Addressing Climate Change and Providing New Opportunities for Farmers

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Executive Summary

The Intergovernmental Panel on Climate Change, an international advisory group consisting of 2,500 of the world's leading climate change experts, recently stated that "the balance of evidence suggests that there is a discernible human influence on global climate." Their study found that the average global temperature has increased 0.5 to 1 degrees Fahrenheit over the past century, and is expected to increase 2 to 6.5 degrees Fahrenheit over the next century.[i] These increases are believed to be due to emissions of gases that trap heat in the atmosphere, creating a greenhouse effect. The most prevalent of these gases is carbon dioxide, which is emitted whenever fossil fuels are burned.

Most of the energy sector has resisted addressing climate change. A coalition of fossil fuel-intensive corporations questions the validity of the scientific evidence for climate change and opposes efforts, such as the Kyoto Protocol, to limit greenhouse gas (GHG) emissions. Some in the agricultural community join them in opposition, for fear that new taxes on fossil fuels would increase the cost of gasoline, electricity, fertilizers, and other farm inputs, while hurting U.S. competitiveness in global markets. Agriculture is responsible for 7% of total U.S. greenhouse gas emissions.[ii] Large industrial farming operations are heavily dependent on cheap energy to provide commercial fertilizers, inexpensive fossil fuels, and low heating and cooling costs. The use of fossil fuels in the transportation and processing of food, although not included as part of agriculture's GHG emissions, is another significant source.

Any increase in input costs is a significant concern for the farming community. But efforts to reduce GHG emissions can also provide many new opportunities. Climate change mitigation will result in many ancillary benefits, including greater valuation of environmental services provided by agriculture as well as the regeneration of rural communities. Some of the expected positive impacts from climate change mitigation efforts such as the Kyoto Protocol include:

I. **Creating a New Income Source for Farmers through Carbon Sequestration.** One of the simplest and most immediate ways to reduce GHG concentrations in the atmosphere is to promote carbon sequestration in agricultural soils. Practices such as conservation tillage accelerate natural processes that take carbon from the atmosphere and return it to the soil. The credit for the sequestered carbon may then be traded to industries that emit fossil fuel, thereby providing a new income source for the farmer. National farm policy could also be structured to provide incentives for these practices.

II. **Developing New Markets for Biomass and Renewable Energies.** Increased costs for fossil fuels will accelerate demand for renewable energies. New markets are expected to develop for biomass fuels, increasing the demand for corn, alfalfa, switchgrass, and other crops. Furthermore, wind turbines, which are rapidly being constructed in states like California and Minnesota, are frequently sited on agricultural lands, providing farmers with another income source.

III. **Providing Alternatives to Industrial Agriculture.** For the past 50 years, U.S. agriculture has undergone a dramatic industrialization process that has resulted in fewer farms, an oversupply of crops, and eroding crop prices. Cheap fossil fuels have replaced farmer knowledge and ingenuity, resulting in agriculture dominated by huge farms. Addressing climate change and reducing reliance on fossil fuels will help foster farming practices that increase the number of farmers, diversify crops, and maintain rural communities.

IV. **Reconnecting Farmers with Local Markets.** Rapid globalization and reduced transportation costs have resulted in increased agricultural specialization. This has produced strange market connections—the Midwest grain farmer has greater concern for Chinese food consumption than for local food needs. As a result, farmers are vulnerable to economic vagaries throughout the world, and events like the 1998 Asian economic downturn can directly impact U.S. farm income. Furthermore, the U.S. now imports a variety of foods that were once grown here. These global dependencies are facilitated by policies that do not recognize the true costs of transportation and carbon dioxide emissions. As we learn to properly value these costs, U.S. farmers will develop a comparative advantage in reaching U.S. consumers, the largest market for many agricultural products.

V. **Reducing the Impacts of Climate Change on Agriculture.** Climate change could potentially impact temperature, water supplies, weed and insect vectors, and a host of other factors. Farmers will have to cope with an increased frequency and severity of droughts and floods, utilize more pest controls, and manage more variability in crop prices and production. It is in farmers' best interest to minimize these impacts.

