ECONOMIC IMPLICATIONS OF CLIMATE CHANGE FOR AGRICULTURE

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Keywords: Agriculture, climate change, mitigation, adaptation, cost effectiveness, vulnerability

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Summary

Agriculture is ultimately dependent on climate resources. Climate change poses major challenges for global food security over the twenty-first century. Natural sciences and economics analyze the causes and consequences of the climate change threat. Agriculture contributes to emissions of greenhouse gases, particularly through conversion of forest land to agriculture on a global scale. Agriculture is likely to face the severest impact from climate change, with implications for global food security and livelihoods. Mitigation strategies and the impacts of climate change both have economic dimensions. Feedbacks between mitigation and impacts mean that strategies for enhancing carbon sinks will directly affect the adaptive capacity of food-producing sectors. Economic studies of incentives for mitigation of greenhouse gases focus on land-use options, such as afforestation of agricultural land or biofuel crops. The economic assessments of the impact of climate change on agriculture use multi-sector economic models of climate impacts and demonstrate how agriculture is affected through production losses. Global assessments overlay future climate scenarios onto spatial estimates of the agricultural potential of agricultural land. They incorporate trade in agricultural commodities, and model adaptation. These analyses result in scenarios of global agricultural production and trade over century timescales. The same analyses are also undertaken for individual countries. Other approaches, such as Ricardian models, examine the capital value of land based on scenarios of demand and productivity affected by climate variables. Most economic analyses tend to examine the impacts of climatic changes on agricultural production, thereby failing to address the dynamics of food security and the distribution of food and other outputs from agriculture. Future research in this area is likely to focus on refining this understanding of vulnerability to climate change, adaptation strategies and the dynamics of food security.

1. Economics of Climate-Change Mitigation in Agriculture

1.1. Land-Use Mitigation Options

The feasibility of reducing agricultural emissions of greenhouse gases or enhancing sinks in agricultural land has been prominent in many studies of "solutions" to reduce greenhouse-gas emissions. There are many interactions of the terrestrial and oceanic parts of the biosphere with the atmosphere. Interventions at most of these points have been suggested. The major areas for serious consideration are in changing the use of energy resources and the use of land resources. Some energy-related mitigation policies, such as increasing hydro-electricity generation, also have implications for agriculture and land use. The primary interventions in the land-use sector are in stopping present deforestation, in afforestation, and in reduction of methane emissions from agricultural sources such as livestock and paddy-rice cultivation. The contentious issues of equity and responsibility cannot be avoided, particularly at the international level. But there should be scope for bringing about overall emissions in tandem with fulfilling other socially and environmentally desirable outcomes.

1.2. The Interaction of Agriculture and Mitigation through Afforestation

The enhancement of sinks through afforestation, as with the land-use conflicts surrounding stemming deforestation, requires addressing the trade-offs and land-use priorities. Afforestation is not a simple feasible, equitable, or cost-effective strategy for reducing aggregate emissions or recovering the lost biomass carbon. In terms of timing, halting deforestation brings about immediate benefits where the enhancement of carbon sinks through afforestation has its effect on the global carbon cycle over a longer time frame. The rate at which carbon sink enhancement takes place has therefore to be compared with its alternatives such as reducing emissions, or offsetting fossil fuel emissions through biomass or biofuels.

Many studies show that a significant proportion of the world's emissions of carbon could be offset by afforestation either in the tropics, or even in temperate regions. Afforestation may appear to be less costly in tropical countries because the market cost of agricultural land is assumed to be low in many developing countries, compared to agricultural land in the U.S. and Europe. The phenomenon of higher land prices is, however, simply an illustration of how political and economic support for agriculture distorts the markets related to land-use activities and hence distorts land-use decisions themselves. In reality, large-scale radical land-use change through afforestation in the tropics, particularly in plantation forestry, would have many social and economic consequences.

Various studies have attempted to estimate the global potential for carbon sequestration through afforestation, either assuming that all land deforested in the late twentieth century could potentially be reforested; that all areas not "required" for agricultural production could be afforested; or some other criterion. Estimating land availability, although often taking on board population aspects of future land use, relies on the carrying capacity concept to incorporate all the necessary social forces driving land use. To estimate carrying capacity requires knowledge of not only the physical attributes of land and the level of technology that combine to determine the productivity of land but also knowledge of the land requirement, which is influenced by urbanization and non-agricultural income of land users. The demand for land is also fundamentally determined by localized institutions and cultural norms, such as inheritance law and practice.

	Temperate afforestation (U.S.)	**Tropical afforestation**
Area required to sequester total global emissions	465 million ha	465 million ha
Establishment costs	$230 per ha	$400 per ha
Land costs	$400 per ha	$0 per ha
Total costs for 465 million ha	$372 billion	$186 billion

Note: Area required removes 2.9 billion tons of carbon (btC), which they take as being added annually to the atmosphere, based on an average yield class of 15 $m^3/ha^{-1}/yr^{-1}$ (= 6.24 $tC/ha^{-1}/yr^{-1}$)

Table 1. Estimated costs (US$) of afforestation in the U.S. and tropics to offset global carbon emissions

(*Source*: Adapted from R.A. Sedjo, Forests to offset the greenhouse effect, *Journal of Forestry* **87**(7) (1989), 12–15)

The costs of establishing forests to sequester the estimated world emissions of carbon each year in the United States have been estimated as the sum of the actual costs incurred in planting the trees and the cost of purchasing the land (see Table 1). This gives an estimate of US$372 billion, equivalent to 8% of the gross national product of the U.S., as a lower bound estimate and purely financial cost of afforestation. The cost is likely to be higher because the scale of forestry required would mean bringing productive agricultural land into forestry, with correspondingly much higher land costs. Further, the real cost of forestry includes the opportunity cost: the cost of the next-best foregone alternative. Although agricultural production is higher than it would be under free market conditions due to distorting price support in both the U.S. and Europe, the costs of agricultural production foregone is not included in the above calculation, and hence the figure represents a lower bound estimate.

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Biographical Sketch

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