Reducing Greenhouse Gas Emissions from Australian Agriculture:The Role of Benchmarking in Driving Best Management Practice

AUGUST 2006

A discussion paper prepared by the Climate Change in Agriculture and Natural Resource Management (CLAN) Agriculture Working Group to inform consultation on the potential for development of emissions intensity benchmarking in Australian agriculture

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REQUEST FROM THE COUNCIL OF AUSTRALIAN GOVERNMENTS

At its meeting of 10 February 2006, the Council of Australian Governments (CoAG) agreed on a Plan for Collaborative Action on Climate Change. Part of the Plan asks the Natural Resource Management Ministerial Council (NRM MC):

"To report on the potential for development of emissions intensity benchmarks in agriculture and associated environmental management systems."

> ***Purpose of the discussion paper***
>
> ***This discussion paper informs consultation on the potential for emissions intensity benchmarking in Australian agriculture as a new approach to reducing greenhouse gas emissions.***

The approach taken in the discussion paper is to explore a model for how innovation may drive reductions in emissions through improving management practices. Given the context of the CoAG request, a focal point will, of course, be consideration of the most appropriate role for governments in the process.

Voluntary mechanisms will continue to be the key to driving innovation in management practices. New approaches to reducing greenhouse emissions intensity should not increase the regulatory burden facing farmers.

Responses are invited from all levels of government in Australia, peak industry bodies, and research organisations. The report from the NRM MC to CoAG provides an opportunity to develop a *cooperative and consistent* national approach to emissions benchmarking in Australian agriculture. The report will need to be delivered to CoAG before the end of 2006.

Leaders from Australian agriculture have previously called for consistent policies between jurisdictions to ensure a common national framework for emissions management (Government-Business Climate Change Dialogue, 2003). In a similar vein, the Report by the Agriculture and Food Policy Reference Group, *Creating our Future* (the Corish Report) released earlier this year recommends that governments and industry work in a coordinated way to support consistent approaches to policies and programmes affecting Australian agriculture. It proposes that such consistency is an 'essential foundation of success' for the future of Australian agriculture. The request from CoAG concerning the potential for developing emission intensity benchmarking therefore clearly builds on stated industry positions.

Figure 1. The CoAG request builds on stated industry positions

2

INNOVATION: THE MAINSTAY OF AUSTRALIAN AGRICULTURE

Markets for Australian agricultural products fluctuate - often wildly. Climate is highly variable both within and between seasons; agricultural soils in Australia are rated as some of the poorest in the world; competitors have subsidy schemes. Yet Australian agriculture remains prosperous domestically and internationally, and it continues to provide a solid foundation for Australia's regional development. How come?

Australian agriculture has only a 200 year history, and this presents an unusual, if not unique, set of challenges and opportunities among the major agricultural production and exporting countries. Australian agriculture is continuing to move through distinct stages in terms of capacities, motivations, and priorities of land managers, but unlike most other countries, this is firmly superimposed on (or embedded in) rapid and inherent changes from natural ecosystems to highly managed production units.

At the present time, Australian farmers possess an unprecedented capacity to act – both positively and negatively – on the environment. They are driven by the dual motivations of achieving a competitive return from the land base while maintaining or improving the real asset value of that land.

Figure 2. More than 85% of Australian farmers are members of grower discussion groups to develop and implement best management practice.

A feature of this phase is the emergence of a large range of management tools and advisory services designed to assist with meeting the responsibilities and priorities of the modern-day land manager. Environmental management systems and similar tools are already generating multiple benefits – for individual farmers, for the wider community, and for the environment. At times such outcomes have been purposely engineered, while at other times they have arisen much less deliberately – although are no less welcome.

Productivity in the Australian agricultural sector has continued to grow throughout its history. Over recent decades (1974 – 2004) the productivity of the agricultural sector has grown on average by 2.8% per year, a considerably higher rate than that achieved by the economy as a whole (Productivity Commission, 2005). Without question, it is the inventiveness of producers and processors, and the knowledge derived from research that dominantly provides the mechanisms for these continued high rates of productivity improvement.

An estimated $1 billion is invested in primary industry research and development each year by governments, higher education institutes, R&D corporations, and the private sector. Half of this comes directly from Rural R&D corporations and companies, supported directly by contribution from grower levies. An additional but unquantifiable amount of research is undertaken by farmers themselves, contributing substantially to the overall thrust of better business performance.

The continuing development of improved management practice in agriculture relies upon innovation as the key (Fig. 3). While this is obvious in a general sense, there is no doubt that this applies equally to management and reduction of greenhouse gas emissions from agriculture.

