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An Agricultural Law Research Article

Climate Change: Can Agriculture Adapt?

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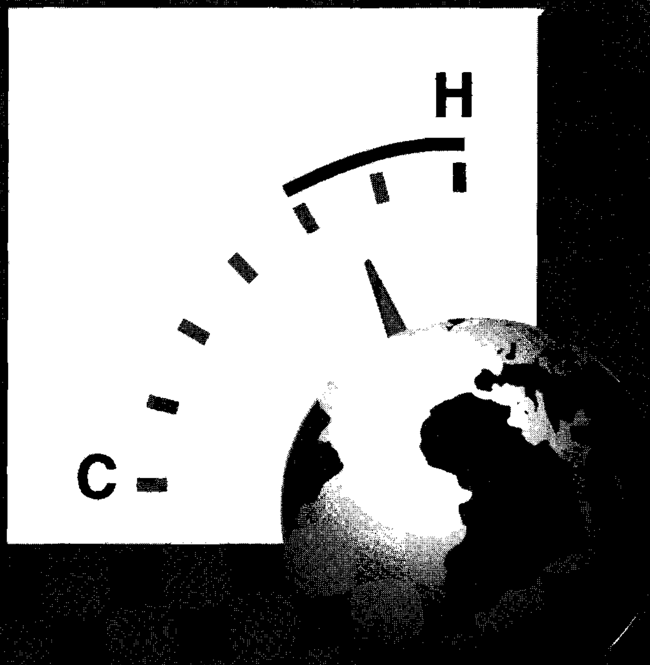

Climate Change

Can Agriculture Adapt?

by John Reilly

Climate is changing, or so say most scientists. While not without controversy, the recent (1995) report of the Intergovernmental Panel on Climate Change (IPCC) concluded that "the balance of evidence suggests a discernible human influence on the global climate" and that "climate is expected to continue to change in the future." Further, "the average rate of warming would probably be greater than any seen in the last 10,000 years, but the actual annual to decadal changes would include considerable natural variability." These conclusions have given new impetus to international efforts to limit greenhouse gases, and agriculture figures prominently in these decisions (see sidebar, p. 8). As climate changes, the question of whether agriculture can adapt is important, both to understand how much to control global greenhouse gas emissions and to gauge what actions would make agriculture more resilient.

Research on adaptation in agriculture

Interested parties strongly disagree about agriculture's ability to adjust to climate change. Some see adaptation as a gradual process that may undetectably alter the choices we make; others anticipate that wrenching changes will be needed to avoid widespread loss. Table 1 is perhaps the best summary of what is at issue for agriculture in the adaptation debate. Work at the Economic Research Service by Darwin and colleagues shows large reductions in cereal production (18–29 percent) without adaptation (column 1)—that is, farmers continue to plant the same crops year after year even as climate changes. If, however, farmers respond, markets operate to provide price signals to further shift production, and agriculture shifts to new land that is currently not farmed (largely warming areas in Canada and Russia), then climate change may generate overall modest (less than 1 percent) increases in cereal production (column 4). Much of this adjustment can occur on existing farmland even before prices change to signal shifts of production to different regions—instead of 18–29 percent losses (column 1), cereal production falls by only 2–6 percent (column 2). Markets also play a role in reallocating production across regions and existing agricultural lands; allowing markets to work in this way results in virtually no change in cereal production from the reference case without climate change (column 3). These estimates do not include the positive effects of CO_2 fertilization on plant growth and water use efficiency. Based on experimental evidence, this effect could increase crop yields 10 to 15 percent with a doubling of CO_2 levels.

Results such as those above have comforted some but have raised significant new questions for others. Can we just assume that farmers will know what to do as climate changes? What will these changes mean for farm-dependent communities and, in particular, for poor areas of developing countries where what you eat is largely what you grow? Existing research does not provide convincing answers to these questions.

What does it mean to adapt?

Different researchers and observers have different definitions of adaptation and different preconceptions about the ease of adaptation.