Instead of refuting the science that signals climate change and stalling climate change negotiations, members of the agricultural community should support farm organizations that negotiate with environmentalists, industry, and policy makers to produce policies beneficial to agricultural interests. This paper assesses some of these opportunities and presents policy recommendations.

Background on Climate Change Negotiations

Climate change negotiations were initiated in 1990 by the Second World Climate Conference. Over 130 nations were represented, and the Conference's declaration stated that changes in global climate were a "common concern of humankind," and that different countries would necessarily have different levels of responsibility toward mitigation.[iii] While the Conference yielded no framework for action, it did lay the foundation for the adoption of the Framework Convention on Climate Change (FCCC), which was negotiated in time for the 1992 United Nations Conference on Environment and Development, known as the Earth Summit.

The FCCC recognized the problem of climate change and spelled out the first steps for action. Specifically, it instituted a reporting structure, whereby signatory nations would be responsible for reporting GHG emissions, providing technology transfer to developing nations, and taking initial steps to limit future GHG emissions to 1990 levels.[iv] Yet despite these accomplishments, the UNFCCC was merely a framework for action rather than a specific outline of emissions limits or methods to achieve the limits.

The Kyoto Protocol added depth to the original FCCC. Signed in December of 1997, the Protocol added better-defined emissions standards, firmly outlined the responsibilities of developed nations, and presented strategies for GHG reduction, including sustainable development, tradable emissions permits, and the development of carbon "sinks".[v] Under the Protocol, the U.S. is to reduce GHG emissions to 7% below 1990 levels by the years 2008-2012. While the Protocol has yet to be ratified by the United States and many other nations, the effects of ratification and compliance will be dramatic—significant reductions in GHG emissions and a likely increase in resource prices, particularly energy.

Farmers are concerned about the Protocol's impact on input supplies to farmers. Energy (fuel and electricity) and fertilizers, both of which result in GHG emissions, accounted for 16% and 29% of U.S. corn farmers' total input costs in 1998, respectively.[vi] Countering this liability is a potential advantageous aspect of the Protocol, the establishment of carbon "sinks." Plant growth captures carbon dioxide from the atmosphere and converts it to biomass and soil carbon. Certain agricultural and forestry practices can accelerate the sequestration of carbon in the soil and terrestrial ecosystems, thereby offsetting carbon dioxide emissions elsewhere. Protocol negotiators are considering the possibility of landowners receiving carbon "credits" for these practices, which could then be sold to carbon dioxide emitters. The U.S. Department of Energy estimates that for the U.S. to reduce demand sufficiently to meet Kyoto obligations, carbon will need to be valued at $348 per metric ton.[vii] This could result in a 53% increase in fuel prices, but it might also provide a lucrative carbon market for farmers and others who sequester carbon.

A second concern to agricultural interests is how the Protocol will affect competitiveness in international grain markets. While the Protocol calls for a significant reduction in U.S. GHG emissions, many U.S. competitors in these world markets are designated as developing countries and do not have mandated emission restrictions. However, many of these countries also have significantly higher fuel prices. Higher U.S. fuel costs, instead of creating a greater disparity, would actually create a more equitable balance, when viewed on a global scale. Second, the trend for U.S. exports of corn, soybeans, and wheat has been flat or negative since 1980.[viii] Brazil and Argentina have been able to capture new markets because their land values and labor costs are considerably less than those in the U.S. Instead of competing with these countries to become the lowest-cost producer of cheap grains, U.S. farmers may be better served by capturing value-added opportunities in the U.S., including the value of carbon sequestration.

