Climate Change Interactions with Agriculture, Forestry Sequestration, and Food Security

L. Peña-Lévano[1], F. Taheripour[2], W.E. Tyner[3]

Previous papers have addressed the importance of forest carbon sequestration (FCS) as an alternative mitigation policy for climate change. However, the existing literature has not explicitly addressed the impacts of this policy on the global food supply. Here we argue that an aggressive FCS policy which tends to extend demand for forest land could become an indirect threat for food security. A major expansion in forest land could increase competition for land. This change could lead to a reduction in available land for food production. This could reduce food supply, increase food prices, and negatively affect food security at the global scale. These effects can be worse for developing regions, because of their low economic status, greater dependence on commodities for food, high carbon emission intensiveness, and fewer mitigation options. This suggests the need for more research to better understand the consequences of using a FCS policy for food security across the global scale.

This study aims to improve our understanding of the interplay between greenhouse gas (GHG) emissions reduction policies, climate change, land use, and FCS and their impacts on the global economy, food security, and land use. To accomplish this task, we developed a new Computable General Equilibrium (CGE) model. The model is a mixture of two well-known GTAP (Global Trade Analyses Project) versions: GTAP-BIO and GTAP-AEZ-GHG. The first model has been developed and extensively used to evaluate the economic and land use consequences of energy and biofuel policies. This model is designed to trace the land use changes due to changes in economic variables (such as biofuel production or policy) and biophysical conditions (such as changes in crop yields due to climate change). However, this model is incapable of evaluating the impacts of a forest carbon sequestration policy. The second model incorporates a detailed GHG emissions database and is designed to evaluate the economic impacts of some GHG emissions mitigation policies including a FCS policy.

To fulfill the main objectives, we first defined a policy to reduce GHG emissions at the global scale. The policy consists of a global uniform tax on GHG emissions and a FCS subsidy. The carbon tax is measured in \$/metric ton of CO_2 equivalent. The FCS subsidy is measured in \$/metric ton of carbon sequestered in forest land. Then using our new CGE model we developed several simulations to examine the extent to which this policy could affect the global economy, food supply, and land use under different assumptions on future changes in climate conditions. For example, following the IPCC 5th Assessment Report, in one simulation we calibrated the emissions tax (and the FCS subsidy) to reach a 50% reduction in the global GHG emissions, while we ignored that fact that climate change will affect crop yields in future. Several papers in the literature show the extent to which FCS can be used to reduce GHG emissions. Then we departed from this traditional setup by taking into account the fact that climate change will affect crop yields in the future, which could make the FCS policy very expensive to implement.

Our preliminary results indicated that a high level of carbon tax \$150/t CO_2e is required to achieve a 50% reduction in global GHG emissions, when we ignore the impacts of climate

[1]Luis Peña-Lévano, Ph.D. candidate, Agricultural Economics Department, Purdue University, West Lafayette, Indiana, USA; [2]Farzad Taheripour, Associate Professor, Agricultural Economics Department, Purdue University, West Lafayette, Indiana, USA; [3]Wallace E. Tyner, Professor, Agricultural Economics Department, Purdue University, West Lafayette, Indiana, USA. Corresponding author: L. Peña-Lévano, email: lpenalev@purdue.edu.

change on crop yields. In this case forest carbon sequestration plays a major role in emissions reduction (18%). The expansion in forest cover makes less land available for crops across the world (reduction of 333 Mha). Overall, the most affected crop sectors were: paddy rice and coarse grains. Likewise, harvesting area decreased for the USA, China, India and Sub Saharan Africa.

As a result, there were huge rises in food and commodity prices predicted. This significantly reduced GDP in many regions, especially emerging economies (i.e. China, India, Sub-Saharan Africa). Global welfare was reduced by $916 billion, impacting important economies such as the USA and China. These results suggested that high levels of forest carbon sequestration have unintended consequences that would not be socially acceptable.

Our additional simulation results indicated that future climate change worsened the above consequences. The predicted crop yield changes resulting from climate change caused more land to be needed for crop production. In addition, crop yield reductions decreased overall production. There were significant increases in crop and livestock prices - by more than a factor of 2. Two important implications of this research were: 1.) Developing countries were affected much more severely, and 2.) Because of the predicted adverse impacts, it may prove quite difficult to negotiate stringent GHG emissions reductions policies.