Webster's dictionary defines "adapt" as "to make fit (as for a specific or new use or situation) often by modification." A Canadian task force reported that climate adaptation can mean preventing loss, tolerating loss, or relocating to avoid loss (Smit). The adaptation debate also hinges on who or what is adapting. Europe has its wine regions, the Swiss their picturesque alpine farms, and the Japanese their rice, each of which may well be threatened under a changing climate. For those who focus on the individual farmer or farming community, successful adaptation means maintaining these local agricultural systems more or less intact.

At the opposite end of the spectrum are those who look to the global granary. If wheat and corn production shifts north to Canada and Russia but global production levels are maintained, then markets have facilitated successful adaptation of world food production. If the wine regions of France fail, then the world market can supply Canadian Bordeaux or Finnish Chardonnay. And, even where production fails for some crops, cultural tastes can adapt. If the American consumer can live with Uncle Ben's converted rice, then cannot the Japanese learn to be less fussy or at least import their rice from the new Siberian grain belt? By substituting lower-priced products whose range of production has expanded for higher-priced products that can no longer be grown, our aggregate well-being can be maintained. Sons of winegrowers can take up computer programming. Daughters of fisherman can learn to be winemakers. Cattle-herders can graze sheep or move to a job in the village.

On the other hand, Iowa could be the land of cotton, but if adaptation means junkyards filled with useless corn planters and harvesters, abandoned buildings dotting the landscape, and farmers who know only corn leaving in search of a livelihood, severing ties with friends, family, and community, then what does it mean to adapt? For one camp, all of these adjustments are a costly burden and should be avoided by limiting greenhouse gas emissions. The other camp argues that, because climate change will be slow, the adjustment costs will be small relative to the cost of reducing greenhouse gas emissions

In short, the camps split over whether to place the emphasis on the ultimate survival of the species or on the losses along the way. For a long time, climate change action advocates opposed study of adaptation strategies—their fear being that any effort to consider adaptation was an abandonment of the goal of preventing climate change. The question remains, would we be better off to avoid these costs by stopping climate change? Unfortunately, confidently assessing costs beyond what has been done requires some significant improvements in research.

Other unknowns

In large part we can't accurately forecast adjustment costs because we still can't accurately predict climate change. Until very recently, researchers have run General Circulation Models (GCMs) independently of similarly complex ocean circulation models; to combine them tests the limits of computational power. Oceans create a significant thermal inertia in the system. Without oceans the atmosphere warms up rapidly and the time-path results can be misleading. The thermal inertia of the ocean is one reason we are already committed to another twenty years of global warming, even if no further increase in atmospheric concentrations of greenhouse gases occurs. Other factors also limit the usefulness of time path (or, as they are known in the trade, transient) scenarios. Sulfate aerosols, a by-product of burning coal with high sulfur, have a cooling effect, possibly fairly large. GCM scenarios have not included sulfate aerosols, and the accuracy of future scenarios will depend on our ability

Table 1. Percentage changes in the world supply of cereals: estimates based on alternative climate models

	(1) No Adaptation No Market Response	(2) On-Farm Adaptation No Market Response	(3) On-Farm Adaptation Market Response, Land Use Fixed	(4) On-Farm Adaptation, Market Response, Land Use Response
GISS	−22.9	−2.4	0.2	0.9
GFDL	−23.2	−4.4	−0.6	0.3
UKMO	−29.6	−6.4	−0.2	1.2
OSU	−18.8	−3.9	−0.5	0.2

Source: Darwin et al.

