious decline within this century due to global warming unless emissions of carbon dioxide and other greenhouse gases are substantially reduced from their rising path, and developing countries will suffer much steeper declines than high-income countries, according to a new study.<sup>1</sup>

Developing countries, many of which have average temperatures that are already near or above crop tolerance levels, are predicted to suffer an average 10 to 25 percent decline in agricultural productivity by the 2080s, assuming a so-called “business as usual” scenario in which greenhouse gas emissions continue to increase, according to the study. Rich countries, which typically have lower average temperatures, will experience a much milder or even positive average effect, ranging from an 8 percent increase in productivity to a 6 percent decline.

Individual developing countries face even larger declines. India, for example, could see a drop of 30 to 40 percent. Some smaller countries suffer what could only be described as an agricultural productivity collapse. Sudan, already wracked by civil war fueled in part by failing rains, is projected to suffer as much as a 56 percent reduction in agricultural production potential; Senegal, a 52 percent fall.

China, further from the equator than most developing countries, could escape major damage on average, although its south central region would be in jeopardy. The picture is similar

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<sup>1</sup> *Global Warming and Agriculture: Impact Estimates by Country*, by William R. Cline.

in the United States, with projected reductions of 25 to 35 percent in the southeast and the southwestern plains but significant increases in the northern states.

Overall, agricultural productivity for the entire world is projected to decline from levels otherwise reached by between 3 and 16 percent by 2080s as a consequence of global warming. The damages would continue to deepen in the following century in the face of still greater warming.

The projections are the work of William Cline, a senior fellow at the Center for Global Development (CGD) and the Peterson Institute for International Economics. Cline is a pioneer in the study of the economic impact of global warming, having published an early comprehensive study of the issue in 1992.

“Some analysts have suggested that a small amount of global warming could actually increase global agricultural productivity. My work shows that while productivity may increase in a minority of mostly northern countries, the global impact of climate change on agriculture will be negative by the second half of this century,” Cline said.

“There might be some initial overall benefit to warming for a decade or two but—because future warming depends on greenhouse gas emissions today—if we delay action it would put global agriculture on an inexorable trajectory to serious damage,” he added.

Cline’s new book, *Global Warming and Agriculture: Impact Estimates by Country*, builds on climate models used by the Intergovernmental Panel on Climate Change (IPCC), the world’s leading scientific body on the issue.

He has combined six of these climate models with other modeling techniques and statistical tools relating agricultural productivity to climate to produce the most comprehensive estimates available, applying a consistent methodology to more than 100 countries, regions, and sub-regions within the larger countries. Previous studies have provided regional estimates or country estimates for just a handful of countries. The book is published jointly by CGD and the Peterson Institute for International Economics.

“Bill’s projections are sobering and alone they understate the potential problem,” said Nancy Birdsall, president of the Center for Global Development. “Governments and millions of poor people in developing countries have limited ability to cope with such changes. At least a billion people live in the poorest countries that are likely to be worst hit by this slow-moving crisis. This will be a serious problem for us all.”

Cline said that the productivity losses could be even greater than he has calculated because of more insect pests, severe drought, and scarcity of water for irrigation, changes that are likely to accompany climate change but are not explicitly included in the models he used in the study.

The book's projections are based on changes in temperature and rainfall predicted in six of the most widely accepted climate models under the leading international scenario for rising greenhouse gas emissions. Cline combines these climate projections with crop models and "Ricardian" models to obtain estimates of the likely impact of global warming on agriculture. (Ricardian models link land price data to temperature and precipitation, as well as soil types and other variables.)

### **Uncertainty about Carbon Fertilization**

Cline presents a range of estimates to reflect uncertainty about plant-growth benefits from an atmosphere richer in carbon dioxide. Because plants absorb carbon dioxide (CO<sub>2</sub>) from the air in their growth process, scientists have suggested that as CO<sub>2</sub> concentrations in the atmosphere rise, plant growth will increase.

This carbon fertilization effect has been demonstrated in laboratories, but recent open-air field experiments indicate smaller gains. The alternative set of estimates of less serious impacts in developing countries and slightly positive impacts in some rich countries assumes that there will be a substantial carbon fertilization effect. Cline says that although a carbon fertilization effect of the magnitude he uses (+15 percent by the 2080s) is plausible, it remains uncertain.

"I think it would be extremely risky to assume that carbon fertilization is the solution to this problem," Cline said.

### **Will Better Agricultural Technology Offset Climate Losses?**

Another area of uncertainty in the estimates involves technology. Analysts sometimes argue that technological change in agriculture will boost yields so much by late this century that any losses to global warming would be easily managed.

But Cline shows that the pace of the green revolution has slowed, with annual global yield gains falling from 2.8 percent per year in the 1960s and 1970s to 1.6 percent in the past quarter century.

After considering increases in world food demand from higher population and incomes, and the likelihood of sizable diversion of agricultural land to production of bio-fuels instead of food, he argues that there will be a relatively tight race between global agricultural supply and demand by late in this century, with little room for damages from global warming.

“With additional investments in technology and adaptation, the effect of climate change on actual agricultural production could be reduced, but because these inputs raise the cost of production, prices would also rise,” he said. Similarly, increased irrigation could help farmers cope with droughts and excessive heat, but water shortages and the high cost of irrigation systems mean it will not solve the problem, Cline said.

Fred Bergsten, the director of the Peterson Institute, said that Cline’s study “shows that although the two largest polluting countries, China and the United States, will not yet suffer overall agricultural losses by late this century, both will experience substantial internal regional losses that should persuade them to participate in action to avoid severe domestic dislocations.”