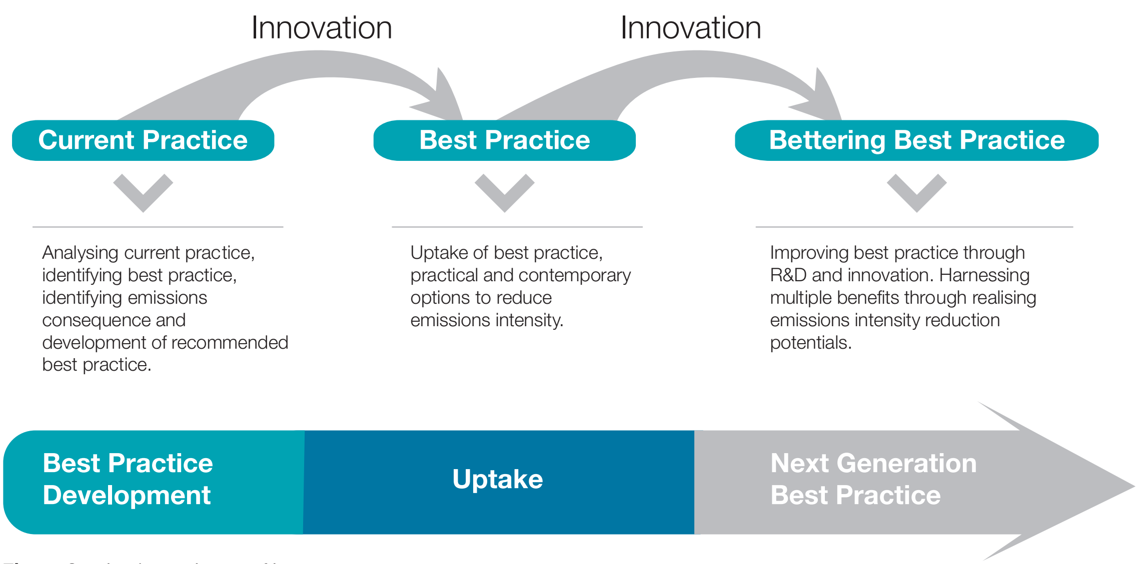

Figure 3. Adoption pathways of best management practice to reduce emissions intensity relying on innovation.

Current practice provides, for instance, an opportunity for us to identify the emissions consequence of that practice and the emissions sensitivity response of farming operations and management decisions (Fig. 3). Research and development predominantly targets incremental improvement, and within this framework accepted best practice is defined and adopted. In every case, the concept of bettering best practice is predicated on creativity and the development of tools and processes that otherwise are not available. There is an opportunity for the next generation best practice to provide additional means to harness the multiple benefits (production, financial, environmental) that can be achieved through reducing emissions intensity. The challenge is to provide an emissions intensity framework to capture the innovation of Australian agriculture and to deliver this outcome.

Analysis of major advances in production observed over the past 100 years or so can likewise be used to demonstrate innovation and the adoption of innovative farming practices (Fig. 4). The relative improvement at each step in this productivity curve is seen as a new benchmark in best practice - before yet another innovation leads to the next leap in yield.

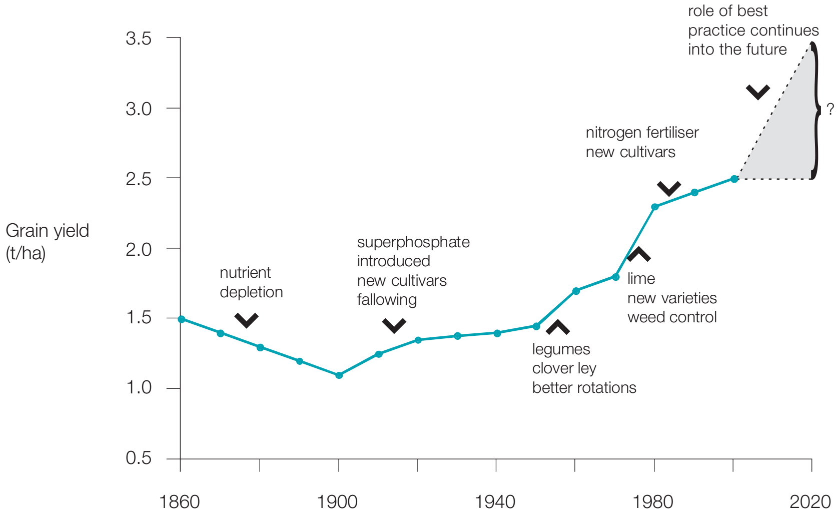

Figure 4. Changes in wheat yield each decade from 1860 to the present (Donald 1965; Angus *et al*. 2001) and projected increases beyond 2000.

