Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/envsci

The true extent of agriculture's contribution to national greenhouse gas emissions

M.J. Bell *, *J.M. Cloy*, *R.M. Rees*

SRUC, West Mains Road, Edinburgh EH9 3JG, UK

ARTICLE INFO

Available online 28 February 2014

Keywords:
Agriculture
Greenhouse gas emissions
Emission inventories
Land-use change
Carbon accounting
Scotland

ABSTRACT

The agricultural sector is a significant contributor to greenhouse gas (GHG) emissions, and a growing global population means that agricultural production will remain high if food demands are to be met. Mitigation methods to reduce emissions from this sector are thus required, along with identification and quantification of emission sources, so that the agricultural community can act and measure its progress. International legislation requires the submission of annual reports quantifying GHG emissions from agriculture. The importance of attributing the correct sources of emissions to the agricultural sector is clear; however the current approach taken by the IPCC, and reported to the UNFCCC, omits emissions from soils during agricultural land-use change from its agricultural inventory.

This paper questions the IPCC approach, and the attribution of agricultural land-use change emissions to a separate category: 'Land-use, Land-use change and Forestry'. Here a new approach adopted by the Scottish Government is examined, and compared to IPCC guidelines and national communications submitted to the Department of Energy and Climate Change (DECC) and the UNFCCC. The new Scottish Government approach attributes emissions from both land-use conversion and agricultural land under continuous use to the agricultural sector, in addition to those emissions from livestock and energy use on farms.

The extent of emissions attributed to the agricultural sector using the Scottish Government approach is much greater than that using the other approaches-largely resulting from the inclusion of cropland conversion in the Scottish Government calculations. Attribution of these emissions to the agricultural sector gives calculated emissions of 10.63 Mt CO_{2eq} in 2009, compared to 7.06 Mt CO_{2eq} using the IPCC guidelines. This has implications for the agricultural community and may influence how and if they choose to act to reduce emissions. A large reduction in emissions from cropland conversion since 1990 means that total agricultural emissions in Scotland have fallen 26.64% when calculated by the Scottish Government, compared to a drop of only 19.13% reported to the UNFCCC.

1. Introduction

Livestock and arable farming play an essential role in global food production, and are economically and politically important (Herrero et al., 2011). There is pressure on the agricultural sector to produce food for a growing global population-having more than tripled since 1930 (Desjardins et al., 2007), and predicted to reach 9 billion by 2050 (Wollenberg et al., 2012). This increase in population has resulted in a 3 fold increase in cereal production and a 4 fold increase in meat production from 1960 to 2010 (Smith, 2013). More than 41% of the

* *Corresponding author*. Tel.: +44 01315354214.
E-mail address: madeleine.bell@sruc.ac.uk (M.J. Bell).
http://dx.doi.org/10.1016/j.envsci.2014.02.001
1462-9011/

European Union's land area was reported as being under agricultural production in 2007 (Firbank et al., 2013), and predictions suggest that increases in global food production of at least 50% by 2050 will increase demands for agricultural land in Europe and elsewhere (Firbank et al., 2013). In 2009, as much as 3.1 million ha in the UK was planted with cereals. It is clear that the agricultural sector is increasing in size-but exactly how this is impacting on greenhouse gas (GHG) emissions remains uncertain, as do the opportunities for mitigation.

Within the scientific community there is increasing recognition that agriculture in general, and livestock production in particular, contribute significantly to GHG emissions (Bellarby et al., 2013; Galloway et al., 2007; Herrero et al., 2011). As a result, the global agricultural community is committed to reducing emissions to safeguard the environment; however, it must simultaneously meet the demands of a growing human population, and their increasing requirements for food high in quality and quantity. There is a need to improve the efficiency of agricultural production if we are to meet global food supply demands, and decrease agriculture's impact on climate change. Quantification of the impacts that agriculture is having on the environment is thus of major importance.

