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Modelling approaches for greenhouse gas emissions projections from the waste sector

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ABSTRACT

The Mitigation and Action Plans and Scenarios (MAPS) program is a collaboration amongst developing countries to establish the evidence base for long-term transition to robust economies that are carbon efficient and climate resilient. The program endeavours to contribute towards ambitious climate change mitigation, aligning economic development with policy and planning. This case study paper describes the baseline and mitigation analyses conducted in four countries in Latin America, namely Peru, Colombia, Chile and Brazil, for the solid waste and wastewater sub-sectors. The paper provides an overview of the approaches used in the individual countries, a description of the modelling framework, the drivers of emissions considered, data used, main assumptions and a summary of how mitigation approaches were considered in the analyses. Across all four of the reviewed countries, the generation of waste and wastewater was linked to population, and in some cases GDP, with the emissions determined from the volumes of waste/wastewater treated via different routes. However, the different countries' models varied quite substantially in terms of the IPCC guidelines followed, extent of country-specific information included and the number and type of mitigation actions investigated. The availability of information in the different countries provides a limitation to the analysis which can be conducted. A greater degree of resolution in information and more locally-specific information will lead to results that are better representative of the actual emissions from a particular country.

Keywords: MAPS; Climate mitigation; Waste management; Greenhouse emissions; Projections; Wastewater

1. Introduction

Countries around the world are coming under increasing international and domestic pressure to identify and implement actions to reduce greenhouse gas (GHG) emissions from all sectors of their economies. The Mitigation Action Plans & Scenarios (MAPS) programme (www.mapsprogramme.org) is a collaboration amongst developing countries that has helped establish the evidence base for planning to reduce GHG emissions in participating countries, through combining research and stakeholder interest with policy and planning. The analyses conducted under the programme seek to provide information on potential emissions from the sector under a business as usual or reference scenario, and under scenarios in which GHG mitigation options are implemented. At the time of writing the programme was at the advanced stages of being rolled out in four countries in Latin America: Peru, Colombia, Chile and Brazil.

This case study paper describes the baseline and mitigation analyses conducted in these countries for the solid waste and wastewater sub-sectors. The paper provides an overview of the approaches used in the individual countries, a description of the modelling framework, the drivers of emissions considered, data used, main assumptions and a summary of how mitigation approaches were considered in the analyses. The paper was developed by reviewing and critiquing relevant information contained primarily in the following doc-

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uments, in which further information on the results and approaches used in other sectors can be found: for Peru in PlanCC (2014), for Colombia in Universidad de los Andes (2015) and IDEAM et al. (2015), for Brazil in IES Brasil (2015) and for Chile in MAPS Chile (2014). The aim of the paper is to provide a point of reference for other countries seeking to undertake similar analyses.

2. Overview of the literature on projecting emissions from the waste sector

The Intergovernmental Panel on Climate Change (IPCC)'s Guidelines for National Greenhouse Gas Inventories provide methodologies for calculating a country's greenhouse gas emissions associated with various activities in a particular year, with Volume 5 of the guidelines focusing on the waste and wastewater sectors (IPCC, 2006). In the IPCC guidelines, different methodologies are provided to take into account different levels of data availability. Where country-specific data is not available, generic global or regional data is provided in the guidelines to support the calculations.

Information required to calculate emissions from solid waste management includes volume of waste generated in the calculation period, composition of waste, disposal route and disposal site management practices. For Municipal Solid Waste (MSW), the volume of waste generated is linked to factors including population and waste generation per capita, while composition is linked primarily to GDP/income level. Industrial waste parameters are linked primarily to the types of industry. Emissions from landfill sites are also impacted by historical waste disposal (as waste degrades over time). The IPCC guidelines specify a first order decay model for waste disposed of to landfill to account for this consideration. For full details the reader is referred to the guidelines (IPCC, 2006).

Emissions from wastewater management are linked to wastewater volumes, wastewater composition and management route. Once again, domestic wastewater volumes are linked to population and diet, while industrial volumes and composition are linked to industry type (IPCC, 2006).

While the guidelines' main focus is on greenhouse gas inventory development for a particular year, the calculation methodologies are equally well applied to projecting emissions into the future under different scenarios of waste generation and greenhouse gas mitigation. Here projections of a number of key parameters are required, which for the waste sector include population, GDP, changes to waste management practices etc. Such approaches are used by the IPCC in projecting future emissions from this sector (Edenhofer et al., 2014). There is a selection of publications in the academic literature focusing on long-term emissions projections from waste and wastewater management from countries, regions and/or cities (e.g. Loureiro et al., 2013; Chiemchaisri and Visvanathan, 2008; Friedrich and Trois, 2016; Nielsen et al., 2009). This paper serves to add to that literature, with a specific focus on developing countries. It is noted that there is also a significant body of literature which explores the impact of individual policies and/or technologies on emissions, which is not considered further here.

3. Emissions from solid waste management

3.1. *Modelling the baseline emissions projections*

The same broad approach to developing the baseline emissions projections from solid waste management was used in all four of the countries. Firstly, projections of the future volumes and compositions of solid waste were developed—with composition being relevant as it is the organic fraction of the waste stream that is responsible for the generation of GHG emissions. Population and gross domestic product (GDP) were both recognised as being the key factors impacting on both the volume and composition of solid waste in all four countries. While population growth is directly linked to increasing waste volumes, the impact of GDP on solid waste from the residential sector is twofold. Firstly, an increase in GDP/income levels results in a per capita increase in waste volume. Secondly, growth in GDP is associated with an increase in the proportion of inorganic components relative to organic components in the waste stream, as increased buying power typically increases the recyclable components in the waste stream and leads to an increased consumption of processed and packaged foods.

Once projected waste volumes and compositions had been established, these were used to project greenhouse gas emissions by looking at current waste management options in each country and, in some cases, those that are likely to be used in the future (with no conscious mitigation effort). The only GHG considered was methane (CH_4) from the anaerobic degradation of waste in landfill. In Peru, only waste generated in urban areas was included given the current high level of urbanisation and the projected urban growth rates. In both Colombia and Chile regional waste generation projections were developed and aggregated to give the national figures. Chile further took cognisance of the impact of climatic variance, such as temperature and humidity, on the rate of generation of methane emissions from landfills, assigning a specific reaction constant to each region. In Brazil, the difference between rural and urban generation, in addition to seasonal impacts on waste generation was noted, however these distinctions were not explicitly modelled. Furthermore, in Brazil the baseline emissions scenario included consideration of implementation of current government mitigation policies and measures, requiring judgement when constructing the baseline emissions scenario as to the extent to which these policies would be implemented.

Table 1 provides further information on the key features of the modelling approaches used for the projection of baseline emissions.

While the generic approach to modelling the emissions from solid waste management in each of the countries can be seen to be similar, some differences in both model construction and input parameters can be observed in Table 1. While all countries link waste generation to population, only Peru, Chile and Brazil include a provision for the change in volumes of waste generated per capita with a growth in GDP. In these countries waste generation per capita was linked to GDP through a trend relationship using country specific data, an appropriate approach given the historical evidence of this relationship. Furthermore, despite the recognition of the influence of GDP on waste composition, not all countries accounted for this relationship. In Peru no changes in waste composition with GDP were considered, while in Columbia