New Technologies, Industry Developments and Emission Trends in Key Sectors: The Agricultural Sector

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Contributions to Emissions

The agricultural sector (excluding land clearing) contributed around 20 per cent of Australia's net greenhouse gas emissions in 1996 (Commonwealth of Australia, 1998). The main sources of these emissions were methane from the digestive systems of cattle and sheep and nitrous oxide from soils (the latter in part associated with fertiliser use).

Vegetation clearance for agriculture is a further important contributor to Australia's greenhouse gas emissions. At present the current rate of land clearing for agriculture is in excess of the rate of revegetation occurring in Australia., implying a net positive contribution to global warming emissions.

The forestry sector also has an important influence on greenhouse gas emissions. Carbon dioxide removal occurs as a result of increased vegetation and the expansion of production forestry can be an important means of offsetting some of emissions enhancing effects of the primary sector.

If we consider both food and non-food agriculture resulting from the advanced manipulation of organisms (in particular), output from the agricultural sector is likely to increase quite significantly over the next fifty years in both developed and developing countries. Higher production in the agricultural sector will lead to higher greenhouse gas emissions, the extent of which is driven largely by locational aspects of the diffusion of advanced information and materials technologies. The associated effects on emissions are likely to be negligible in the developed world but large in the developing countries, particularly in East and South Asia and Latin America (Dewick, Green and Miozzo 2002).

Ways of Reducing Emissions

The National Greenhouse Strategy is aiming to reduce gas emissions from agricultural production. Sustainable agricultural management practices aimed at delivering reductions in net greenhouse gas emissions are to be promoted through programs addressing a broad range of issues. The strategy aims to reduce emissions from agriculture by appropriate farm practices and technologies, while enhancing greenhouse sinks through increased forestry and revegetation and reduced vegetation clearance.

Enhancing Greenhouse Sinks

The establishment of vegetation can provide significant greenhouse benefits through the sequestration of carbon. This is particularly the case where there is a low initial carbon content in soil and vegetation. Initiatives include increases in vegetation associated with production forestry and the development of reserves and protected lands that permit revegetation. The forestry sector is thought to provide a net sink equivalent to 5 per cent of national net greenhouse gas emissions (Commonwealth of Australia, 1998).

The CRC for Greenhouse Accounting (2000) has made the following points.

1. Potential gains in soil carbon stocks that may come about as a result of alternative crop or pasture management are difficult to predict because responses vary with regional climate and soil type in ways that are not currently well understood.
2. Carbon stocks in woody vegetation may be occurring across large areas of grazed woodlands as a result of changing fire and grazing practices. Other changes in management in the Australian rangelands, such as destocking, shifts in grazing practice, and revegetation of degraded areas with shrubs may also result in increases in carbon stocks.
3. There has been a rapid recent expansion occurring in the area of Australian forest plantations. There may also be some potential for increasing carbon stocks or reducing greenhouse emissions as a result of changing forest management practices, but the information base and analytical capacity to quantify these potential changes is currently very poor.
4. There is still a significant lack of information related to area and carbon stock associated with non-commercial revegetation activities.

A number of policies have been adopted or are envisaged that are designed to enhance greenhouse sinks (Commonwealth of Australia, 1998).

1. Bushcare. The ultimate goal of Bushcare, the National Vegetation Initiative (NVI), is to reverse the long-term decline in the quality and extent of Australia's native vegetation communities. The program has provided substantial funding for vegetation programs.
2. Farm Forestry program. This program seeks to further the development of farm forestry by incorporating commercial tree growing and management into farming systems.
3. Plantations for Australia: The 2020 Vision. This seeks to build internationally competitive, market focused and sustainable plantation growing and processing industries with significant private sector investment.

It has been found that, despite the application of government programs such as the Natural Heritage Trust, Australia's biodiversity was in steady decline, with broad-scale land clearing a major source of the problem. Queensland accounts for 95 per cent of Australia's land clearing, with clearing rates as high as 500,000 hectares a year. The report called for the Government to shift its focus from repairing damaged environments to maintaining largely undamaged

ecosystems, saying that the maintenance of healthy ecosystems would cost up to 100 times less than repairing any damage. It also recommended clear policies on property rights, compensation, and a system in which land-clearing permits could be conditionally traded between landowners or bought back by the Government. Report by the Prime Minister's Science, Engineering and Innovation Council: *Sustaining our Natural Systems and Biodiversity*.