Superphosphate fertiliser was introduced into Australian agriculture in the first half of the last century, and yields continued to rise until another limiting factor took effect – identified as nitrogen. Innovation – based first on clover ley farming and subsequently by legume crops in rotation improved nitrogen fertility. Strategic use of inorganic nitrogen also assisted to push Australian agriculture to new 'benchmarks'. In time, however, elevated nitrogen led to a tendency of soil acidification, especially in some higher rainfall environments of south eastern, northern, western and southern Australia; and liming was introduced routinely. Soil acidity was counteracted also with the development and implementation of new acid tolerant varieties. Better weed control, and the associated reduced need for aggressive tillage (i.e. the introduction of minimum till practices) pushed grain yields even higher, and so new benchmarks were set again. Holistic farm and crop management has started a further push.

Figure 5. Sustained efficient productivity targeting high-value markets, the lifeblood of regional Australia.

3 THE CHALLENGE OF GREENHOUSE GAS EMISSIONS FROM AUSTRALIAN AGRICULTURE

The agricultural sector is estimated to account for about 16% of Australia's total greenhouse emissions (National Greenhouse Gas Inventory 2006) making it the second largest source of greenhouse emissions in the economy (Fig. 6). To put this figure into international perspective, it is the second highest proportional contribution to national emissions (New Zealand being the highest), and substantially outweighs corresponding values in the EU (10%) and the USA (5.5%), for instance.

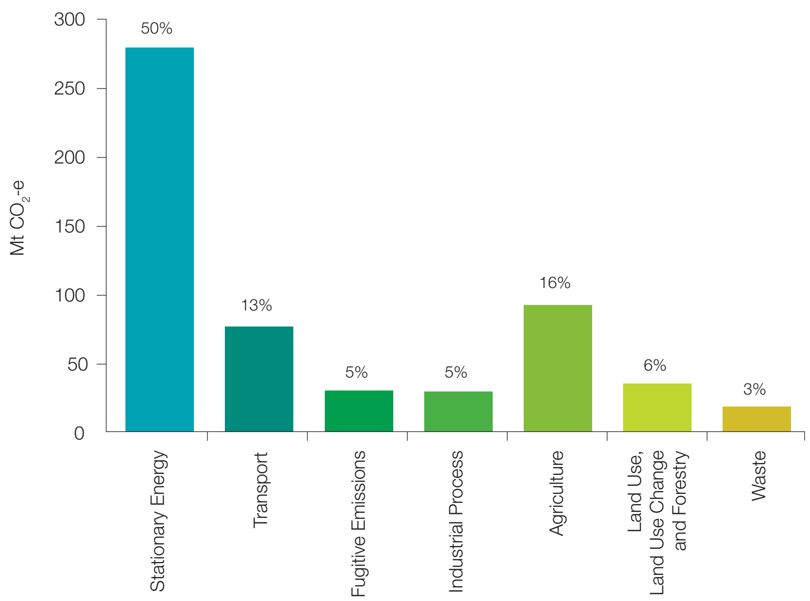

Figure 6. Australia's greenhouse gas emissions by sector, 2004 (National Greenhouse Gas Inventory 2006).

The Australian inventory uses accepted methodology of the Intergovernmental Panel on Climate Change (IPCC), as indeed also do the countries mentioned above. This means that the emissions from energy, transport and land-use change associated with agriculture are reported elsewhere in the inventory. Consequently, when the total spectrum of emissions associated with the agricultural sector is taken into account (especially when viewed within a supply-chain context) the contribution of the agriculture sector to the total national emissions is considerably higher than that shown in the national inventory.

Nonetheless, for the purposes of this discussion paper, the emphasis will remain on the potential for developing emissions intensity benchmarks from activities that are essentially (or predominantly) farm-based.

Reducing emissions from Australian agriculture represents both a challenge and an opportunity. Agricultural greenhouse emissions represent a loss of valuable resources from the production base, and hence taking action to reduce these emissions provides real opportunities to deliver multiple (productivity, financial, environmental) benefits for farmers.

Emissions benchmarking has already been considered for other parts of the economy (e.g. stationary energy). However, agriculture will present a set of new challenges that are not present or reflected in other sectors, as outlined below:

Complexity of systems:

Emissions are a result of natural processes as well as human activities. Climatic and environmental factors may be the dominant driver of short-term emissions trends, sometimes relatively independent of farming practices.

Climatic and Environmental Variability:

Climatic and environmental factors vary from region to region and even from farm to farm, making comparisons not straight forward.

Tailored management practices:

Management practices are tailored specifically to individual needs and production type, adding to the complexities for establishing a comparative base.

Interacting sources of emissions:

Emissions from different agricultural practices are interlinked. Change to management which reduces emission from one source may very well increase emissions elsewhere or from another source.

Figure 7. Agriculture presents a new set of challenges for emissions intensity benchmarking that is not reflected in other sectors.

