



Innovations for a sustainable future: rising to the challenge of nitrogen greenhouse gas management in Latin America

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Latin America encompasses a dizzying array of ecosystems and socioeconomic models, and the region will be highly vulnerable to the projected impacts of climate change in the next century. At the same time, Latin America can significantly contribute to the mitigation of greenhouse gases (GHG) emissions within a sustainable development framework. Land use conversion with associated biomass burning, agriculture with N fertilizers and animal waste are the main anthropogenic sources of nitrous oxide (N₂O) emissions in the region, and have increased markedly in the last decades. Effective sustainable management for the mitigation of N₂O emissions requires the proper evaluation of all sources, many of which are still roughly estimated or unknown, testing alternatives to reduce primary sources, and technological innovation for higher resource-use efficiency within the farm. Current barriers might be overcome through policies that support sustainable practices that reduce negative environmental impacts and simultaneously maintaining ecosystem function and services.

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Introduction

A recent analysis of the challenges for Latin America and the Caribbean (LAC) region related to physical and socioeconomic impacts of climate change concluded that the region is particularly vulnerable to the observed and projected effects of climate change due to its geographic location, population distribution, infrastructure, and reliance on fragile or non-renewable natural resources for economic activities and livelihood [1*]. The conservative projection of yearly economic damages in LAC caused by some of the major physical impacts associated with the projected rise of 2°C in global mean air temperature is approximately 2.2% of the region's 2010 gross domestic product (GDP, \$4.6 trillion). Potential losses of this magnitude clearly undermine the region's prospects for improvements in the quality of life by significantly limiting development options and severely restricting access to natural resources and ecosystem services, all with socially damaging consequences for equity and poverty levels [1*].

While the region shows genuine vulnerability to the projected impacts of climate change, LAC can also significantly contribute to the mitigation of greenhouse gases (GHGs) emissions within a sustainable development framework. Latin America accounted for 8% of the world's GHG emissions in 2005 [2], which include nitrous oxide (N₂O), carbon dioxide (CO₂) and methane (CH₄). Although N₂O is naturally present in the atmosphere as part of the Earth's nitrogen cycle, human activities are increasing the amount of atmospheric N₂O, particularly through agricultural activities. Specifically in Latin America, land use change (biomass burning — 50%), agriculture (N-fertilizers — 10%) and animal waste (40%) are the main sources of N₂O anthropogenic emissions [3]. Such increase is of particular concern due to the radiative forcing potential of N₂O (300 times that of CO₂ over a 100-year timescale on a per mole basis) and the strong correlation with increased emissions and agricultural intensification in the region.

Recently, the impacts of changes on the regional N cycle in Latin America were evaluated [4*]. These authors highlighted the lack of detailed information on many aspects of the nitrogen cycle, which is a serious impediment to our ability to evaluate and project how human

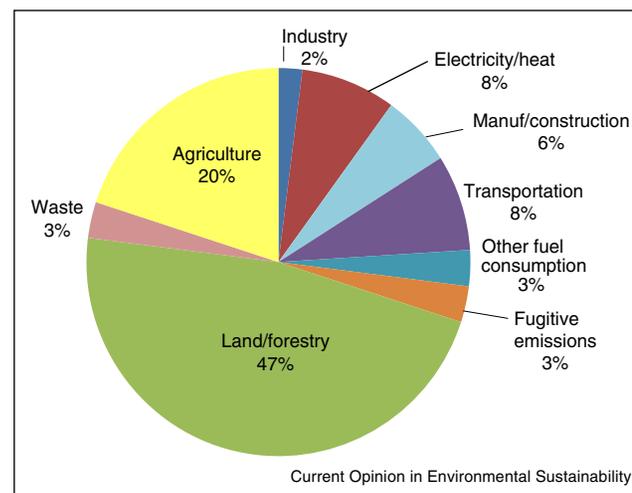
activity is altering nitrogen pools and turnover at regional scales. Here, we expand this assessment to focus on the main drivers involved in human activities associated with increased GHGs and specifically nitrous oxide (N₂O) emissions in Latin America. In addition, we highlight potential mitigation strategies and projections for research needs and priorities.