Encouraging Sustainable Forestry and Vegetation Management

The sustainable management of vegetation, including forests, can provide significant greenhouse benefits in addition to supporting the broad objectives of ecologically sustainable development. Reducing the rate and extent of vegetation clearance is important for maintaining greenhouse sinks, and for reducing the considerable emissions associated with soil disturbance and vegetation decay.

The States and the Territories have prime responsibility for sustainable vegetation management including controlling or regulating land clearing and protecting remnant vegetation. The Commonwealth and State governments cooperate in the development of regional forest agreements. The National Landcare program supports activities that contribute to the sustainable management of land, water and vegetation resources. Bushcare, the National Vegetation Initiative, aims to reverse the long term decline in the quality and extent of native vegetation cover. Governments work collectively on this, based on commitments outlined in their Natural Heritage Trust Partnership Agreements (Commonwealth of Australia, 1998).

The Commonwealth Government is developing a new national policy framework for managing our natural resources over the next decades. The framework builds on the achievements of the Decade of Landcare and the Natural Heritage Trust. Key elements of the new policy approach being considered include (i) focussing on tackling natural resource management issues at the regional level; (ii) encouraging partnerships and strategic investments with stakeholders; (iii) using a wider mix of policy instruments; (iv) building capacity and continued support for research and development. Continuation of the landcare ethic will be critical to the success of these new policy approaches.

The discussion paper 'Managing Natural Resources in Rural Australia for a Sustainable Future' developed by Commonwealth, State and Territory governments outlines future policy directions and possible actions for natural resource management (Department of Agriculture, Fisheries and Forestry 1999). The paper was released for public comment in December 1999. A Commonwealth natural resource management ministerial group is considering the Commonwealth's future approach to natural resource management and funding beyond June 2002.

'Best practice' natural resource management continues to evolve. A wider mix of policy tools is likely to be needed to encourage this development. While regulation is a necessary component of nay successful policy mix, a reliance on regulatory measures alone is inadequate to drive the necessary change. One approach to improving future natural resource management with some potential is increased deployment of economic and market-based instruments. Appropriately designed grants, charges, trading regimes and taxes are all economic or market-based instruments that have been suggested for consideration of part of a new policy mix. These instruments provide an opportunity to redress market and institutional failures that are prime causes of natural resource degradation. The possibilities for establishing property rights and trading arrangements for carbon credits are being given close attention as a way of addressing greenhouse issues (Thompson and Heffer 2000).

Reducing Greenhouse Gas Emissions from Agricultural Production

The National Greenhouse Strategy (Commonwealth of Australia, 1998) advocated the incorporation of greenhouse considerations into agricultural management practices. It saw the following issues being addressed.

1. The reduction of energy use in agricultural production through:
    - The expanded use of precision farming;
    - Increasing the use of renewable energy on farms;
    - Introducing farm energy budgets;
    - Re-using agricultural waste especially for on-farm applications;
    - Accelerating the replacement of old machinery with newer more energy-efficient equipment; and
    - Enhancing the use of alternative fuels and the use of transport modes with low emissions per tonne-kilometre of freight.
2. Conservation cropping, to be promoted by such practices as:
    - Minimum tillage and controlled traffic;
    - Significant reduction of cultivated/bare fallow;
    - Direct drilling;
    - Ley systems and crop rotations;
    - Stubble retention;
    - Strategic use of inorganic fertiliser and legumes; and
    - Use of deep-rooted plants.
3. Improved animal husbandry. Key management practices to be promoted are:
    - Improved feed conversion efficiency through breeding and culling programs;
    - Farm management practices such as supplementary feeding, herd health, improved pastures and feedlotting;
    - Farm management practices which promote stocking rates that minimise the risk of degrading pasture cover, root material and soil carbon; and
    - Consideration of alternative and new animal species for production.

