To Mitigate or to Adapt? That is the Question Posed by Global Warming to U.S. Agriculture

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Experts predict that the earth is warming from accumulation of greenhouse gases (GHGs) in the atmosphere. If such warming is in fact underway, two broad responses are (1) to mitigate or (2) to adapt. Because mitigation is a national and international issue rather than just a sector issue, this essay takes no stand on whether governments should or should not pursue mitigation policies. But the choice of policies impacts agriculture. Mitigation policies such as carbon taxes or cap and trade, if pursued, will raise expenses of U.S. agricultural by billions of dollars whereas benefits to the industry (mostly from carbon offsets) will be only in the millions of dollars. Thus agriculture must address policies of adaptation whether global warming continues or is mitigated. This essay addresses these and other issues of climate change for agriculture.

Magnitude of warming

Global warming is the byproduct of atmospheric accumulation of greenhouse gases including carbon dioxide and methane. Such gases from manmade and other sources trap heat from the sun in the atmosphere. The Intergovernmental Committee on Climate Change (IPCC), an interdisciplinary team of some of the world's most knowledgeable climate scientists, predicts significant changes in global temperature:

> For the next two decades a warming of about 0.2°C per decade is projected for a range of emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Afterwards, temperature projections increasingly depend on specific emissions

> scenarios. Since the IPCC's first report in 1990, assessed projections have suggested global averaged temperature increases between about 0.15 and 0.3°C per decade from 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade, strengthening confidence in near-term projections (IPCC, 2008, p. 45).

Some experts predict that global food output in aggregate will change little due to global warming, with expansion in northern regions such as Canada and Siberia compensating for contraction in tropical and subtropical Africa and Asia. Over approximately one century, according to the IPCC (2008, p. 48):

> Global crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1 to 3°C, but above this it is projected to decrease.

Other analysts come up with different projections. In table 1 Cline (2007, p. 96) summarizes "consensus" results from six climate models assuming 4.4 degree C rise in temperature and 2.9 percent rise in precipitation by the 2080s. By the 2080s, global agricultural output is projected to be reduced 3.2 percent from trend due to global warming. Warming is projected to add 7.7 percent to agricultural output in industrial countries while reducing output by 9.1 percent in developing countries. Africa and Latin America are expected to experience the largest setbacks.

Table 1. Summary estimates of impact of global warming on world and regional agricultural output potential by 2080s

	Percent increase with CO_2 fertilization
Global	
Output-weighted	-3.2
Industrial countries	7.7

Developing countries	-9.1
Africa	-16.6
Asia	-7.2
Middle East N. Africa	-9.4
Latin America	-12.9

Source: Cline (2007), p. 96

Although the smallest temperature increments are expected in the tropics and the largest in the polar regions, dislocations and hardships will be most severe in the tropics and subtropics because that is where the majority of the world's food insecure people live. Crop production is projected to fall as much as half in some African countries.

Unsettled science of global warming

Several aspects of greenhouse gas (GHG) emissions and resulting global warming complicate achieving efficient resource allocation. First is the problem of uncertainty and incomplete science. The science of climate change remains unsettled. Scientists do not agree among themselves. Although the majority of climate scientists contend that global warming is underway, much uncertainty remains regarding the level and incidence of impacts.

Another problem is that global warming is what economists call an *externality*. Individuals and firms do not set out directly to produce GHGs. Instead, global warming mostly is the byproduct of greenhouse gas buildup from burning fossil fuels to produce energy. Greenhouse gas accumulation is an economic externality in that much of the cost from GHG accumulation accrues to society rather than just to individuals and firms emitting the gases. The result is excessive energy use to the extent that individuals and firms do not pay the incremental full cost of producing and using energy. For markets to send proper signals for efficient resource allocation, incremental private costs entering the accounts of gas emitting firms and individuals must match social cost accruing to society.

In an absence of markets and prices, governments too lack incentives for efficient energy production. Most policymakers are short termers whose constituents are less than enthusiastic about paying more taxes and energy costs now to correct for environmental damage that might accrue well after the policymakers have left office. Furthermore, any one nation is a bit player whose actions alone cannot control global warming. Given the free flow of GHGs across borders, it is tempting for any country to be a free rider, relying on others to control emissions.

Policies to mitigate global warming

Despite or because of such pitfalls, multilateral efforts are underway to reduce GHG emissions. Countries are attempting to jointly act to control GHGs, with individual countries accepting targets to cut GHGs using policies of their own choosing. A simple and efficient policy expedient for a participating country is a tax on carbon imposed at the coal mine or oil refinery, and on imported fossil fuels. The tax is designed to correct the negative externality, bringing the incremental private cost to the level of the social cost.

