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POLICY OPTIONS TO MANAGE GREENHOUSE GAS EMISSIONS FROM THE LIVESTOCK SECTOR: AN AUSTRALIAN PERSPECTIVE

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ABSTRACT

The interface between policy and science provides rich opportunity to frame both the policy and science agendas for the reduction of emissions of greenhouse gases from agriculture. The current Greenhouse Gas in Animal Agriculture Conference (2007) provides a valuable forum for the development and integration of the two. Compared with the level of investments worldwide into technologies to reduce emissions from energy generation and transport, investments into managing and reducing emissions from the agriculture and land sectors have lagged, sadly, far behind. Nonetheless, there still remains strong opportunity to reduce substantially the net emissions from the land-based sector while also improving productivity and financial return (both short and long term). Over the past few decades, it has probably been the science agenda that provided the main impetus for understanding the management of processes that give rise to greenhouse gas emissions from agriculture and for improving management options to reduce these emissions. However, recently a range of new policy approaches (both in Australia and elsewhere) have come into play, and these approaches are now demanding a greater suite and possibly a different set of information from science – and over a short timeframe – to provide the technical means for change to be implemented. The challenge for science is to understand the new demands from the policy agendas, and to resolve how the science community can best deliver what is required. In this way science will be delivering additional benefits to agricultural industries and rural communities as activities in the land-based sector align with national interest and opportunities.

INTRODUCTION

Agriculture is estimated to give rise to 90% of the world's emissions of nitrous oxide and 50% of the emissions of methane (EPA 2001). The values for Australia are somewhat similar (85% and 60% respectively). Overall, the emissions of these two gases from Australian agriculture are estimated to contribute about 16% of the total national emissions, with methane from livestock (13%) contributing about the same as the whole transport sector.

Australia's reporting of greenhouse gases aligns with IPCC best practice guidelines, and as such, emissions from land use change, energy use and transport in agriculture, and sequestration of carbon in forest systems are all reported elsewhere in the national accounts. While it is difficult to disaggregate energy and transport emissions into specific industries, it is not unreasonable to assume that the total emissions from the agriculture sector are likely to be about twice the estimate of the non-CO_2 emissions alone. In any case, it is clear that any national approach to reduce emissions of greenhouse gases needs to include a strong focus on the agriculture sector.

The argument has been developed previously (see Ugalde *et al.* 2005) that it is the interface between science and policy that provides the best opportunity for creating improved (and innovative) solutions to address greenhouse gas emissions from agriculture. Within our current structures, clearly there are opportunities for those operating in government and industry to become increasingly adept at defining the directions and type of science that will be purchased, and correspondingly, those in science have the opportunity to become increasingly and more finely attuned to the policy questions and approaches.

There is now overwhelming evidence that the earth is experiencing changes in the dynamics of climate and in the balances within controlling mechanisms that in no way can be considered normal. Governments, industry, science, and societies alike are increasingly recognising the challenge of climate change that lies ahead. The purpose of this paper is to outline some of the emerging approaches in Australia to address the management of greenhouse gas emissions from agriculture, with an emphasis on non-CO_2 emissions, especially methane from livestock. In turn, science may need to engage with these approaches a little differently to how it has in the past.

REPORTING STRUCTURES FOR EMISSIONS OF METHANE FROM LIVESTOCK

As a party to the United Nations Framework Convention on Climate Change (UNFCCC), Australia annually reports greenhouse gas inventories using methodologies conforming to international guidelines adopted by the UNFCCC. These methodologies will continue to be refined over time.

In addition, the Australian Government, through the Australian Greenhouse Office publishes the National Greenhouse Gas Inventory, prepared under the reporting provisions applicable to the Kyoto protocol. The principal difference between the reporting requirements of the UNFCCC and the Kyoto protocol relates to the accounting of land use change and forestry.

The methods currently used to estimate emissions from Australian agriculture utilise both the IPCC default values and country-specific methodologies and emission factors – known as tiers 1 and 2. For methane emissions from livestock, tier 1 methodologies consider only livestock type and numbers, whereas tier 2 methodologies consider feed intake, animal productivity, diet quality and some options in management.

Tier 2 methods are also used to estimate emissions from the major livestock sub-categories. Given the differences in farming systems in Australia, separate equations are used for pasture fed cattle, lot fed cattle, dairy cattle, sheep, pigs, and other livestock. Data on livestock numbers are sourced from the Australian Bureau of Statistics (ABS) census and survey data. In addition, data on the number of feedlot cattle are sourced from the Australian Lot Feeders Association (ALFA) quarterly survey, and milk production statistics come from Dairy Australia. Other primary data used in equations (for instance, live-weights, live-weight gains, pasture digestibility, feed intake, lactation status) are based on reviews of published data and expert assessments. (For more information see National Inventory Report 2005, Australian Greenhouse Office.)