4. Manure management and thus use of biogas and other technologies by intensive animal industries.
5. The reduction of biomass burning and management practices which enhance soil carbon, including:
    - Adoption of green cane harvesting;
    - Strategic native pasture management and practices including stocking strategies;
    - Stubble mulching and conservation tillage practices in cropping industries;
    - Increased strategic management of woody weeds; and
    - Alternative use of crop residues (such as cane trash for mulch).

Increased efficiency in the production of animal products will reduce methane emissions, especially from sheep and cattle. Specific government measures to promote this include extension programs targeting rangeland systems and new animal waste processing systems for intensive livestock holdings.

CSIRO has patented an anti-methanogen feed additive which suppresses methane emissions by 100 per cent. However, it results in marginal production gains and has to be fed daily. CSIRO has also patented a methanogen vaccine suitable for sheep and cattle which is achieving an 18 per cent reduction in emissions with some significant production gains. Further research, development and commercialisation of these products is required. In addition, Queensland scientists have found microbes in the stomach of kangaroos which could have relevance to the reduction of flatulence in sheep and cattle. These bacteria could be grown in a laboratory and introduced to sheep and cattle using a drench gun. The bacteria could also improve the efficiency of native pasture use by promoting faster growth of wool and meat.

Agriculture and the Global Knowledge Economy

The emissions-reducing strategy outlined above forms part of a more general approach needed to achieve long-term environmental sustainability in Australian agriculture.

Australia has a bigger stock of knowledge about how to grow food, fibre and forest products sustainably than almost any other country on earth. There is a significant growth potential from forming clusters of dynamic small companies utilising these knowledge assets and capturing global market opportunities for ideas, technology and know-how (Cribb 2000).

While the potential of the Australian agricultural sector is great, it needs to be recognised that important aspects of its current development are unsustainable. The sector can only reach its long term potential if it reconciles economic and environmental considerations through the development of a sustainable agricultural system.

The Concept of a Sustainable Agricultural System

The concept of a sustainable agricultural system embraces the triple-bottom line of economic, environment and social considerations. The economic goal is to achieve, and if possible, extend, international best practice in agriculture in order to meet global competitive challenges. The environmental goals are to minimise the overall environmental footprint of agriculture by making the optimum use of scarce natural resources, minimising waste, and contributing to the resolution of climate change problems. The social goal is to contribute to the maximisation of regional development opportunities.

Economic and Social Sustainability

The economic sustainability and social sustainability of the agricultural system implies .achieving the full economic potential of the sector for regional and export development. This, in turn, requires a whole series of attributes focussing on the emerging areas of competitive advantage associated with product quality and differentiation. This enables the constraints of commodification to be escaped and market power developed. It places agriculture in the realm of the global knowledge economy in which attributes such as skills and knowledge become key attributes of competitiveness.

Environmental Sustainability

The aim is to facilitate the ecologically sustainable development of agricultural industries so that they contribute to Australia's economic wellbeing, protect the biological and physical resource base on which agricultural industries depend, and improve human health and safety. It is noted that most of Australia's soils are old and, as a result, they have a thin zone of fertility in the topsoil and are easily degraded. Degradation occurs as a result of compaction, waterlogging, acidification, erosion and salinity. There is widespread concern about the degradation of farm land. Pressures are exerted by clearing, over-stocking, cropping on marginal land, irrigation, and introduced species such as rabbits and goats. The low profitability of so many agricultural enterprises reduces resource care.

A Framework for the Development of the Agricultural Sector

The objective is to ensure the ecological sustainability of agriculture while improving its economic prospects. These goals will require changing land use patterns and the development of a more value-added orientation in agriculture. Continuous innovation will be the key to success.

The major facets of the development framework should be:

- Sustainable agriculture;
- Research and development;
- Innovation;
- Product quality;
- Market development;
- Logistics;

- Finance; and
- Collaborative development.

Sustainable Agriculture

The National Landcare Program, which includes soil conservation, saving remnant bush and tree planting, has been of vital importance in addressing a key aspect of conservation. It has been very successful in mobilising land-owners and communities to improve environmental conservation and encourage the adoption of sustainable land-use practices.

