Towards an Integrated Agricultural Greenhouse Gas Model:
Greenhouse Gases from Agriculture Simulation Model (GreenAgSiM)

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Introduction

THE PRESENT MODEL AIMS to quantify greenhouse gas (GHG) emissions from changes in agricultural activity on a global scale. It is based on the FAPRI Agricultural Outlook Model, which is used to project changes in agricultural activity in approximately 35 countries and regions covering 13 crops (grains, oilseeds, rice, cotton, sugar) and two major livestock categories (cattle and swine). The FAPRI model is used to project the impact of policy changes on agriculture, and then the GreenAgSiM model is used to calculate the impact of these changes on GHG emissions. The GreenAgSiM model can be used to evaluate the GHG implications of a change in agricultural, bio-energy and environmental policies in the US and elsewhere. It follows closely the guidelines for GHG inventories established by the Intergovernmental Panel on Climate Change (IPCC).

Methods

THE MODEL HAS TWO main parts: agricultural production and land-use change. The main GHGs emitted from agricultural production are methane from animals (CH_4) and nitrous oxide (N_2O) from manure and fertilizers, which account for 10%-12% of anthropogenic global emissions. The land-use change part of the model captures CO_2 emissions from land conversion related to cropland expansion/reduction. To measure the emission, we relate each emission category with activity data derived from the FAPRI Agricultural Outlook Model.

Emission sources and activity data

Emission Category	Activity Data
CH_4 Enteric Fermentation	Number of animals
CH_4 Manure Management	Number of animals, temperature
N_2O Manure Management	Number of animals, manure management system
N_2O Agricultural Soil Management	Nitrogen use, number of animals, crop area
CH_4 Rice Cultivation	Rice area
CO_2 Land-Use Change	Change in crop area

To measure carbon emissions from land-use conversion, the distribution of cropland on the first administrative level (e.g., states in the US) was determined using FAO's Global Spatial Database of Agricultural Land-Use. Second, a map of native vegetation was merged with a map of global ecological zones to determine the type of vegetation in a particular state. The data gathered was then matched with IPCC default values of biomass carbon. We assumed that land taken out of production reverts to native vegetation over 20 years. We also assume that no deforestation takes place in the US and that all US cropland expansion comes from grassland/Conservation Reserve Program.

Potential Uses of the Model

POSSIBLE APPLICATIONS AND USES of the model:

- The effects of an increase in grain yield or other events that increase land productivity on greenhouse gases
- The effects of policy changes involving anhydrous ammonia use on GHG emissions
- The effects of policy changes related to conservation tillage in GHG emissions
- The impact of the EPA-proposed "sin" tax on livestock for methane emissions
- Offset options that trade off the positive impact of national yield increases or beneficial policy changes against other policies that result in an increase in agricultural GHG emissions

Example

Wheat Production and Biomass Carbon in China

THE FOLLOWING SERVES AS an example of how an expansion or contraction of wheat production in China affects biomass carbon. Figure 1 shows the global ecological zones and Figure 2 contains information about the type of vegetation (forest, shrubland, savanna, or grassland).

IPCC default values depend on the ecological zone and the vegetation and thus a weighted average can be constructed from the first two maps. The spatial allocation of wheat (Figure 3) allows us to determine in which area a change in wheat production most likely will take place and how it will affect the carbon content of biomass.

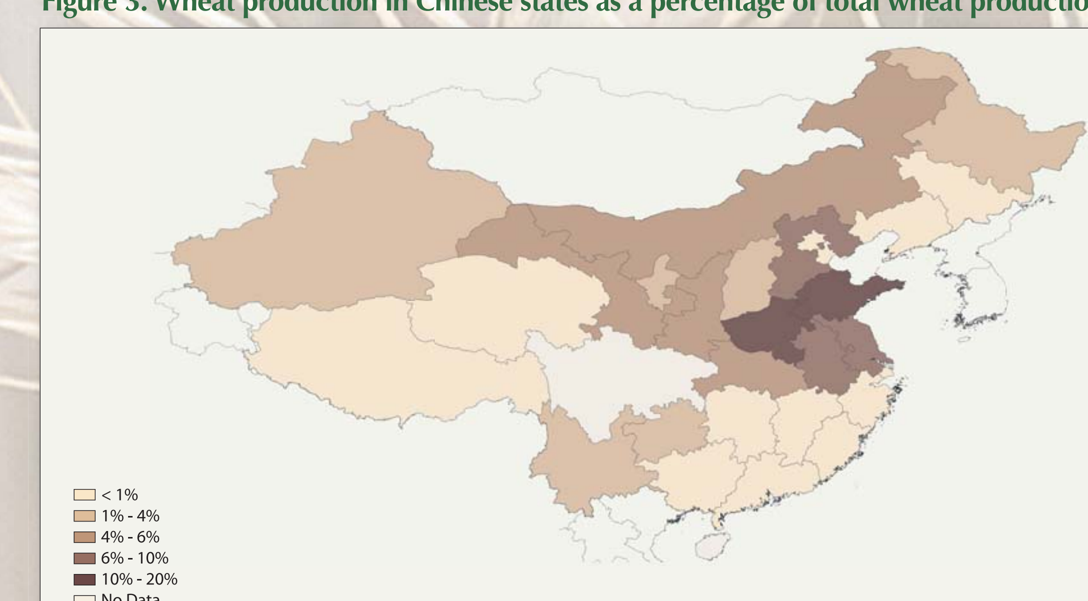
Figure 1. Global ecological zones in China

Source: FAO

Figure 2. Vegetation in China

Source: Olson et al.

Figure 3. Wheat production in Chinese states as a percentage of total wheat production



Source: FAO

Conclusion

THE MODEL AT HAND is the first version of a globally integrated agricultural greenhouse gas model that can be used to answer a wide array of questions concerning greenhouse gas emissions and agriculture. It is conceived as a tool for policymakers to make informed decision in a carbon constrained world. It will be continuously refined to always reflect the most current knowledge of greenhouse gas emissions from land use and agricultural production.

References

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