4

FRAMEWORK FOR EMISSIONS INTENSITY BENCHMARKING

The **intensity** of greenhouse gas emissions can be reduced in two ways:

- Increasing output per unit of emissions, or
- Lowering emissions per unit of output.

This discussion paper proposes that either option is equally valid.

Benchmark was originally a surveyors term meaning 'a mark used as a reference point'. Today, we employ a much broader concept that takes into account *benchmarking* as **a dynamic tool for continuous improvement**.

For the purpose of this study, *benchmarking* is defined as an **on-going systematic process to search for and attain best practice**, as adapted from Australian National Industry Extension Service (NIES) Best Practice Manual, 1993.

The ultimate **intent** of *benchmarking* is to implement new or revised practices based on knowledge of better operational mechanisms that lead to superior competitive performance.

Benchmarking may be incremental or step-wise, but fundamentally, as best practice is a continually moving process, so too is benchmarking a continuing quest for improvement.

Hence, the **power** of benchmarking is that it provides a mechanism to move from current practice to best practice, and subsequently from best practice to better than best.

The **approach** taken in *benchmarking* is as follows:

1. Identification of the key performance indicator to be attained,
2. Rigorous comparison of current practice against recognised best practice,
3. Development of a shared understanding of the nature and magnitude of the performance gap(s),
4. Design and implementation of changes necessary to move from current practice to best practice standards.
5. Monitoring performance and comparing expected and actual outcomes.

Structurally, there are four (not necessarily exclusive) options for benchmarking:

1. **Internal:** Comparing practice with internal standards, possibly time-based, such as year-to-year performance
2. **Competitive:** Comparing practice with the toughest external standard
3. **Functional:** Comparing practice with standards perceived to be feasible within your sector
4. **Generic:** Comparing practice with other sectors that may have (but not necessarily) some similarity to your own.

The link between benchmarking and environmental management systems

While the link between benchmarking and management systems is not automatic, environmental management systems appear to have some potential as one practical way by which emissions intensity benchmarking could be introduced into Australian agriculture.

In this context, however, incorporation of climate change issues into environmental management is not dependant in an absolute sense on the development of emissions intensity benchmarking. Emissions intensity benchmarking if developed would add to the available set of tools currently available to farmers.

What is an environmental management system?

Environmental management systems are an integrated management system that a business can use to identify and manage its impacts on the environment and improve production efficiencies. An environmental management system provides a reliable method of documenting adoption of environmentally sound practices.

Environmental management complements and builds on existing activities such as property management planning, best management practices, codes of practice, hazard analysis and critical control point, product certification, and quality assurance schemes. As a voluntary, flexible ‘systems approach’ it aims to achieve continual improvement in environmental, business and marketing performance.

Figure 8. The Furphy water tank: An Australian icon in both war and peace.

“Good better best,
Never let it rest
Till your good is better
And your better best”

J Furphy and Sons 1900

5 EXPLORING POSSIBLE AREAS FOR EMISSIONS INTENSITY BENCHMARKING

Strategic Action Plans from Australian jurisdictions indicate a focus on five main sources of emissions from agriculture. As a lead to discussion, the potential of emissions intensity benchmarks in these five areas is considered:

1. Nitrous oxide from nutrient and soil management of agricultural land
2. Methane from management of livestock
3. Carbon dioxide from energy use on farm
4. Emissions from livestock waste
5. Vegetation as carbon sinks.

There are many documents, research papers, or strategic plans that address the sources and management of greenhouse gases from agriculture. The following is not intended to be a comprehensive review, but merely a snapshot to assist consideration of the possibility of emissions intensity benchmarking.

Obviously there are regional and sectoral differences in emissions intensity from farming systems across Australia. Therefore any approach to benchmarking as a tool for continuous improvement will have to take this variability into account.

5.1. Nitrous Oxide from Nutrient and Soil Management of Agricultural Land

Nitrous oxide from agricultural soils represents around 3.5% of Australia's total emissions. Equally important, nitrous oxide release is indicative of an escape of nitrogen from farming systems. Anywhere between 20% and 80% of nitrogen applied to the soils escapes without being taken up by the plant for growth and production (Peoples *et al* 2004). The amount of nitrogen lost depends on environmental and management conditions. Hence, clearly there is scope in Australian agriculture for improving nitrogen-use efficiency, tightening up the nitrogen budget, and delivering multiple benefits (Fig. 9).