The newer Bushcare program represents a new era in vegetation management in which native vegetation is conserved and celebrated for its intrinsic ecological value, managed for biodiversity conservation and enhanced for sustainable production. It aims to reverse the long-term decline in the quality and extent of Australia's native vegetation communities. Working with community groups, land managers, industries and government agencies at all levels, Bushcare will invest more than $350 million over the next four years on three main fronts:

- To take responsibility to conserve, enhance and sustainably manage remnant native vegetation;
- To greatly increase and improve revegetation activities; and
- To encourage the integration of native vegetation into conventional farming systems.

Bushcare gives priority to projects at a regional or catchment scale which integrate management of remnant vegetation with extensive revegetation for a range of purposes, including:

- Conserving biodiversity;
- Rehabilitating degraded areas, on and off reserves;
- Safeguarding and improving agricultural production;
- Enhancing greenhouse gas sinks;
- Lowering saline water-tables;
- Improving water quality and wetlands management;
- Conserving wildlife habitat; and
- Providing products including timber, flowers, foliage, oils, fruits, nuts, honey, and services including shade, shelter, pest control and amenity.

The future of Australian agriculture will lie with a combination of measures to arrest and reverse the current environmental degradation, and the encouragement of more value-added activities in the areas best suited to agriculture. Efficient water use and effective salinity and soil water-table management are of critical importance to the long-term viability of Australian agriculture. Other factors of importance are: appropriate land use; responsible use of water resources and handling of waste; and the development of more environmentally sustainable methods of pest, weed and disease control.

Research and Development

The Research and Development Corporations (RDCs) have bee established to encourage the research and development of new technologies. They work closely with their industries and research providers to determine priority areas of research funding, which will deliver high rates of return to their industry and government investors. One of the most outstanding attributes of this approach is that it has allowed growers to predict issues that will become important for stakeholders.

The ecological sustainable development exercise made the following points about the desired directions for agricultural research and development in Australia.

1. Research on the environmental impact of agriculture needs to be more closely integrated with that on production. In many instances, the environmental problems can be solved only by changing production practices.
2. There needs to be better integration between many different scientific disciplines needed to provide a comprehensive understanding of the functioning of agro-ecosystems.
3. Reform is needed in the relationship between research, education and extension in Australian agriculture. Scientific research and development which are integrated with extension and teaching must be a cornerstone in Australia's development of an ecologically sustainable agriculture (Ecologically Sustainable Development Working Groups, 1991).

Innovation

The central message is that the Australian farm sector needs to be highly innovative if it is to compete against subsidised producers on global markets, provide opportunities for regional economic development and contribute to the overcoming of environmental degradation. Research and development programs and the dissemination of information on new technologies are the two key aspects of an innovation strategy. Australia is fortunate to possesses a strong research infrastructure because of the long-standing work of the CSIRO and the development of a broad range of Rural Research and Development Corporations (RDCs) and Cooperative Research Centres (CRCs). The models of research are providing greater scope for collaborative public/private research with strong industry linkages. The aim should be to capture the benefits of technological advances for Australia.

The principal areas of innovation required are listed below.

<u>Salinity</u>

The principal objective should be to arrest the spread of dryland salinity. Airborne geophysics can now be used to investigate land degradation and salinity. A recent breakthrough means that we can identify and target the most effective management options for individual landscapes. The breakthrough has three components: airborne electro-magnetic data collection; airborne magnetic data collection; and airborne radio-metric. The technology provides a cheap way to target investment in actions to reduce salinity hazards.

Strategies to address salinity and rising water tables need to be implemented through a catchment-based approach. A catchment plan has to be prepared using data obtained from airborne geophysics. Revegetation is required, especially in areas higher in the catchment. The planting of trees needs to meet particular environmental conditions, facilitate recharge to control rising water tables, and, hopefully, provide some commercial applications. Pasture management to maintain cover in late spring prevents capillary rise of salts to bare soils surface. Deeper rooting perennial pasture species utilise more water than others. Excess water should be removed by surface drainage, taking care to fit into whole-of-catchment plants. In some situations, such water needs to be harnessed and used for more salt-tolerant crops. Further drainage to aquaculture and eventual drainage for evaporative salt pans may be required as part of a total catchment management system.