Creating a New Income Source for Farmers Through Carbon Sequestration

In addition to carbon emissions from fossil fuel use, agriculture has emitted carbon dioxide through the tillage of soil. Undisturbed prairies, forests, and wetlands hold an enormous amount of carbon, both aboveground in plant biomass, and within the soil. When these lands are converted to agricultural use, most of the carbon in the biomass is lost to the atmosphere. Additionally, whenever soil is tilled, soil carbon is converted to carbon dioxide. Over the past century, agricultural soils have been a significant source of carbon dioxide emissions. Soils in the central U.S. corn belt presently contain only about 61% of the carbon that the soil once contained under native vegetation.[ix] The continued soil disturbances that result from tillage not only release carbon dioxide, they prevent plant and animal matter from decomposing and replenishing the missing carbon. This leads to highly erodible, poor quality soil.

Yet farmers do have options to reduce carbon loss. Conservation tillage—practices that leave plant residue on the field rather than plow it under—allow carbon to build in soils instead of being released into the atmosphere. As carbon increases, soil quality improves as nutrients and water are better retained, and earthworms thrive. Rainfall held by the soil percolates slowly into groundwater aquifers rather than running off into surface waters. Soil erosion is reduced by 50% or more, thereby improving water quality.[x] Conservation tillage also requires less tractor work, reducing gasoline use.

Many farmers already recognize the agricultural and environmental benefits of increasing soil carbon. Nationally, about 37% of U.S. cropland is under conservation tillage.[xi] However, these practices can temporarily increase financial risk, and the adoption of conservation tillage in many northern climates has stagnated due to these economic concerns. Reducing tillage requires the farmer to incorporate new management skills and gain knowledge on how to address pest problems without relying on the plow. Second, farmers in climates with short growing seasons are concerned about soil temperatures. Plowing a field in the spring allows the soil to warm more quickly, allowing the farmer to plant slightly earlier. In northern climates, any delay in planting puts the farmer at risk of reduced yield.

For widespread adoption of conservation tillage, farmers will need incentives or insurance to overcome these risks. The cumulative potential for U.S. cropland to sequester carbon through conservation tillage is enormous – up to 107 million metric tons according to a recent report, which constitutes about 4% of total U.S. GHG emissions.[xii] Most farmers have found that conservation tillage can be incorporated with no loss of yield. Of course, offsetting 4% of fossil fuel emissions is only one piece of the puzzle and does not address the larger tasks ahead such as promoting energy conservation and increasing the use of alternative energy sources. Yet, compared to reductions in fossil fuel emissions from utilities, the speed at which these practices can be incorporated provides some policy advantages.

Several policy options are available to promote conservation tillage. The development of a carbon market has received the most attention. Several Canadian power utilities have created a coalition, GEMCo, which is actively seeking to form agreements with farmers using carbon-sequestering practices. GEMCo has agreed to pay a group of Iowa farmers for carbon credits. Farmers can produce these carbon credits by incorporating specific practices, such as no-till, or using manure instead of commercial fertilizers. Several other organizations, including a company founded by the originator of the sulfur dioxide trading scheme, are also advocating for the development of this market.

The wildcard in the development of a carbon market is the price of carbon. A demand does not currently exist to produce a reliable market value. Several different trading schemes may result from negotiations surrounding the Kyoto Protocol. Which, if any, carbon-sequestering practices are recognized by the Kyoto Protocol will determine farmers' participation in carbon markets. The extent of trading that will be allowed is also a key factor. Options include trading internationally, limiting trading to developed countries, permitting trade only within national boundaries, or a combination of these approaches. A USDA study on carbon trading estimated that the price of carbon could range from $14 to $200 per metric ton, based on the level of trading allowed.[xiii]

The price of carbon will have a large impact on whether or not more farmers adopt conservation tillage. Many farmers are already incorporating conservation tillage practices and would be happy to participate regardless of the carbon price. However, the majority of farmers do not utilize conservation tillage, and may need a considerable incentive to purchase new equipment and develop new management skills. Several farmers have mentioned that they believe a minimum incentive of $10 per acre would be required for accelerated adoption of conservation tillage. Given that many soil scientists estimate that no-till can sequester about 0.2 metric tons per acre, that would necessitate a carbon price of $50 per metric ton.[xiv]

Models exist for governments to exercise their responsibility for environmental protection, but they must be adapted. The largest and most successful government conservation program has been the set-aside of cropland through the Conservation

Reserve Program (CRP). CRP has idled millions of acres of highly erodable land. CRP provides farmers with an annual payment, usually for a 10-year period, to plant perennial vegetation. The idled land quickly sequesters carbon. However, this system is flawed for long-term carbon sequestration because carbon is lost if the land is returned to conventional tillage practices after the 10-year reserve.