The Intergovernmental Panel on Climate Change (IPCC) recognises that increased atmospheric GHG concentrations are partly responsible for global temperature rise, and under the Kyoto Protocol industrialised countries are committed to reducing overall GHG emissions to 20% below 1990 levels by 2020 (Franks and Hadingham, 2012). Targets in the UK are even greater, with the Climate Change Act of 2008 demanding reductions of 80% below 1990 levels by 2050 (DEFRA, 2012). Reductions in emissions from the agricultural sector are therefore expected, as it is responsible for approximately 10–12% of global (Crosson et al., 2011) and 9% of UK (DEFRA, 2012) GHG emissions. There is growing consensus that we need to manage agriculture so that its impacts on climate change are restricted (Renwick and Wreford, 2011). It is also important that the methodologies used to report data are robust and provide an accurate estimate of emissions in order to allow policy makers to make informed decisions. According to Wollenberg et al. (2012), even "modest shifts" in agricultural practices can reduce emissions-but the agricultural sector needs to be aware of how and where to act. The Common Agricultural Policy (CAP) has meant that over the last two decades the extent of the UK's reported agricultural emissions has declined (although these do not reflect imported food products), as livestock numbers and nitrogen fertiliser use have been reduced (DEFRA, 2012). Even so, a contribution of approximately 9% to total UK GHG emissions from agriculture in 2010 (DEFRA, 2012) implies that further reductions are required.

The global climate is already changing and impacting how we farm the land, the types of crops that can be grown, and future food production (Renwick and Wreford, 2011). It is vital, therefore, that the influence of agriculture on climate change is identified and portrayed to those within the sector. Although mitigation may come at a cost to the agricultural community in the initial stages, the benefits gained will limit many future potential negative climatic impacts. It is thus important that all agricultural sources of emissions are identified now, so that the agricultural industry can act to protect its future. If future climatic change results in unproductive land (Firbank et al., 2013), then it is very likely that land-use change will take place to limit the impact on overall food production. It is important then that we can gauge how this forced land-use change will impact on GHG emissions, and further affect the climate.

As part of the United Nations Framework Convention on Climate Change (UNFCCC) agreement, the UK is obliged under international legislation to submit annual reports of anthropogenic GHG emissions (Cowie et al., 2012; Misselbrook et al., 2010; Thistlethwaite et al., 2012). Submission of these inventories allows key sources of pollution to be identified and highlighted to the public and policy makers. Inventories can help guide where to focus mitigation efforts and assess how effective they are over time. But if these are not accurate, transparent and easily interpreted, we may miss the opportunity to undertake effective mitigation (Ellison et al., 2011; Herrero et al., 2011; Wang et al., 2011). Inventory quality was identified as an important issue by the IPCC in 1996 (Lim et al., 1999) and the case study described here will use and compare results from three different inventory approaches to illustrate that improvements could still be made.

2. Objectives

Before identifying changes we can make to reduce GHG emissions we need an accurate GHG emission baseline inventory. Without this we cannot target the changes that need to be implemented, and in which sector, to gain maximum benefit. The UNFCCC requires that all signatories use a comparable methodology to report their national emission inventory (Brown et al., 2001). It is widely accepted that global climate change is a challenge to be addressed but firstly the link between agriculture and climate change must be assessed and presented accurately and consistently. Flaws in the assessment of agriculture's contribution will lead to dispute, failure to trust the science, and consequently, failure to act. Global recognition of the extent of agriculture's contribution to GHG emissions is required, as is quantification of how its contribution compares to that of other emission sources.

Although many nations have attempted to quantify and pin-point their GHG emission sources, uncertainties remain, and improvements in the methodologies used are regularly reported. The extent to which IPCC reporting guidelines identify, describe and quantify agricultural emissions is critical for effective mitigation. This paper will address this issue by comparing different reporting metrics and evaluating their role in mitigation policies. The aim here is to highlight the different methods available to calculate/report national agricultural GHG emission inventories, the variation in outputs produced, and the problems and challenges this can cause. Outputs produced by different methodologies could influence how the agricultural community will act and respond to a changing climate and their impacts upon it. Here we show how the use of different inventory and accounting methods can skew interpretation of the agricultural sector's performance in meeting obligations to reduce