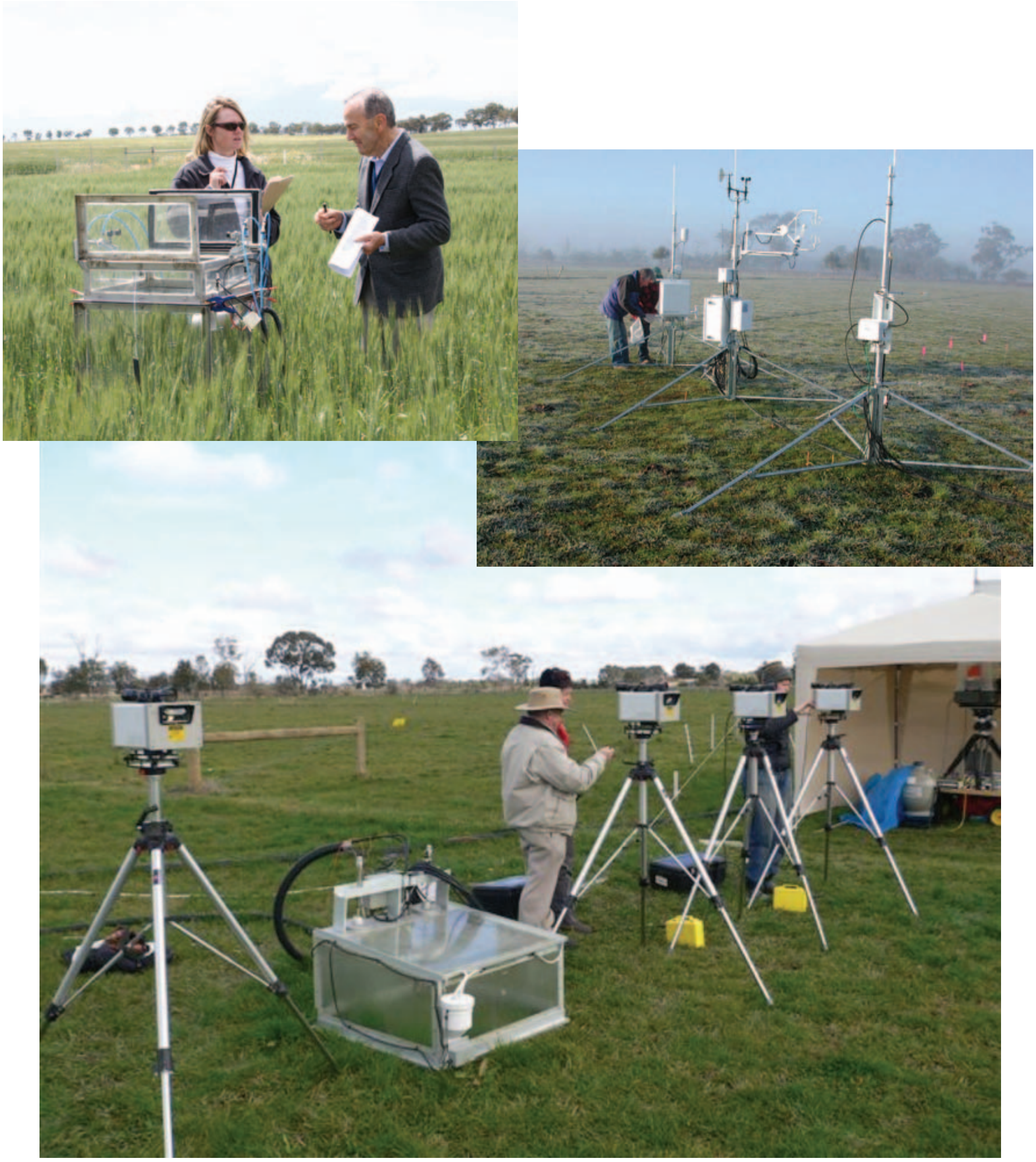

Figure 9. A range of techniques can be used to measure losses of gaseous nitrogen from Australian farming systems – leading management to a tighter nitrogen budget and increased nitrogen use efficiency.

Nitrous oxide derives from two separate processes, known as nitrification and denitrification pathways (Fig. 10), and the activities of these pathways in soils are highly dependent on soil conditions (Table l). In short, nitrous oxide emissions are reduced where waterlogging, compaction and anaerobiosis are reduced. In most cases these practices will be linked to improvements in soil structure as well as better water infiltration and storage.

