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Low Emission Development Strategies in Agriculture. An Agriculture, Forestry, and Other Land Uses (AFOLU) Perspective

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Summary. — As countries experience economic growth and choose among available development pathways, they are in a favorable position to adopt natural resource use technologies and production practices that favor efficient use of inputs, healthy soils, and ecosystems. Current emphasis on increasing resilience to climate change and reducing agricultural greenhouse gasses (GHG) emissions strengthens the support for sustainable agricultural production. In fact, reducing losses in soil fertility, reclaiming degraded lands, and promoting synergistic interaction between crop production and forests are generally seen as good climate change policies. In order for decision-makers to develop long-term policies that address these issues, they must have tools at their disposal that evaluate trade-offs, opportunities, and repercussions of the options considered. In this paper, the authors combine and reconcile the output of three models widely accessible to the public to analyze the impacts of policies that target emission reduction in the agricultural sector. We present an application to Colombia which reveals the importance of considering the full scope of interactions among the various land uses. Results indicate that investments in increasing the efficiency and productivity of the livestock sector and reducing land allocated to pasture are preferable to policies that target deforestation alone or target a reduction of emissions in crop production. Investments in livestock productivity and land-carrying capacity would reduce deforestation and provide sufficient gains in carbon stock to offset greater emissions from increased crop production while generating higher revenues.

Key words — climate change, land use change, low emission development, AFOLU

1. INTRODUCTION

Resource use in many developing countries, from crop production to deforestation is responsible for the bulk of greenhouse gasses (GHG) emissions, and there are instances in which the agricultural and forestry sectors can provide low-cost climate change mitigation opportunities (Golub *et al.*, 2013; Lubowski & Rose, 2013; Smith *et al.*, 2007). From a technical point of view, reducing expected increases in GHG emissions in agriculture requires the adoption of transformative approaches in the use of resources. Emphasis has been placed on methods that increase the efficiency in the use of fertilizers, water, and fossil fuels, as well as waste reduction. A growing body of literature analyzes the effects of alternative agricultural practices (Antle & Stoorvogel, 2008; Diagana, Antle, Stoorvogel, & Gray, 2007; Gilhespy *et al.*, 2014; Schneider & Smith, 2008; Smith *et al.*, 2013; Tenningkeit, Kahrl, Wolcke, & Newcombe, 2012; Tschakert, 2007). The livestock sector has also been the target of research on mitigation opportunities (Golub *et al.*, 2013; Li *et al.*, 2012; Schils, Olesen, del Prado, & Soussana, 2007), and the mitigation potential of forests, soil, and other biomass has been amply analyzed as well (Cacho, Marshall, & Milne, 2005; Lubowski & Rose, 2013; Makundi & Sathaye, 2004; Torres, Marchant, Lovett, Smart, & Tipper, 2010). However, from a policy-making perspective, the design of low emission development strategies is an example of multi-objective decision making in which policies target the reduction of GHG emissions while other goals such as increasing agricultural productivity and food security or attaining objectives such as export goals or economic growth are preserved. It is also important to consider that all countries are part of a global economic system, and therefore it is critical that policies are devised with full recognition of the role of the international economic environment which, with its effects on commodity prices, can significantly affect the long-term viability and the budgetary implications of mitigation policies. The challenge at hand is to reconcile the limited spatial resolution of macro-level economic models that operate at a global or national level with models that function at a higher spatial resolution to properly account for changes in carbon stocks and GHG emissions. The

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number of analyses that confront this challenge is still small, but it is growing given the importance of the information that these studies can provide to policy makers. Schneider and Smith (2008) estimated mitigation potentials of U.S. agriculture with regionally disaggregated data and changes in welfare within the agricultural sector. Golub *et al.* (2013) examined the impact on food consumption and income of implementing mitigation policies at national and regional levels. Rutten, van Dijk, van Rooij, and Hilderink (2014) evaluated the effects of a series of climate change and economic growth scenarios on Vietnam's economy. Dace, Muizniece, Blumberga, and Kaczala (2015), used a system dynamic model to assess the effect of a group of policies on agricultural GHG emissions in Latvia. Havlík *et al.* (2014) estimated the effects of transitioning to a more efficient livestock production system on GHG mitigation and the economy, and Lubowski and Rose (2013) provided a review of a number of studies that model mitigation potentials of the Reducing Emissions from Deforestation and Forest Degradation (REDD) program along with conservation, sustainable management of forests, and enhancement of forest carbon stocks policies.