Moreover, CRP has created an unnecessary dichotomy in land use. Cropped land is used for maximum production, frequently with little regard for environmental impacts, while CRP land is managed solely for environmental benefit, completely precluding any economic use. Carbon sequestration provides an excellent way to merge economic and environmental concerns.

The USDA could accelerate the adoption of conservation tillage by instituting a program similar to CRP for tillage practices. Like CRP, farmers would bid against other farmers for enrolling land into the program. Many of the environmental benefits of CRP would still be produced by land under conservation tillage, but farmers would still be able to receive an income from crops, thereby significantly reducing the cost of the federal program. Furthermore, this program would expand the potential for farmers to participate in carbon markets. For example, if a farmer could receive $7/acre for no-till through this federal program, then the carbon market would only need to provide $3/acre, or $15 per metric ton, to reach $10/acre, the necessary level to attract widespread farmer interest. The government payment would also provide a floor for farmers adopting conservation tillage, providing a guaranteed income from these new practices.

Developing New Markets for Biomass and Renewable Energies

Farmers, in comparison to most industries, use relatively small amounts of fossil fuels and are becoming more efficient every year. Farmers used the same amount of energy in 1994 as they did in 1978 to produce 80% more output.[xv] Even more important, farmers are the source of a variety of fossil fuel alternatives—from biofuel and biochemical feedstocks to land suited for wind energy generation—that place them solidly at the foundation of a new resource base. Farmers would do well to consider themselves fossil fuel *competitors* rather than consumers, poised to benefit from the transition to an economy that is less dependent on fossil fuels and more environmentally responsible.

Alternatives to petroleum include renewable energy sources such as solar, water, wind, and biomass. Biomass, a plant-derived source of both fuels and industrial products, can replace both the energy and the chemicals supplied by petroleum products. Farmers would have an important and lucrative role in producing a new, plant-derived resource base. Some studies predict that biofuels may eventually reduce $25 billion of oil imports and account for 10% of U.S. electrical generation.[xvi]

Biomass as a resource and fuel supply is not a new idea in the United States. Ethanol has been produced as a fuel since the early 1900's, when Henry Ford's Model T was designed to run on either ethanol or gasoline. Although ethanol has since been overshadowed by abundant and cheap fossil fuels, it has recently made a comeback. The oil supply disruptions in the 1970's boosted both interest in and production of ethanol. Yearly production has jumped from 175 million gallons in 1980 to 1.4 billion gallons in 1998.[xvii] Recent legislation has begun to encourage more research and development of biomass. In 1999, President Clinton issued an Executive Order that calls for tripling U.S. biomass use by 2010, a step that would reduce emissions to the equivalent of taking 70 million cars off the road.[xviii] A bill currently in the Senate, the Biomass Research and Development Act of 2000, would provide nearly $300 million over the next six years for bioenergy research and development.

Ratification of the Kyoto Protocol would create a much greater demand for biomass sources. Biomass utilization can assist in reducing GHG emissions both through fossil fuel replacement and long-term carbon storage in biomass sinks.[xix] Ethanol produced from corn and blended with gasoline in a 10% ethanol/90% gas mix called gasohol provides a 2% GHG emission reduction per vehicle mile. When the fuel used is E85 (85% ethanol/15% gas) the emissions reduction is 24-26% per mile. Ethanol produced from cellulosic feedstocks such as grass, trees, corn stover and other agricultural wastes provides even greater emissions reductions: 8-10% for gasohol and 68-91% for E85.[xx]