It is estimated that a ton of carbon in the atmosphere costs society about $26 by contributing to global warming that in turn causes excessive heat, unstable weather, tropical diseases, flooding as the sea level rises from melting glaciers, and the like (see Nordhaus, 1993). Thus a tax of $26 on each ton of carbon in fossil fuels presumably would raise private cost to align with social cost and thereby improve resource use efficiency. Non-fossil fuels including wind, solar, nuclear, and geothermal energy sources would not pay that carbon tax and hence would enjoy market signals to expand. Although a carbon tax would remove the need for the current policy of subsidizing consumption of renewable and noncarbon based energy, some proceeds from the carbon tax could be used to promote research in promising technologies such as better batteries for hybrid vehicles, enzymes or organisms to efficiently break down cellulose for cellulosic ethanol, and carbon storage processes for clean coal.

Many politicians, especially in countries producing and consuming fossil fuels, are far less enthusiastic than are economists about carbon taxes to address global warming. Several countries prefer a cap and trade (CAT) policy—a procedure used with success in the U.S. to control sulfur dioxide emissions efficiently. Under CAT, the government would issue permits to emit carbon with the overall volume of permits ideally reduced to the point that firms would be willing to pay $26 to be able to emit another ton of carbon.[1] Either CAT or a carbon tax gives incentives for the nation's goods and services to be provided efficiently by processes minimizing greenhouse gas emissions.

The economic impact of the CAT depends on how initial emission permits are allocated. Emitters favor CAT because initial permits to emit greenhouse gases can be doled out free in proportion to historic use. A problem with free initial permits is that irresponsible heavy historic polluters are rewarded with generous emission permits. It may be argued that GHG emitters should have to pay for continuing to do "bad things", even if they got a free ride in the past.

[1] It is probably not a coincidence that this estimate from the Congressional Budget Office, $26 for the cost in damage to the environment from another ton of atmospheric carbon, is also the estimated price that firms would have to pay under cap and trade to purchase a permit to emit a ton of carbon by 2019 (see Good, June 8, 2009, p. 2). Thus a carbon tax or a CAT can end up with similar results though the former sets price whereas the latter fixes quantity of allotments.

After the initial distribution, as markets are opened to buy and sell permits the profligate historic energy users with a generous supply of permits will gain financially by selling some of their allowance to other firms.[2] The latter must purchase permits to expand gainful output of goods and services at a time when the supply of permits has been sharply reduced by government mandate.

A third alternative to a carbon tax or a cap and trade policy is a government command-and-control system whereby the government hands out carbon permits without use of markets. Such a system encourages corruption and favoritism as emitters bribe or otherwise politically influence government officials to obtain the limited available permits.

A carbon tax or CAT is superior not only to command and control but also to the widely practiced current system of subsidies to favored energy sources. A carbon tax or CAT quota of proper size will raise the cost of emitting greenhouse gases to levels that will encourage clean energy sources such as wind, solar, geothermal, biofuel, and nuclear to be profitable—without subsidy to the extent that they meet the market test.

The ability of agriculture policies to slow global warming is limited by several factors. One is that food production accounts for only 13 percent of manmade sources of GHGs. Another is that biofuels (with some notable exceptions such as ethanol from sugar cane in Brazil) contribute only marginally to climate control. A gallon of ethanol produced from U.S. corn requires nearly a gallon of fossil fuel equivalent in the form of motor fuel, fertilizer, pesticides,

[2] U.S. cap and trade rules, as proposed by Congress in mid 2009, would encourage industrial firms expanding output and attendant carbon emissions to purchase offsetting carbon credits from farmers. For example, farmers could sell credits for reducing carbon by planting trees, restoring wetlands, no-till cropping, or installing waste biodigesters.

transportation, and processing. Adding the cost of externalities such as soil erosion, contamination of water supplies, and expansion of cropland at the expense of forests and wildlife makes production of ethanol marginal for the environment and economy. Some also fault biofuel subsidies for raising global food costs. Despite these shortcomings, biofuels such as cellulosic ethanol may indeed have a continuing role in supplying energy. Sound economic policy, however, calls for it to do so by passing the market test without government subsidies such as mandates, tax advantages at the gasoline pump, and import duties.