In this article we demonstrate that different models, all widely accessible to the public, can be brought together to help policymakers in their evaluation of trade-offs, opportunities, and repercussions of alternative mitigation policies in the agricultural sector. While the focus of this work is on Colombia, the analytical framework can be applied to any country interested in exploring country-wide effects and the economic viability of climate change mitigation policies in agriculture. The approach is based on the use of public and widely accessible data and we believe that the flexibility and transparency of the approach proposed in this study can increase decision-makers' trust in the results. Naturally, additional data and targeted surveys can increase the accuracy of the results and the framework does not create barriers for the inclusion of additional input. Nonetheless, it is clear from our analysis that policy-makers need substantial support in their decision-making process as the range of options they face can be very diverse and the effects of their decisions have important, and sometimes unexpected repercussions. The effects of the policies we simulated cover the entire spectrum of potential outcomes. We found win-win policies (reducing land allocated to pasture increases profits and carbon stock and reduces GHG emissions), policies with tradeoffs (limiting deforestation in the Amazon increases carbon stock, decreases emissions, but reduces profits), and policies that could generate clearly inferior results (increasing the area allocated to oil palm cultivation beyond certain amounts reduces carbon stock, increases emissions, and reduces profits). Stakeholders, from government agencies to producer and consumers' organizations to farmers will benefit from policies devised with the support of solid evidence and the effects of which can be investigated and evaluated by all the parties affected.

2. GREENHOUSE GAS EMISSIONS IN COLOMBIA

In 2010, Colombia presented its second National Communication on Climate Change to the United Nations Framework Convention on Climate Change. The report contains data from the last National Greenhouse Gases Inventory carried out in 2004. Colombia contributes 0.37% (180,010 Gg) of the total worldwide emissions of GHG (49 Gt). Emissions are composed of 50% carbon dioxide (CO_2), 30% methane (CH_4), 19% nitrous oxide (N_2O), and the remaining 1% classified as chlorofluorocarbons (CFCs).

According to the last National Greenhouse Gases Inventory, agricultural activities emit 38% of total emissions, and land use, land use change, and forestry account for another 14%. Of the emissions resulting from agricultural activities, 48.5% are due to enteric fermentation, 47.5% from agricultural soil management, and 2% from emissions related to rice cultivation. Traditionally, Colombia has a large number of smallholder farmers and there is also a well-established culture of cattle ranching with both small and large livestock keepers. Urbanization and industrialization have been growing in Colombia, but agricultural and forestry activities are expected to grow and continue to claim a large share of emissions. Although the agriculture sector represents 7% of the gross national product, the sector employs 18% of the population (CIA (Central Intelligence Agency), 2014).

Colombia has developed plans and policies that address climate change mitigation identifying priority sectors with high GHG emission rates. A working group led by the Ministry of Environment and Sustainable Development (MADS) has selected target areas for low emissions development in the agriculture, forestry, and land use sectors. These include reducing emissions from deforestation and forest degradation, oil palm, livestock, forestry, and fertilizers. In December 2015, the government of Colombia presented its Intended Nationally Determined Contributions (INDCs) at the Conference of the Parties in Paris and this document includes contributions from the AFOLU sector.

According to official government statistics (IAvH *et al.*, 2007; IGAC, 2013), 52% of Colombia's 115 million hectares is covered by natural forests, mostly within the Amazon basin but also forests along the Pacific coast and in the northern part of the country. Cultivated pastures and native savanna grasslands make up 26% of the land area. These lands are characterized by cattle grazing with low stocking rates and frequent natural and anthropogenic fires. Cropland is mostly concentrated in the intermountain valleys, making up about 4% of the land surface (see Figure 1).

In 2011, the Instituto Nacional de Hidrología Meteorología y Estudios Ambientales de Colombia (IDEAM) and MADS quantified national deforestation rates and trends (Table 2.1). The average annual deforestation rate over the entire period is some 238,000 hectares and the Amazon and Andes regions appear to be areas particularly at risk.

Prior to 2000, estimates of forest clearing suggested that two-thirds of this clearing was due to the pastureland encroaching into forest and one-third due to cropland expansion (Etter, McAlpine, Wilson, Phinn, & Possingham, 2006). A more recent analysis has suggested that 90% of forest clearing during 2005–10 was due to pastureland development (Nepstad, Tepper, McCann, Stickler, & McGrath, 2013).

Colombia is the fifth largest producer of palm oil and its production area is expected to increase. Official projections (MADR (Ministry of Agriculture & Rural Development), 2011) indicate that there will be little changes in cropland area over the coming decades, with the exception of oil palm. Oil palm is expected to increase substantially after 2016, due to its high demand for food products and biofuels. However, oil palm development mostly occurred on lands that were already cleared of their forests, a trend that according to some studies is expected to continue, at least partially (Castiblanco, Etter, & Aide, 2013). Pasturelands and livestock production may change substantially in the coming years. According to the Colombian Federation of Cattle Ranchers (Federación Colombiana de Ganaderos, FEDEGAN), the Colombian livestock inventory totals 23.5 million head of cattle and 39.2 million hectares of pasture. With less than one head of