Regional GHG emissions by sectors

Brazil contributed half of all regional GHG anthropogenic emissions in 2005 and together with Mexico, Venezuela and Argentina, accounted for nearly 80% of total emissions [2]. The share of total emissions among economic sectors is more critical when considering potential mitigation measures that could be adopted in the region. In 2005, the sectors 'Land use changes and forestry (LUCF)' and 'Agriculture' contributed with largest shares of total anthropogenic GHG emissions across the region, with 47% and 20% respectively (Figure 1). The Venezuelan national inventory, however, showed differences in the relative emissions by sector. The energy sector represented the largest source of GHG (75% of total emissions) followed by agriculture (17%) while LUCF represented a *net sink* of approximately 14 300 Gg CO₂ eq [5] (MARN-Venezuela, 2005). In addition N₂O emissions country-level emissions ranged widely, with 3% (Mexico) to 28% (Argentina) of total anthropogenic GHG emissions for the region (www.unfccc.int/ghg_data_unfccc).

GHG emissions from LUCF also showed important changes in other countries. Brazil's share of regional and global GHG emissions from land use changes was particularly significant in 2005, but has declined in the last decade. A recent update of emissions figures [6] indicate that in 2010, Brazil had reduced GHG emissions by nearly half, to 1.25 Pg CO₂ eq, compared to baseline emissions of 2.03 Pg CO₂ eq in 2005, strongly associated with the reduction of deforestation rates in the Amazon basin. In Argentina, between 1990 and 2000 [7], the LUCF sector showed greater relative changes, however, but with an increase in the net carbon sink of nearly 200%. Native

Figure 1



Contributions of total anthropogenic greenhouse gas emissions in Latin America and the Caribbean (LAC) from different sources, 2005. The contributions refer to percentage shares of total anthropogenic GHG emissions from LAC, and not the total fraction of each sector's (i.e. energy) contribution.

Source: Vergara [1*] based on data compiled from World Resources Institute (2012).

vegetation conversion to agriculture and ranching also decreased in Mexico between 1990 and 2010 [8], which probably contributed to decreased GHG emissions in this country as well.

The comparison of N₂O emissions by country (Table 1) indicates that Brazil is by far the largest emitter in the region. In general, agriculture accounts for the largest share of N₂O emissions in the region (up to 96.8%). Globally, N₂O emission from agriculture is equivalent to about 66% of total gross anthropogenic emissions [9]. Agriculture plays a key role in the LAC economies, accounting for approximately 6% of regional gross domestic product (GDP) and 15% of employment in

Table 1

Total anthropogenic emissions of greenhouse gases (GHG, Tg CO₂ eq) and N₂O (Tg CO₂ eq) from the largest emitters in Latin America. Data based on National Inventories of GHG submitted to the UNFCCC and prepared according IPCC guidelines

Country	Argentina		Brazil		Mexico		Venezuela
	2000	2000	2005	2000	2006	1999	
Total GHG	238.70	2087.66	2191.86	563.23	711.65	177.90	
Total N ₂ O (% of total GHG)	67.56 (28.3%)	169.20 (8.1%)	546.00 (24.9%)	12.13 (2.1%)	20.51 (2.9%)	16.15 (9.1%)	
N₂O by sectors (% of total N₂O)							
Agriculture	65.39 (96.8%)	121.68 (71.9%)	476.20 (87.2%)	7.46 (61.5%)	6.99 (34.1%)	15.42 (95.5%)	
Land use change	0.06	6.45	20.90	0.31	0.17	0.01	
Energy	1.01	2.98	12.10	2.50	10.95	0.22	
Industry	0.15	6.17	22.80	0.11	0.36	0.08	
Waste	0.96	3.84	14.00	1.96	2.05	0.42	

Source: www.unfccc.int/ghg_data_unfccc, July 18, 2014.

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