Table 1 gives an indication of trends in methane emissions from enteric fermentation between different livestock sectors. Overall, methane emissions from livestock have declined between 1990 and 2005, but this has been due to a 40% decrease in sheep numbers over this time, brought about mainly by several periods of extended drought and less favourable price structures on world markets for wool, relative to grain.

IMPLICATIONS OF THE IPCC FOURTH ASSESSMENT REPORT

The IPCC Fourth Assessment Report (2007) takes the view that despite significant technical potential for mitigation in agriculture, there has been little progress in the implementation of mitigation measures in agriculture on a global scale. Barriers to implementation are unlikely to be overcome without policy and economic incentives, regulations and other programmes, such as those that promote global sharing of innovative technologies. The report proposes that mitigation potential in this sector will be enhanced when structures are put in place that harness the synergies between climate change, sustainable development, and environmental quality. In many regions, non-climate policies related to macro-economics, agriculture and the environment have a larger impact on agricultural mitigation than climate policies.

Agricultural mitigation measures often have synergy with sustainable development – and many have the capacity to impinge on a range of social, economic and environmental aspects of sustainability. Many options also have co-benefits (improved efficiency, reduced cost, other environmental benefits) as well as trade-offs (e.g. increasing other forms of pollution), and balancing these effects will be necessary for successful implementation.

Greenhouse gas emissions from agriculture globally are expected to rise due to population growth and changing diets in developing countries. According to current projections, the global population will increase by about 50% by 2050 (to 9 billion). There is still the possibility, however, that the expected increase in greenhouse gas emissions from agriculture may be offset somewhat by improved, region-specific management practices and emerging technologies that may permit a reduction in emissions per unit of food produced.

There is no universally applicable list of mitigation practices. Practices need to be evaluated for individual agricultural systems based on climate, soil type, topography, social setting, and historical patterns of land use and management.

The role of alternative mitigation strategies changes across the proposed range of price for carbon. At low prices, the dominant strategies would be those consistent with existing production such as changes in livestock diet formulation and manure management. Higher prices allow for the use of more costly animal feed-based mitigation options. The contribution of agriculture to mitigation from the use of bio-energy and carbon sequestration would depend on the relative prices of the fuels, carbon pricing, and the balance of supply and demand. For more information see IPCC Fourth Assessment Report, Working Group III 2007.

DRIVERS OF CHANGE TO ADDRESS LIVESTOCK EMISSIONS

Sustained productivity improvements have long been the engine driving growth in Australian agriculture. Australian farmers have continually pursued more efficient ways to produce more output from less input, to offset declining terms of trade and maintain viability (see ABARE, 2007).

The past 20-30 years in particular have seen strong improvements in the efficiency of production within Australian agriculture. The overall productivity of the agriculture sector (a measure of the efficiency with which inputs are converted to outputs), while of course subject to seasonal variations, exhibited an average growth rate of 3 per cent per year over the period 1974-75 to 2003-04 (Productivity Commission, 2005).

Improved production technologies and more efficient farming systems have been supported by investments in research and development by government and industry, and have been enabled by the skill and innovation of Australian farmers. There are perhaps innumerable examples of the practice changes sitting behind the continuous improvements illustrated by the above statistics. A list for the livestock sectors, would include the shift from extensive rangeland systems to more intensively managed feedlots, sustained improvements in feed quality and dietary management, and advances in genetic and breeding technologies, all of which have coalesced to deliver ongoing reductions in finishing times.

The greenhouse intensity of agricultural activity has in the past been quite tightly linked to productivity – but more and more we are now recognising the greenhouse advantages of production efficiency. Greenhouse gas emissions from agriculture are now fairly well-understood as an escape of valuable resources from farming systems. Emissions of methane, for example, can represent the loss of greater than 10 per cent of the total feed energy ingested by cattle – a substantial loss to the energy budget of the livestock industries (Kurihara *et al.* 1999). Similarly in the broad acre cropping and horticultural industries, between 30 and 70 per cent of nitrogen applied to Australian crops escapes without being channelled into production – including as a range of gaseous products (Peoples *et al.* 2004).