Irrigation salinity is the other problem. Advanced irrigation techniques using less water, and more effective watering techniques and control mechanisms, have now become available.

Land Degradation

The processes of land degradation can be divided into three main types:

- Soil erosion loss and deposition (including water erosion and wind erosion);
- Soil degradation which involves the alteration of soil characteristics (soil salinity, degradation of soil structure, soil fertility decline, soil acidification, water repellency, waterlogging and soil pollution); and
- Ecosystem change (including vegetation degradation and the introduction of animal and plant pest species).

Some forms of land degradation have taken a considerable period of time to develop since the initial phase of clearing and agricultural use. Similar if not greater time frames may be required to incrementally redress them. In the meantime, there is evidence that some types of land degradation are accelerating.

Some categories of land degradation can be addressed using a catchment approach. – addressing the underlying problems which occur away from the areas in which proximate symptoms occur. This is the case with localised salinity and some types of soil pollution as well as aspects of water erosion.

Land planning is the key policy instrument for dealing with land degradation, along with the adoption of precision agricultural technologies. To the former, planning issues should cover:

- Water erosion control through appropriate techniques for pasture and animal management, the use of earthworks, and increasing soil infiltration in horticultural areas;
- Wind erosion can be controlled through the use of windbreaks, avoiding overstocking, and mulching stubble;
- Eutrophication can be controlled through appropriate fertiliser management, vegetation cover, etc.; and
- Revegetation to remedy the decline of native vegetation.

Precision agriculture was only introduced in Australia in the early 1990s. It is a high-tech crop management system that comprises on-the-go yield monitors (to measure crop yield and quality), real-time GPS (Global Positioning Systems) and other information technologies such as control technologies for the application of inputs, remote sensing, and systems which assemble and integrate the information received form particular components of the system. While the technology looks complex, its application can be quite simple. It offers the rewards of improved crop management by reducing the level of uncontrolled variation which currently exists in farming systems. It also reduces environmental risk by enabling continuous control of inputs such as fertiliser, spray or irrigation water, reducing the risk of leaching nitrogen or phosphates, restricted use of pesticides, and reducing areas under cropping to the most suitable and sustainable locations.

Biotechnology

The applications of genetic engineering in plant agriculture can be separated into three phases – gene technology and conventional breeding, gene technology and transgenics, and genomics. Gene technologies are already assisting conventional breeding by improving the efficiency and speed of cultivar development. The process of transgenics enables the addition of new properties via a gene construct. Genomics will possibly become the most significant phase of the new technologies. The science of genomics can be divided into three areas: functional genomics (where the role of each gene in a genome is determined), microarray and related techniques (where the expression of thousands of genes can be monitored simultaneously), and genome sequencing (where a plant's entire genetic sequence can be recorded and analysed).

The new era of biotechnology is a further evolution in genetic modification and cross-breeding, in that it:

- Allows useful characteristics – in a single gene rather than blocks of DNA – to be transferred;
- Eliminates the need to back cross to eliminate unwanted traits; and
- Can introduce genes from species other than the host.

Benefits for farmers include the capacity for plants and animals to be more environmentally adapted - for example, crop plants resistant to drought, heat or salt, and plants or animals resistant to viral or parasitic diseases; plants requiring fewer spray treatments, and the accelerated breeding of plants , and more nutritious foodstuffs. This would facilitate greater productivity per hectare, potentially reducing the area that agriculture needs, and enabling greater conservation of biodiversity. At the same time, consumer preferences can be more readily addressed. Finally, the less-energy-intensive developments in organism manipulation may replace chemical production as a source of materials, thus providing a new suite of market opportunities for the agricultural sector.[1]

[1] There will be increased demand for the production of certain crops if biomass reaches its potential and we move to a more 'carbohydrate' economy. This might occur as a result of cost reductions in industrial