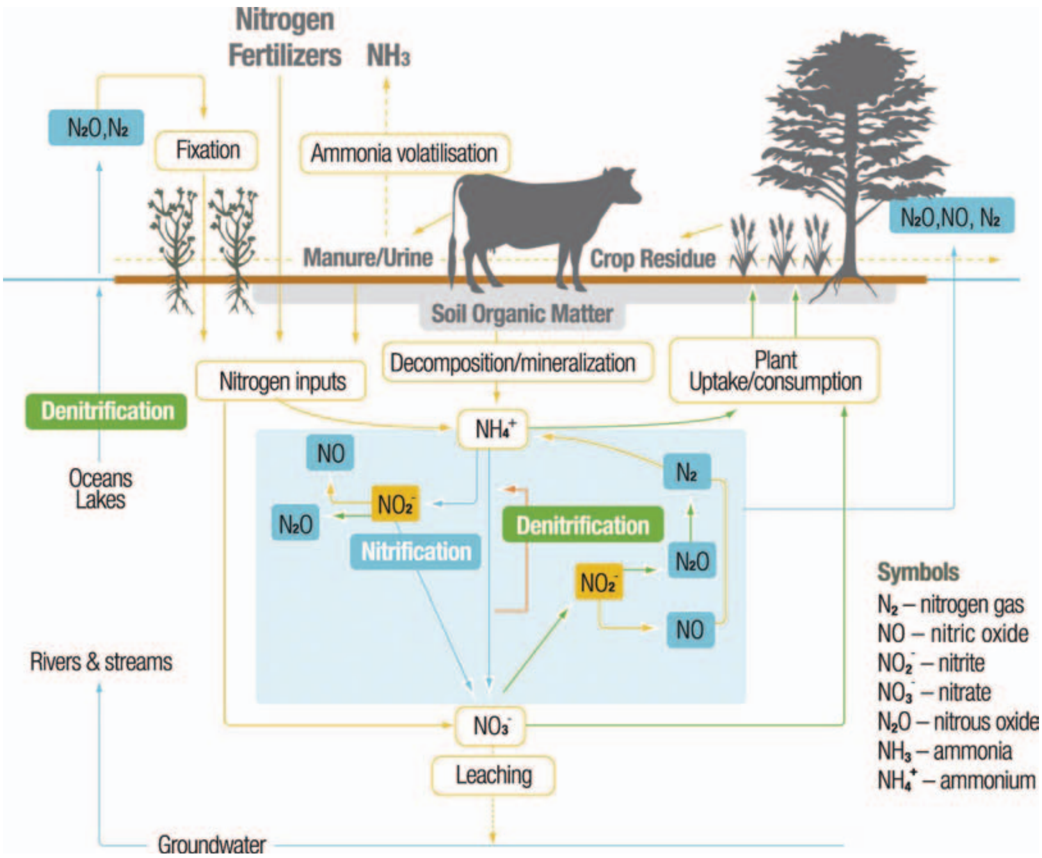

Figure 10. Pathways of nitrogen conversion in soils.

Table I Soil conditions that may affect nitrification and denitrification.

	Soil Conditions Inhibiting	Soil Conditions Promoting
Nitrification: Conversion of ammonium to nitrite and nitrate, release of nitrous oxide.	• Dry • Waterlogged • Low oxygen levels • Highly acidic • Cold (<5°C)	• Neutral-slightly acidic • Moist, warm • Aerobic conditions • High organic carbon levels
Denitrification: Conversion of nitrate nitrite, release of nitrous oxide	• Highly acidic or highly alkaline • Available oxygen • Dry • Cold	• Waterlogged • Anaerobic conditions • Neutral pH

Capacity of Management Practice to Reduce Emissions Intensity

Management practice in nutrient and soil management has the potential to reduce emissions through:

1. Better fertiliser management:
   - setting realistic yield goals based on the capacity and characteristic of the farm,
   - improving the timing of application to maximise nutrient uptake by the plant,
   - improving fertiliser application techniques to improve nutrient placement,
   - improving water use in relation to fertiliser application.
2. Better soil management:
   - ensuring continuous plant cover,
   - managing and conserving soil structure,
   - implementing practices such as stubble retention.
3. Other strategies
   - Using of controlled release fertilisers, urease inhibitors and nitrification inhibitors.

5.2. Methane from Livestock

Methane from sheep and cattle is estimated to account for over 12% of Australia's total greenhouse gas emissions and 70% of agricultural emissions (National Greenhouse Gas Inventory, 2006). It derives as a bi-product of feed digestion in the rumen, primarily breakdown of cellulose, in a process known as enteric fermentation.

The emission of methane from livestock represents a direct loss of feed energy - between 7 and 10% of energy ingested by ruminant livestock escapes as methane (Figs. 11, 12). Hence, practices that limit methane emissions in most cases provide a boost to animal productivity.

Figure 11. Calorimeters measure whole energy budgets of livestock, including energy that is wasted as methane.