Corn is currently the source of 90% of the ethanol produced in the United States, which utilizes 6% of the U.S. corn harvest.[xxi] Corn growers became the dominant supplier of ethanol feedstock because corn production is a mature industry with the infrastructure and capacity in place to deliver the product. However, cellulosic feedstocks – things such as corn stalks that are generally considered byproducts – are expected to become the raw material of choice in the near future. Cellulosic ethanol not only provides greater emissions reductions, it is also a more efficient fuel based on its energy output to input ratio. A 1995 report by the Institute for Local Self-Reliance calculates that the energy contained in a gallon of corn ethanol is about 1.4 times the amount of energy required to grow the corn and convert it to ethanol at an average-efficiency farm and processing plant. With state-of-the-art technology, this ratio improves to 2.5:1. The ratio is even better for cellulosic ethanol, estimated at about 2.6:1.[xxii] Cellulosic feedstocks are less expensive and tend to require less fertilizer and less energy to harvest than corn, which accounts for their growing popularity. Furthermore, many of these feedstocks are currently considered waste. Materials such as corn stover, wood trimmings, and wheat or rice straw can all produce cellulosic ethanol and create a new income stream for farmers.

Furthermore, the farmers' role in ethanol production need not be limited to growing the feedstock. An increase in ethanol demand will require new production infrastructure. Biomass is bulky and difficult to transport, which means that processing plants need to be located near the supply. This new infrastructure could provide a role for farmers in processing as well as producing the feedstock, by giving them the opportunity to become owners of the manufacturing enterprise. Ethanol production is more labor-intensive than oil-refining, and lends itself to smaller-scale, local ownership. Thus it can be beneficial for the local, rural economy by providing both employment and income. Although Archer Daniels Midland (ADM) is currently the largest ethanol producer by far, the fastest growing sector of the ethanol-refining industry is the small and medium-sized, locally-owned refineries.[xxiii] In fact, ADM produced up to 75% of U.S. ethanol in the late 1980s but today is responsible for only half that share.[xxiv] With the greater demand for ethanol that the Kyoto Protocol could generate, the number of refineries would only grow, giving farmers greater opportunity to become involved.

The other renewable energy source with huge potential to benefit farmers and rural communities is wind power. Just three Upper Midwestern states—North Dakota, South Dakota and Minnesota—have the potential to produce 74% of the U.S. electrical demand through wind power.[xxv] Farmers in California and Minnesota already receive thousands of dollars from wind farms for easements, while local governments receive hundreds of thousands of dollars in tax income. Researchers found that in Iowa, compared to gas-fired power plants, wind power produces more jobs, less pollution, and reduced energy costs.[xxvi] The local benefits will only grow as research and development pushes the cost of wind power below more traditional sources. According to the American Wind Energy Association, wind power is now more cost-effective then nuclear or hydropower and very competitive with coal and gas.[xxvii]

A website has been developed specifically to help farmers and rural landowners understand the economics of wind energy and the benefits to rural communities: http://www.windustry.org

Providing Alternatives to Industrial Agriculture

Historically, human energy use was constrained by our ability to utilize the solar energy captured in plants. As recently as 1850, the U.S. was 91% dependent on biomass for energy. Now, only about 3% of our energy comes from biomass.[xxviii] The combustion of inexpensive fossil fuels has allowed us to create intensive industrial processing in many sectors, including agriculture.