Genetic modification of animals for agriculture is more complicated, more controversial and further from commercialisation than developments in plant biotechnology. The main developments in biotechnology for animals are new vaccines and diagnostic capabilities[2]. Biotechnology is also used to select animals for breeding. Possible future applications of biotechnology to animals include transgenic animals (including aquatic animals) with extra growth hormones to improve their weight gain and feed conversion, animals which produce more and/or better milk or better wool growth and sheep which defleece themselves. Other new opportunities relate to both plants and animals being developed which are capable of producing pharmaceuticals, industrial chemicals and new fibres and fuels. While Australia has access to the relevant technologies for mammalian genetic modification, the pace of international programs has not been matched locally, and this could compromise the competitiveness of local industries. Animal transgenesis provides an example of how strategic investment in key emergent technologies at a local level can be critical for both the establishment and maintenance of industries of international importance.

Other Areas of Innovation

Integrated pest management is an important area of technological development.
The Cotton and Horticultural RDCs are particularly active in this area.

A further major area of innovation is in relation to analytical techniques. The primary innovation has been the development of rapid instrumentation techniques for the measurement of crop parameters, including chemical flavour analysis of food crops.

Developments in information technologies and nano-technologies could significantly affect the harvest process. Progress in nanotechnology and materials manipulation (particularly nano-fabrication and nano-electronics) will play a major role in producing more energy-efficient harvesting equipment (incorporating lighter, smarter materials) for use in the advanced economies (Dewick, Green and Miozzo 2002).

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enzymes enabling plant extracts to be used in the production of high quality-low cost industrial products. Other downstream growth sectors using products from a biotechnology-boosted biomass industry may include food, pharmaceuticals, textiles, construction, chemicals, fuels and fertilisers Dewick, Green and Miozzo (2002).

[2] Commercial application of transgenesis technology to animals has until recent times been restricted by inherent limitations of existing methodologies and a shortage of candidate genes for transfer. Recent advances, notably in the areas of mammalian reproductive technologies and whole genome sequencing, provide, for the first time, realistic prospects for directed genetic modification of the mammalian genome in a commercially relevant manner. Augmentation of traditional breeding objectives with transgenic technologies can be expected to improve the efficiency of existing breeding programs, while the opportunity to introduce novel genes and gene combinations, and modify endogenous genes with precision, raises the possibility of developing animals with novel properties, specifically designed for niche markets of enormous value. Examples include transgenic sheep and goats that express high value proteins for use as human pharmaceuticals, and the development of pig organs genetically modified for use in xenotransplantation into humans.

Skills

With the emphasis on innovation in agriculture, new skills will be needed. This has implications for existing agricultural courses and for extension services. Maintaining a capacity in higher education to attract and train talented researchers will also be important.

Integrated Whole Farm Management

The Draft National Strategy for Ecologically Sustainable Development (Ecologically Sustainable Development Steering Committee, 1992), recognised the need to develop and strengthen integrated approaches to management of resources through whole-farm, catchment and regional planning. It recommended a number of initiatives designed to promote land manager group approaches to agricultural management, as well as additional financial incentives for landcare.

Product Quality

There is a need to add value through maximising quality at appropriate costs. This involves:

- Producing varieties of crops or livestock that best meet emerging market requirements, particular where premium prices are on offer;
- Meeting product consistency requirements through the use of quality specifications and quality control;
- The enhancement of product quality by the ability to define, measure and specify quality attributes and thereby send clearer signals to the markets; and
- Avoiding the introduction of exotic pests and diseases.

The Development of Markets

There are five key issues to deal with.

1. Tackling international trade barriers – note the activities of the Cairns Group.
2. Developing product differentiation as a means of competitive advantage – moving away from bulk commodities to emphasising unique qualities. The Pink Lady apple is a distinctively Australian variety and is successfully exported from Western Australia.
3. Developing Australian brands based on:
   - A clean green image, emphasising also the environmental sustainability of supply (organic foods represent an important area with significant long-term potential);
   - Emphasising the quality for cost component;
   - The innovative qualities of the particular products being branded; and
   - Using geographic indications as a market tool.
4. Using wine and food tourism as a means of developing market recognition of Australian brands.
5. Developing adequate marketing budgets on a collaborative basis to finance the building of Australian brands and the international market recognition of such brands.