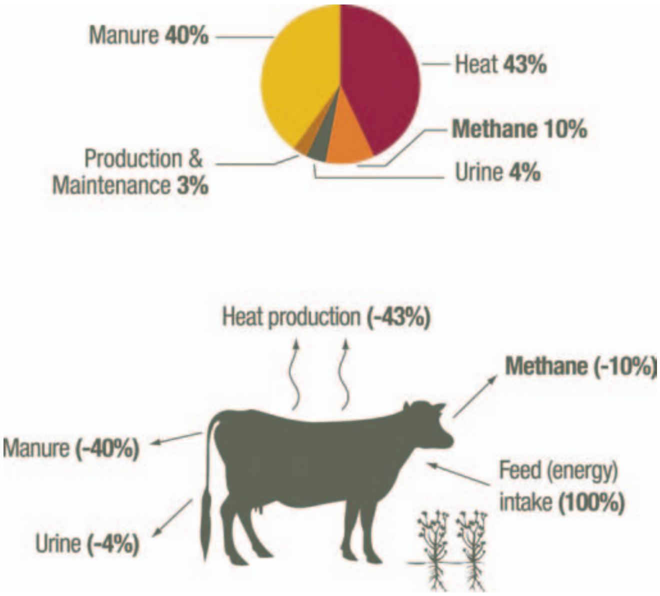

Figure 12. Energy use by livestock. Sample distribution of ingested energy in cattle with a liveweight of 360kg and growth rate of 0.6kg/day, fed on medium quality forage diet – typical conditions in northern Australia (adapted from Kurihara et al. 1999)

Methane is primarily removed from the rumen through the mouth, while smaller proportions are either absorbed into the blood and released through the lungs, or are passed through the intestinal tract.

The amount of methane produced during enteric fermentation is greatly influenced by management of animal nutrition, in particular:

- the level of feed intake (higher levels of intake generally result in the production of more methane),
- the biochemical pathways associated with rumen fermentation, and the composition of the microbial population of the rumen (in turn influenced by diet).

Capacity of Management Practices to Reduce Emissions Intensities

Management practices which have the potential to reduce emissions from livestock are:

- Improving nutrition and feed management by optimising feed intake levels, and the quality and digestibility of feed,
- Managing herds and flocks to reduce the number of unproductive animals,
- Improving animal genotype through targeted breeding,
- Improving animal health management,
- Rumen modification through feed additives,
- Vaccination of livestock to maintain health.

5.3. Carbon Dioxide from Energy Use on Farm

In estimates to date through *Greenhouse Challenge for Agriculture*, carbon dioxide from energy and fuel use on farm range from about 10% of total greenhouse gas emissions (broadacre farms) to 45% (intensive irrigated farm with water pumping). Improving energy efficiency and using alternative fuels where possible are effective ways to reduce greenhouse gas emissions and cut costs associated with electricity and fuel use (Figs. 13, 14)

Figure 13. Passive and renewable energies: towards cost and greenhouse neutral.

Capacity of Management Practices to Reduce Emissions Intensities

Carbon dioxide emissions from energy and fuel use on farm may be managed across a wide range of farm operations. As an aid to discussion, some possible options are mentioned.

Choice and use of farm machinery and equipment

- Matching machinery and equipment appropriately for the task,
- Identifying the main areas where energy is used, and developing a long-term plan to improve efficiency of equipment,
- Considering energy efficiency as a factor in selecting new equipment,
- Switching to alternative fuels with lower greenhouse emissions,
- Obtaining energy from renewable sources such as solar panels and bioenergy.

Farm design and construction

- Effective farm design and layout, including positioning of paddocks, fencelines, plantations, and road access points,
- Survey and design of paddocks to maximise operational efficiency and to accommodate controlled-traffic systems where appropriate,
- Maximising use of natural light and ventilation in farm buildings,
- Insulating buildings, storage and refrigeration devices, and heating and cooling pipes,
- Installing energy efficient lighting systems,
- Using light coloured, heat reflective paint on roofs and walls where appropriate.

Farm operations

- Developing and following a regular maintenance schedule for machinery and vehicles,
- Adopting minimum till and controlled traffic techniques in cropping operations,
- Improving the efficiency of fertiliser and chemical applications to help save on fuel consumption,
- Installing solar-powered water pumps in place of electric or diesel-powered models if possible,
- Improving the efficiency of irrigation practices

Figure 14. Dynametric measurement of drawbar force and fuel flow show substantial reduction in energy for tillage and sowing operations where stubble is routinely returned to the soil.

5.4. Emissions from Livestock Waste

Fifteen percent of all emissions from the livestock sector is attributable to management of livestock waste (National Greenhouse Gas Inventory, 2006). Of this, around 50% is from piggery waste, 30% from beef feedlots, and 20% from dairies.

Both methane and nitrous oxide are emitted during the decomposition of organic matter from livestock waste, but when well managed manure and wasted feed are potentially useful inputs to the agricultural production systems. Emissions intensity benchmarking and best practice guidelines in this area could consider both means to reduce waste, and means for employing better waste management strategies (Fig. 15).

There are two types of decomposition of livestock waste, and each has different greenhouse gas consequences.

