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In Brief

Global Warming and Agriculture
Impact Estimates by Country

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Unabated global warming will reduce global agricultural capacity at least modestly by late in this century, contrary to some estimates that it will benefit global agriculture over that period. The damages will be the most severe and begin the soonest where they can least be afforded: in the developing countries. The losses will be much larger if carbon fertilization[1] benefits fail to materialize, especially if water scarcity limits irrigation.

Temperatures in developing countries, which are predominantly located in lower latitudes, are already closer to or beyond thresholds at which further warming will reduce rather than increase agricultural capacity, and these countries tend to have less capacity to adapt. Moreover, agriculture accounts for a much larger share of GDP in developing countries than in industrial countries, so a given percentage loss in agricultural potential would impose a larger income loss in a developing country than in an industrial country. This study starkly confirms the asymmetry between potentially severe agricultural damages in many poor countries and milder effects in rich countries.

A small amount of warming through, say, the next two or three decades might benefit global agriculture (with some countries gaining more than others). But it would be a serious mistake to do nothing about global warming on grounds that some studies have estimated global agricultural gains rather than losses for the first few degrees of warming. The delay of some three decades for ocean thermal lag before today's emissions generate additional warming is a sufficient reason not to stop the clock at, say, 2050 in an analysis of the stakes of climate change policy for world agriculture over the coming decades.[2] This study therefore chooses the final three decades of this century (the "2080s" for short) as the relevant period for analysis.[3]

Cline uses two types of agricultural impact models, "Ricardian" statistical economic models and process-based agronomic crop models, combined with leading climate model projections, to develop comprehensive estimates for over 100 countries, regions, and regional subzones in the largest countries. He develops a "consensus" set of geographically detailed estimates for changes in temperature and precipitation by the 2080s and applies these climatic changes to the agricultural impact models.

[1] Increase in yields as a result of increased concentration of carbon dioxide in the atmosphere.

[2] Warming at the ocean's surface is initially partially dissipated through heat exchange to the cooler lower layers of the ocean. Only after the lower levels warm sufficiently to reestablish the equilibrium differential from the surface temperature does the "committed" amount of warming from a given rise in carbon concentration become fully "realized."

[3] However, damages could continue to grow throughout the following two centuries before atmospheric concentrations of carbon eventually begin to decline once again from mixing into the deep ocean. Even if carbon emissions collapsed after the 2080s back to well below today's levels, the delay of some three decades for ocean thermal lag means that the warming and effects estimated in this study would substantially underestimate the eventual equilibrium warming and damages.

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He estimates global agricultural output capacity (including carbon fertilization) to decline by about 3 percent by the 2080s. But if the carbon fertilization effect did not materialize, the losses would be at about 16 percent.[4] These losses would be disproportionately concentrated in poor countries. On average, developing countries would suffer losses of 9 percent. Damages would be severe in Africa (17 percent average loss), Latin America (13 percent average loss), and South Asia (30 percent average loss in India and 20 percent in Pakistan). The losses would be much larger if the benefits from carbon fertilization did not materialize (averaging about 21 percent for all developing countries, 28 percent for Africa, and 24 percent for Latin America).

This study is particularly important for the cases of China and India. China is already the second-largest emitter of carbon dioxide (after the United States but ahead of the European Union), and its cooperation will surely be crucial to effective action against global warming. Although this study finds China a modest gainer in agriculture under business as usual warming (increase in agricultural capacity by about 7 percent with carbon fertilization), the estimate turns to a loss (7 percent reduction in agricultural capacity) if carbon fertilization effects do not materialize or are offset by excluded damages. For India, prospective losses are massive (as large as about 40 percent in the absence of carbon fertilization).

For Australia, one of the two steadfast opponents of the Kyoto Protocol, the principal international initiative against global warming, the study suggests that a more positive position on global warming abatement would be in its long-term interests. The estimates for Australia indicate losses of around 16 percent even with carbon fertilization (with much larger losses suggested by the Ricardian estimates). As for the United States, the other principal opponent, although the estimates show an aggregate gain of 8 percent in the case with carbon fertilization, they indicate a comparable loss (6 percent) if carbon fertilization is excluded. Moreover, regional losses are pronounced: by about 30 to 35 percent in the Southeast and in the Southwest Plains, if carbon fertilization is excluded (and about 20 to 25 percent even if it is included).

The findings of this study strongly suggest that policymakers in both industrial and developing countries should ensure that international action begins in earnest to curb global warming from its "business as usual" path. Moreover, illustrative summary calculations suggest it would be a serious mistake to downplay the risks of future agricultural losses from global warming on grounds that technological change, for example in new seed varieties, will swamp any negative climate effects. The pace of global agricultural yield increases already decelerated from 1961–83 to 1984–2005, and a sizable portion of agricultural land will likely be diverted to the production of ethanol for fuel by late in this century.

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[4] Moreover, the Ricardian models count on availability of more water for irrigation under circumstances in which there could easily be less water. Neither the Ricardian nor the crop models deal with increased damage from pests or more frequent and more severe extreme weather events (e.g., floods and droughts). For several reasons, then, declines in global agricultural capacity by the 2080s could thus easily be greater than the estimates in this study and perhaps lie in the range of 10 to 25 percent.