Growing food has traditionally resulted in a net gain of energy for humans, as more energy was captured through photosynthesis by the harvested plants than was expended in human labor. For example, researchers found that, in 1945, one calorie of energy input into corn production yielded four calories of energy output. By 1979, the return had diminished to 2.4 calories of output for every one calorie of input.[xxix] If the energy inputs for processing, packaging and transporting a can of corn are incorporated, then nine calories are needed to capture one calorie of energy output. The energy inefficiency is even more dramatic in animal agriculture – it takes 35 times more energy to produce and bring a quarter pound of hamburger to the dinner table than its caloric food value.[xxx] On average, the modern food system expends 10 to 15 calories for every one calorie of energy produced.[xxxi]

This reliance on an energy source that is consumed more quickly than it can be regenerated is obviously not sustainable. The present system can only exist as long as inexpensive fossil fuels are available. Fossil fuels are cheap only because governments subsidize the production and use of these products. A recent report by the Institute for Local Self-Reliance concluded that U.S. citizens would be paying from $0.21 to $1.34 more per gallon of gasoline if the price accounted for the subsidization of roads and military protection and the neglect of environmental and health impacts.[xxxii] A less analytical, but more comprehensive, estimate by the Worldwatch Institute in 1989 did factor in GHG emissions and the true cost was even higher: $4.50 per gallon.[xxxiii] These numbers were calculated without considering the climate change impacts of fossil fuels. But climate change may soon become the motivation to increase fossil fuel costs. In less than 150 years, humans have increased the carbon dioxide concentration in the atmosphere by about 10%. Actions to reverse carbon dioxide increases are needed, and will inevitably result in changes in energy consumption and agricultural production.

Promoting the appropriate use of carbon is more than an important step toward addressing climate change. It can also create other changes in agriculture that protect our natural resources. For example, the production of nitrogen fertilizers and pesticides requires intensive energy use. Fertilizer use expanded three times between 1960 and 1980, and herbicide use increased four and a half times.[xxxiv] If the pollution costs from this energy use were appropriately incorporated in the future, farmers would have more of an incentive to utilize manure, integrated pest management, and other preferred management practices. Grazing and other beneficial land uses would compare favorably to large confined livestock operations, which rely on cheap energy for cooling, feeding and watering the animals. Furthermore, 75% of the food grown on farms is processed before it is consumed.[xxxv] With true energy costs factored in, locally produced foods with minimal processing and packaging would have an economic advantage over the highly-processed foods that travel long distances to supermarkets.

Inexpensive fossil fuels are purported to be beneficial to farms and rural communities. At the farm scale, the less spent on fossil fuels and fertilizers the better for farm income. But in the aggregate, system behavior is more complex. Cheap fuels foster agricultural industrialization, which has led to a dramatic decline in the number of farms. Significant increases in crop yield, made possible by greater horsepower and commercial fertilizers and pesticides, have led to oversupply and a continual erosion of crop prices. Many once-thriving rural communities are now struggling to keep schools and stores open. A section (one square mile) of Midwest farmland that at one time could provide an income for several families can now barely keep one family economically viable.

U.S. agriculture has had a long trajectory toward large, industrialized, corporate agriculture. Small farms are considered unproductive, inefficient, and a relic of the past. A *Wall Street Journal* article stated that "In fact, local dairies aren't necessary anymore. Megafarms are springing up in such places as New Mexico and Idaho that produce milk far more cheaply than the postcard pretty Vermont dairy farm."[xxxvi] However, the perceived efficiencies of industrialized agriculture may be more the result of improper accounting than any societal benefits. When an assessment of farm efficiency considers only the yields of particular commodities and productivity per farmer, then industrial agriculture has an apparent advantage. Yet the United States Department of Agriculture, in its 1998 publication *A Time to Act*, recognized that small farms provide several societal benefits, including:

- Diversity of landscape, ownership, cropping systems, cultures, and traditions;
- Environmental benefits, including the "production" of clean air and water, improved soil quality, and carbon sequestration;
- Empowerment of community members through more equitable economic opportunity, greater social capital, and greater accountability to the community;
- Places for families to nurture children, acquire values, and pass knowledge and skills;
- Increased personal connection to food; and
- Strengthened rural economies.[xxxvii]

If these indicators could be incorporated into our definition of efficiency, small farms—and less energy-intensive farms—would be seen as far more advantageous than large farms.