Logistics

Logistics is about transportation, inventory management and communications The big issues for the future focus on the importance of supply chain management. Meeting ever more complex consumer demands requires much greater coordination across the supply chain than can be achieved under traditional arms-length business approaches. The most effective approach is

chain reversal: supply chains building demand-driven competitive strategies focused on areas such as product innovation, efficient logistics and stock management, and meeting customer-defined quality requirements. European supermarket chains are targeting requirements such as value for money, a diverse and changing selection in any product category, quality, tracking and tracing to underpin food safety, freshness and shorter life time for products, convenience, and environmental sustainability.

The Rural Industries RDC Global Competitiveness program aims to identify important impediments to the development of a globally competitive Australian agricultural sector and support research that will lead to options and strategies to remove them. Part of its work program will address the linkages between various stages in the producer to consumer chain and identify areas – regionally, nationally, or internationally – where they can be better integrated and their efficiency improved.

The use of information technologies including e-commerce and associated new business models are an important aspect of contemporary logistics. The Rural Industries RDC has been active in lifting internet knowledge. At the same time it is raising awareness amongst internet providers that their content must be improved. The RIRDC itself has developed an innovative e-shop where growers and producers can access information on diverse issues.

Key benefits to agriculture from the adoption of e-commerce are:

- More efficient process for procurement of inputs through ordering and payment on-line;
- Better information on the availability and price of inputs (and even cooperative buying);
- Removal of intermediaries thereby reducing transport requirements and minimising adverse consequences for product quality;
- Cost reduction through online marketing and selling products;
- Increased access to markets; and
- Timely information on weather, stock information and prices.

Financing Development

It is dear that a future sustainable agricultural sector in Australia will be much more capital intensive than it presently is. The optimum farm size is likely to grow even larger as scale economies associated with greater capital and technological intensity keep growing. Corporate ownership of agricultural lands will become more extensive and capital markets will assist in providing a greater proportion of equity in farming development. Agricultural investment funds may become a significant source of equity for farming developments.

Collaborative Development

Collaborative development has the potential to contribute greatly to the evolution of an ecologically sustainable but internationally competitive agricultural sector in Australia.

First, there is a need to establish a vision for the future of the sector. Characteristics should be targeted such as clean and green environmentally sustainable, innovative, global leadership in

specific branded market segments, expanded industry capacity in terms of volume, value and brand development, improve profitability.

Second, it is desirable to articulate quantitative and qualitative goals for individual industries – say ten years out, perhaps further.

Third, it is worthwhile outlining the resources needed to achieve future goals – the development and adaptation of land resources, water use, capital expenditures, employment, finance.

Fourth, a government/industry partnership framework can contribute to the development of the sector, with appropriate government support in areas like training, strategic data collection, and so on.

Fifth, it is desirable to develop deeper collaborative arrangements between government, industry and other stakeholders including research institutions and the education sector. The collaborative arrangements can be used to drive technology platforms, and the realisation of the shared industry vision.

Conclusions

1. The contribution of agriculture to global emissions has two unusual features:
   - a significant proportion of these emissions are associated with methane from the digestive systems of ruminants and nitrous oxide from soils; and
   - vegetation clearance for agriculture is also a significant contributor to emissions while revegetation and forestry in particular reduce emissions by acting as a carbon sink.
2. The strategy for reducing emissions associated with agriculture focuses on:
   - reducing emissions from agricultural production through improved practices and the introduction of new technologies; and
   - enhancing greenhouse sinks through afforestation and revegetation while reducing land clearing.
3. The greenhouse strategy for agriculture needs to be considered in the context of a comprehensive approach to securing environmentally sustainable agriculture. There is a strong connection, for example, between overcoming soil degradation and restoring carbon sinks.
4. Achieving a sustainable agricultural sector in the widest sense will require substantial investments of technology, capital and skilled labour. This is best achieved if, at the same time, the economic competitiveness of the sector can be boosted. This can be achieved in an integrated framework for the development of Australian agriculture that stresses R&D, innovation, product quality, market development, and advanced logistics.

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