- Aerobic decomposition occurs in the presence of oxygen and is linked biochemically to microbial respiration. Aerobic conditions exist in actively composted manure stockpiles, dry aerated deep litter and in treatment ponds with light volatile solids loading, and ponds with mechanical aeration.
- Anaerobic decomposition occurs in conditions of low oxygen potentials, and involves breakdown pathways not linked to normal respiration. Anaerobic conditions exist in wet manure, compacted stockpiled manure, saturated deep litter, treatment ponds with heavy volatile solids loading, and anaerobic digesters.

Figure 15. Benchmarking to turn waste and cost into resource and profit.

Capacity of Management Practices to Reduce Emissions Intensities

Best management practice to reduce emissions from livestock waste could focus on the following areas:

Feed Management

- Use of decision support tools such as AUSPIG, PIGBAL, DAIRYBAL and BEEFBAL to improve feed efficiency.
- Use of grain treatment processes that maximise digestibility and minimise the amount of organic matter in manure (e.g. steam flaking or grain tempering).
- For dairy cattle, use improved pastures and grain-based supplements to improve the digestibility of rations.

Feed Waste Reduction

- Design of feeding systems to maximise feed usage, and to reduce spillage and spoiling of feed (Feeding system designs for feedlots can be found in 'Designing better feedlots' manual, Watts and Tucker, 1994).
- Minimising wastage by monitoring feed areas to ensure feed is not supplied in excess of animal requirements.
- Monitoring weather conditions to avoid feeding immediately before rainfall events, as wet feed is more likely to spoil.
- Removing spoilt feed from the feed system and deposit it in the manure stockpile.

Manure Management

- Applying manure removed from pens or soil onto the surface of vegetated land areas if practical and operational considerations allow,
- Applying of nutrients based on an assessment of crop demands (as above),
- Using active composting instead of stockpiling practices,

Treatment and Storage ponds

- Dewater ponds by irrigation to crops or pastures to avoid overtopping and reduce anaerobic conditions,
- Ensuring solids that accumulate at the bottom of the pond as a by-product of anaerobic digestion are removed, to be stockpiled, actively composted or spread directly onto land.
- Investigating covering of anaerobic ponds for abatement of greenhouse gas emissions or entrapment and subsequent use of biogas for electricity generation.

5.5. Vegetation as Carbon Sinks

Vegetation establishment and management on farms can provide productivity and environmental benefits. Revegetation and managing remnant vegetation for biodiversity purposes and benefits such as wind breaks and shelter for livestock can contribute to reducing overall on-farm emissions, by sequestering carbon from the atmosphere (Fig. 16).

Capacity of Management Practices to Reduce Emissions Intensities

The capacity of vegetation ecosystems to sequester carbon is clearly influenced by management decisions as demonstrated, for instance, by:

- Species selection and site preparation during establishment for optimal survival and growth,
- Replanting in ways to ensure consistent cover,
- Protecting plantings from fire, pests and disease.

Where savannah burning is a necessary management practice, adopting planned approaches to burning and avoiding high intensity fires can optimise vegetation sink capacity.

Figure 16. Multiple benefits from healthy profitable ecosystems increasing the real asset value of the land.

6 FRAMING RESPONSES

The Climate Change in Agriculture and Natural Resource Management Working Group (CLAN, constituted under the NRM MC) invites responses from Australian jurisdictions, agricultural industry bodies, and research organisations to make comment on the issues raised in this discussion paper.

The responses will be used to frame the report from the NRM MC to the CoAG as requested (see Section 1).

Responses are invited to any issue raised. But the CLAN Working Group would be particularly pleased to see responses to the following questions:

1. Does emissions intensity benchmarking provide the potential to be an effective mechanism to continually improve the management of greenhouse gas emissions from Australian agriculture?
2. If so, how can the objectives of innovation, partnership, and consistency be best incorporated into emissions intensity benchmarking?
3. What mechanisms can be used to ensure that emissions intensity benchmarking delivers real and tangible benefits to growers and to Australian agriculture generally?
4. What is the role of governments in developing national emissions intensity benchmarking?
5. What measures could be implemented to achieve better coordination of research nationally relating to benchmarking of emissions from agriculture?
6. What type of mechanism could be used to implement emissions intensity benchmarking in Australian agriculture? Would environmental management systems be an appropriate tool?
7. Indicate any strategic planning documents published by Commonwealth, state and territory governments, peak industry groups, or research organisations which you consider should be included to inform a state-of-knowledge or information-gaps analysis relating to the issues of reducing emissions intensity from Australian agriculture?

Responses should be lodged by **29 September 2006**, and forwarded to:

Director, Greenhouse and Agriculture
Australian Greenhouse Office
Department of the Environment and Heritage
GPO Box 787
Canberra ACT 2601

Or via email to **david.ugalde@deh.gov.au**
The AGO website contains further details on the consultation:
http://www.greenhouse.gov.au/agriculture/index.html

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