Furthermore, the efficiency argument does not consider the historical large-farm bias in government policy. *A Time to Act* further states that "Farm payments have been calculated on the basis of volume of production, thus giving a greater share of payments to large farms, enabling them to further capitalize and expand their operations...Recent changes in Federal tax policy provide disproportionate benefits to large farms through tax incentives for capital purchases to expand operations. Large-scale farms that depend on hired farmworkers for labor receive exemptions from Federal labor law afforded workers in every other industry, allowing them the advantage of low-wage labor costs."[xxxviii] The subsidization of fossil fuels contributes to this large-farm bias. Contrary to President Kennedy's assertion, a rising tide does not lift all boats. Rather, these perverse subsidies are thwarting the comparative advantage of small farms, and masking the economics that should limit farm size.[xxxix]

Reconnecting Farmers with Local Markets

While governments throughout the world have been actively negotiating GHG emission reductions as part of the Kyoto Protocol, these same governments have embraced liberalized agricultural trade policies that will substantially increase the energy demands of global agricultural production and distribution systems. Increased trade liberalization is promoted as a method to maximize efficiency, yet it ignores what may soon be the primary indicator of efficiency—fossil fuel consumption. Agriculture has become increasingly specialized. Rather than growing a diversity of crops for local consumption, farmers produce a few commodities for markets throughout the world. This fundamental contradiction is a testament to our failure to effectively integrate environmental and economic policy.

Moreover, agricultural trade liberalization has done little to help farmers. U.S. farm income has plummeted in recent years as several commodities have dropped to the lowest real price in decades. Farmers have responded by expanding production with increased acreage and more industrial practices. These trends may work for some individual farmers, but can be devastating for other farmers and the rural communities whose viability depends on family farms and their related businesses.

A 1969 study by the U.S. Department of Energy estimated that the average food item in the U.S. travels 1,300 miles, and the authors admit that the oversimplified model considerably underestimated transportation requirements.[xl] Since then, the trend has been toward greater distance and durability, and greater disconnect between production and consumption.[xli] This development has disturbing environmental and economic implications. Not only do GHG emissions increase, but roads are widened, river navigation increased and ports expanded, all with detrimental impacts on the environment.

Midwestern consumers rarely eat produce grown in the Midwest. Regional farmers have largely abandoned that market because of cheaper produce imported from California, Mexico and other locations. Ninety percent of all fresh vegetables consumed in the United States are grown in California's San Joaquin Valley.[xlii] Midwest farmers have countered by becoming the world's largest exporter of corn and soybeans. This has resulted in more volatility in farm income as Midwest farmers are subjected to the economic fluctuations and dietary preferences of consumers in Asia and Europe.

A group in the United Kingdom, Sustain, has documented the increase in "food miles" in that country. Sustain found that the average distance UK food traveled increased by 50% between 1978 and 1998.[xliii] This separation between farmer and consumer has contributed to virtual monopolistic control exerted by supermarkets in many towns and villages. The five largest retail chains in the UK account for 80% of the market. Furthermore, many of the external costs of this transport, including air pollution, traffic congestion, and road construction, are largely unacknowledged. For example, many international food companies are advocating expanded road construction through the Trans-European Network, which may cost up to $580 billion over 15 years.[xliv]

Reconnecting farmers with local markets can provide a variety of benefits, from more stability in farm income to greater food security. U.S. farmers are ideally located in one of the largest and wealthiest populations in the world, but unfortunately many of the markets are being lost to cheaper imports. Only through the subsidization of fossil fuels—and externalization of environmental damage from fossil fuels—is this transportation possible. Addressing these market deviancies will not only reduce GHG emissions, but will also allow U.S. farmers to obtain a greater market share of food and energy consumed in the U.S.

Reducing the Impacts of Climate Change on Agriculture

The impact of climate change on agriculture may be enormous, and has likely already begun. Since 1970, U.S. agriculture has achieved greater crop productivity, but variability in yields and price has increased. Extreme weather events and pest infestations have caused this yield variability, with enormous economic impacts. For example, the 1988 Midwest drought resulted in a 30% reduction in U.S. corn production and $3 billion of relief payments to farmers.[xlv] Furthermore, both pest damage and insecticide use have increased since 1970, causing the destruction of 1/3 of U.S. crops. These multiple stresses and ensuing feedback loops, as well as human interactions with these stresses, create an extremely volatile system with unknown economic and environmental impacts.