Notes: Climate change scenarios are those from the Goddard Institute for Space Studies (GISS), Geophysical Fluid Dynamics Laboratory (GFDL), United Kingdom Meteorological Office (UKMO), and Oregon State University (OSU) general circulation models that have been logged at the National Center for Atmospheric Research (NCAR) for use by other researchers. These scenarios represent simulated change in climate that occurs when carbon dioxide levels are doubled in the atmosphere. There are a number of efforts to make more generally available recent and transient runs of a suite of GCMs

Flooding and drought—the two extremes often associated with global warming. Will farm-dependent communities know how to adapt to changing conditions?

to predict emissions of sulfur as well as carbon dioxide. Greenhouse gases last for decades in the atmosphere, so most of what is in the atmosphere has been there for years; a change in emissions of 20 or 30 percent for a few years does not have much effect on concentrations. In contrast, sulfur compounds last in the atmosphere for a matter of days, so emission cutbacks immediately reduce concentrations. Sulfate aerosols also largely affect regions, cooling areas downwind. Failure to incorporate sulfate aerosols combined with the coarse resolution of GCMs sharply reduces the accuracy of estimates of the spatial pattern of climate change and the temporal pattern, particularly for small geographic areas.

Climate change involves other uncertainties. For example, it is quite conceivable that a gradual mean global change in temperature and precipitation can contain abrupt changes at regional and local scales that create confusing and difficult-to-predict periods of rapid change. Changes in precipitation patterns seem particularly difficult to characterize given that they may be governed by differences in ocean-land temperature, other atmospheric constituents like sulfates, and large-scale phenomenon like El Niño and the North Atlantic Oscillation, which themselves may be affected by global climate change.

Reducing vulnerability

There is now a fairly general consensus that we cannot stop climate change for many years. Inertia in earth systems and in human systems precludes quick reductions in greenhouse gas concentrations and temperature change. Furthermore, no one proposes cutting emissions enough to freeze concentrations at their current levels, because to do so would cause unacceptable costs to energy-based industries and the world's economies. The Kyoto agreement proposes to cut emissions from 1990 levels by a few percentage points in the developed countries of the world. Even if these cuts were extended to the rest of the world, atmospheric concentrations would continue to increase because 1990 emissions levels were well above the rate at which greenhouse gases are naturally removed from the atmosphere. As a result, even if the Kyoto agreement is successfully ratified, prudence suggests that we begin to think about how social and economic systems that depend on climate can best adapt to climate change.

The Intergovernmental Panel on Climate Change identified both technological and socioeconomic means to help agriculture adapt to climate change, as outlined below.

Technological potential to adapt:

- *Sowing dates and other seasonal changes.* Plant two crops instead of one or a spring and fall crop with a short fallow period to avoid excessive heat and drought in mid-summer. For already warm growing areas, winter cropping may become more productive than summer cropping.
- *Crop varieties and crop species.* Most major crops already have seed varieties for different climates.
- *New crop varieties.* The genetic base is very broad for many crops, and biotechnology offers new potential for introducing salt tolerance; heat, drought, and pest resistance; and general improvements in crop yield and quality.
- *Water supply and irrigation systems.* Both technologies and management methods already exist to increase irrigation efficiency and reduce problems of soil degradation, but inadequate economic incentives have encouraged wasteful practices.
- *Tillage.* A warmer climate will hasten oxidation of carbon in soils. Tillage practices that incorporate residue in the soils can combat this loss and improve soil quality.
- *Improve short-term climate prediction.* Accurate six-month to year-long forecasts could reduce losses due to weather variability. The El Niño signal, the spreading of warm water across the Pacific, is the basis for such predictions now and works well for some regions where the El Niño has strong effects on the weather.
- *Other management adjustments.* Virtually all components of the farming system from planting to harvesting to selling might be modified to adjust to climate change.