The role of agriculture

The foregoing discussion points to only a modest role for agriculture in controlling greenhouse gases. The Environmental Protection Agency (see Good, June 8, 2009, p. 1) estimates that U.S. agriculture will be able to supply only 300 million tons of carbon credits, most of it from trees rather than crops (see footnote 2). That is on average about one ton of carbon sequestered per acre over and above that from conventional cropping. That carbon must be sequestered **in perpetuity** unless the farmer buys back the obligation. If the discount rate is 5 percent and the sequestered ton of carbon is worth $26, the farmer can break even by spending up to $1.30 per acre annually to retain the carbon. The farmer will lose money if he has to sacrifice as little as one-half bushel of corn production per acre to sequester that carbon.

The social benefits of additional carbon sequestration on farms appear to little more than cover the cost of a public agency to monitor compliance. No-till farming is one of the most effective practices to sequester carbon in many parts of the Corn Belt, building up organic matter in the soil that is beneficial in retaining moisture, reducing erosion, and providing nutrients to crops. No-till in such cases can be the most profitable enterprise without any subsidy and thus carbon sequestration comes at no cost to the farmer (Tanner and Tweeten, 2005). Indeed, no-till is widely practiced in some farming regions. With no-till, weeds must be controlled with herbicides—but the chemicals are losing their efficacy as resistance builds in weeds. A contract to sequester carbon in perpetuity is breeched and sequestered carbon is returned to the atmosphere if tillage is employed to control weeds resistant to herbicides.

Sales to industry of carbon offsets (defined as credits farmers can build up by conservation practices and planting trees to sequester carbon in the soil) are likely to cover only a small portion of the additional costs incurred by farmers due to global climate control measures. For example, in the U.S. in just one year, 2035, climate control measures are projected to add as much as $50 billion to U.S. farm fuel, fertilizer, and pesticide expenses due to higher energy prices (see Good, June 23, 2009, p. 2). This number dwarfs likely farm earnings from sale of carbon offsets to power-generation and other industries. If 300 million of carbon offsets are sold for $26 per ton, the annual benefit to agriculture in 2035 discounted at 5 percent is only $390 million.

Climate control beyond agriculture

This very low benefit-cost ratio applies only to U.S. agriculture. Evaluating the case for global warming mitigation requires a look at agriculture and other sectors on a *global* basis. Southgate and Sohngen (2007, p. 12; see also Mendelsohn et al., 1994) concluded that the effect on overall global agriculture and forestry output would be minimal if temperatures would rise 1.0 to 4.0 degrees Celsius due to GHG accumulation in the 21st century. They estimated for these industries that economic costs of global warming mitigation exceeded benefits of mitigation. While agricultural output would fall in warmer regions, forestry output would rise in subtropical regions of Africa and South America. Hardships from the rise in sea level would be especially severe in low lying areas such as found in Bangladesh.

Cutting global GHGs is not cheap. Weyant et al.(2006), based on results from 15 well-known energy models, predicted that temperature suppression of just 25 percent from the business-as-usual trend would cost 0.4 percent of GDP in 2025 and 4.8 percent in 2100. Such high costs for only 25 percent suppression could markedly deter support for mitigation.

Policy implications

What is responsible climate change policy for the world food system in such circumstances? While climate control by a united front of the world's nations may be the only feasible policy, such a policy may not be attainable for several reasons. Greenhouse gases are global public "bads" that do not respect geographical boundaries. The vast majority of the world's some 200 countries acting individually are too small for any one country to have a perceptible impact on climate control. A nation might be willing to control its greenhouse gases only as part of a global effort with other countries. On the other hand, if other countries control their emissions, any one country can have climate control as a free rider, continuing to emit while the rest of the world reduces greenhouse gases. Most countries will want to be free riders.

Countries have a history of taking bold and costly political action only when faced with a clear and present crisis. The fact that scientists continue to debate whether global warming is occurring does not make political decisions easier. Political systems throughout the world are distracted from controlling GHGs because they face other major problems such as food insecurity, armed conflict, disease, and poverty.

In short, any country and industry would be remiss not to have a contingency plan for a future where global greenhouse gas control has failed for whatever reason. Policies "for all seasons" are a critical backstop for agriculture, and include research on varieties genetically modified to resist heat and drought stress, infrastructure to facilitate farm input and output movement, and open trade so that food can move from regions of abundant supply to regions of diminishing supply due to global warming. Because cropland is not a promising vehicle for climate control and trees sequester much more carbon than crops per hectare, a useful policy is to promote high crop yields to minimize crop area so that area in forests can be retained and expanded.

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