Three major uncertainties exist regarding climate change and agriculture:

- How regional changes in temperature and precipitation affect crop growth and pest vectors.
- How increased levels of carbon dioxide will affect crop growth, weed growth, and insects.
- How well farmers can adapt to climate change.

Several studies have attempted to quantify these uncertainties. A recently released report from the Center for Climate Systems Research at Columbia University, the Department of Plant Pathology at Iowa State University, and the Center for Health and the Global Environment at Harvard Medical School stated that "the combination of long-term change (warmer average temperatures) and greater extremes (heat spells, droughts and floods) suggest that climate change could have negative impacts on U.S. agricultural production. Economic losses in some U.S. agricultural regions could rise significantly due to greater climate variability, and to increases in insects, weeds, and plant diseases."[xlvi]

The fact that carbon dioxide concentrations in our atmosphere have risen substantially over the past 100 years, and that these changes may require increased management by farmers, is largely undisputed. Fortunately, many of the practices farmers can use to reduce GHG emissions will help prepare them for changes in climate.

These include:

- Diversifying production. Planting a variety of crops allows farmers to lengthen crop rotations and take advantage of local demand. Crop diversity will also reduce the risks from extreme weather conditions, pests, and disease.
- Increasing soil carbon. This not only helps offset carbon dioxide emissions, it creates a healthier soil better able to withstand drought and other extreme weather conditions.

- Re-establishing local markets. This will reduce GHG emissions from transportation while limiting the farmer's exposure to fluctuations in world production and prices, which are likely to accelerate as abnormal weather patterns increase.

National policies should be implemented that foster these practices.

Conclusion

Climate change and climate change mitigation will have significant impacts on U.S. agriculture. Yield fluctuations, which have increased significantly in the past 30 years, have likely resulted from changes in climate. Consequently, crop prices have been volatile, and small farmers that do not have sufficient capital to endure low prices have suffered.

Meanwhile, U.S. farm policy has been biased toward large, industrialized farms that rely on transport to international markets—an agricultural system that has significantly contributed to GHG emissions. This system only remains viable through fossil fuel subsidies and other policies that mask underlying inefficiencies. Unfortunately, many farming organizations see no choice for agriculture but to rely on foreign oil and international markets, and they therefore perceive climate change mitigation as a threat.

We, however, have found that climate change mitigation will present many new opportunities for farmers. Industrial agriculture has placed us on a path of weak crop prices, low farm income, the loss of farmers, and environmental degradation. With the promise of lucrative markets overseas, it has eroded the connection between farmers and local consumers. Increasing the cost of fossil fuels would increase the value of farmer knowledge and ingenuity, helping to reverse the depopulation of farming communities.

Furthermore, climate change mitigation will increase the need for two undervalued products—sequestered carbon and renewable energy. Climate change negotiations may very well allow farmers to participate in carbon markets by receiving credits for increasing carbon in the soil. Corporations that want to take advantage of the current low price of carbon have already initiated trades with farmers. Additionally, farmers can take advantage of higher fossil fuel prices by producing competitive products such as biomass fuels and wind energy. This production shift can serve not only to reduce U.S. carbon dioxide emissions, but also to retain more of the production benefits in the Midwest, rather than transferring them to transnational oil corporations.

We agree that the principal dispute that many farm organizations have with the Kyoto Protocol—the loss of international competitiveness due to higher input costs—needs to be addressed so that U.S. farmers are not faced with adverse short-term impacts. But overall, the opportunities that climate change mitigation provide far outweigh the risks. U.S. agriculture needs to be actively involved in these negotiations to assure that farmers can participate and benefit in efforts to reduce GHGs.

About the Authors

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