Socio-economic capability to adapt:

- *Improved general education and training.* Particularly in developing countries, a better-trained workforce has more employment options and is better able to evaluate information of new farming systems and technologies.
- *Identification of the present vulnerabilities of agricultural systems.* Current weather variability exacerbates soil degradation, pest infestation, and water management. A better understanding of these current problems and their remedies will help farmers adapt if the problems worsen with climate change.
- *Agricultural research focused on full evaluation of the economics of farming systems.* While it may be difficult to fully identify all the ways climate affects agricultural production, it should be possible to evaluate which farming systems do well as conditions change. Such evaluation should be specific to different farming locales. Such a focus recognizes that climate change is only one of the host of things that will change for farmers over the next few decades.
- *Interactive communication between farmers and researchers.* Research must ultimately be evaluated by its on-farm success. The idea that the research process can be separated into basic, applied, and technology transfer components gets in the way of successful communication that can lead to real problem solving.
- *Agricultural research as a foundation for adaptation.* Preservation and use of genetic material will be needed to adapt crops and livestock to new environmental conditions.
- *Food programs and social safety nets.* Improved social safety nets can provide insurance against food supply disruption or loss of income related to climate change.
- *Transportation, distribution, and market integration.* Policies which maintain transportation infrastructure and promote efficient markets can help ensure adequate food and fiber supplies as production shifts and becomes more variable.
- *Examine the agriculture and resource policy environment.* Farmers' ability to adapt can be promoted through domestic agricultural policies that promote response to market conditions, efficient water pricing, and freer trade policies.

A qualified optimistic outlook

Agriculture has great potential to adapt to climate changes brought on by increasing levels of greenhouse gases, but we are still quite uncertain about what those climate changes might be. Agriculture has adapted to many large changes in the past. For U.S. agriculture, the boom of the 1970s and the bust of the 1980s demonstrates that agriculture can respond to change. However, those changes imposed many costs on producers and rural communities. Normal variability in climate, including drought and weather extremes, imposes significant costs on agriculture. While it is hard to know exactly how to relate the costs of normal weather variability to the problem of long-term climate change, these events clearly indicate that weather and climate can be disruptive. In concluding that agriculture can adapt to climate change, it is probably useful to remember the nature of the concept as used in the natural sciences, notably that adaptation does not ensure the survival of individuals within a population. Although climate changes that are possible over the next hundred years or so won't render the world unable to feed itself, adjusting to climate change could impose local and individual hardship. ■

■ For more information

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Climate Change Policy and Agriculture

The Framework Convention on Climate Change (FCCC), negotiated in Rio de Janeiro, entered into force in March 1994. It is the governing international agreement on climate change. Its ultimate objective is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." Most observers believe that the definition of "dangerous" requires both scientific investigation and judgment and discussion within the political system.

The so-called Kyoto agreement—reached in December of 1997 in Kyoto, Japan, the follow-on to the FCCC—was intended to nail down the specifics of greenhouse gas stabilization. Given the difficulties of such an agreement, few were surprised that it left many issues unanswered (What is a dangerous level of greenhouse gases? How and when will the developing countries participate? What greenhouse gas sinks should be included and how will they be credited toward individual country commitments? What specific mechanisms for the trading of emissions rights among countries will be allowed?).

More surprising perhaps was that substantive commitments were made. Annex B sets out quantified emissions limitations as a percentage of base year (for most countries 1990) levels for thirty countries ranging from 92 percent for most Western European countries and 100 percent for Russia and the Ukraine to 108 percent for Australia and 110 percent for Iceland. The United States agreed to 93 percent. Annex A of the agreement lists carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, perflourocarbons, and sulfur hexaflouride as subject to control. The United States sought broad inclusion of gases and sources of these gases for economic reasons—the U.S wanted to maintain flexibility to seek out the cheapest sources to control, rather than limit policy at the outset by ruling out some gases or some sources.

Some loose ends to the Kyoto agreement await further negotiation. At least 55 percent of the FCCC Annex I countries (OECD plus Eastern Europe) contributing at least 55 percent of 1990 emissions must ratify the agreement for it to take effect. But even if the agreement achieves target reductions, global warming questions still loom ahead. Agreed reductions will only slightly reduce developed country emissions and developing country emissions will still grow. So, worldwide concentrations will continue to grow indefinitely. To halt climate change, future agreements will need more severe reductions and inclusion of most, if not all, countries.

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