The close links between efficiency and greenhouse impacts mean that improvements in productivity will almost invariably have resulted in reduced emissions per unit of product (although in some cases, overall emissions may have increased). Improving the efficiency of livestock production – i.e. by increasing the proportion of feed energy that is converted to meat, milk or wool – will by definition result in lower methane emissions per unit of product. By the same token, taking steps to increase the efficiency with which crops use applied nitrogen will reduce losses – including as nitrous oxide. The story is much the same where the resource in question is carbon – whether in soils, on-farm vegetation, or in fossil fuels. Actions to reduce greenhouse gas emissions will typically result in multiple benefits, achieving positive production, financial, and broad environmental outcomes.

Agriculture faces particular challenges when it comes to managing greenhouse gases. Emissions from agriculture are highly diffuse: in Australia, they arise from over 60 per cent of the total land mass and from more than 100,000 individual enterprises (ABS, 2007). They also vary widely across both space and time. Measuring emissions, even over a small area, is inherently difficult and expensive, presenting a range of challenges for accounting and mitigation.

The ability for Australian agriculture to engage meaningfully in emissions management (and eventually trading) schemes, has built significantly over the past five or so years. The Australian Government has invested around $25 million in the Greenhouse Action in Regional Australia (GARA) programme, which includes a strong focus on research and development aimed at improving understanding and building capacity within the agricultural industries to cost effectively reduce greenhouse gas emissions. Government investment in R&D under the programme has been matched threefold by industry and research partners, resulting in a research portfolio with a value of around $50 million. Key areas of focus include methane emissions from livestock, emissions from agricultural soils (primarily nitrous oxide), carbon stocks on farms, and improving the capacity of land based industries to adapt to the impacts of climate change.

Voluntary partnerships with industry have also been a central element of Australian Government activity in this area, and are the primary means for delivering outputs from the GARA research programme. Greenhouse Challenge Plus is the Government's leading programme for effecting change within industry – including in agriculture – to reduce greenhouse gas emissions. The programme supports both the development of emissions reporting, and the implementation of company level action plans to achieve cost-effective abatement. It is based entirely on partnerships between Government and industry to deliver greenhouse-gas reductions and commercial advantage to agribusiness, simultaneously.

Recognising the particular challenges faced by agricultural businesses in managing emissions, Greenhouse Challenge Plus provides a tailored approach to land-based members. To overcome the difficulties still associated with accounting for emissions on farms, the programme takes a more qualitative or action-based approach than that in other sectors, linking member activity and reporting to best practice in agricultural emissions management. In a world-leading approach, it provides members with tools and information to move towards best practice, and to demonstrate continuous improvement in key areas of farm management.

In 2006, the Council of Australian Governments requested emissions intensity benchmarking in agriculture as a new approach to reducing greenhouse gas emissions (Australian Greenhouse Office 2006).

Benchmarking is taken as an ongoing systematic process to search for and obtain best practice. One of its strengths is that it provides a mechanism to move from current practice to best practice, and subsequently from best practice to bettering best practice. As an approach, it therefore has strong similarities with that taken in Greenhouse Challenge Plus for agriculture. Emissions intensity benchmarking has been endorsed widely by industry as offering a model for innovation in improving productivity and reducing emissions. Governments are currently considering potential frameworks and approaches for the implementation of such a scheme nationally.

FRAMEWORK FOR NATIONAL ACCOUNTING OF LIVESTOCK METHANE USING REMOTE TECHNOLOGIES

The National Carbon Accounting System (NCAS) provides a means of estimating carbon stocks and hence fluxes of carbon from the land sector Australia-wide. Activities are currently underway to expand NCAS to be able to provide a comprehensive account of emissions from the land sector – covering both the carbon and non-CO_2 emissions.

The development of remote systems for emissions accounting requires input from a range of high quality data sets. These data represent the building blocks from which models such as NCAS can be developed in the first instance. Subsequent data provides the validation and testing that is required to ensure that outputs are a realistic approximation of real time measurements.

NCAS provides a GIS spatially referenced platform at a 25m resolution that incorporates a vast array of climatic, biophysical and vegetative data assembled in a sophisticated computer model to produce greenhouse accounts at various scales. The model is designed to quantify carbon stock changes and emissions of greenhouse gases from managed land systems. Currently, the inclusion of emissions of nitrous oxide from the land sector is well advanced. The model includes the process functions that enable interaction between nitrogen and carbon cycles. These can be interrogated at the farm level or aggregated to the regional or State level using agricultural land use and management information.

The Greenhouse Action in Regional Australia Programme provides the platform for robust site specific emissions data from agriculture and forest systems. There are now more than 50 projects in this program that are obtaining fundamental data that can feed into model development and validation

The long term goal of the NCAS platform is to account for the fluxes of all greenhouse gases from land managed systems in a comprehensive wall-to-wall accounting system. Clearly, modelling approaches are the sensible and practical means of obtaining large scale greenhouse gas emissions accounts on a national scale from land based systems. It is simply not possible or practical to quantify the on-ground emissions from every soil type, farming practice or crop species grown throughout the range of agro-ecological zones in the Australian landscape.