Birdsall said that the study’s findings will have important implications for the global policy debate about how to address climate change:

“Policymakers in rich countries and developing countries are only now beginning to understand that the impact of climate change will be profoundly unequal,” Birdsall said. “These alarming new projections are yet another indication that people who are concerned about global poverty also need to be deeply concerned about global warming.”

The following table, adapted from Cline’s *Global Warming and Agriculture: Impact Estimates by Country*, shows the range of likely impacts on agricultural productivity with and without carbon fertilization for rich countries and developing countries, and the totals for each.

**Summary Estimates for Impact of Global Warming on  
World Agricultural Output Potential by 2080s (percent)**

	Without carbon fertilization	With carbon fertilization
World	-16	-3
Rich countries	-6	8
Developing countries	-21	-9
Median	-26	-15
Africa	-28	-17
Asia	-19	-7
Middle East- North Africa	-21	-9
Latin America	-24	-13

<sup>1</sup>Based on Cline, William, *Global Warming and Agriculture: Impact Estimates by Country*, Table 7.1.

**Estimated Impact of Global Warming by the 2080s on World Agricultural Productivity, without and with Carbon Fertilization (percent)**

Country	Without carbon fertilization	With carbon fertilization	Country	Without carbon fertilization	With carbon fertilization
Afghanistan	-25	-13	Malaysia	-23	-11
Algeria	-36	-26	Mali	-36	-26
Angola	-26	-15	Mexico	-35	-26
Argentina	-11	2	Morocco	-39	-30
Australia	-27	-16	Mozambique	-22	-10
South East	-12	1	Myanmar	-39	-30
South West	-14	-1	Nepal	-17	-4
Central East	-23	-12	Netherlands	-7	7
Central West	-35	-25	New Zealand	2	18
North	-41	-33	Niger	-34	-24
Bangladesh	-22	-10	Nigeria	-19	-6
Belgium	-7	7	North Korea	-7	7
Brazil	-17	-4	Other Central Asia	-6	8
Amazonian	-27	-16	Other Eq. Africa	-60	-54
NE	-19	-7	Other Horn of Africa	-17	-4
South	-16	-3	Other South Amer.	-43	-34
Burkina Faso	-24	-13	Other S. Africa	-47	-39
Cambodia	-27	-16	Other West Africa	-33	-23
Cameroon	-20	-8	Pakistan	-30	-20
Canada	-2	13	Peru	-31	-20
Central America	-24	-12	Philippines	-23	-12
Central Europe	-5	9	Poland	-5	10
Chile	-24	-13	Portugal	-10	4
China	-7	7	Romania	-7	7
Beijing NE	-1	14	Russia	-8	6
Central	-3	12	Saudi Arabia	-22	-10
Hong Kong SE	-10	4	Scandinavia	11	28
NW	-3	12	Senegal	-52	-45
South Central	-15	-2	South Africa	-33	-23
Tibetan Plateau	5	21	South Korea	-9	4
Yellow Sea	-9	4	SE Europe	-9	5
Colombia	-23	-12	Spain	-9	5
Cuba	-39	-30	Sri Lanka	-20	-8
DR Congo	-15	-2	Sudan	-56	-50
Ecuador	-29	-18	Syria	-27	-16
Egypt	11	28	Tanzania	-24	-13
Ethiopia	-31	-21	Thailand	-26	-15
France	-7	7	Turkey	-16	-4
Germany	-3	12	Uganda	-17	-4
Ghana	-14	-1	Ukraine	-5	9
Greece	-8	6	United Kingdom	-4	11
India	-38	-29	United States	-6	8
NE	-44	-36	Alaska	-5	10
NW	-43	-34	Lakes NE	5	21
SE	-29	-19	Pacific NW	10	26
SW	-32	-22	Rockies Plains	28	47
Indonesia	-18	-6	SE	-28	-18
Iran	-29	-18	S Pacific Coast	-6	8
Iraq	-41	-32	SW Plains	-35	-25
Italy	-7	7	Uzbekistan	-12	1
Ivory Coast	-14	-2	Venezuela	-32	-22
Japan	-6	8	Vietnam	-15	-2
Kazakhstan	11	28	Yemen	-28	-17
Kenya	-5	9	Zambia	-40	-31
Madagascar	-26	-15	Zimbabwe	-38	-29
Malawi	-31	-21			

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**About the Author**

**William R. Cline** is a senior fellow jointly at the Center for Global Development and the Peterson Institute for International Economics. He has been a senior fellow at the Institute since its inception in 1981. During 1996–2001, while on leave from the Institute, he was deputy managing director and chief economist at the Institute of International Finance. He was a senior fellow at the Brookings Institution (1973–81); deputy director of development and trade research, office of the assistant secretary for international affairs, US Treasury Department (1971–73); Ford Foundation visiting professor in Brazil (1970–71); and lecturer and assistant professor of economics at Princeton University (1967–70). His publications include *The United States as a Debtor Nation* (2005), *Trade Policy and Global Poverty* (2004), *Trade and Income Distribution* (1997), *International Debt Reexamined* (1995), *International Economic Policy in the 1990s* (1994), *The Economics of Global Warming* (1992), *United States External Adjustment and the World Economy* (1989), *The Future of World Trade in Textiles and Apparel* (1987), *Mobilizing Bank Lending to Debtor Countries* (1987), *The US-Japan Economic Problem* (1985), *Exports of Manufactures from Developing Countries* (1984), and *International Debt: Systemic Risk and Policy Response* (1984).