The National Accounting Toolbox (NCAT) provides the interface for land managers to calculate farm-level emissions of carbon dioxide using owner specific data, and is currently being improved to include nitrous oxide emissions. The Toolbox can also be used to quantify soil carbon sequestration under different crop and soil management practices. Fluxes of greenhouse gases can be estimated from allocating carbon and nitrogen between soil, microbial biomass, vegetative growth, root biomass, organic matter, and gaseous losses at a single site location. NCAT is a public release version of NCAS that is the same, but allows for defaults and management actions to be modified to reflect site specific information and to test response to management change under these conditions.

The NCAS modelling construct is sufficiently sophisticated and robust to allow the accounting of methane into a national system of greenhouse gas accounting – albeit with additional development. From a land systems perspective all of the primary factors that are related to pasture production are already included in the NCAS model, and the additional steps to convert this to animal production seem relatively straight forward.

The fundamental requirements for pasture production are the mainstream components of the NCAS model, and they can be interrogated over space and time using the GIS linked spatial data and the time series climatic data sets. This enables an estimate to be made of the feed available to grazing animals throughout seasons and years.

Animal production will naturally be associated with a range of factors including; genetics, feed quality and quantity, feed utilisation, supplementary feeds and stocking rates. All of these factors will in some way determine the degree of feed conversion efficiency and the subsequent loss of methane to the atmosphere. NCAS has a plant growth function that is linked to an allocation of nitrogen and carbon in soil and plant processes driven by climate and changes in water availability, temperature and soil conditions.

In a similar way that nitrous oxide fluxes have been incorporated into the NCAS framework, the incorporation of methane fluxes will require a substantial collaborative effort from all stakeholders. The Greenhouse Action in Regional Australia Programme provides the building blocks through a number of site specific projects that are analysing methane emissions from different animal production systems. Outputs from these investments will be incorporated into the NCAS as it is further developed for full greenhouse accounting from managed land systems.

Accounting for total greenhouse gas balances from the land sector is particularly challenging, and it needs to be based on assessments of all major pathways and processes involved in the utilisation and loss of carbon and nitrogen in plant and animal systems. NCAS provides the fundamental platform on which other more mechanistic models can lie, to provide the comprehensive assessment of greenhouse gas emissions across a range of systems without the need for site specific analysis.

THE CHALLENGE FOR SCIENCE

Ultimately, change will be driven by the extent to which industry actions align with, or exceed, community values and expectations, and undoubtedly these vary around the world. In Europe, as elsewhere, there is a strong multi-functional requirement of agriculture within rural communities. This is not as strong in Australia, primarily by virtue of the lower populations in rural areas, and so Australia is less-well placed than some other countries to capitalise on this. Nonetheless, without exception, the social requirements of rural communities need to be taken into account in the delivery of the greenhouse policy agendas of governments and agricultural industries. Underpinning this, and essential for the delivery of change for managing greenhouse gas emissions in agriculture, are issues of skills, training, lifestyle considerations, and of human and financial capital.

There is no doubt that right now, many countries around the world are in the midst of a very solid (re)appraisal of opportunities for driving major reductions in greenhouse gas emissions, including from the agriculture sector – and Australia is no exception. There is also no doubt that science will be called upon – possibly at relatively short notice - to deliver key pieces of information that will be required for the development and implementation of the land-based greenhouse gas emissions agenda. So for a start, it will be absolutely essential for the science community to be actively engaged with the developing agendas, and be prepared to be responsive, and adapt (with work programmes and institutional allocation of funding) as options become clearer. As far as Australia is concerned, building the non-CO_2 components into NCAS is already identified as a corner-stone. This is the mechanism that will provide consistency in accounts from the national level right down to paddock scale.

There are a range of new questions being asked relating to the development and implementation of national accounting. Essentially, accounting traditionally reports only what has happened. Any new regime based on adaptation and emissions abatement needs to be based on process approaches and modelling. This will provide guidance, and options for the land sector to be able to engage actively, and to test and adopt improved management practices, in order to create change for advantage.

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Table 1. Estimated annual emissions of methane from enteric fermentation across several livestock classes (Mt CO_2-e; from AGO National Inventory Report 2007)

	1990	2005
Beef cattle	32.9	34.8
Feedlot cattle	0.4	1.9
Dairy cattle	5.8	7.3
Sheep	24.6	14.4
Other	0.3	0.3